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A General Equilibrium Approach to Modeling Water and Land Use Reforms in Uzbekistan

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Abstract

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In 2000 and 2001, agricultural producers in Uzbekistan were severely affected by the worst draught of the last two decades. Since the agricultural sector depends mainly on the availability of irrigation water, the draught harmed the income of the rural population, for which the agricultural sector is the main employer. The question arises, why the irrigation system was extended so far and why such a high share of the population depends on the agricultural sector. This question is of particular importance because the government of Uzbekistan has attempted to foster the development of non-agricultural sectors and the gradual economy-wide reform towards market-orientation since independence in 1992. One instrument of this political goal is a system of regulations concerning the domestic cotton market. This system imposes production targets and administrative prices on the producers, who, on the other hand, benefit from subsidized inputs. The raw cotton is then further processed into fibre, which is a relevant source of foreign-exchange earnings. These earnings are then used to import investment goods, which have a high share in the total import volume. These imports of investment goods stand in contrast to the stable employment-share of the different economic sectors. In order to gain a better understanding of the feedbacks between economic sectors and the government, the general framework of the Uzbek economy is described in chapter 2 and the application of a general equilibrium model is proposed. The applicability and the properties of such a model-approach are then discussed in chapter 3. The compilation of a consistent database from different and sometimes contradicting sources is particularly important here. The implemented model is then used to simulate several scenarios in chapter 4, which focuses on the cotton-market regulations. This eventually shows that agricultural producers do not necessarily benefit from a liberalization of the cotton market.

Zusammenfassung

Ein allgemeines Gleichgewichtsmodell für die Reform von Wasser- und Landnutzung in Usbekistan.

In den Jahren 2000 und 2001 litten die Landwirte Usbekistans unter der verheerendsten Dürre der letzten zwei Jahrzehnte. Aufgrund des ariden Klimas hängt Landwirtschaft in Usbekistan wesentlich von Bewässerung ab, so dass die Dürre die pflanzliche Produktion in Mitleidenschaft zog. Da die Einkommen der Bevölkerung zu großen Teilen von der Landwirtschaft abhängen, führte dies zu massiven Einkommensverlusten. Diese Ereignisse werfen die Frage auf, warum die Bewässerungssysteme in Usbekistan so weit ausgedehnt wurden und warum ein so hoher Anteil der Bevölkerung vom Agrarsektor abhängt. Diese Fragen sind insofern von Relevanz, als dass die Regierung Usbekistans seit der Unabhängigkeit 1992 die Absicht verfolgt, die Entwicklung von nicht-landwirtschaftlichen Sektoren zu fördern und den Agrarsektor sowie die Volkwirtschaft graduell in Richtung einer Marktwirtschaft zu reformieren. Ein Instrument dieser Politik ist ein System von Reglementierungen des Baumwollmarktes. Zu den Regelungen gehören administrierte Produktionsmengen und Produktpreise auf der einen Seite, sowie die subventionierte Vergabe von Inputs auf der anderen. Die so erzeugte Rohbaumwolle wird weiter zu Fasern verarbeitet, deren Export eine bedeutende Quelle für Deviseneinkünfte ist. Diese Einkünfte werden zum großen Teil für den Import von Investitionsgütern verwendet. Der hohe Anteil von Investitionsgütern am Gesamtimport steht in Kontrast zu dem gleich bleibenden Anteilen der Sektoren an der gesamten Beschäftigung. Um ein besseres Verständnis dieser Wechselwirkungen zwischen den Sektoren und Politik zu bekommen, werden in Kapitel 2 zunächst die Rahmenbedingungen diskutiert und die Verwendung eines allgemeinen Gleichgewichtsmodells als analytisches Werkzeug vorgeschlagen. Dieses wird in Kapitel 3 diskutiert. Von besonderer Bedeutung sind hier die Anwendbarkeit dieses Modellansatzes und die Zusammenstellung einer konsistenten Datenbasis auf Grundlage verschiedener, teilweise widersprüchlicher Quellen. Das so implementierte Modell wird in Kapitel 4 zur Simulation verschiedener Szenarien herangezogen, wobei der Schwerpunkt auf der Baumwollmarktordnung liegt. Es kann gezeigt werden, dass die Produzenten von Agrargütern nicht notwendigerweise von einer Deregulierung profitieren.

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List of Acronyms

c.p.	ceteris paribus
CAC	Central Asian Countries
CDF	Cumulative Distribution Function
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGEM	Computable General Equilibrium Model
CIS	Community of Independent States
DLR	Deutsche Gesellschaft für Luft- und Raumfahrt
EU	European Union
EXR	Exchange Rate
FAO	Food and Agricultural Organization of the United Nations
FOREX	Foreign Exchange
FSU	Former Soviet Union
GDP	Gross Domestic Product
GDPF	Gross Domestic Product at factor cost
GDPM	Gross Domestic Product at market prices
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IOC	Input-Output-Coefficients
IOT	Input-Output-Table
ME	Maximum Entropy
MEM	Mixed Estimation Method
MERS	Multiple-Exchange-Rate System
ML	Maximum Likelihood
MRS	Marginal Rate of Substitution
n.a.	Data not available
NSC	National Statistical Committee of Uzbekistan
OblStat	Regional Division of the Ministry for Macroeconomics and Statistics in Khorezm
OblVodKhos	Regional Division of the Ministry for Agriculture and Water Resources in Khorezm
OLS	Ordinary Least Squares

PDF	Probability Density Function
SAM	Social Accounting Matrix
SNA	System of National Accounts
USD	US-Dollar
UZS	Uzbek Soum
WFP	World Food Program

Physical units

ha	hectare [10^5 m^2, 10^{-2} km^2]
km^2	square kilometre [10^6 m^2]
t	metric ton [10^3 kg]
km^3	cubic kilometre [10^9 m^3]

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1 Introduction

In the years 2000 and 2001, Uzbekistan was affected by the most severe water-shortage of the last two decades. While the entire country felt the impact of this drought, the region of north-west Uzbekistan, south of the Aral Sea, was especially affected. In Khorezm, for instance, the annual flow of the Amu Darya River, the main provider of irrigation water for this part of the country, reached only 40% of the long-term average in 2000 and 34% of the flow in 2001. For the first time since the early eighties, the total harvested area in Uzbekistan declined in response to a lack of irrigation water. In the most affected regions, such as Khorezm, the total real output value of the plant-producing sector dropped in 2001 by 33% in comparison to the corresponding value in 1998. Given the fact that the regional incomes primarily depend on irrigated agriculture, either directly or indirectly, the drought in 2000/2001 caused serious harm to the economic welfare of the population in Khorezm and Uzbekistan as a whole.

However, farmers in Uzbekistan have been using the water flows from Amu Darya and Syr Darya to irrigate their fields since ancient times and the sufficient provision of water was not guaranteed in the past nor will it be in the future. However, due to population growth and the extension of the irrigated area, the probability of receiving an adequate supply of water has decreased to a level that raises concern about the sustainability of the current and future agricultural production system. For instance, in 1982 around 800 thousand people lived in Khorezm and 200 thousand hectares of land were irrigated. The probability of receiving at least the needed inflow was around 88%. By 1999, the population had grown to 1.3 million people and the irrigated area to 275 thousand hectares. Assuming constant stochastic properties of the Amu Darya's annual flow, the probability of attaining sufficient amounts of water had decreased to 74%. In other words, a system as observed in 1982 has to face one drought year on average in a decade while the system as observed in 1999 will be confronted with three drought years in the same period, and in fact two of these draught years already occurred in 2000 and 2001. Although it cannot necessarily be concluded that there will definitely be another draught year before 2009, the likelihood for water-shortages has definitely increased. At the same time, the number of people in Khorezm whose income depends on agricultural production has also increased. Consequently, there is a growing number of people who have had to rely on an increasingly risky resource.

There are two basic strategies that can be used to improve the security of the regional incomes. First, the water-efficiency of the irrigation system can be enhanced in such a way that the given area is irrigated with less amounts of water while the agricultural output is kept constant. The prevalence of furrow-irrigation combined with a badly maintained channel-network causes huge water-losses during the transport from river to the fields and then on the fields themselves. However, regarding the wide range of governmental regulations for agricultural production, changes of agricultural policies might be of higher importance than just technological improvements. Policies include the free provision of irrigation water, administratively set production-levels and prices for cotton and wheat, and the absence of reliable long-term titles on farmland, and they do not create an incentive structure for farmers to invest in better irrigation technologies. Any set of considerations to increase the water-efficiency of crop-production in Khorezm must take the administrative environment into account. However, a strategy that focuses only on agriculture might have some shortcomings in the long run. Higher water-efficiency would decrease the risk of not having sufficient water-availability at the given level of production activity, and it would also cause a higher marginal productivity of the factor land. Combined with a given growth rate of the population, this would result in the further extension of irrigated area and consequently a further increasing water demand. After some years, water-demand as well as the risk of not getting sufficient amounts of water will have reached the same level as in 1999 and even more people will be affected. Of course, the situation would be worse without agricultural reforms, but the fundamental problem of reliance on a risky resource will remain unchanged.

This line of argumentation leads to the proposition of a second strategy. Instead of only focusing on agriculture, the development of regional processing industries, especially of labor intensive light manufacturing, could be a more sustainable approach. Again, the administrative environment does not promote private investments, and respective legal reforms would be necessary. However, investments will need to take place regardless if the labor-to-capital ratio in the regional economy is not meant to increase. Without investment in any sector of the economy of Uzbekistan, the marginal productivity of the growing labor force will decline steadily and, if market forces take effect, labor-incomes in general will decrease. The main question in this context is consequently not, whether investment in the regional economy should take place, but rather in which sectors it should take place. While developing only the agricultural sector might be disadvantageous, as outlined above, developing an agricultural processing industry would require labor, energy, and machinery, which are only available in restricted amounts in the short run in Uzbekistan.

Both outlined strategies need to be considered in the context of the Uzbek economy as a whole. The nation's external trade-balance largely depends on exports of cotton fibre and on the domestic production of wheat that was pushed by the government since independence in order to decrease imports from abroad. Centrally managed fibre exports contribute largely to the governmental budget and are an important source of foreign-exchange earnings, which is used in turn to subsidize imports of capital goods and food commodities. So, while decreasing the agricultural production level and developing other sectors might be advantageous for the national economy in terms of risk-management and private incomes, it might be just as likely to cause problems for the governmental budget. If the national economy loses trade earnings due to declining agricultural output, the source of public investments becomes questionable.

It appears that a development strategy has to take inter-sectoral and budget-related feedbacks into account. It cannot be evaluated based on a simple sequence of causes and effects but rather on a system of interdependent actions and events. Due to the repercussions of production activities on national external-trade, the consequent effects on the governmental budget and the interactions between agriculture and industrial sectors, an analytical framework that accounts for all these features would be adequate. An applicable and well-tested approach is a computable general equilibrium model (CGE) as developed by the International Food Policy Research Institute (IFPRI). In its standard version, this modeling approach represents an open economy with external trade, producers, consumers, government, factor- and product-markets on a more or less aggregated level. In this macro-economic framework, the primary factors of production are labor and physical capital. Although this modeling approach would help to address the relevant issues, the specific settings of the Uzbek economy must be taken into account. Therefore, the significant influence of governmental policies on the economic processes as well as the relevance of irrigation water need to be considered while applying a blueprint of a model on this specific economy.

This study basically aims to compare the two aforementioned strategies for improving the security and level of incomes in Uzbekistan with the means of a general equilibrium model. Because this study is part of the research project "ECONOMIC AND ECOLOGICAL RESTRUCTURING OF LAND AND WATER USE IN THE REGION OF KHOREZM, UZBEKISTAN" (VLEK ET AL. 2000), the focus lies not only on the national economy of Uzbekistan, but also on the settings in the region of Khorezm, which is in several respects very typical for the country. So is the regional economy mainly based on irrigated agriculture and subject to the same policies and processes that shape the economic transformation on the national level. Because of the project's activities, it was possible to obtain a multitude of data that was not available on a national level. When necessary, these sets of information will be used as indicators for the situation on the country-level. This study begins with a description of the situation of the national economy of Uzbekistan in the following chapter 2. After a general overview on the geographical and demographical settings and the economic structure, the particularities of the country's economy will be discussed. This will include a detailed description of the patterns of naturally given water supply and the corresponding demand for irrigation water. Although it is difficult to discuss the most relevant political impacts in a concise way, the main issues like production targets and multiple exchange rates will be discussed in chapter 2 as well. The modeling concept and the compilation of the required dataset are explained in chapter 3. This begins with an outline of the structure of the CGE approach and a discussion of the applicability on a regulated economy like Uzbekistan. Of particular interest here are the impacts of governmental regulations on production-decisions of relevant agents in the context of a model setting that relies on the existence of equilibria. After that, the compilation of the main dataset, a social-accounting matrix, based on the available information is explained, beginning with the setup of a consistent system of national accounts and the establishment of a social accounting matrix on the highest possible aggregation level. This macro-SAM is then further disaggregated, basically with two steps. In the first step, an intermediate structure or meso-SAM is assembled based on additional data available at his level of aggregation. Missing data was then calculated based on available data and whenever such data was non-existent on plausible ad-hoc assumptions, which again were based on discussion with various experts during field trips between 2002-2005. One such example occurred in the case of tax rates, in which the relatively weak assumption was made that the average tax rates were applied for all sector aggregates (for instance: the macro-rate of value-added tax applies on the meso-level as well). The resulting meso-SAM was unbalanced and required the correction by a maximum-entropy algorithm. This allowed for the estimation of a balanced meso-SAM based on an available set of likely or supported entries, which was a starting point for a more detailed assessment of monetary and quantitative flows within the economy of Uzbekistan, which has to have a strong focus on agricultural inputs. Because the main source of information refers to the region Khorezm, the regional datasets are used as an approximation for the input-output relations on the national level as well. Having thus estimated the price-ratios of major agricultural inputs, the results are used to disaggregate the above-mentioned meso-SAM further into a micro-SAM that displays the monetary and quantitative flows not only between agriculture and other sectors but also within these categories as well. Again, the resulting micro-SAM was balanced with a maximum-entropy approach.

The general-equilibrium analysis is then carried out based upon this estimated micro-SAM. The relevant settings of the model and the simulations are described in chapter 4. The experiments focus on policy-changes related to the Uzbek cotton market and on technological changes in agriculture, and the resulting impacts on the economy as a whole will be examined. At the end, Chapter 5 summarizes the main findings and gives an outline of research questions resulting from the findings of this study.

2 Country Background

A fundamental condition for the comparison of different reform strategies is a detailed understanding of the prevalent situation of agriculture in Khorezm and Uzbekistan as a whole. Availability of water resources plays a pivotal role, but the legal-administrative framework of agricultural production and marketing is of equivalent importance. This chapter gives an overview of the most relevant determinants.

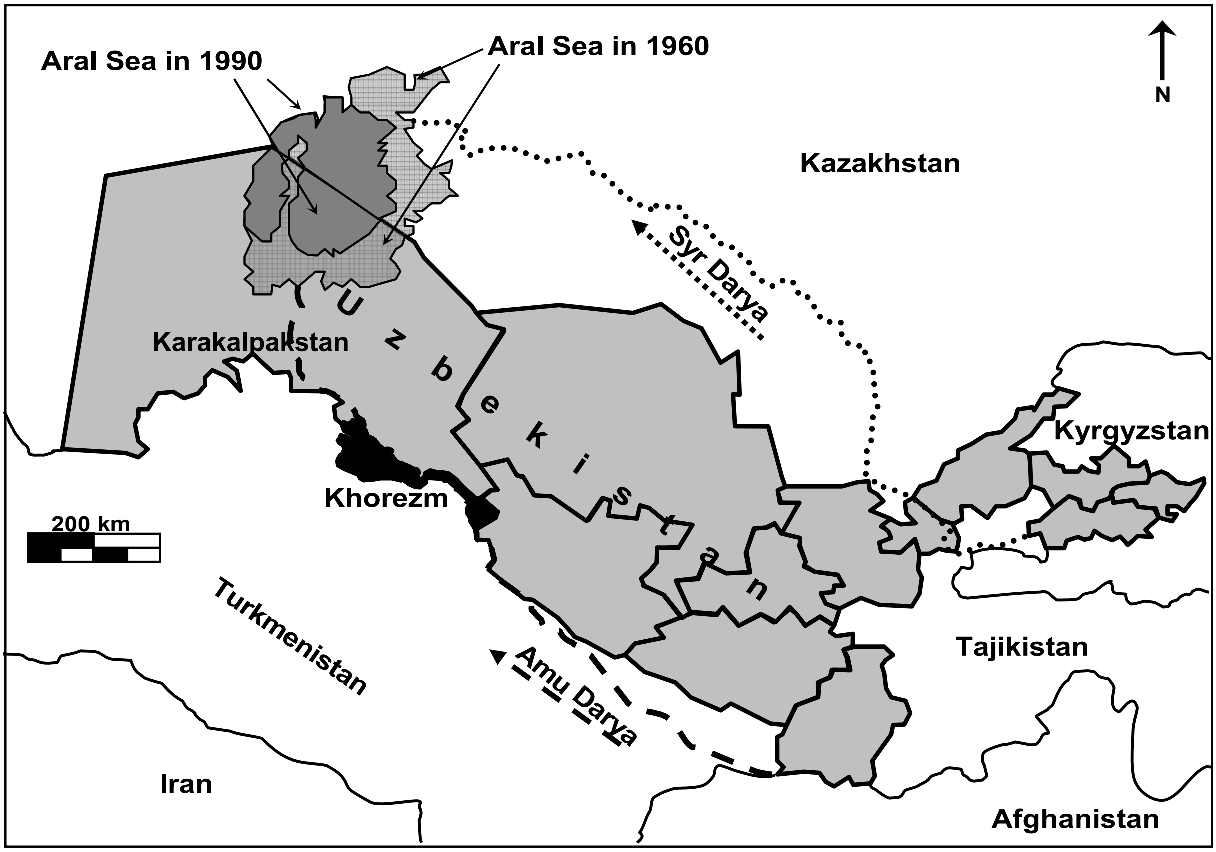
A major challenge for this study was the assessment of valid and consistent datasets for the regarded economic processes. Data were collected during field visits in Khorezm and Tashkent from different official bodies and from international organizations such as the FAO, the IMF, the WORLD BANK, the ADB, and many more. A comparison of the obtained datasets shows that they differ significantly from one another, and a decision must be made about which information is most trustworthy. A systematic ranking of sources by their credibility is difficult and would be subject to the researcher's preferences and thus, rather arbitrary. In order to obtain a set of information with considerable reliability, an approach based on an examination of 'inner consistency' and triangulation was used. In this approach, any dataset that did not contradict itself was assumed to be preferable to others that did not fulfill this requirement. If two consistent datasets contradicted each other, the set that corresponded to a higher number of other sets in the relevant aspects was chosen. When only one set provided information for any indicator, this set had to be trusted.

