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Composition of the Integrated Model for the Chirchik-Akhangaran-Keles Basin and Selected Results

Project River Twin

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Determining composition of models

- Set of models used,

- Database,

- GIS.

Approach used in the project in modeling of basin functioning and development is usually called as «***algorithm concept*».** Such approach considers a set of models **M1,M2, . . . , Mk**, that describe various aspects of system behavior. Then, the algorithm of system behavior as a whole is formed though different combinations of operating models. Taking into account great number of various models used in the project, with different variable sets, dimensions, programming languages, and data formats, for correct assembling of the **Integrate model** it is necessary to take a range of assumptions on formal description of model interaction that make it possible to operate uniquely with variables of various models at different stages of their operation.

Main blocks of the Integrated regional model

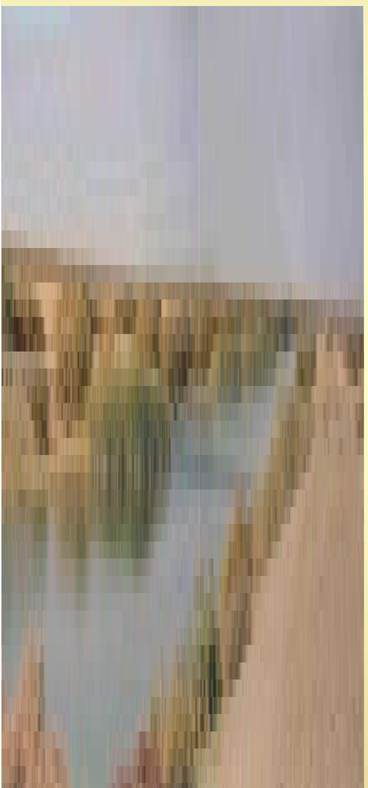
- Climatic block.
- Regional development scenarios block.
- Hydrological block.
- Ecological block.
- Economic block.
- Visualization and analysis of the results.

GIS variables

Let set symbols for spatial variables processed by GIS tools. Geoinformation systems usually use two types of mapping data presentation – first, location of an object relative to the earth, i.e. **x**=[x1, x2] – spatial coordinates, and, second, attributive (descriptive) characteristics of the object, for example, z(**x**) – raster layer of elevations. For the Chirchik-Akhangaran-Keless basin, this layer is realized in cells 90×90 m and is a reference relative to which other raster and vector layers are formed. Each raster layer has one attribute, for instance, z^g(**x**) – raster layer of water tables. Each vector layer corresponds to specific objects having a set of attribute information, for instance, cities, rivers, rayon's, etc. In vector layers, boundaries and orientation of objects are determined by a set of points that, if joined straightly, make images of the objects. The points themselves are defined by coordinates:

- 1 – point objects, by one coordinate "**x**",
- 2 – linear objects, by a set of "k" coordinates "[**x**0, **x**1, . . . , **x**k-1, **x**k]",
- 3 – area objects (polygons), by a set of "k" coordinates "[**x**0, **x**1, . . .**x**k-1, **x**0]".

Database



- The central concept in the **Database** is «***information object***»**.** In order to define various objects uniquely in the whole space-time project set, the composite coding system (place:time) is used.
- Each object, during its registration, takes a unique code ”j:t” , where: the first index “j” characterizes its location, while the second index “t” is a year when the object was created physically.
- Economic sectors in the Chirchik-Akhangaran-Keless basin:
- 1 – Industrial sector, including energy production (hydropower and heat power),
- 2 - Agriculture,
- 3 - Agro-industry,
- 4 – Service sector, including communal sector.

Coupling of objects in space

Spatial coupling of objects is based on network theory, where every object "j", according to its type (point, linear or areal) is associated with a set of arcs reflecting its links in the general water infrastructure in the basin. Each arc corresponds to particular water flow directed to relevant economic sector of a particular object. Direction of arcs is based on direction of water movement. Set of all objects {j} and set of arcs "{j,k}" (flows) form connected oriented graph $G(J,I,t)$, $j \in J \equiv \{j\}$, $(j,k) \in I$, $\forall (j,k)$, $j \in J$, $k \in J$, $k \neq j$, corresponding to water infrastructure in the basin in specific period of time "t". Every mathematical model works only with a part of information objects; therefore, own interface is needed for a particular model to form respective partial oriented graph

Operation chain of the main blocks in Integrated model.