In order to keep the decision-process as transparent as possible, the most critical figures are discussed in more detail in the following chapters. The compilation of a more consistent data set will be a task for the future and could be done in a fully consistent way much more efficiently with direct support from official Uzbek bodies. However, for the time being, we must compile data from various sources, which results in a challenge of making the best use and judgment of the data. In this sense the process is second best.

2.1 Geographic, Hydrological, and Demographic Outline

Uzbekistan is located in the centre of Central Asia, bordering Kazakhstan in the north and west, Kyrgyzstan and Tajikistan in the east, and Afghanistan and Turkmenistan in the south (see figure 2.1). It comprises 12 provinces (*Oblasts*) and the Autonomous Republic of Karakalpakstan in the north-west, where the Aral Sea is also located, which water body is shared with Kazakhstan. The total area of the country amounts to 447 thousand km^2, around 10% of which is used for crop production. Given the low annual precipitation rate of 110-200 mm/a, the bulk of the agricultural area must be irrigated with water from the different rivers crossing the country. Amu Darya and the Syr Darya are the most important rivers in the area. Consequently, crop production is concentrated in the river valleys (FAO/WFP 2000). The case-study region of Khorezm is located along the Amu Darya, south of Karakalpakstan and bordering Turkmenistan (figure 2.1).

Figure 2.1 Stylized Map of Uzbekistan



Source: Own presentation based on WORLD BANK, 1999

Amu Darya and Syr Darya, as well as associated smaller rivers in their basins, are the main source of irrigation water in Uzbekistan. With an average contribution of 54.1 km^3 to the annual flow of the Amu Darya, almost half of the water in the Aral Sea basin originates from Tajikistan (49.4%, see table 2.1), followed by Kyrgyzstan with a contribution of 27.6 km^3 to the Syr Darya basin (26.3% of the water resources in the Aral Sea basin). Altogether, the rivers in the Aral Sea basin convey an average amount of 111.4 km^3 per year, 99.7 km3 of which are withdrawn for agricultural purposes by the different countries. While only 11.2% of these flows are generated within Uzbekistan, 52.3 km^3 on average are used here (52.4% of all withdrawals).

Table 2.1 Average[7)] Generation and Distribution of River Water Resources in the Aral Sea Basin, by Countries (in km^3)

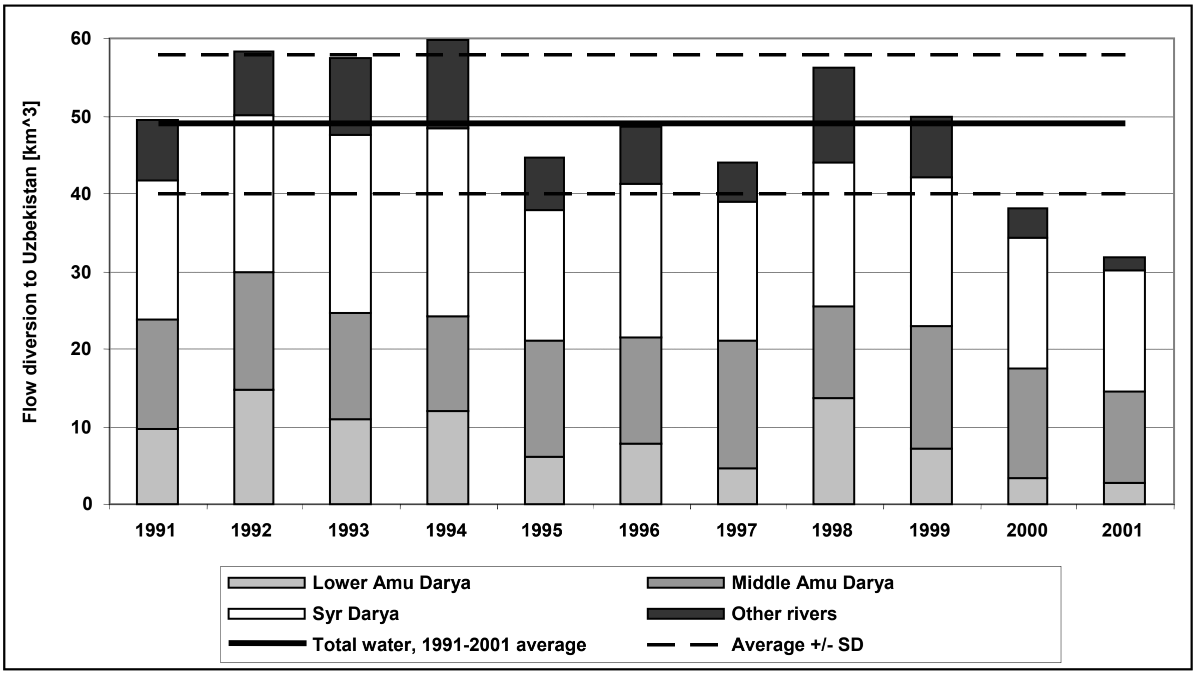
	Amu Darya[5)]	Other rivers in Amu Darya basin[6)]	Total Amu Darya basin	Total Syr Darya basin	Total Aral Sea basin	Country share (in percent)
Origin of water resources[1)]						
Afghanistan	3.3	7.5	10.8	0.0	10.8	9.7
Kazakhstan	0.0	0.0	0.0	2.4	2.4	2.2
Kyrgyzstan	1.7	0.0	1.7	27.6	29.3	26.3
Tajikistan	54.1	0.0	54.1	1.0	55.1	49.4
Turkmenistan	0.0	1.4	1.4	0.0	1.4	1.3
Uzbekistan	0.0	6.3	6.3	6.2	12.5	11.2
Total	**59.0**	**15.2**	**74.2**	**37.2**	**111.4**	**100.0**
Diversion of water resources[2),3)]						
Afghanistan	0.0	2.0[4)]	2.0	0.0	2.0	2.0
Kazakhstan	0.0	0.0	0.0	9.0	9.0	9.0
Kyrgyzstan	0.2	0.0	0.2	4.0	4.1	4.1
Tajikistan	6.9	0.5	7.4	2.2	9.6	9.6
Turkmenistan	22.7	0.0	22.7	0.0	22.7	22.8
Uzbekistan	23.8	7.6	31.4	20.9	52.3	52.4
Total	**53.6**	**10.1**	**63.7**	**36.0[4)]**	**99.7**	**100.0**
Share of Uzbek withdrawals from total generation (in percent)						
	40.4	49.7	42.3	56.1	46.9	

Sources:
1) CAWATER 2005
2) Data related to Amu Darya: MCKINNEY AND KARIMOV, 1996
3) Data related to Syr Darya: MCKINNEY AND KENSHIMOV, 2000
4) Akmansoy and McKinney, 1997

Notes:
5) Water from Vakhsh, Pyandzh and Kafirnigan Rivers
6) Surkhan Darya, Kashka Darya, Zerafshan
7) The figures above were compiled from different sources which used different datasets. The averages displayed here refer therefore to different periods between 1986 and 1999.

The total diversions of surface water to Uzbekistan are shown in figure 2.2 for the period from 1991 to 2001. The average is here with 49 km^3, which is a bit lower than indicated in figure 2.1 (52.3 km^3). This was a result of the use of different data as well as the inclusion of the draught years 2000 and 2001. Water availability in those years was below average minus one standard deviation and therefore lowest in the depicted decade.

Figure 2.2 Diversion of Aral Sea Basin River Flows to Uzbekistan, 1991-2001 (in km^3)



Sources: *Lower Amu Darya:* *Flow rates at Tuyamuyun (OblSelVodKhos, 2002), multiplied with the average share of Uzbekistan's withdrawals along the lower Amu Darya (McKinney and Karimov, 1996)*
Middle Amu Darya: *Wegerich 2005 and FAO 2005, minus flows of the lower Amu Darya*
Syr Darya: *Total annual Syr Darya runoff (Cai et al, 2001) multiplied with the average share of Uzbekistan's withdrawals along the Syr Darya (McKinney and Kenshimov, 2000). Figures for 1999 to 2001 were estimated based on total Aral Sea basin data.*
Other rivers: *Difference between total Amu Darya Basin withdrawals and withdrawals from Amu Darya only (Wegerich, 2005, McKinney and Karimov, 1996)*

Note: *The 1991-2001 average displayed here is lower than the corresponding figure in table 2.1, because of the inclusion of the draught years 2000/2001.*

In figure 2.2 above, the Amu Darya flow was separated into lower and middle sections. This was done in order to better understand the relevance of the water supply of the regions Khorezm and Karakalpakstan, which are both located in the river delta and faced the impact of the drought to a greater extend than other regions in Uzbekistan. Nevertheless, the entire country was affected, which can be seen in figure 2.3, which shows the development of areas used for plant production between 1960 and 2002. The long-term dynamics from 1960 to 1999 show a steady growth with rates that initially increase but after the mid-80s begin to decrease. These dynamics do not apply for the drought years, when the harvested areas shrunk for the first time in the observed period. However, it must be noted here that the area data from 1992 to 2002 as provided by the FAO (2004) refer to harvested rather than to planted areas, whereas the data for 1960-1990 (VLEK ET AL. 2002) refer to irrigated areas. Nonetheless, under the assumptions that almost all planted areas have to be irrigated and that in years with sufficient water supply all planted areas are harvested, the data between 1960 and 1999 have been used to approximate a logistic function of the following form:

$$A_t^{planted} = \frac{A^{potential} - A_{1960}}{1 + \mathbf{exp(}\alpha_0 + \alpha_1 \cdot t\mathbf{)}} + A_{1960} \qquad (2.1.1)$$

With: $A_t^{planted}$: Interpolated planted areas in year t

A_t : Irrigated/harvested area in year t from dataset

t : Time

$A^{potential}$: Maximum potential planted area (to be estimated)

α_0, α_1 : Parameters of logistic function (to be estimated)

Logistic functions are widely used for the estimation of processes of limited growth (e.g. Greene 2003), especially in the special case with a minimum level of zero and convergence towards unity for high levels of the explaining variable (here t). This would be the case here if $A^{potential}$ was set to unity and A_{1960} set to zero. The sample figure for 1960 was used here as the minimum level of the planted area, whereas the maximum level had to be estimated just as the parameters α_0 and α_1. As a consequence, equation (2.1.1) could not be transformed into an equation that is linear in parameters and hence, a maximum-likelihood estimation was carried out to obtain the parameters of interest. The results are shown in table 2.2 below:

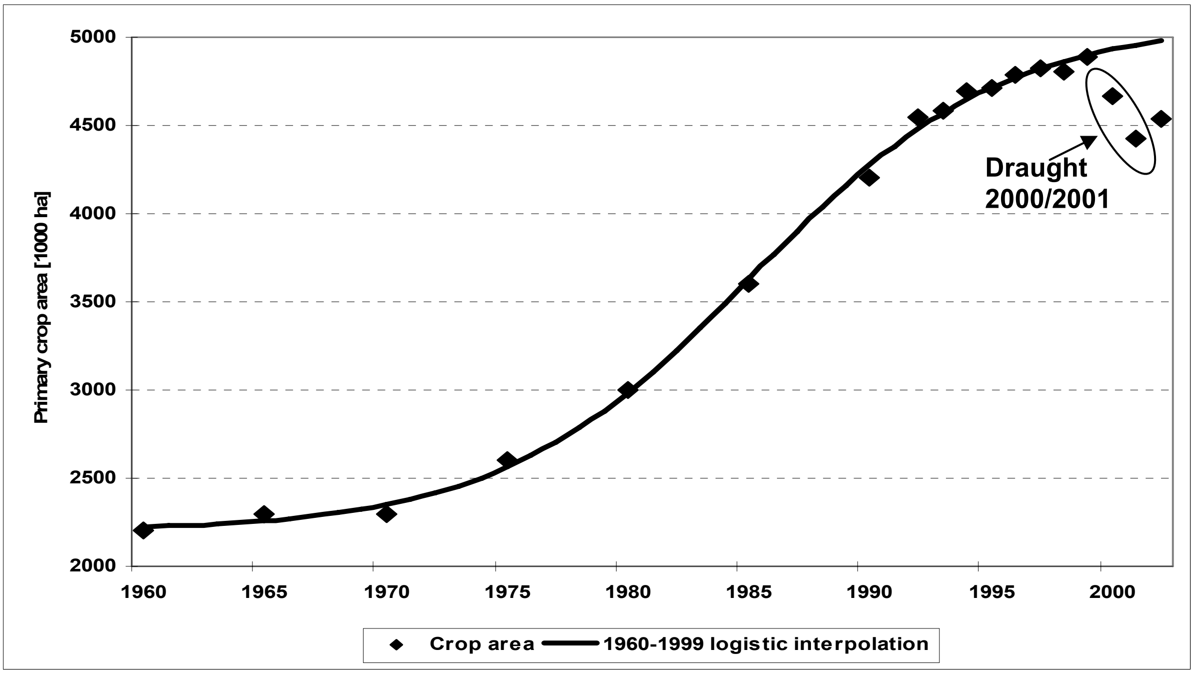
Table 2.2 Statistics of Area Interpolation for 1960 to 1999

$A^{potential}$	**5.087**[1)]
α_0	5.0
α_1	-0.2
R^2	0.999

Note: 1) The estimation was conducted on a million-hectare scaling

The most interesting result here is the figure for the potential area planted. If the dynamics of planted areas indeed follow a logistic growth pattern, then the maximum will be reached at a level of about 5087 thousand hectares. This figure is well above FAO data from 2004, which indicate a maximum level of 4833 thousand hectares for 1999. This level was in fact surpassed in the same year by the harvested area (4893 thousand hectares) as provided by the same source. Despite such deviations, all figures indicate that the system of plant production in Uzbekistan is operating close to or already above a naturally given capacity limit and it is therefore unlikely that the agricultural areas can be expanded much further.

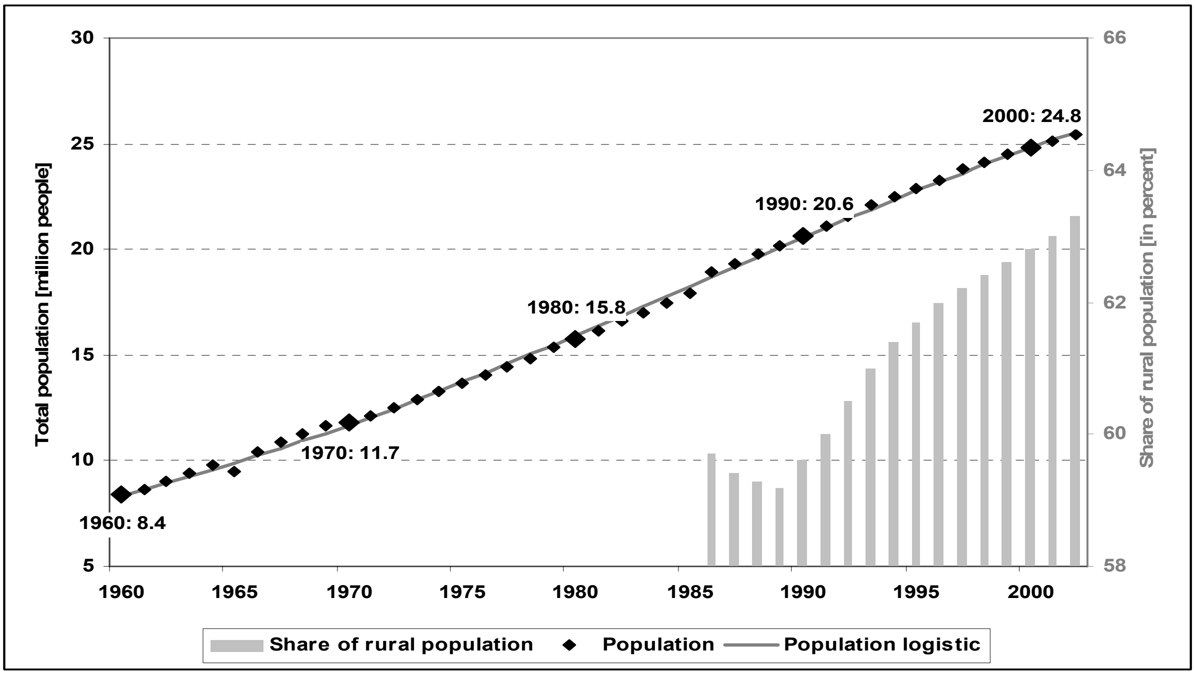
Figure 2.3 Primary Crop Area in Uzbekistan, 1960-2001 (in 1000 ha)



Sources: 1960-1990: VLEK ET AL. 2001
1992-2002: FAO 2004

One of the driving forces behind the steady increase of planted areas is the growth of the Uzbek population (figure 2.4), which tripled between 1960 (8.4 million people) and 2002 (25.4 million people). Of particular interest here is the share of the rural population, which decreased to 59.2% in the late eighties, but increased again during the nineties to a level of 63.3% in 2002.

Figure 2.4 Long-term Population Dynamics in Uzbekistan, 1960-2001



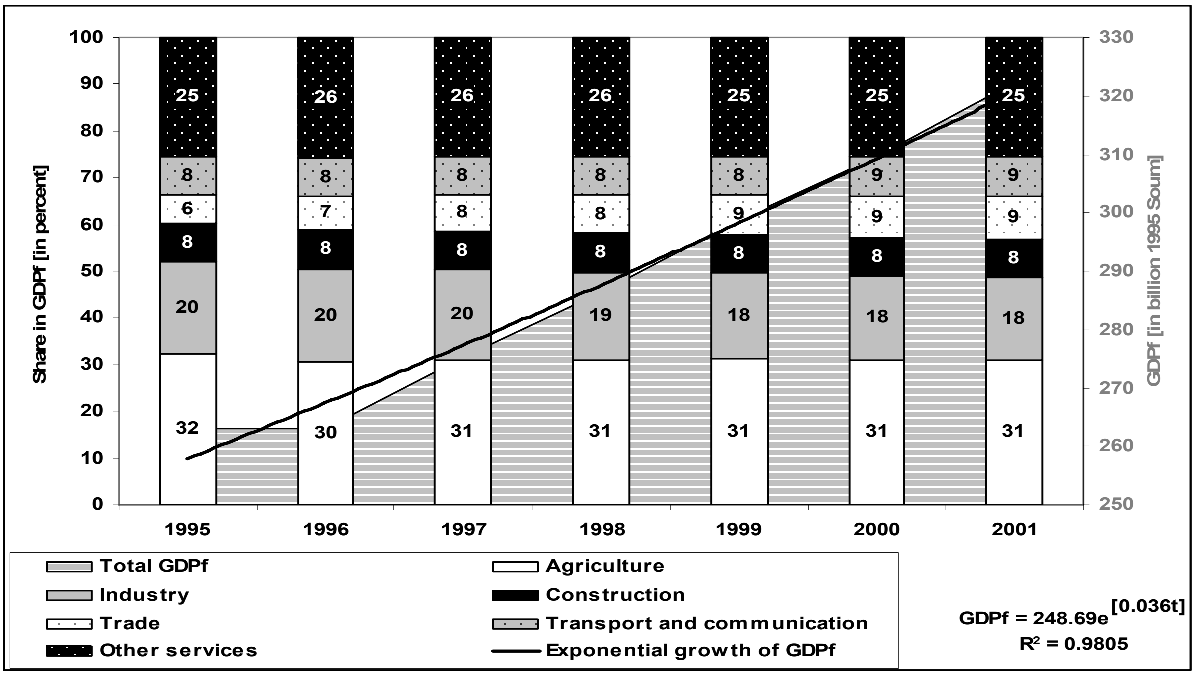
Sources: *1960-1985:* *LAHMEYER 2003*
1986-2002: *ADB 2004*

The fact that the majority of the population dwells in rural areas rather than in cities contributes to the relevance of the agricultural sector and shapes the overall economic structure as will be shown in the following chapter.

2.2 National Economy and Employment by Sectors

Agriculture was the most relevant sector in the Uzbek economy during Soviet times and after independence and it remains this way today. As a Soviet Republic, Uzbekistan became the major producer of cotton in the Soviet Union and its national economy still depends on this sector. It is, however, the explicit target of the Uzbek government to decrease the dependency on agriculture by fostering the development of other sectors, especially industrial processing of agricultural products into food products in order to achieve a higher level of self-sufficiency in this area. This target could not be reached until 2001 as agriculture contributed 32% to the gross domestic product at factor cost (GDPf) in 1995 and 31% in 2001 (ADB 2004). The share of the industrial sector even declined from 20% to 18% in the same period, whereas the service sector as a whole increased from 40% to 43%. Construction remained stable with 8% of total GDPf.

Figure 2.5 Sectoral Composition of GDP at factor cost, 1995-2001

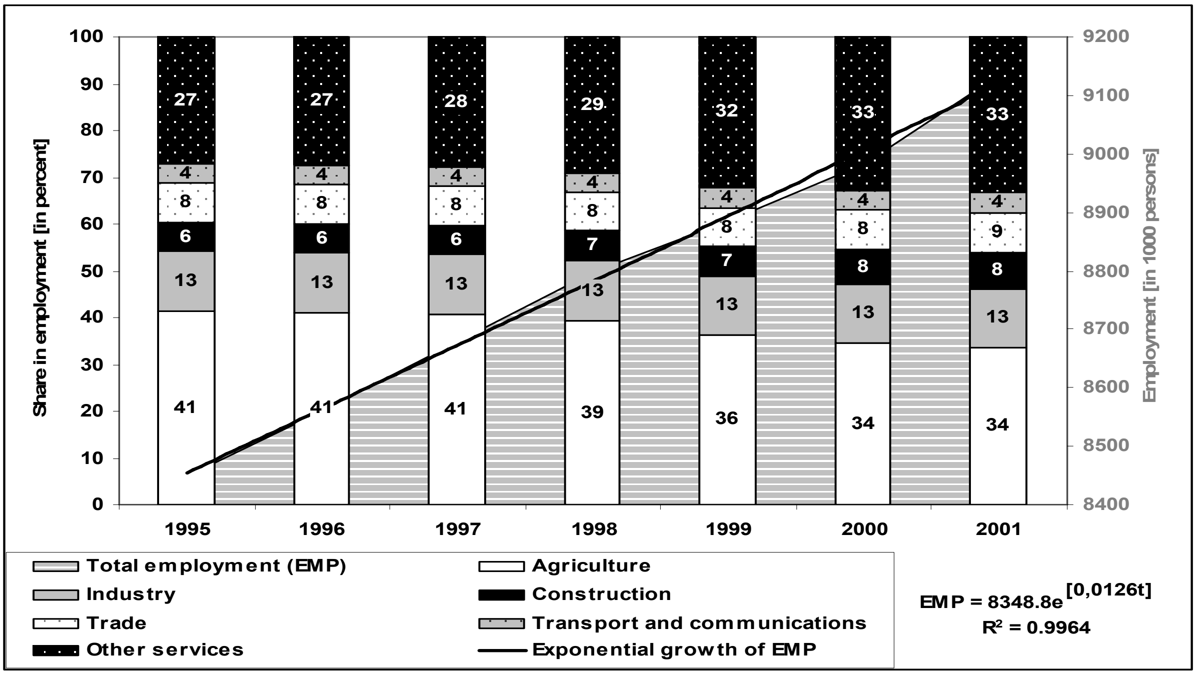


Source: ADB 2004, own calculations

This structure of the national economy is, in general, reflected in the employment patterns (figure 2.6), but a closer investigation reveals some remarkable details.

Whereas the agricultural share in GDPf remains stable at 31% on average, the share of agricultural employment declined from 41% in 1995 to 34% in 2001. Especially between 1998 and 2000 – the years during which the dissolution of former state farms gained speed – the share of agricultural employment dropped by 5%, an indication that not all employees of the former state-owned farms could find employment in the new farm structures and had to find other sources of income. The only other sector with significantly changing shares in total employment is what we call “other services” sector, which is mainly comprised of public services such as education and social security (IMF 2000, CEEP 2003). The change in employment share here amounts to 4% between 1998 and 2000, so it seems that a significant share of former agricultural workers was provided with employment opportunities by the government.

Figure 2.6 Sectoral Composition of Employment, 1995-2001



Sources: ADB 2004, CEEP 2003, IMF 2000, own calculations

If this is the appropriate interpretation of the data displayed in the two figures above, it can be concluded that the government is still the largest employer in Uzbekistan, and that there is no considerable growth of employment opportunities in private sectors outside of agriculture.

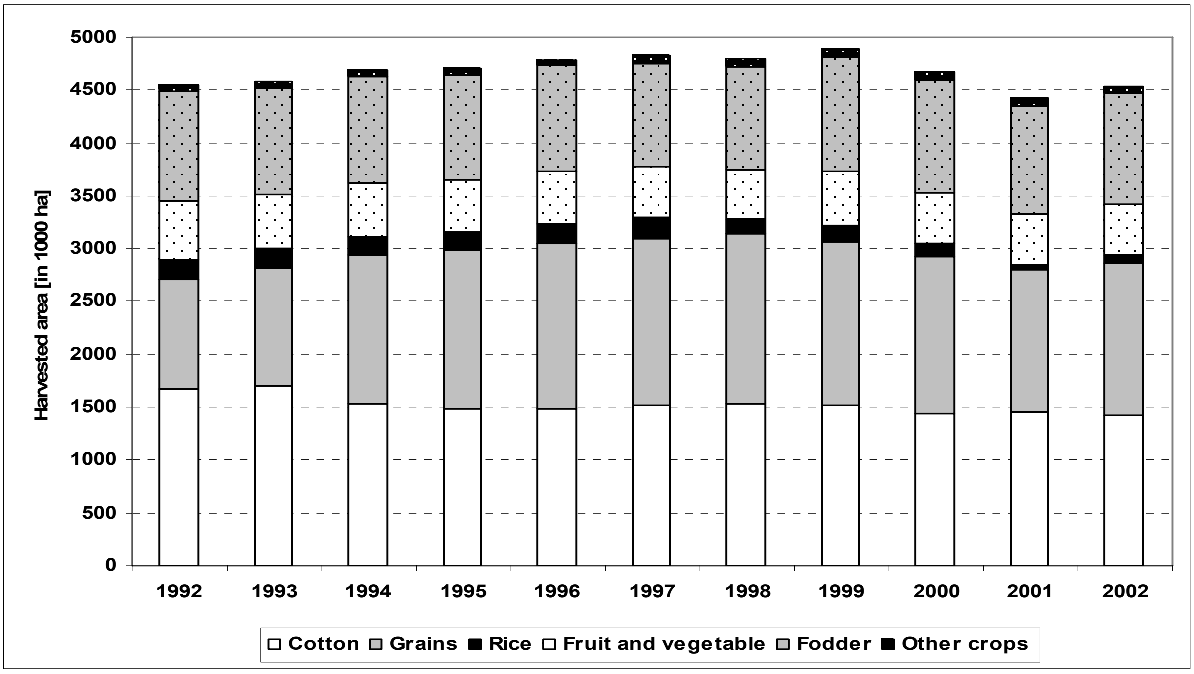
2.3 Agriculture in Uzbekistan

As outlined in the previous chapter, agriculture remained the biggest single sector in Uzbekistan during the first decade of independence, whether it is measured in terms of income generation or employment. The situation of agricultural producers in Khorezm and Uzbekistan in general is the focus of this chapter. In the following chapter, a detailed description of the national and regional economic sub-system is provided, and the main issues like land-allocation, types of producers, and the role of the state are discussed.

2.3.1 Plant Production

The dynamics of harvested and (estimated) planted area have been outlined in chapter 2.1 at an aggregated level. The composition of the harvested area by crops is displayed in figure 2.7 below:

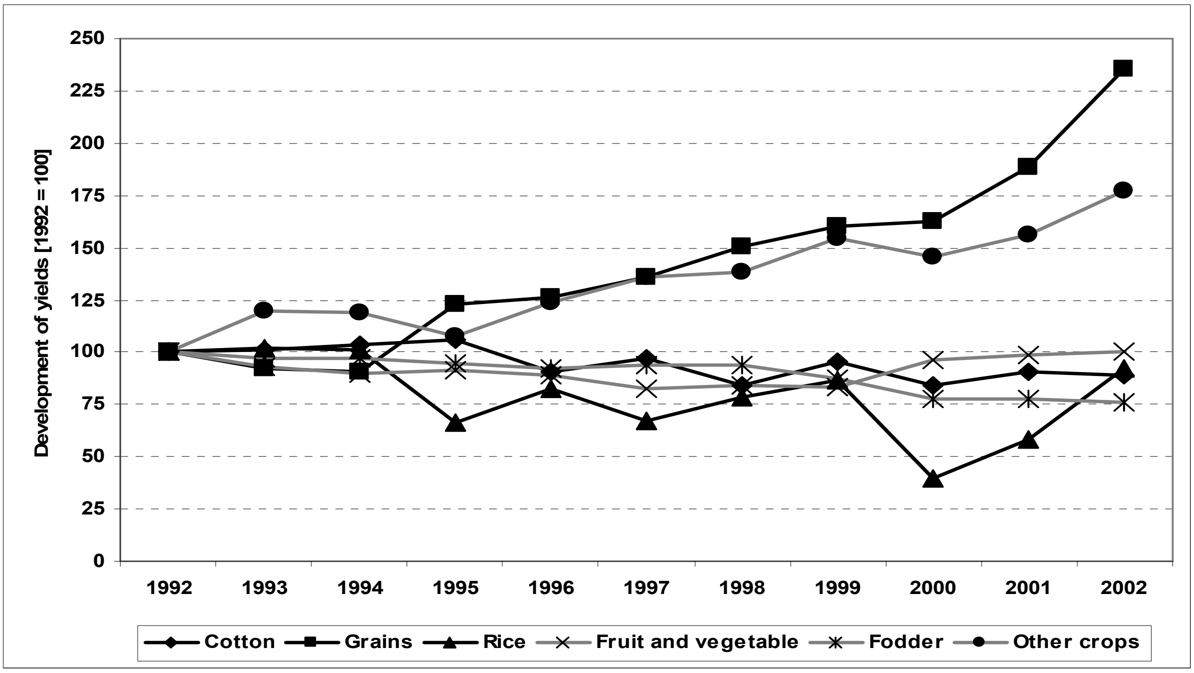
Figure 2.7 Patterns of Plant Production in Uzbekistan, 1992-2002 (in 1000 hectares)



Source: FAOSTAT 2004

While the total harvested area increased steadily between 1992 and 1999, the harvested area of cotton declined from 1667 thousand hectares to 1412 thousand hectares in 2002. The growing acreage allocated for grain production comes from land formerly used for cotton cultivation and land that was previously not cultivated. The data underlying figure 2.7 show no significant decline of cotton-area due to the draught in 2000/2001. In these years, rice and grain harvests declined particularly in comparison to previous years, not only in terms of harvested areas but also in terms of the yields per hectare. As can be seen in figure 2.8, rice yields reached the lowest levels of the whole decade after independence and the otherwise remarkable growth of grain yields slowed down from 1999 to 2000 but then accelerated again in 2001 when the harvested area had been adapted to a lower level.

Figure 2.8 Development of Yields in Uzbekistan, 1992 to 2002 (in percent of 1992)



Source: FAOSTAT 2004

Cotton yields continued to decline until 2002 to 88.7% of the level from 1992, but there is no significant impact of the drought. Although the yields dropped in 2000, this did not exceed the general yield fluctuations in other years of the regarded period.

2.3.2 Farm Types

So far, the question of agricultural production in Uzbekistan has been addressed by looking at cropping activities and animal production from a general point of view. However, it is also necessary to examine the prevalent categories of farm units in which agriculture takes place. Especially the legal-administrative settings of the farm types and their interactions shape the agro-economic system of Uzbekistan.

Basically two types of farms existed in Uzbekistan during the system of the former Soviet Union (FSU). The bulk of the area was cultivated under the control of collective farms (*Kolkhozes*) and state farms (*Sovkhozes*). Such large-scale farms allocated their areas according to centrally set production plans. A much smaller area was cultivated by household-plots of less than one hectare, and on these plots, the ‘owners’ were allowed to produce at will. After gaining independence from the FSU in 1991, Uzbekistan followed what is called by several authors a ‘gradual’ reform path (e.g. BLOCH 2003, KANDIYOTI 2002, WEHRHEIM 2003) from a centrally planned towards a market economy. This terminology stands for a set of sometimes contradicting (KANDIOTY 2002) policies that are meant to serve the objective of maintaining economic and social stability in the short run as well as taking advantage of operating market forces in the long run. In particular, the agricultural sector is subject to a variety of regulations that reflect the ambiguous intentions of the government: The former collective and state owned farms were transferred into joint-stock companies (*Shirkats*), which are supposed to be devolved eventually into ‘private farms’. This process is expected to be accomplished in Khorezm by 2005 whereby all Shirkat-lands will be divided into smaller units. Yet, even so-called ‘private farms’ must fulfill administered production targets for cotton and wheat and are required to sell significant parts of their output at governmentally set prices to governmental or quasi-governmental institutions. Farmlands remain the property of the state and are leased to farmers on the base of contracts with limited duration, although these contracts can last up to 50 years. Because of these severe restrictions, which do not create an environment comparable to the usual concept of a private farming sector, the term *Fermer* will be used in the following for this farm-type. The initially mentioned household-plots persist and will be referred to as *Dekhan*.