1. Climatic scenarios - horizon of 25 years, time resolution of 1 month.

2. Cycle for every year – resolution of 1 month:

-Development scenarios,

-Socio-economic block (regime of requests),

-Hydrological block,

-Ecological block,

-Hydrological block (management regime),

-Socio-economic block (regime of productivity).

3. GIS – visualization of results.

ALGORITHMS

One of the procedures required for coupling of various models is a procedure for formatting of data received from any model or the Database to another model. Such procedures would be symbolized as “ ***F*** ” as derived from usually used term «formatting» but with wider meaning. Full ***F*** – formatting of data between the models consists of the following stages:

- matching of dimensions,
- spatial interpolation/aggregation,
- temporal interpolation/aggregation (or modeling!),
- adjustment of data values to a value range acceptable for given model,
- adjustment of data to model format.

The second, third, and fourth stages are not trivial and need consultations with model developers.

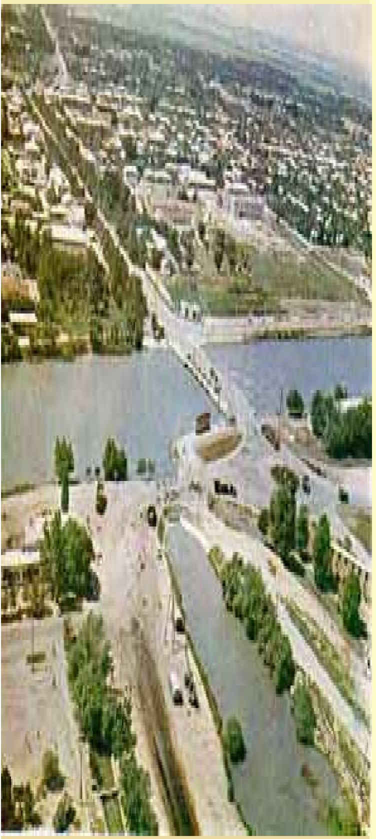
Indicators and criteria for basin development assessment

Assessment of basin development in time assumes that criterion (or criteria) quantified through parameters of basin elements is available. Depending on objective to be achieved and formulated, criteria can include economic, technological, and ecological basic characteristics in various combinations.

Criteria of basin development optimality can be different but they all represent, necessarily in numerical values, trade-offs between “good” and “bad” as we see now.

Enlarged indicators based on data about current state of basin elements and reflecting their integrated characteristics would be used during analysis of basin functioning and development in the long term.

SOCIO-ECONOMIC BLOCK



In the proposed variant of Socio-economic block, whole activity in the region is divided into the following components:

I – non-agricultural product processing industry,

II – agricultural product processing industry,

III – service sectors, including municipal economy,

IV – agricultural production sectors.

The main macroeconomic parameter indicating living conditions in the region is gross domestic product, GDP.

GDP of province is an additive result of various production activities, which is generated as a certain share (different for various production sectors) of their gross product.