The legal-administrative settings of Fermers and Dekhans are shown in table 2.3 according to KANDIOTY (2002) and BLOCH (2002)

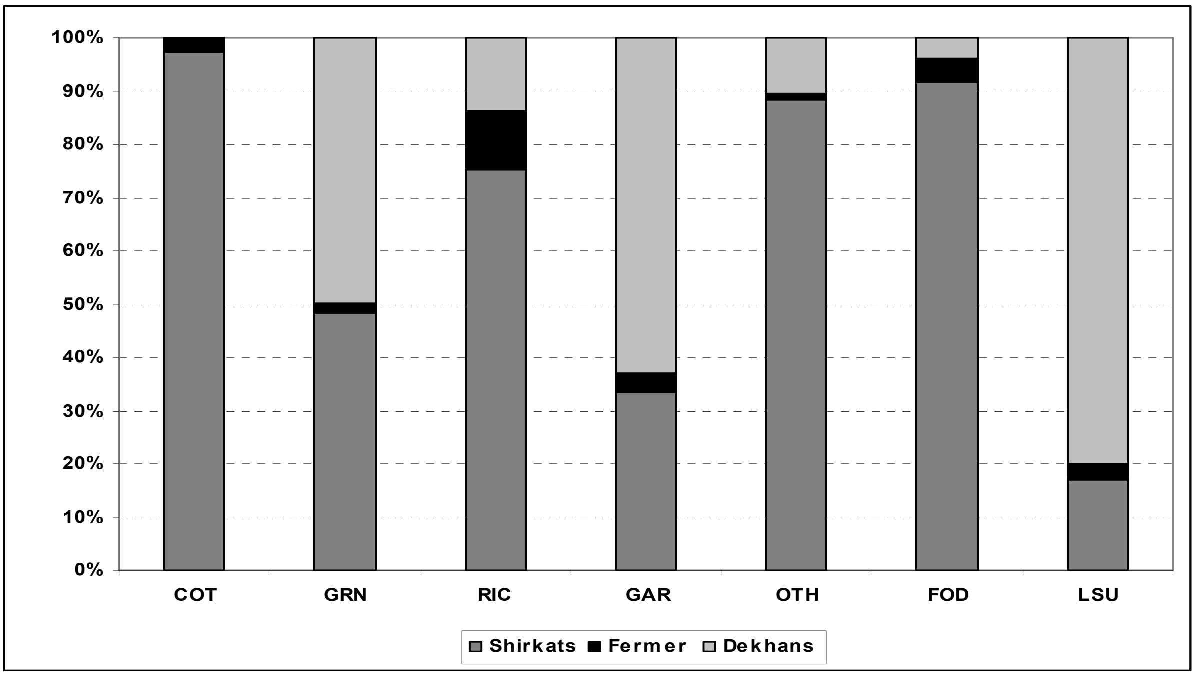
Table 2.3 Regulations Concerning Fermer and Dekhans

	Fermer	Dekhan
Application	Written application including a business plan and description of desired area. To be approved by the administration of the respective Shirkat and the regional administration (*Hokimiyat*).	Application to be approved by the administration of the respective Shirkat and the regional administration (*Hokimiyat*).
Size	Three different categories according to proposed specialization (business plan): 1. Animal Husbandry: A minimum stock of 30 animals is required. Access to needed irrigatable and non-irrigatable land is set accordingly (around 100 ha). 2. Crop Production: At least 10 hectares of irrigatable land. 3. Horticulture and Orchards: At least 1 hectare of irrigatable land. Upper limits for any farm size are not specified.	Between 0.35 and 1 ha, depending on the quality of the land. Areas for residential buildings are included.
Tenure	10 to 50 years, can be renewed. Might be withdrawn as penalty for frequent non-fulfillment of production targets (see below)	Life-long, can be inherited
Regulations	Agricultural activities are regulated by lease-contracts: 1. Animal Husbandry: No further (or unknown) regulations 2. Crop Production: Targets for the production of cotton and wheat are formulated on the national level and then broken down to the regions, districts, and finally to the crop-producers. Targeted production can easily occupy the major part of the agricultural activities. 3. Horticulture and Orchards: No further (or unknown) regulations	No regulations
Taxes	Land tax of 44000 Soum/ha/a (2003), exempted in the first two years after creation of the farm.	No taxes

Source: Kandioty (2002), Bloch (2002), Ilkhamov (no date)

These administrative regulations have a significant impact on the economic behaviour of the respective units. Figure 2.9 illustrates the shares of the different farm units in several production activities for the year 1999, just before the drought years. Given the fact that Shirkats are entirely devolved into Fermer by 2005, the small share of this unit in 1999 indicates that the process of transformation accelerated remarkably in the last six years. The data shown here is also surprising in some other respects. First, although the production of wheat is subject to governmental regulations, the freely operating Dekhans produced half of the total output in 1999. This observation contrasts to the case of cotton, which is also under the control of the government, but is produced by Fermers and Shirkats only. It seems that wheat production is an economically sensible alternative for farmers, which contradicts the results from other studies (e.g. IMF 2000), where the state-order for wheat production is perceived as a binding constraint for the agricultural producers. However, the available data indicate a governmental purchase of roughly 30% of the total wheat production; and the remaining 70% is sold on the market. This 'market' for wheat might still be determined by an oligopoly of governmentally owned mills, but the Dekhans apparently opt for this activity nonetheless.

Figure 2.9 Output-shares of Farm Units in Khorezm, 1999

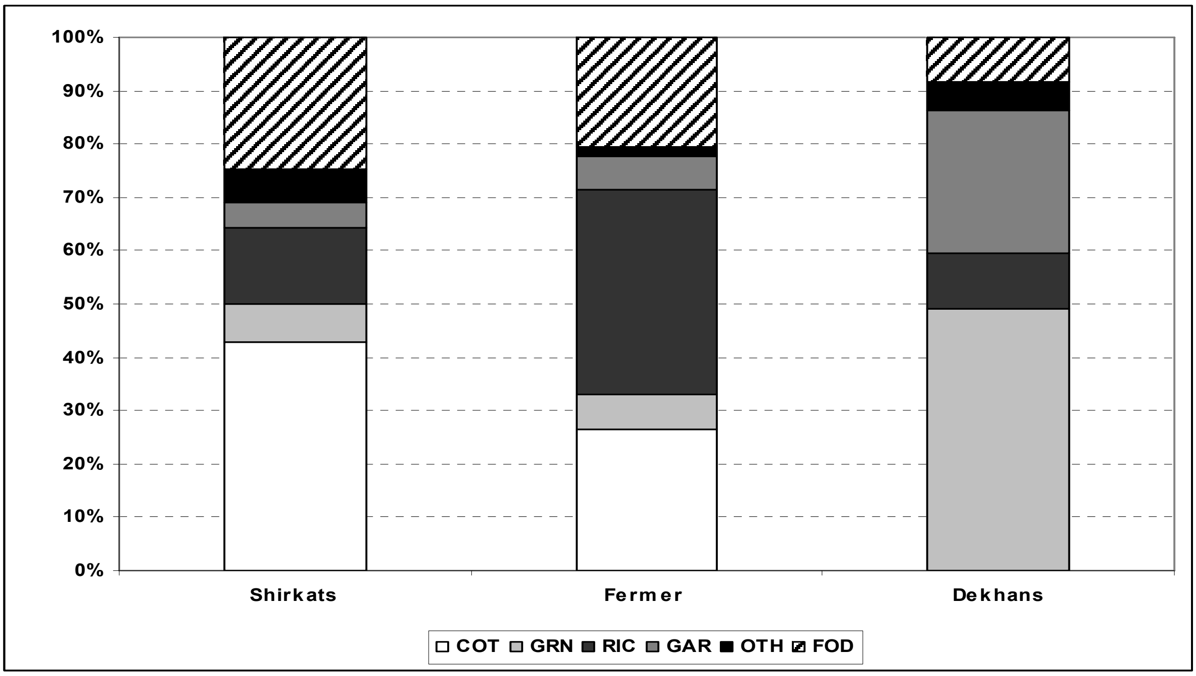


Source: OBLSTAT 2002b

COT: Cotton | *OTH: Other Market Crops (especially potato and sugar beet)*
GRN: Wheat and Other Cereals | *FOD: Animal Fodder*
RIC: Rice | *LSU: Livestock Unit*
GAR: Fruit and Vegetable

The second interesting observation is the relatively high share of Fermers in the production of rice. It has to be noted here that rice production is not promoted by the government, but it apparently owns the rice-mills in Khorezm. This is the only explanation for the high share of governmental purchases of rice (around 50% in 1999), since there are no minimum-production targets. In this case, the newly invented Fermer seem to have a preference for rice, perhaps because of a comparatively high gross-margin. If this were the case, Dekhans would also opt for this alternative, but instead, they apparently preferred to grow wheat, even though water was not scarce in 1999, what prevented them from growing the highly water-demanding rice in the following drought years. A possible explanation might be that wheat can be grown in orchards, and Dekhans have the highest share of them (included in the category GAR in figure 2.9). Such a production pattern relies on cheap availability of labor force, especially during the harvesting season, which is the case in Khorezm.

Figure 2.10 Area-shares of Crops in Farm Units in Khorezm, 1999



Source: OblStat 2002b

COT: Cotton	*GAR: Fruit and Vegetable*
GRN: Wheat and Other Cereals	*OTH: Other Market Crops (especially potato and sugar beet)*
RIC: Rice	*FOD: Animal Fodder*

The third interesting observation is the high share of Dekhans in animal production and the low share in fodder production, which mainly took place in Shirkats in 1999 and recently in the Fermer-sector as well. With the Dekhans as the major consumers

of fodder, it is remarkable that other farm units generate the needed supply. In 1999, the area-share of fodder production in the total area of Fermers ranked second after rice (see figure 2.10).
The information available indicates that the different farm units interact on several levels, both formally and informally. Thus, it would not be sensible to treat them separately. They will be regarded as an interdependent system in the following discussion.

2.3.3 State Order and Market Prices

Agricultural production in Uzbekistan and hence, Khorezm, is largely state controlled. Targets for wheat, rice and cotton (crops which account for the bulk of the area sown), are set centrally and broken down by region, district, and individual farm. The state also directly controls production and prices of inputs and processing as well as exports of cotton and imports of wheat. The enforcement of the "State Order" system as it is known for cotton and wheat, (rice is also affected by state plans) has severely exacerbated the problems that have been experienced during the droughts in 2000 and 2001. District governors and the public and private farmers in their jurisdiction are required to plant all available areas of each crop in order to fulfill their targets, regardless of whether sufficient irrigation water is available or not.

Table 2.4: Governmental Purchase of Main Crops, in thousand tons

		1998	1999	2000	2001
Cotton	Purchased	217	290	199	243
	Produced	217	290	199	243
	%	100%	100%	100%	100%
Wheat	Purchased	41	45	50	43
	Produced	162	163	153	123
	%	25%	28%	33%	35%
Rice	Purchased	87	70	2	0
	Produced	161	141	38	13
	%	54%	50%	6%	2%

Source: OBLSTAT 2002b

Farms and Shirkats are required to sell a considerable proportion of their output to the government at set prices, the surplus (if available) might be sold to the market at

prices which are to some extent still under governmental control. Table 2.4 gives an impression of the share of governmental purchase for the three mentioned crops.
Since there is no cotton demand/buyer other than from the government, the share of governmental purchase is always 100%. This observation supports the assumption that there is no incentive for farmers and Shirkats to produce more cotton than targeted.
Planned production targets and their respective real fulfillment are shown in table 2.5:

Table 2.5: Fulfillment of Production Targets, in thousand tons

		1998	1999	2000	2001
Cotton	Planned	290	290	280	280
	Real	217	290	199	243
	%	75%	100%	71%	87%
Wheat	Planned	31	37	50	40
	Real	41	45	50	43
	%	133%	121%	100%	107%
Rice	Planned	87	70	70	21
	Real	87	70	2	0
	%	100%	100%	3%	1%

Source: OBLSTAT 2002b

It appears that the wheat production target was met in the observed period but cotton and rice show some shortcomings. The water scarcities in 2000/2001 influenced the target fulfillment, especially in the case of rice (which has high water requirements). However, the other crops were similarly affected, though to a lesser extent.
In addition to the determination of production, the prices paid by the government differ from the respective market prices. Cotton is an exception since there is no private demand for cotton. Prices paid by the government are compared with market prices in table 2.6.
There is a general tendency for market prices to be higher than government prices. The most remarkable difference is the wheat price in 2000 when the government paid roughly half of the market price. The only exception was observed for rice in 1999 when the market paid 13% less than the government.
The effects of rice shortages can be observed in 2000 and 2001 when market prices increased from some 40 000 Soum per ton to some 80 000 or 150 000 Soum per ton respectively.

Table 2.6: Prices for Wheat and Rice, in Soum per ton

		1998	1999	2000	2001
Wheat	Government	12 440	21 051	28 871	47 890
	Market	16 115	38 488	55 240	48 125
	Deviation	30%	83%	91%	0%
Rice	Government	33 710	49 620	61 525	118 580
	Market	41 810	43 186	81 733	153 936
	Deviation	24%	-13%	33%	30%

Source: OBLSTAT 2002b, own results

This observation cannot be explained by an excess supply of rice in 1999, which could have pushed the market price below the government price. Especially by taking into consideration that the quantity of rice available on markets was lower than in 1998 (84 000 tons in 1998, 71 000 tons in 1999, see table 2.5), the supplied information seems to be unreliable and underlying databases should be further examined for accuracy.

2.3.4 Labour and Machinery

As in other countries of the FSU, agriculture became a labor-sink after independence as a consequence of lacking employment possibilities in other sectors (see also LERMAN ET AL. 2004). This development caused decreases in agricultural wages and made it even less attractive for producers to invest in the machinery assets.

Table 2.7 Norm Values for Labour and Machinery Requirements

	LFh/ha	kWh/ha
Cotton	1037	4181
Wheat and Other Cereals	212	3339
Rice	598	3639
Fruit and Vegetables	1618	3769
Other Market Crops	957	3057
Fodder	99	2339

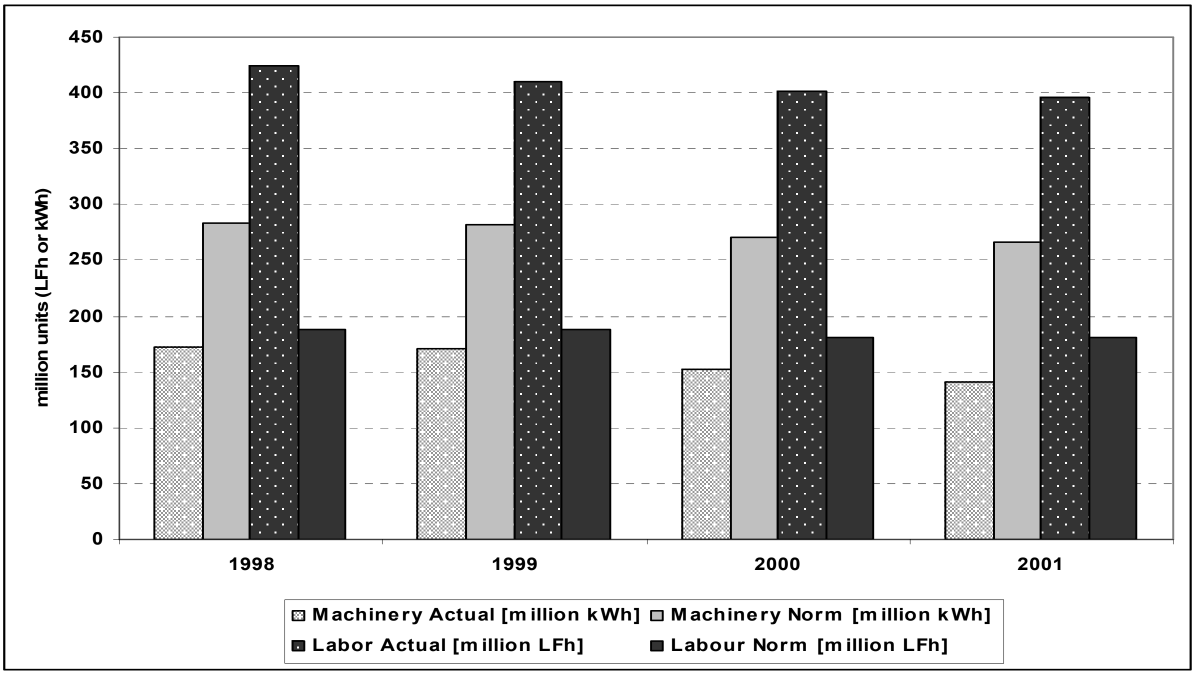
Source: OBLSTAT 2003b

LFh/ha: Labour Force Hours per Hectare *kWh/ha: Kilowatt-hours per Hectare*

A comparison of actual employment of labour and machinery with the norm-values for the different crops from soviet times clearly shows this development.

Based on these values, the total crop requirements can be calculated, and these crop requirements are compared with the actual usage of these factors in the following figure. Indeed, the norm requirements for machinery are much higher than the actual usage. The case of labour shows the opposite pattern.

Figure 2.11 Actual and Norm Values of Labour and Machinery Employment



Source: OBLSTAT 2003b

2.4 Water

Water from the Amu Darya is the crucial input for agriculture in Khorezm and therefore of great importance for the regional economy as a whole. The following chapter will give a detailed analysis concerning the availability, intra-regional distribution, and seasonal patterns of irrigation water.

2.4.1 Data Sources

Irrigation water plays a pivotal role in the agricultural system of Khorezm and a detailed examination of the patterns of water supply and demand is mandatory for this study. There are basically three types of water-related data available:

Monthly discharge from several reservoirs along the Amu Darya

This dataset covers the years from 1981 to 2001. The reservoir of Tuyamuyun is of particular interest here because it is located just before the river enters the irrigation network of Khorezm (HYDROMET 2002). It must be noted, however, that some of the water released from Tuyamuyun is used for irrigation in Turkmenistan and is therefore not available in Khorezm. Unfortunately, information on the approximate amount of water that was branched off was not available for this study.

Annual intra-regional allocation of irrigation-water

Two partly contradicting datasets were available; one covering the years 1988 to 2000 (OBLSELVODKHOS 2002a), the other covering the years from 1997 to 2001 (OBLSELVODKHOS 2002b). While the first dataset provides information about the actual usage of irrigation water, the latter one includes also the planned (or norm) demand and the minimum requirement for the production plan. The figures for the actual water use in 1998 deviate substantially since OBLSELVODKHOS 2002b shows a significantly lower value than OBLSELVODKHOS 2002a. This deviation is of particular importance as it influences any further calculations of crop-specific water allocations. The main question here is whether the total water usage in 1998 was higher than in 1999 or not. HYDROMET (2002) shows, that the discharge from Tuyamuyun in 1998 was much higher than in 1999. However, this does not necessarily mean that the usage of irrigation water followed the same pattern. In order to validate either of these datasets, two additional sources of information were used: The irrigated area as discussed in chapter 2.1.1 and the norm values for water demand of different crops. The latter is the third source of information concerning water and is explained in the following section.

Norm values for crop-specific water requirements

The regional department of the Ministry for Agriculture and Water Resources calculates the expected requirement for irrigation water in a future period based on assumed (formerly 'planned') areas and 'norm' values for the water-demand of different crops. These 'norm' values are calculated according to a hydrological model (HydroModRay 2002) which was developed during soviet times. This model provides estimates for the on-field demand of irrigation water for several crops at different dates during the vegetation period. It distinguishes between different categories of irrigated land, so that the calculated 'norm' values for each crop vary depending on the model's land classification. Table 2.8 shows the weighted average norm values for the regarded crops and crop-aggregates in Khorezm.

Table 2.8 Average Norm Water Requirements in Khorezm

	Water Requirement During the Irrigation Period [1000 m^3/ha]
Cotton	5.6
Wheat and other cereals	4.5
Rice	26.2
Fruit and vegetable	6.3
Other market crops	8.4
Fodder (clover + 'other fodder'; see also figure 2.1)	6.7

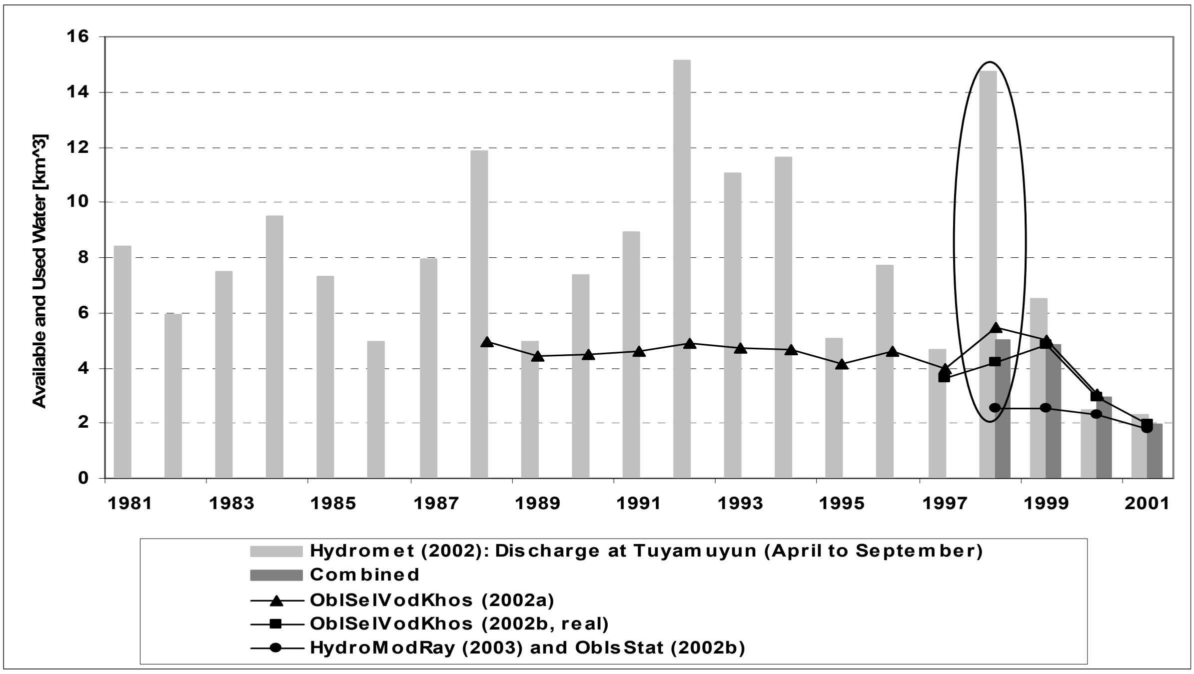
Source: HYDROMODRAY 2002

By multiplying the average water demand as shown above with the areas of figure 5, the total 'norm' requirement is generated as an additional source of information about the allocation of irrigation water.

After comparing the different sources of information discussed above and considering WEGERICH (2003), it can be concluded that OBLSELVODKHOS 2002b seems to be the most reliable source in general, but is not satisfying in 1998. The intra-regional distribution of irrigation water appears to be adequate but the total usage is under-estimated. Consequently, the regional total was adjusted while maintaining the intra-regional distribution.

Figure 2.12 depicts observed and generated patterns of water-supply and usage. The series labeled ‘combined’ will be used in the following as approximation to the real water usage in Khorezm, because it combines all information available and is more plausible than any other single dataset.

Figure 2.12 Water Demand and Supply in Khorezm



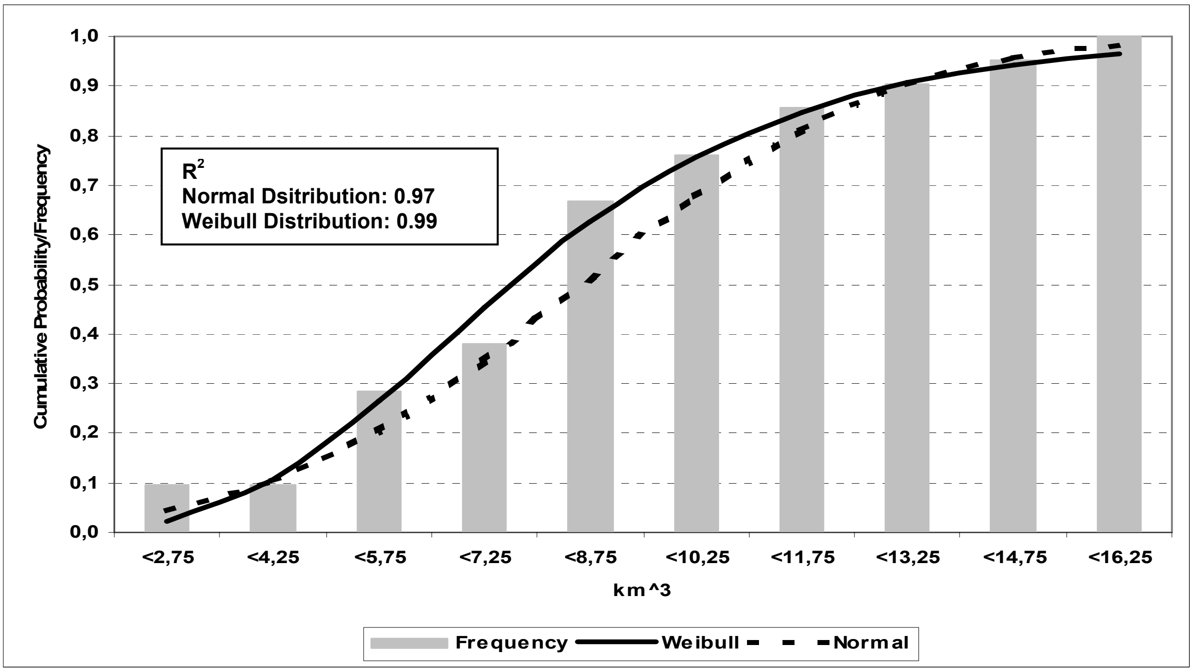
Source: Hydromet (2002), OblSelVodKhos (2002a), OblSelVodKhos (2002b, real), HydroModRay (2003), and OblsStat (2002b); own calculations

2.4.2 Annual Water Supply

Since ancient times, agriculture in Khorezm has depended on the supply of irrigation water from the Amu Darya. In order to get an impression of the amount of water that flowed into Khorezm during are the period between 1982 and 2001, the relative frequencies and approximated cumulative probabilities are depicted in figure 2.13.

It appears that the observed frequency of receiving less than 4.25 km^3 of water inflow in the irrigation period from April to September was around 0.1 in the two decades from 1982 to 2001. This means that such an event occurred in only two years of the observed 20: in 2000 and 2001.

Figure 2.13 Cumulative Frequency of Amu Darya Flow at Tuyamuyun and Approximated Probabilities, April to September, 1982 to 2001

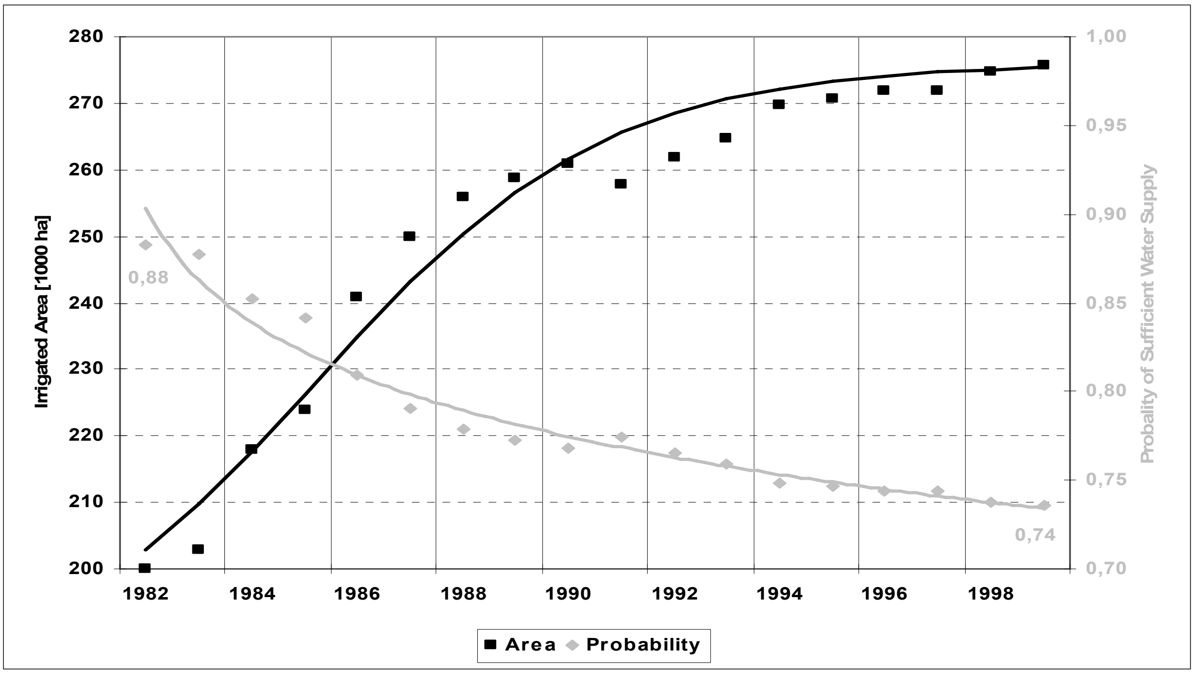


Source: OBLSELVODKHOS and own results

The maximum inflow amounted to 16.25 km^3, and consequently, the relative cumulative frequency of receiving less than this quantity represents a sure event. The annual inflow with the highest relative frequency lies in the range between 7.25 km^3 and 8.75 km^3. In order to get an idea of the distribution of probabilities for the flows, two probability functions were estimated based on the observed data: a cumulative normal distribution function and a Weibull function. Both functions were estimated by using a maximum likelihood approach. It appears that the Weibull function represents a closer approximation to the observed frequencies (see figure 2.13) with a measurement of determination (R^2) of 0.99, while the normal distribution has a slightly weaker fit with an R^2 of 0.97. This result is of particular interest as a Weibull distribution is not symmetric to its mean. In this case, the probabilities to get less than the average ~8 km^3 are higher than in the case of a normal distribution. Thus, whoever assumes a normal distribution of the annual water supply systematically under-estimates the probability of water inflows below the average quantity.

Khorezm consumed around 5 km^3 of irrigation water (OBLSTAT 2002a) in 1999, which was the year with the highest irrigated area in the observed period. The probability to get at least this amount of water is 0.74 according to the Weibull distribution estimated above. The division of the total water supply by the irrigated area in 1999 gives an average volume of 18 thousand m^3 per hectare. This remarkably high value is an immediate consequence of the high share of rice in the crop-mix of Khorezm (18% of the irrigated area in 1999; OBLSTAT 2002b). Rice is traditionally a major crop in Khorezm, but the crop mix in general has changed since national independence in 1992. Cotton was to some extent replaced by wheat production due to a strategy of import-substitution (USDA PS&D 2002). However, there is no evidence that the total water demand per unit of area has been declining in the observed two decades, and thus, the calculated value of 18 thousand m^3 per hectare will be used as a constant in the following. Figure 2.14 illustrates observed and interpolated dynamics of the irrigated area in Khorezm and the corresponding probabilities to get the needed water quantities. Starting in 1982, around 200 thousand hectares were irrigated and the probability to get enough water was 0.88. Until 1991, the year just before independence, the area had increased to 260 thousand hectares with a probability level of 0.77.

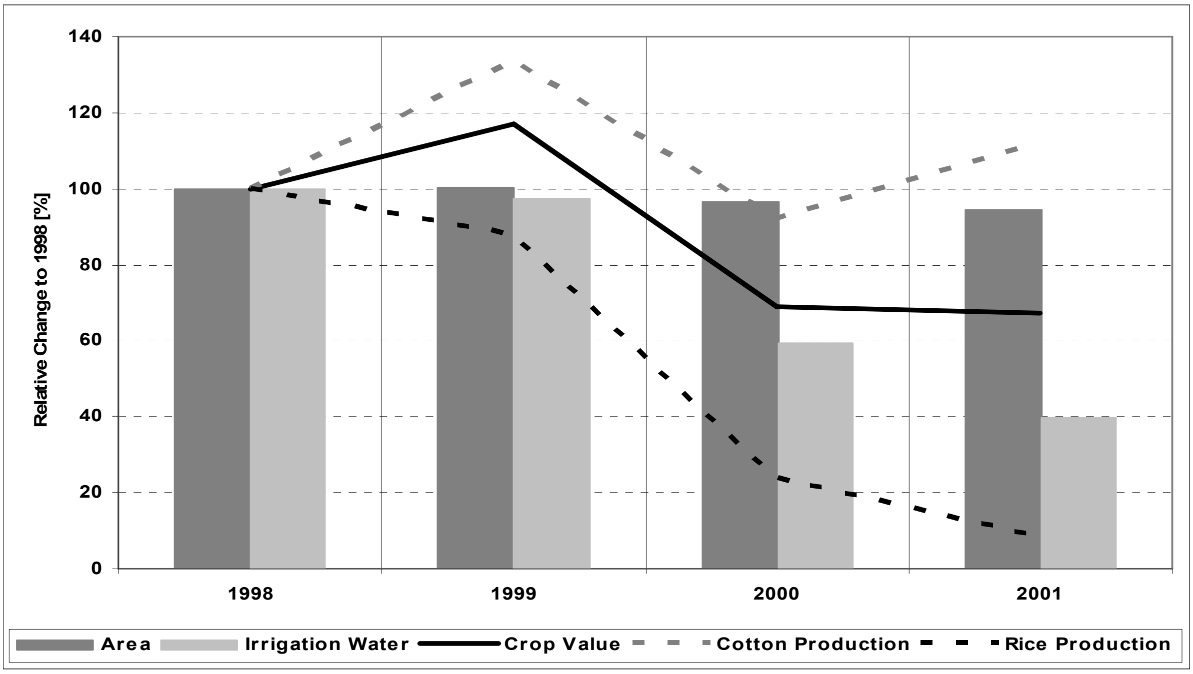
Figure 2.14 Irrigated Area in Khorezm and Probability to get Sufficient Amounts of Water, 1982 to 1999



Source: VLEK et al. 2000, OBLSTAT 2002b, OBLSELVODKHOS, own results

After independence, this process gained speed again and culminated in 1999 at a level of 276 thousand hectares and a probability level of 0.74. The increased risk became evident in the following two drought years. The total harvested area fell by 2001 to 94% of the level in 1998, total rice production to 8% (figure 2.15). Cotton production, however, increased by 12%. The reason is the strategic character of cotton in the Uzbek economy. It is subject to various regulations, among which are centrally set production targets that have to be fulfilled by the producers. If market conditions would have prevailed, then rice production might have declined to a lesser extent because of the higher gross-margins farmers can realize from this crop. The total value in real terms of the crop-output is also depicted in figure 2.15 (bold black line). It seems here that the drop in rice production could have been partially compensated by the higher cotton output, but it has to be noted in this context that market prices for rice rose tremendously in 2001 due to the low harvest.