Basic equations

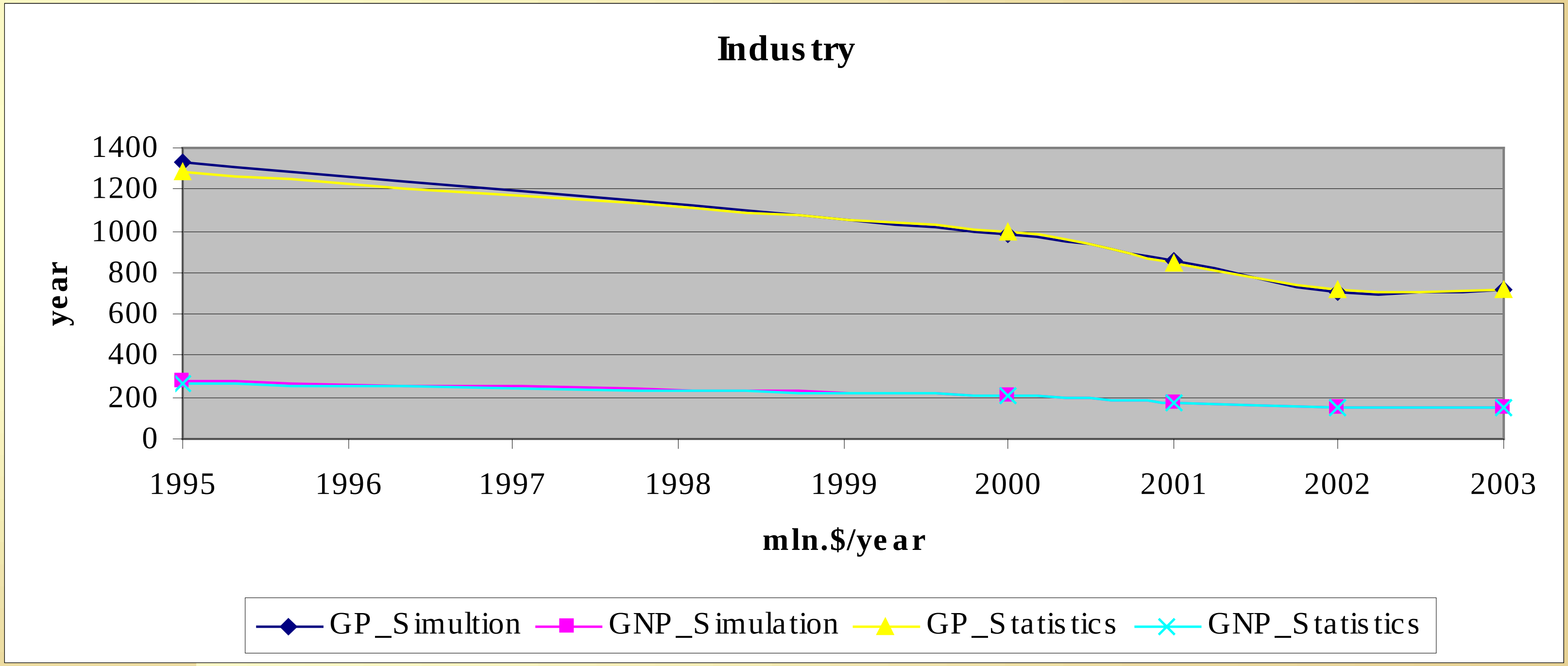
$$\frac{d\Omega_j^\Omega}{dt} = -\Omega_j^\Omega \times (\lambda^{\Omega,N} + \lambda^{\Omega,A}(I^A) - \beta^{\Omega,N}) + \frac{s_j^\Omega(t)\times\Omega_j^\Omega + \Phi_j^\Omega(t)}{c^\Omega}$$

where: $\lambda^{\Omega,N}$ is natural rate of degradation of Ω–type terrain [1/year], $\lambda^{\Omega,A}(I^A)$ is rate of man-caused degradation of Ω–type terrain, I^A is intensity of human impact, s_j^Ω is a cost per unit allocated for Ω–type terrain preservation [$/ha×year], Φ_j^Ω is financial flow to development of Ω–type terrain in the district “j”[$/year], c^Ω is cost per unit of Ω–type terrain development [$/ha], $\beta^{\Omega,N}$ is the rate of natural restoration of Ω–type terrain [1/year].

Output indicators of socio-economic model :

- population (urban and rural),
- number of able-bodied population (urban and rural),
- number of work places,
- water demand of communal sector,
- water demand of industry,
- gross production volumes per sector,
- gross domestic product of the province GDP,
- personal income, urban and rural,
- food supply,
- employment.