Figure 2.15 Effects of the Drought in 2000/2001



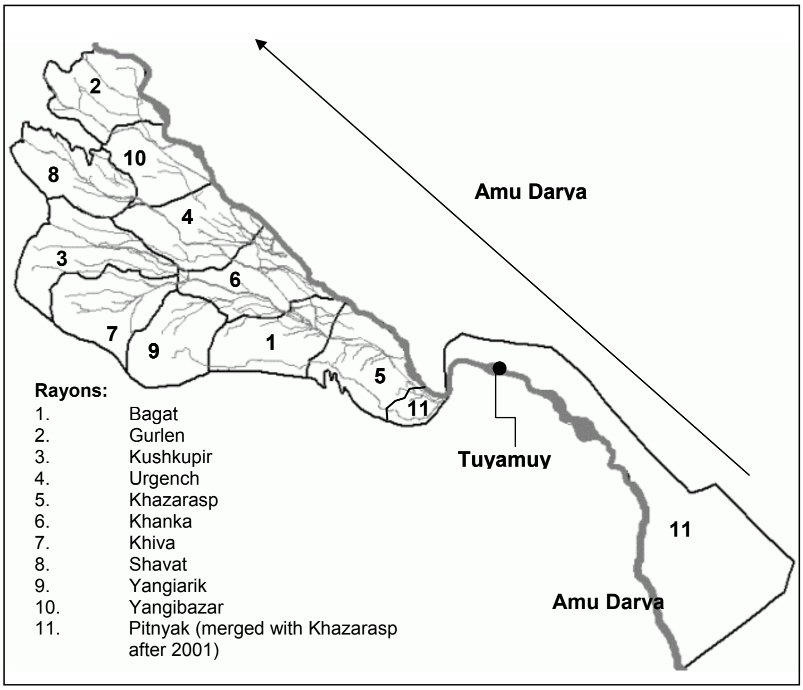
Source: OBLSTAT 2002a

The later observation shows another concern related to the risky dependence on irrigation water: Rice is a staple food in Uzbekistan and thus, has a high share in the consumption-expenditures of private households. Consequently, while those producers who were able to supply rice to the local markets gained some compensation for their smaller yields, low-income households with relatively high food-expenditures felt an additional burden (food price dilemma, see e.g. TIMMER ET AL. 1983).

2.4.3 Intra-regional Distribution of Irrigation Water in Khorezm

Khorezm comprises 11 districts (*Rayon*), four of which are not bordering the Amu Darya directly. Figure 2.16 shows a stylized map of Khorezm and its irrigation network. Irrigated agriculture begins where the Amu Darya fully enters the region and no longer flows along the border to Turkmenistan. Some of the water discharged from the Tuyamuyun reservoir branches off to Turkmenistan, but the better share is fed into the irrigation network that starts in the north-western part of the *Rayon* Pitnyak. A set of main irrigation channels begins here and in the following *Rayon* Khazarasp, which distributes the Amu Darya water further to the western districts Yangiarik, Khiva, Kushkupir, and Shavat.

Figure 2.16 Irrigation Network and Rayons in Khorezm

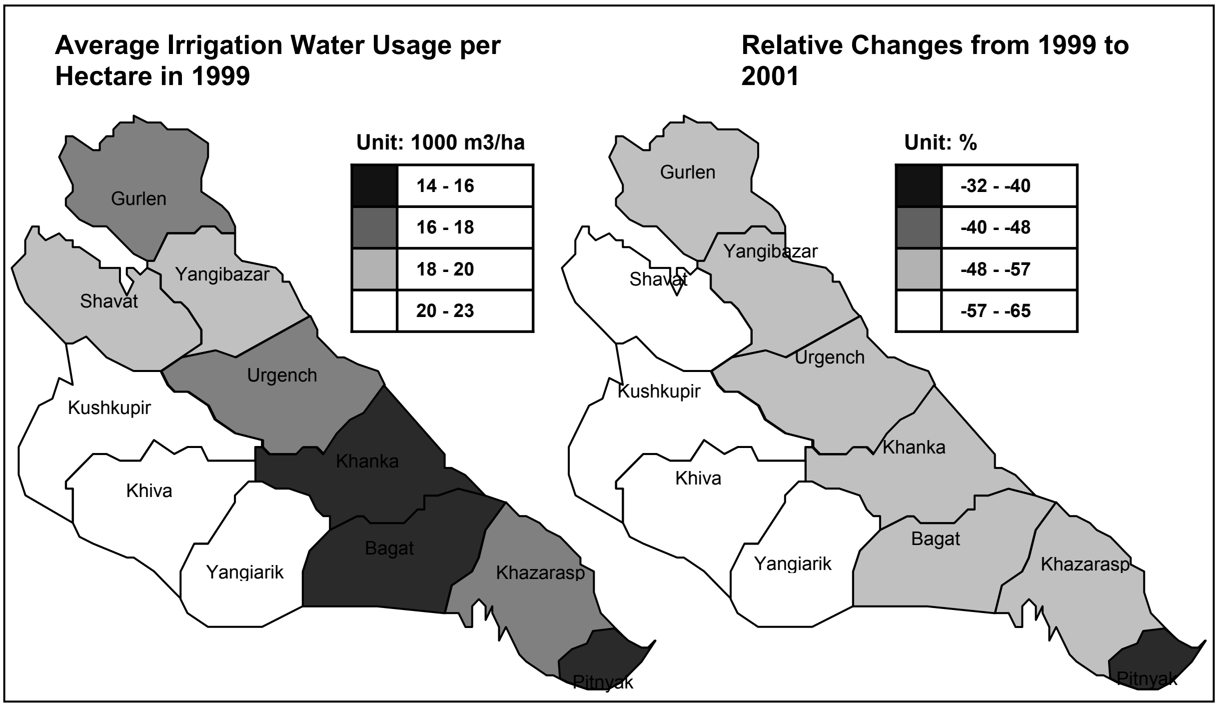


Source: Ressl, Project Data

The four latter Rayons have no direct access to the river and therefore depend not only on the naturally given water supply but also on the water consumption in the districts that border the Amu Darya directly. The down-stream located districts Gurlen, Yangibazar, and Urgench are in a less favourable position than the further up-stream located ones, but immediate access to the origin of irrigation water is still better than reliance on channel-water supply only.

As shown in figure 2.17 (right map), the average irrigation rate per unit of area decreased between 1999 and 2001 by -65% in the off-stream located districts, while the losses range from -48% to -57% along the river. Pitnyak was the exception in 2001 with a loss of only -32% compared to 1999. Surprisingly, in Kushkupir, Yangiarik, and Khiva, the average water usage per hectare of irrigated land in 1999 was with 20000 m^3/ha to 23000 m^3/ha significantly higher than the regional average of 18000 m^3/ha (figure 2.17, left map). On the other hand, the average values for Pitnyak, Bagat, and Khanka, which are all located in the up-stream part of the irrigation network, are with 14000 m^3/ha to 16000 m^3/ha well below the regional average.

Figure 2.17 Average Irrigation Water per Hectare in 1999 and Relative Changes until 2001



Source: OBLSTAT, own maps

A possible explanation could be a higher share of water-intensive crops, e.g. rice, in the cropping activities off the river. Although this seems to be counter-intuitive, it is at least possible. It is also possible, that the high usage of irrigation water is just specific for the year 1999. In order to get a better understanding of the intra-regional water distribution, the different effects of time, crop-mix, and district itself have to be examined in more detail. In the context of estimating area-specific inputs based on aggregated input data JUST (1990) suggests to split the water allocation per unit of area into three effects: a crop-effect, a regional effect, and an annual effect. Here, the water-usage per hectare can consequently be expressed in equation 2.4.1:

$$ASW^{est}_{c,r,t} = ccrop_c + cray_r + cyear_t \qquad (2.4.1)$$

With:	ASW^{est}:	Estimated area-specific water	[1000 m^3/ha]
	ccrop:	Parameter covering the crop-effects	[1000 m^3/ha]
	cray:	Parameter covering the regional effects	[1000 m^3/ha]
	cyear:	Parameter covering the annual effects	[1000 m^3/ha]
	r:	Index for Rayons (districts)	{Gurlen, …, Pitnyak}
	t:	Index for time	{1998, 1999, 2001}
	c:	Index for crops	{Cotton, …, Other}

Following JUST, the total water usage in each region equals the per-hectare values times the allocated areas. The estimation model looks like the following:

$$TAW_{r,t} = \sum_c \left(ccrop_c + cray_r D_r^{ray} + cyear_t D_t^{year} \right) * AREA_{c,r,t} + \varepsilon_{r,t} \qquad (2.4.2)$$

With:	TAW:	Total available water [1000 m^3]
	AREA:	Allocated area [ha]
	D:	Binary (Dummy) variables covering regional and annual effects
	ε:	Error term
	ray:	Index for Rayon Dummies
	year:	Index for year Dummies

The needed data for TAW and AREA are available for the 11 Rayons in Khorezm, the four years from 1998 to 2001 and for 12 crops and crop-aggregates which are summarized here in six categories. So, there are 44 observations for TAW and as many for the areas of the different crops. The model was normalized for the year 1998 and the Rayon Bagat in order to avoid singularity of the matrix of explaining variables (**X**). The number of parameters to be estimated is consequently:

ccrop:	6
cray:	10
cyear:	3
Total:	19

Thus, equation 2.4.2 can be estimated with only 25 degrees of freedom. Therefore, the different effects for crops, district, and years cannot be isolated at a satisfying level of statistical significance and the validity of the results would be questionable. Indeed, it turns out that the results for the crop-effects by estimating 2.4.2 with ordinary least squares (OLS) were not satisfactory. They did not match the available 'norm' values for each input and became negative in some cases, what is highly unrealistic since physical input quantities cannot have values below zero. The source of this problem is the comparatively small database. This issue was then addressed by employing the 'mixed estimation method' proposed by THEIL and GOLDBERGER (1967) which allows for the inclusion of additional information about the parameters to be estimated. The general idea of this approach is to combine the sample-distribution of a parameter-vector **b** with prior information about the mean and variance of the respective parameter. The model was formulated according to GREENE (2003)[1]:

$$E[\boldsymbol{\beta}_{\mathbf{BAY}} \mid \sigma^2, \mathbf{TAW}, \mathbf{X}] = \left(\boldsymbol{\Sigma}_0^{-1} + \left(\sigma^2 \left(\mathbf{X'X}\right)^{-1}\right)^{-1}\right)^{-1} \left(\boldsymbol{\Sigma}_0^{-1}\boldsymbol{\beta}_0 + \left(\sigma^2 \left(\mathbf{X'X}\right)^{-1}\right)^{-1} \mathbf{b}\right) \tag{2.4.3}$$

$$\mathbf{b} = (\mathbf{X'X})^{-1}\mathbf{X'TAW} \tag{2.4.4}$$

$$\mathbf{e} = \mathbf{TAW} - \mathbf{Xb} \tag{2.4.5}$$

$$\sigma^2 = s^2 = \frac{\mathbf{e'e}}{(n-k)} \tag{2.4.6}$$

---

[1] In order to maintain the readability, the variables are named according to Greene (2003).

With: E[ ] Expected value

β_{BAY}: Vector of parameters to be estimated (ccrop, cray, cyear)

σ^2: Variance of $\boldsymbol{\beta}$ (obtained from OLS regression, s^2)

X: Matrix of Area and Dummy variables

$\boldsymbol{\Sigma}_0$: Prior information about variances of $\boldsymbol{\beta}$

$\boldsymbol{\beta}_0$: Prior information about expected values of $\boldsymbol{\beta}$

b: Parameter vector obtained from OLS regression

e: Error term of OLS regression

k: Number of parameters to be estimated (19)

n: Number of Observation (44)

The crucial point of this method is to determine the prior information about expected values of the parameters ($\boldsymbol{\beta}_0$) and their variances ($\boldsymbol{\Sigma}_0$) accurately. Especially when the sample is comparatively small, the weight of the prior information in the estimation process will be very high.

Table 2.9 Estimation Results and Prior Information

	[1000 m3/ha]	b	σ	β_0	$\sqrt{\Sigma_0}$	β_{BAY}	σ_{BAY}	t_{BAY}
Crop Effects	Cotton	**41.61**	13.71	**5.62**	1.69	**13.41**	1.42	**9.42**
	Grains	**-5.55**	19.08	**4.49**	1.35	**6.08**	1.32	**4.60**
	Rice	**4.44**	12.26	**26.20**	7.86	**41.17**	4.22	**9.75**
	Garden Crops	**-4.11**	20.60	**6.29**	1.89	**8.16**	1.86	**4.39**
	Fodder Crops	**16.58**	19.95	**8.42**	2.52	**18.00**	2.21	**8.16**
	Other	**-19.52**	35.30	**6.72**	2.02	**8.07**	2.00	**4.03**
Rayon Effects	Gurlen	**-0.26**	3.05	**0.00**	3.05	**-1.45**	0.82	**-1.76**
	Kushkupir	**0.52**	1.37	**0.00**	1.37	**3.64**	0.54	**6.72**
	Urgench	**-0.35**	1.85	**0.00**	1.85	**0.00**	0.55	**0.00**
	Khazarasp	**-1.11**	1.33	**0.00**	1.33	**1.50**	0.66	**2.26**
	Khanka	**-2.82**	1.39	**0.00**	1.39	**-1.89**	0.55	**-3.44**
	Khiva	**1.32**	1.52	**0.00**	1.52	**2.43**	0.65	**3.77**
	Shavat	**-0.10**	1.04	**0.00**	1.04	**1.82**	0.52	**3.53**
	Yangiarik	**3.63**	1.40	**0.00**	1.40	**3.13**	0.69	**4.51**
	Yangibazar	**1.24**	1.80	**0.00**	1.80	**2.26**	0.67	**3.40**
	Pitnyak	**4.89**	3.59	**0.00**	3.59	**-3.33**	1.69	**-1.97**
Annual Effects	1999	**0.03**	0.95	**-0.54**	0.95	**0.02**	0.39	**0.05**
	2000	**-6.27**	1.21	**-7.12**	1.21	**-5.76**	0.41	**-13.98**
	2001	**-12.58**	1.76	**-10.68**	1.76	**-7.00**	0.63	**-11.07**

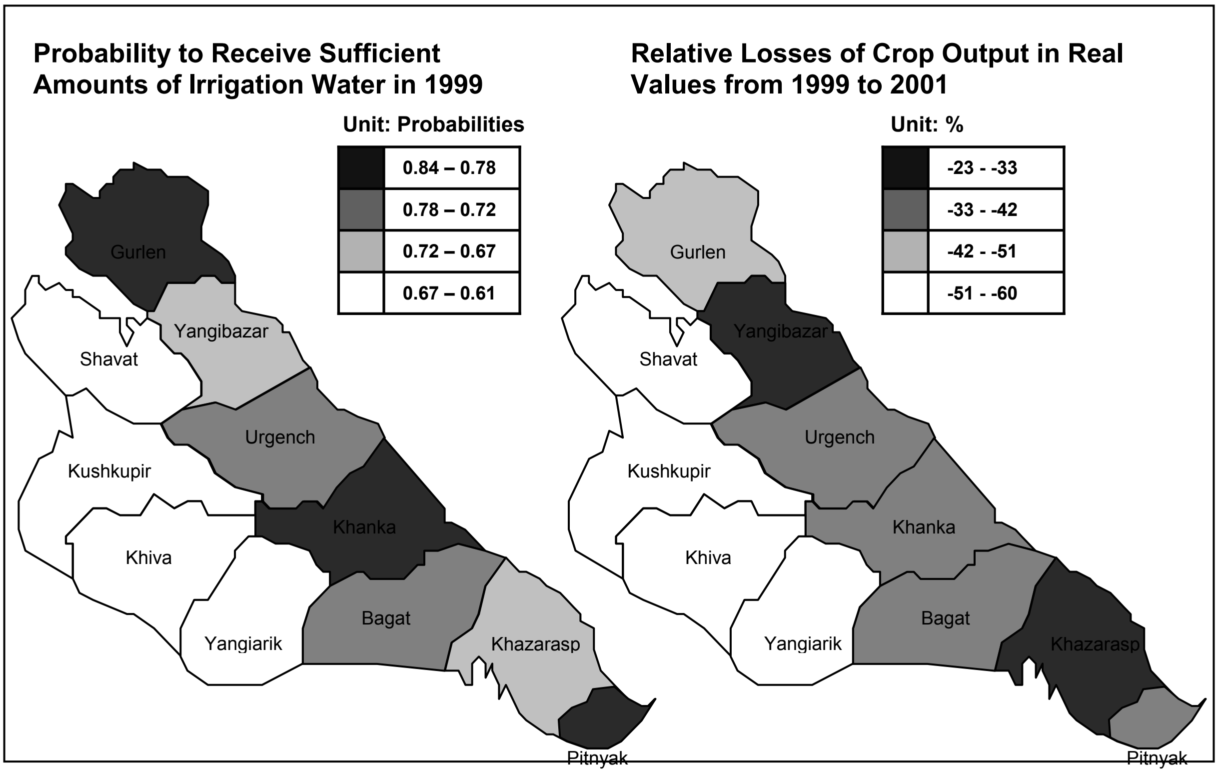
Source: OBLVODKHOZ and own calculations

Consequently, $\boldsymbol{\beta}_0$ was constructed by using the 'norm' values for the inputs in the case of the parameter group covering the crop-effects (ccrop). Prior information for regional effects (cray) was not available and set to zero, according to the assumption that there should be no regional differences in a balanced irrigation system.

The annual effects (cyear) were assumed to equal the average decreases of water availability in entire Khorezm. For the variances $\boldsymbol{\Sigma}_0$ it was assumed in the case of crop effects that the standard-error has to be small enough to make negative values very unlikely. This was achieved by setting the standard errors to 1/3 of the norm values. Variances of the regional and annual effects were taken from the OLS regression.

The results from the estimation are shown in table 2.9. It turns out that the crop effects do not deviate largely from the prior information, an indication that the sample has a low explanatory power in this case. On the other hand, the annual effects do deviate and show plausible results with a positive value for 1999, which was a year with sufficient water supply, and negative values for 2000 and 2001, which were drought years.

Figure 2.18: Probabilities of Receiving Sufficient Amounts of Irrigation Water in 1999 and Relative Changes until 2001



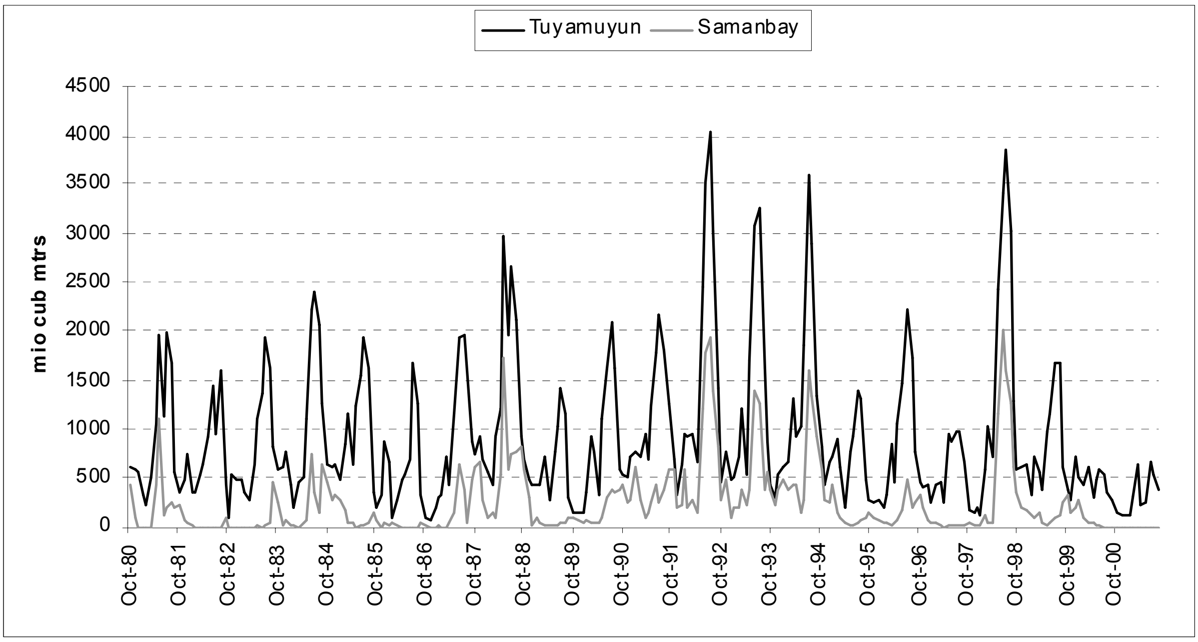
Source: OBLSTAT, own maps

The regional effects show that the water usage per hectare in the regions not bordering the Amu Darya is higher than in the regions along the river. This result seems counter-intuitive but makes sense when water losses are taken into account. In the off-stream regions, more water is needed per hectare in order to compensate for the losses associated with transporting water from the river to the respective regions. These results and the respective ones for diesel and labour are used to calculate the support points for the crop-specific inputs.

2.4.4 Seasonal Patterns of Water Demand and Supply in Khorezm

An examination of the monthly flow rates from October 1980 to August 2001 measured at Tuyamuyun and Samanbay (as depicted in figure 2.19) shows that that there are some periods in which almost no water has left Khorezm. This is indicated by the flow rate at the Samanbay measurement station. Such periods can be observed between October 1981 and 1983, between 1985 and early 1987 and then, a decade later, in 1997 as well as in late 2000 until August 2001. The latter period appeared to be particularly serious and long-lasting, but the situation improved in 2002 and 2003.

Figure 2.19: Monthly Amu Darya Flow Rate

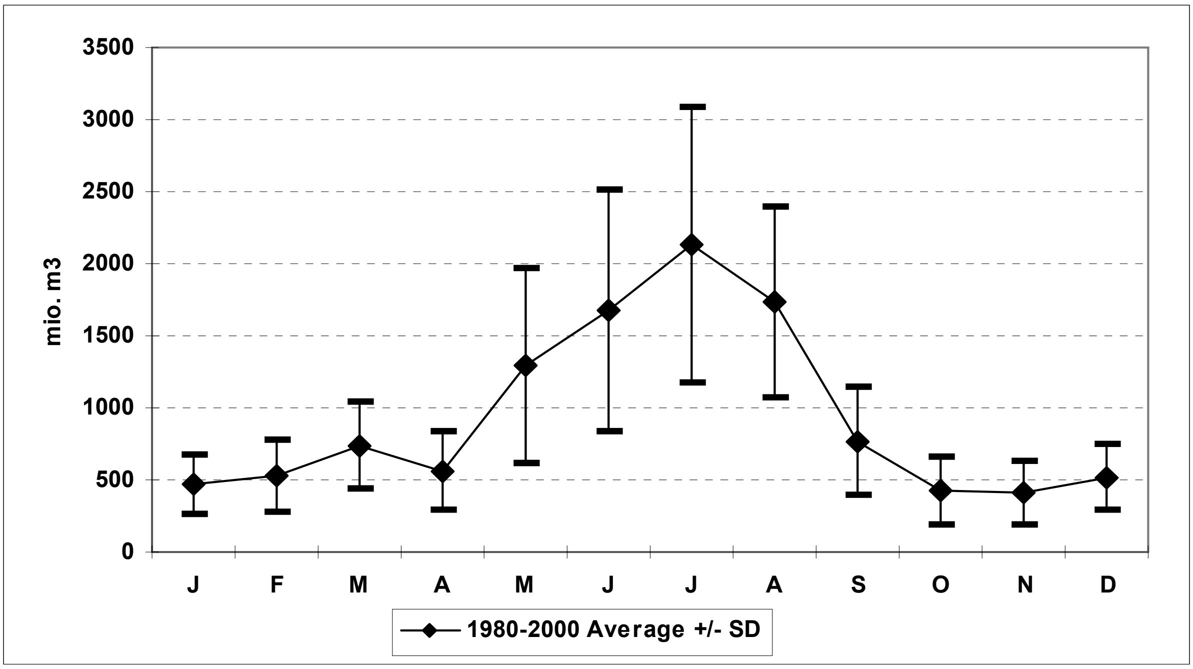


Source: HYDROMET (2002)

At any rate, the last drought period had a serious impact on the entire economy of Khorezm and caused some concern about the future water availability. It also raised the question of the sustainability of the agricultural production patterns in this region. Regarding the last 20 years, no significant negative trend of either water inflow or outflow can be shown and hence, there is no direct reason to assume decreased natural water availability in the future. But the seasonal behavior of the Amu Darya as depicted in figure 2.20 requires some general remarks.

It appears that, in general, the water inflow into Khorezm meets the demand. Water inflow is low in wintertime, when the channels have to be maintained. There is an increased inflow in March, when the fields need to be leached, and during the vegetative period of most plants, which starts in May. On average, the Amu Darya provides an increasing amount of water until August, exactly during the period with the highest temperatures and highest evapotranspiration of the cropped plants. At the same time, the standard deviations are the highest from Mai to August, making water a very risky resource.

Figure 2.20 Seasonal Behaviour of the Amu Darya at Tuyamuyun Measurement Station, 1980-2000 Average +/- Standard Deviation

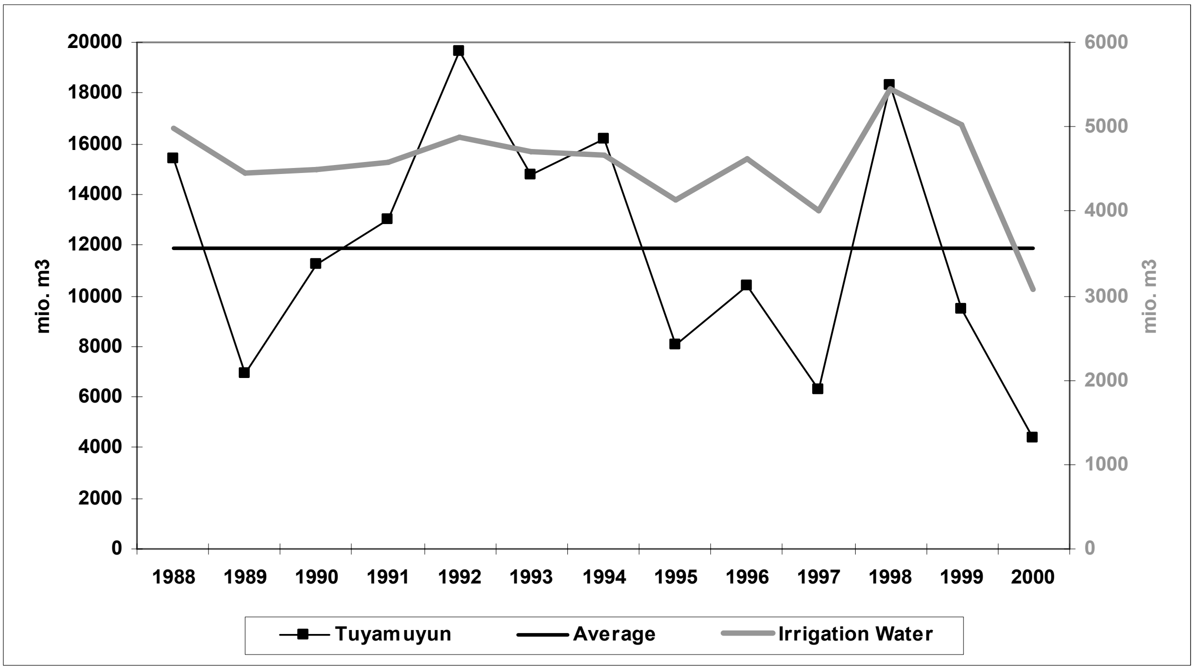


Source: Own calculations

In order to compare the water inflow with the withdrawals for irrigation purposes, the data structure necessitates adding the monthly data at Tuyamuyun to annual values. In addition, the average inflow between 1988 and 2000 is depicted.

It appears that until 1994 the annual withdrawals from the river maintained a stable pattern while after 1994 the withdrawals began following the dynamics of the water supply, although there is no significant change in either scale.

Figure 2.21 Comparison of Water Inflow and Discharge

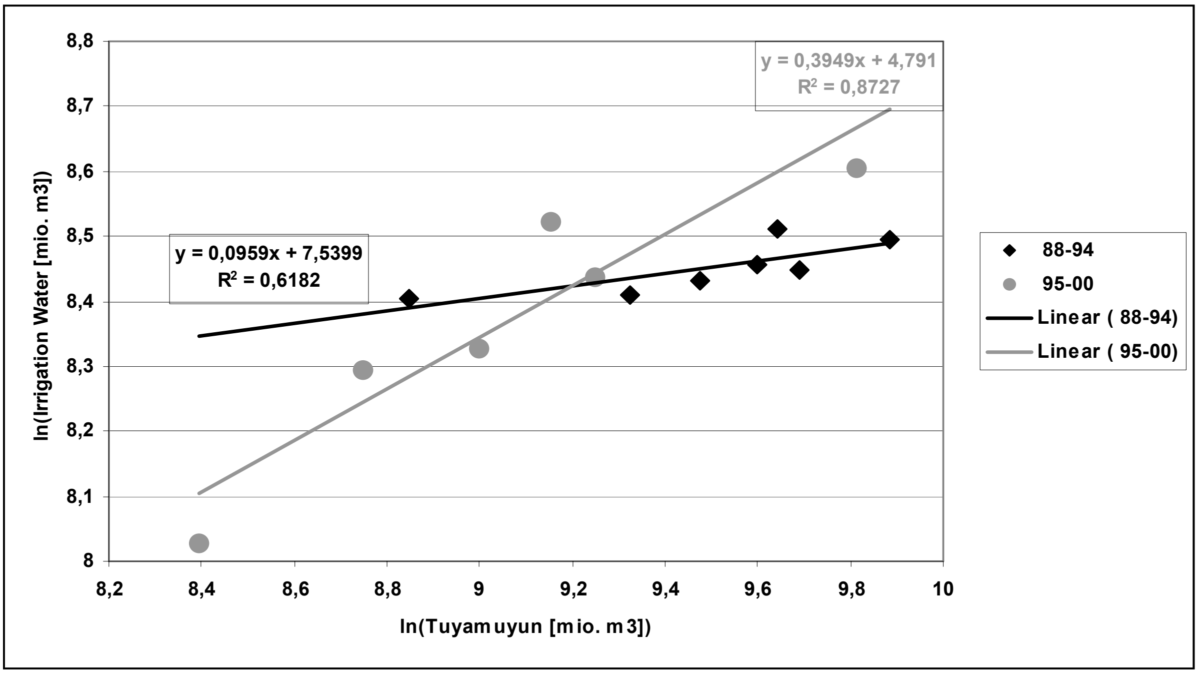


Source: Own calculations

Nonetheless, there is some evidence for a decreased water supply after 1994. Before 1994 only two years recorded a below-average value, and after 1994 there was only one year with an above-average water inflow.

Such changes in the dependency of the irrigation water on the naturally available water can also be quantified by plotting the withdrawals against the supply, which is done in figure 2.22. Here, the natural logarithms of both values have been taken in order to derive the elasticity of irrigation water with respect to water inflow. Before 1994 the resulting elasticity is only 0.1 and the whole model has a measurement of determination of 62%. For the following years, the elasticity amounts to 0.4 with a measurement of determination of 87%. Thus, in the later years, the impact of the water inflow in the withdrawals is higher and more significant.

Figure 2.22 Changes in Dependencies



Source: Own calculations

Although monthly irrigation data is unavailable, it is still possible to conclude from such analysis that the high dependency between the annual values applies to the monthly values as well for the period after 1994: If 1% of the annual inflow came in January, 1% of the annual withdrawals was taken in this month. So, given the annual irrigation volumes (as shown in figure 2.22 compared to the inflows at Tuyamuyun) in the context of the observed monthly percentages of the annual inflow rate (as depicted in table 2.10) the water supply for the irrigation network can be derived.

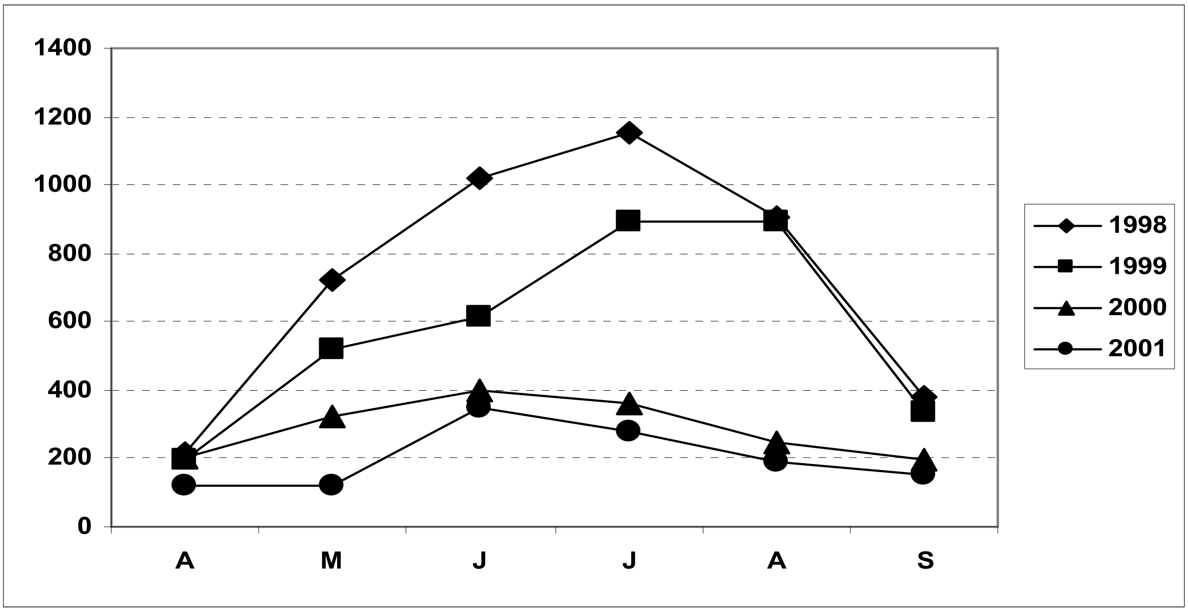
Table 2.10 Monthly Percentages of Annual Flows, 1998 to 2001

	1998	1999	2000	2001
J	1%	3%	12%	3%
F	3%	8%	9%	8%
M	6%	6%	14%	17%
A	4%	4%	7%	6%
M	13%	10%	11%	6%
J	19%	12%	13%	18%
J	21%	18%	12%	14%
A	17%	18%	8%	10%
S	7%	7%	6%	8%
O	3%	4%	4%	4%
N	3%	3%	3%	3%
D	4%	8%	3%	3%
Annual mio. m3	18303	9455	4416	3737

Source: Own calculations

The results, figure 2.23, are shown for the period from 1998 to 2001, which is interesting because of the huge changes in water availability within a short time.