The result of cumulative estimation of major indicators of sub-basin development within Tashkent province



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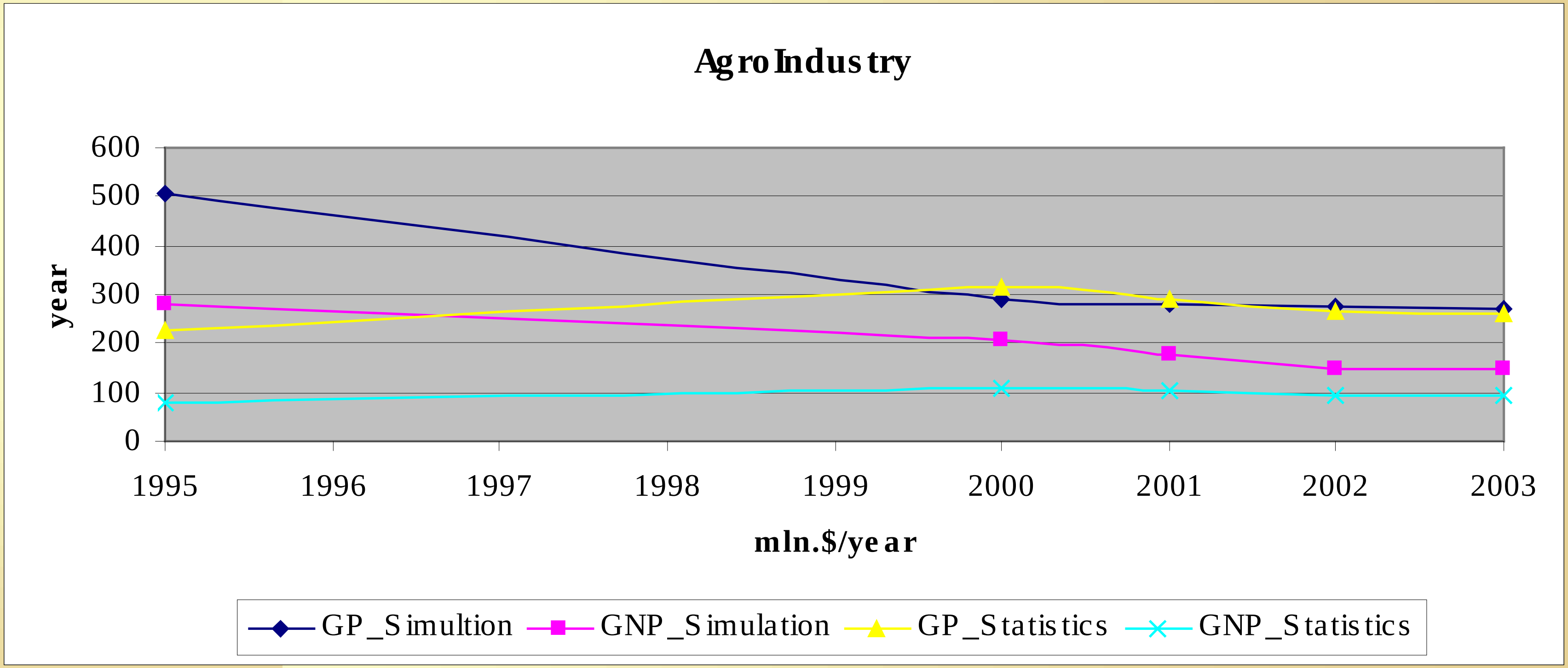

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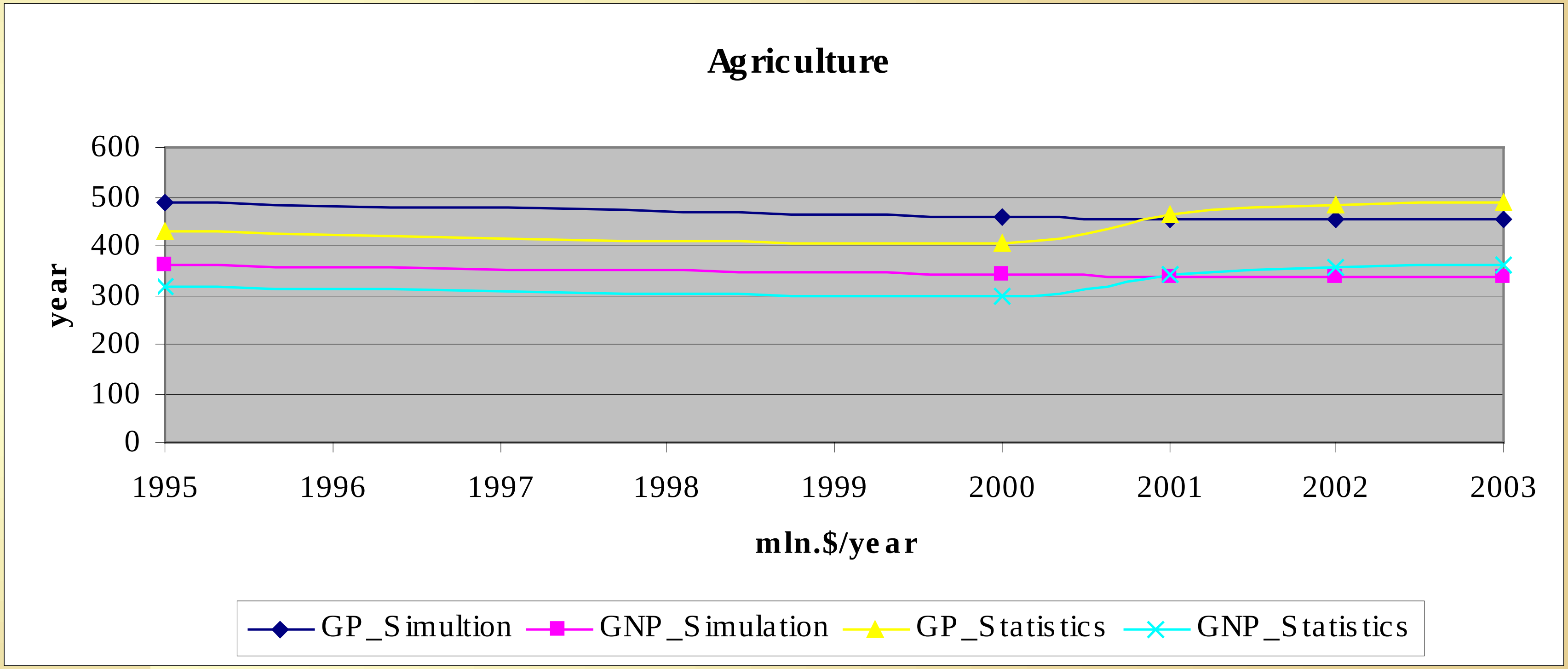

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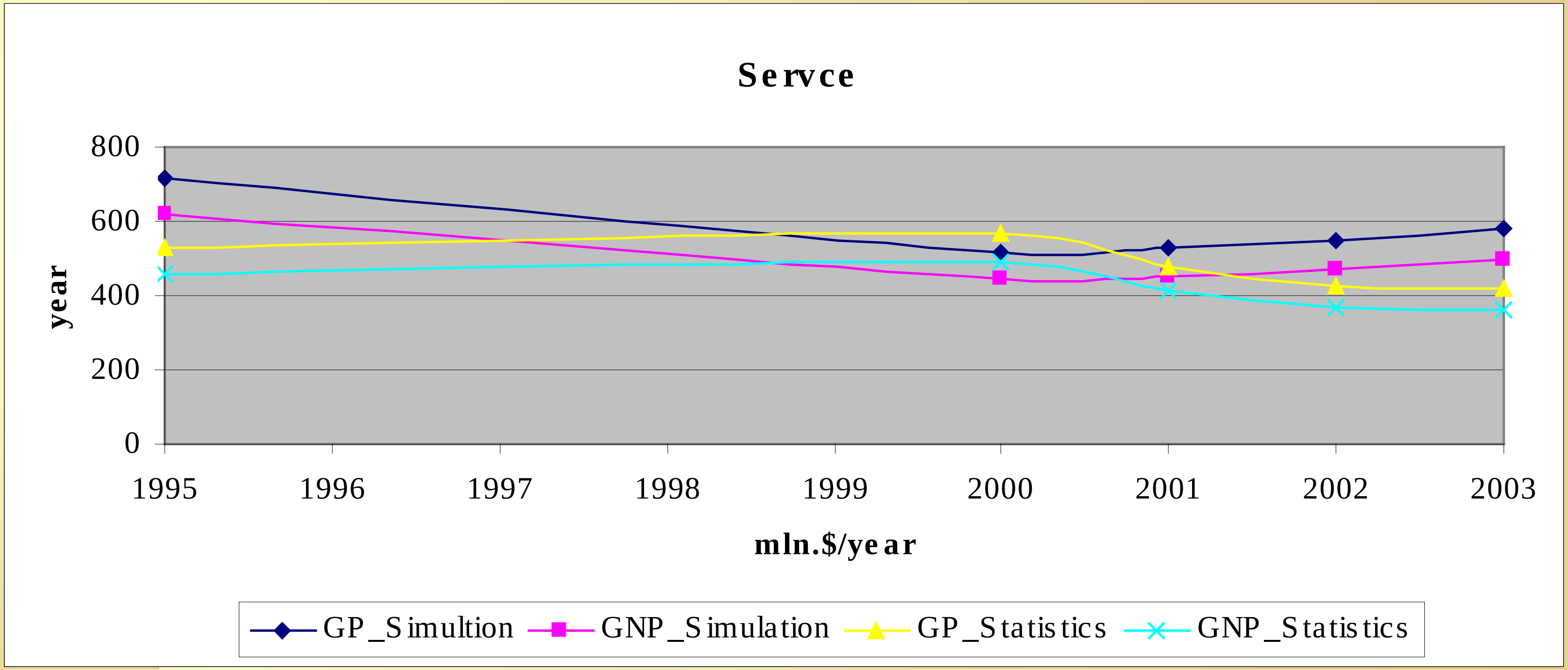


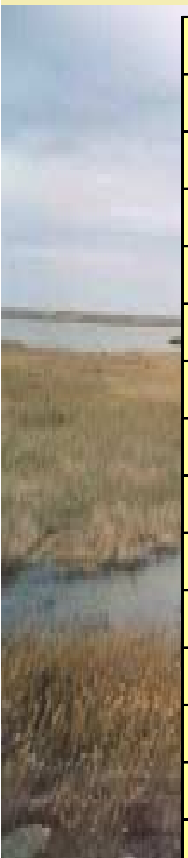
Comparison of simulated and statistical economic indicators for agriculture

Tashkent province (2003)	Simulation			Statistics		
	Gross volume ($)	Profit ($)	GDP ($)	Gross volume ($)	Profit ($)	GDP ($)
Irrigated area	165 352 840	27 640 842	154 492 972	161 537 800	27 045 000	*
Dry land	2 588 561	1 178 278	2 306 504	2 427 600	927 800	
Homestead plots	58 717 113	15 627 113	15 627 113	58 402 000	17 830 900	
TOTAL for crop production	226 658 514	44 446 232	172 426 589	222 367 400	45 803 700	
TOTAL for livestock-breeding	231 510 349	49 960 719	111 124 967	233 753 500	53 559 600	
Grand TOTAL for agriculture	458 168 863	94 406 951	283 551 556	456 120 900	99 363 300	276 590 000

Comparative assessment of crop yields tn/ha

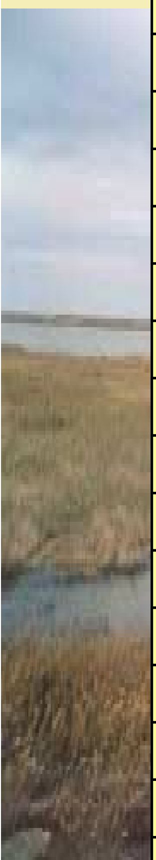
Yangiyul district (actual)	2000	2001	2002	2003
Cucurbits	26.67	14.80	15.47	16.33
Grapes	6.18	7.04	2.36	1.76
Cereals	3.41	3.99	4.81	4.52
Potato	16.50	20.86	19.81	21.78
Kenaf	15.74	14.93	15.30	16.57
Corn	2.74	3.08	3.18	4.01
Maize for silage and green fodder	16.92	22.27	29.20	26.67
Perennial grass of past years for green forage	28.08	22.70	30.08	33.76
Perennial grass of past years for hay	6.81	8.32	10.31	10.90
Perennial grass of current year for green forage	20.99	20.61	27.15	25.54
Perennial grass of current year for hay	11.06	7.38	8.50	9.52
Vegetables	19.08	18.78	20.42	21.06
Annual grass	12.30	14.50	11.90	13.20
Rice	2.73	3.56	4.71	3.27
Fruits	5.37	4.77	5.93	3.15
Cotton	2.37	2.70	1.99	2.05
Fodder roots	17.60	20.00	28.89	25.00

Comparative assessment of crop yields tn/ha



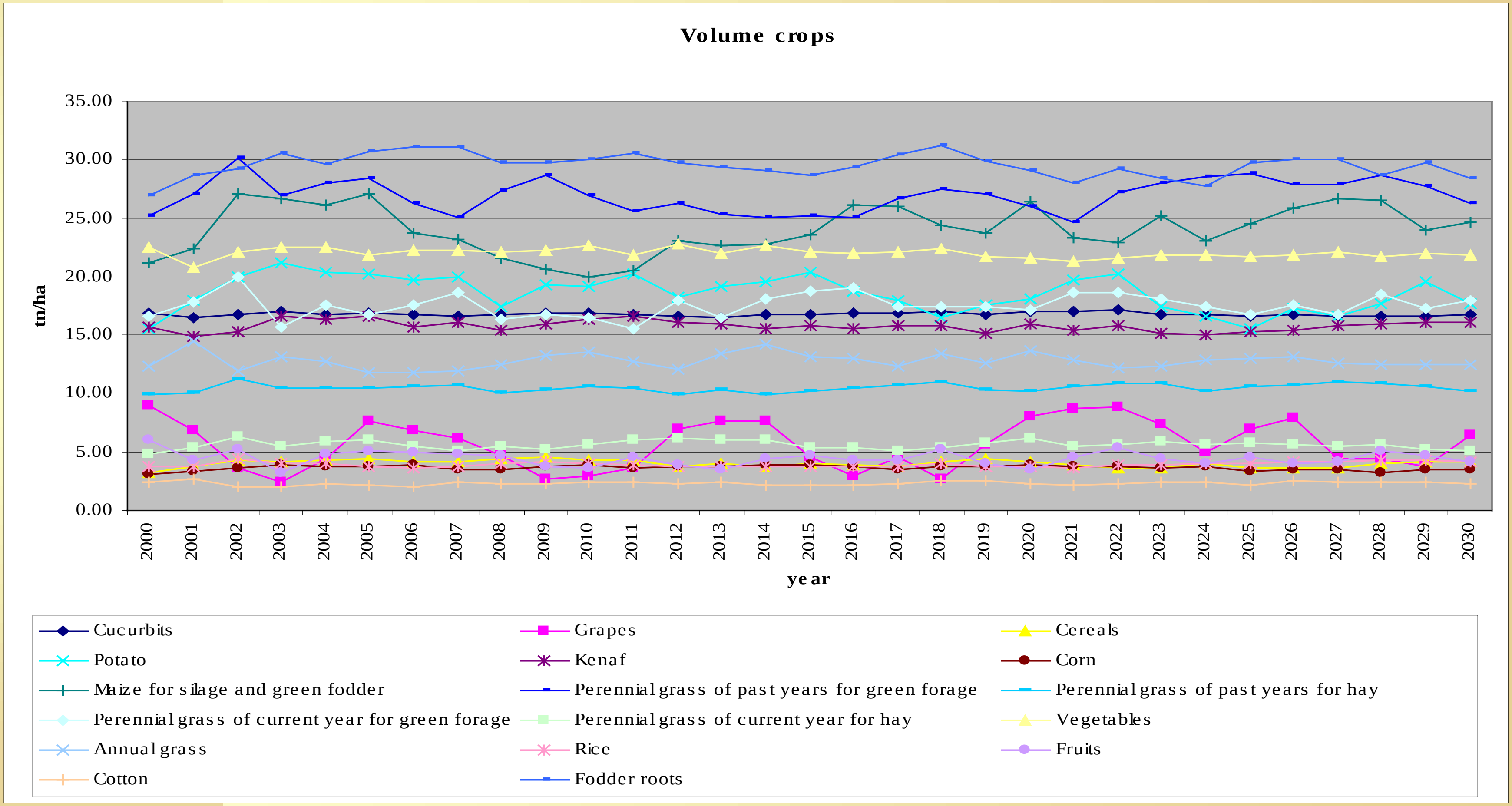
Yangiyul district (simulation)	2000	2001	2002	2003
Cucurbits	19.20	16.70	16.40	15.90
Grapes	4.55	4.75	4.20	3.90
Cereals	4.10	4.30	4.50	4.90
Potato	18.60	19.10	19.60	19.80
Kenaf	15.20	15.30	15.25	15.60
Corn	3.20	3.40	3.60	3.60
Maize for silage and green fodder	19.10	23.10	25.60	25.30
Perennial grass of past years for green forage	11.20	12.30	11.30	11.80
Perennial grass of past years for hay	7.10	7.30	8.10	8.20
Perennial grass of current year for green forage	9.10	9.30	9.80	10.20
Perennial grass of current year for hay	8.10	8.20	8.60	8.50
Vegetables	20.40	20.50	21.20	22.40
Annual grass	9.30	11.20	9.40	10.20
Rice	3.20	3.40	4.50	4.30
Fruits	5.20	4.90	5.40	5.30
Cotton	2.66	2.51	2.65	2.65
Fodder roots	22.60	23.40	25.30	24.20

Comparative assessment of crop yields (ratio)



Yangiyul district (deviations)	2000	2001	2002	2003	Mean for 4 years	Mean square
Cucurbits	-0.33	0.12	0.06	-0.03	-0.04	0.34
Grapes	-0.30	-0.39	0.56	0.76	0.16	1.02
Cereals	0.18	0.07	-0.07	0.08	0.07	0.18
Potato	0.12	-0.09	-0.01	-0.10	-0.02	0.17
Kenaf	-0.03	0.02	0.00	-0.06	-0.02	0.06
Corn	0.15	0.10	0.12	-0.11	0.07	0.21
Maize for silage and green fodder	0.12	0.04	-0.13	-0.05	-0.01	0.19
Perennial grass of past years for green forage	-0.86	-0.59	-0.91	-0.96	-0.83	0.28
Perennial grass of past years for hay	0.04	-0.13	-0.24	-0.28	-0.15	0.25
Perennial grass of current year for green forage	-0.79	-0.76	-0.94	-0.86	-0.84	0.14
Perennial grass of current year for hay	-0.31	0.11	0.01	-0.11	-0.08	0.31
Vegetables	0.07	0.09	0.04	0.06	0.06	0.04
Annual grass	-0.28	-0.26	-0.23	-0.26	-0.26	0.03
Rice	0.16	-0.05	-0.05	0.27	0.08	0.27
Fruits	-0.03	0.03	-0.09	0.51	0.10	0.48
Cotton	0.11	-0.07	0.28	0.26	0.15	0.28
Fodder roots	0.25	0.16	-0.13	-0.03	0.06	0.30

Dynamics of agricultural production



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THANK YOU

for attention