Figure 2.23 Water Supply in the Irrigation Period, 1998 to 2001



Source: Own calculations

Not surprisingly, the water supply is the highest in 1998 and decreases until 2001. The next step would be to derive the corresponding demand curves.

The type of crops planted is the main determinant in the demand for water, and vice versa, the harvested area for each crop depends on the availability of water at the right time. Hence, information about the area sown would provide some insight into the expectations of the actors in agricultural business and the area harvested indicates what can be achieved given certain environmental conditions ("environmental" in the sense of the surrounding conditions for the farmer). The data used here to derive a demand function for water refer to the realized quantities and harvested areas. Although some useful insights into the behavior of farmers cannot be derived, it is still useful to examine their resulting positions in different years. It is at least possible to gain some insights into the response of harvested areas on changes in water supply. With an area of around 100000 ha cotton is the main crop by acreage in the region of Khorezm and target values set by the government determine its production. Thus, the slight increase in 2001 can hardly be explained by an anticipation of the drought in the summer of this year. The same argument applies for the harvested wheat areas, which are state controlled as well, although to a lesser extent. The only possibility for agricultural producers to react to water scarcity is to adapt the rice areas and other crop areas, such as vegetable, fruit and fodder. As rice is the most water-demanding crop in the observed agricultural system, the reaction to water shortages is very significant: The harvested area decreased from 2000 to 2001 by almost 70%, while the aggregated other crop areas decreased by only 14%. It is remarkable that the decline of harvested rice areas from 2000 to 2001 is much stronger than from 1999 to 2000, which was only 21%, while the annual irrigation water declined from 1999 to 2000 by 39% and from 2000 to 2001 by 35%. This asymmetric behavior cannot be explained with respect to the annual values of water supply. However, a possible explanation might be found by examining the monthly patterns of water demand in the irrigation period between April and September.

The monthly water needs for the different crops are calculated based on norm values, which were provided by the regional department of the Ministry for Agriculture in Khorezm. These values are based on results from former soviet hydrologists and are still a sophisticated estimate for the water needs given the local climatic and environmental conditions.

Table 2.11 Monthly Norm Values for Water Needs, in m^3 per ha

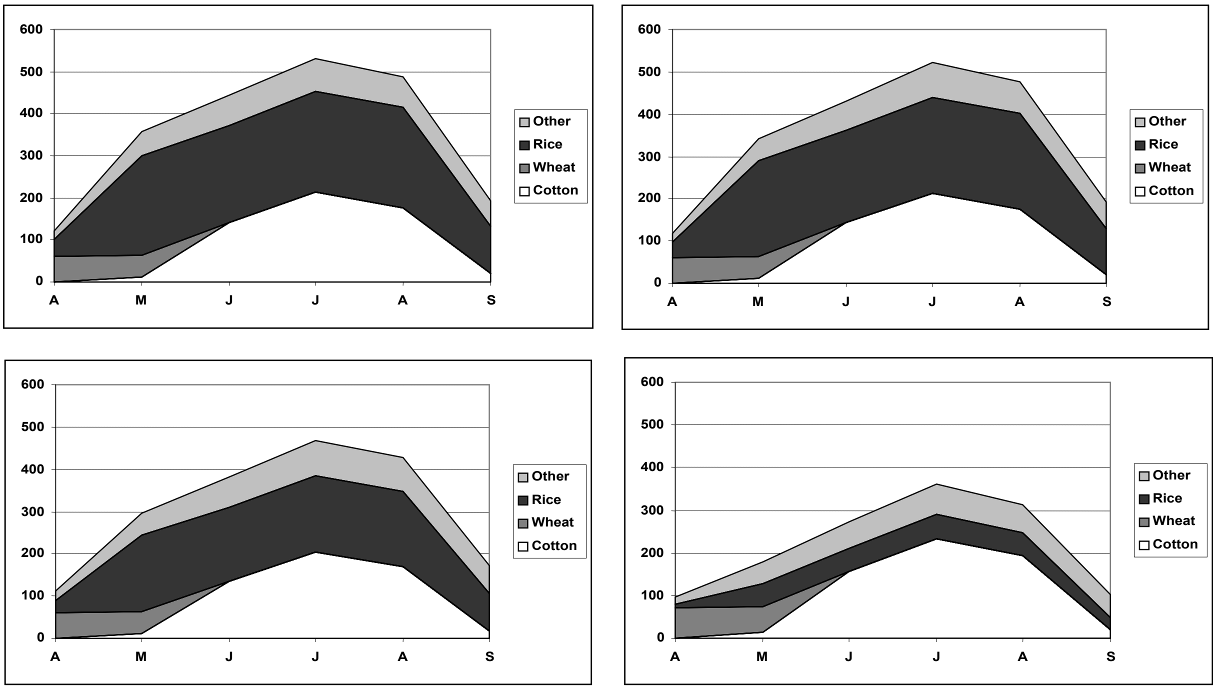
	A	M	J	J	A	S
Cotton	0	119	1418	2128	1756	191
Wheat	1979	1671	0	0	0	0
Rice	916	5680	5497	5680	5680	2748
Maize	0	581	2398	2332	0	0
Clover	1024	1473	1434	1635	1545	1300
Vegetable	526	1630	1578	1630	1630	1578
Potatoes	526	1630	1578	1630	1630	1578
Garden	0	1057	1167	1162	1174	628
Melon	0	813	1166	1220	788	0
Other	0	0	962	1541	1560	1587

Source: Own calculations

As can be seen in table 2.11, most crops have their highest demand in July and August with the most remarkable exception of wheat, which is harvested in June and hence, has its last irrigation period in May. Based on these norms, the total water demands have been derived and are shown in figure 2.24.

Total water demand is always the highest in July, changing from above 600 million m^3 in 1998 to less than 400 million m^3 in 2001. The surfaces of the four diagrams are compared in the following figure 2.25 with the water supply curves derived in figure 2.23. It appears that the water supply exceeded the water demand in 1998 and 1999 during all months of the irrigation period and there was no need to adapt the production plan within these two years.

Figure 2.24 Total Water Demand 1998 to 2001, in million m3

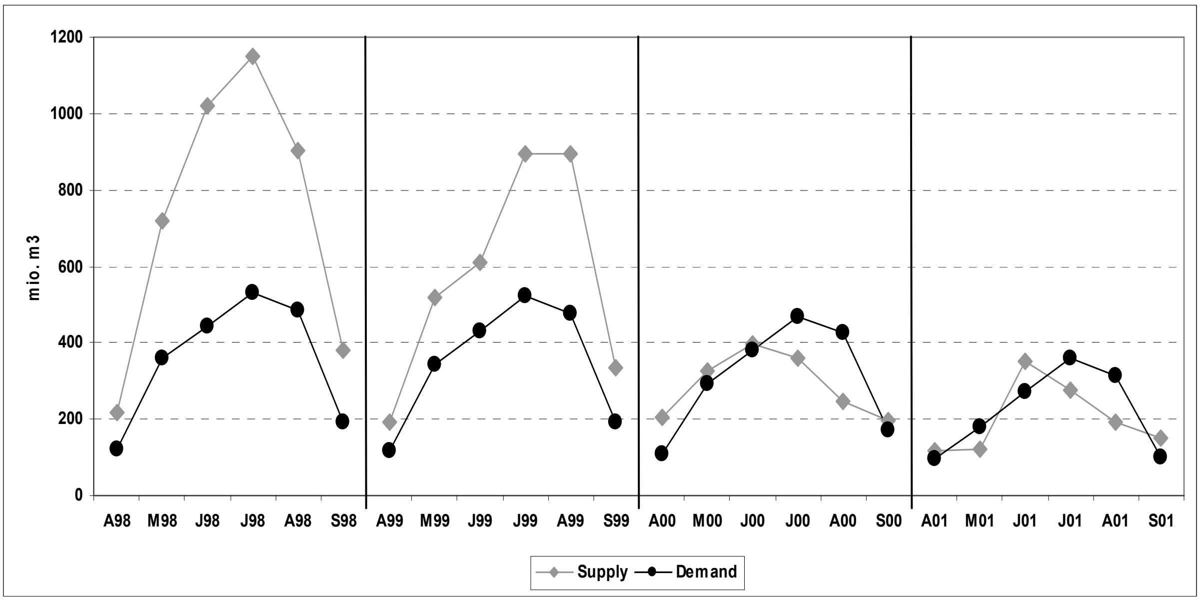


Source: Own results

When the droughts began in 2000, the harvested rice area decreased, but not to an extent which would have ensured a sufficient water supply for all remaining areas: Despite the adaptation of the area, water supply in July and August was still below the recommended quantities. Regarding the situation in 2001, the most noticeable difference is that the water scarcity had already begun in May. This event apparently caused the significant decreases of the harvested rice area but the adaptation was again not sufficient to prevent water shortages in July and August.

Altogether, there have been two months of water availability below the recommended levels in 2000 and three such months in 2001. The question remains whether the shortage of water was 'distributed' among all crops or if only selected crops became undersupplied. As in the case of area changes, it appears that rice is the buffer crop in drought periods, which is plausible because of its high water demand and the resulting water-savings by reducing the area as well as the irrigation density.

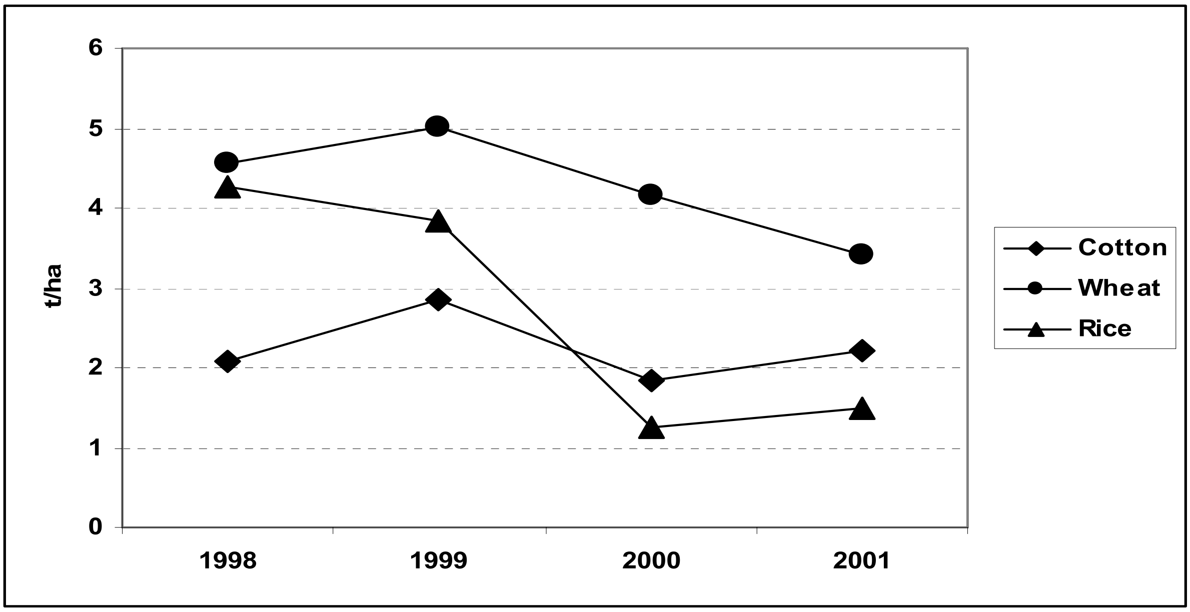
Figure 2.25 Water Demand and Supply in Khorezm 1998 to 2001, in million m^3



Source: Own results

The yield data for the main crops cotton, wheat, and rice as shown in figure 2.26, support this assumption: while the average cotton yields do not show remarkable changes in the observed period. The rice yields fell tremendously from around 4 t/ha in 1998 and 1999 to less than 2 t/ha in 2000 and 2001. The average wheat yields also declined in the drought years, but to a much lesser extent than the case of rice.

Figure 2.26 Average Yields of Main Crops in Khorezm 1998 to 2001, in tons/ha



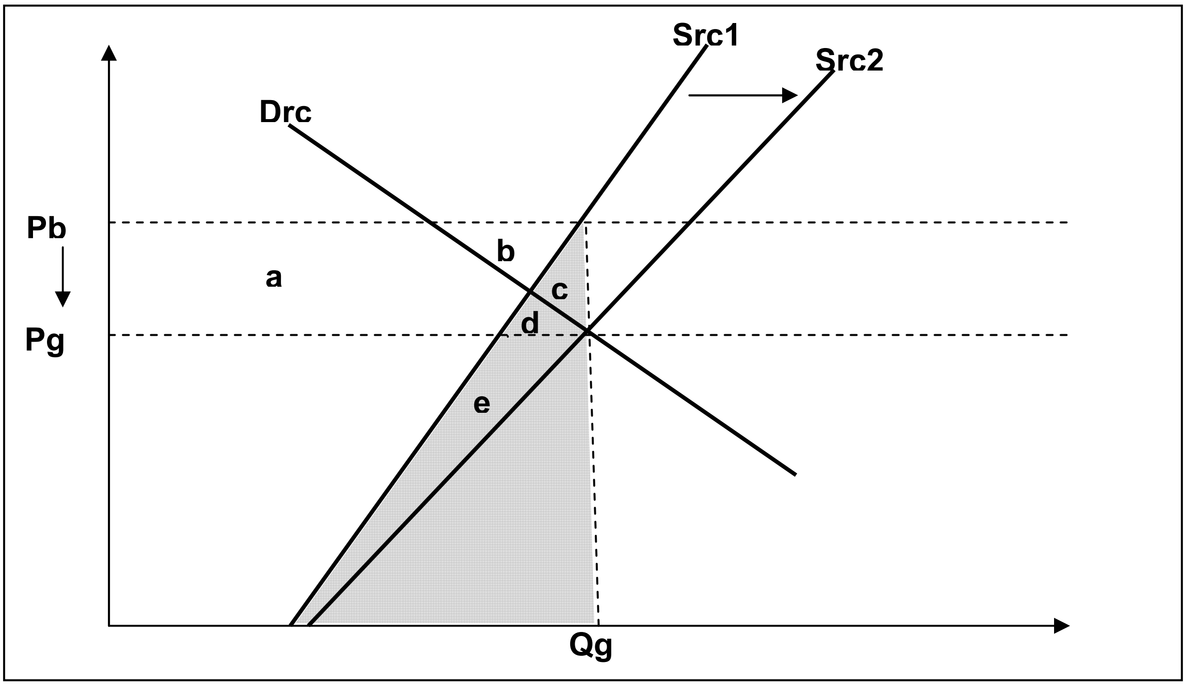
Source: Own results

2.5 The Uzbek Cotton and Wheat Market

Cotton is a strategic crop in Uzbekistan and its production is largely state controlled. The relevant mechanisms are explained in some more detail in the following section. Cotton is the dominant crop within the agricultural sector, accounting for around 32% of the total cropped area between 1998 and 2001 in Uzbekistan (FAOSTAT 2004). The main reason for this dominance is not because cotton is a favourable crop for agricultural producers due to high revenues, but because of the determination of output quantity by the government. Targets for the production are set at a national level and then broken down to regions (*Oblast*), districts (*Rayon*) and finally to the actual producers. In theory, the harvested raw cotton has to be sold by 30% of the target level to the responsible state marketing board (*Uzkhlopkopromzbyt*) at state prices which are usually well below the world market price. The remaining 70% might then be sold to the same organization at prices that are around 20% higher but still below the WMP. Due to the fact that there is no private cotton market and that the production targets are usually very ambitious, the total produced quantity is usually sold to governmental institutions (IMF 2000, WB 1999, KANDIOTY 2001). The resulting supply of raw cotton is then processed into fibres and seeds. Fibres are mainly (but decreasingly) exported or used by the domestic textile industry, and seeds are either redirected to the agricultural producers for sowing purposes or are milled to cotton oil and oil-cake. Cotton oil is an important food product while oil-cake is used as fodder component within the animal husbandry sector. It is evident that the cotton sector as a whole has a significant impact on other areas of the national economy of Uzbekistan and will therefore be examined for the year 2001 in greater detail.

The area used for cotton production amounted to 1452 thousand hectares or 34% of the total cropped area, yielding 3265 thousand tons of raw cotton (FAOSTAT 2004). Given an average state order price of 81330 Soum per ton (OblStat 2002), the domestic value was 266 billion Soum. Raw cotton is not exported and there is no observation for a border price, but a theoretical export price can still be derived based on the price for cotton fibre and processing cost: The cost share of raw cotton in the production of fibre is roughly 73% (WB 1995, including trade cost) and 3.2 tons of raw cotton are needed on average for one ton of fibre (FAOSTAT 2004). The hypothetical border price in 2001 would then be 226 US$ per ton of raw cotton or 237510 Soum/ton at the market EXR, 52% above the state order price. This implicit tax is to some extent outweighed by several supporting policies like free access to irrigation water and tax exemptions for intermediate inputs. The resulting distortions of partial market for raw cotton are illustrated in figure 2.27 in a simplified manner:

Figure 2.27 Partial Market for Raw Cotton



Source: Own presentation, based on Henrichsmeyer and Witzke (1991)

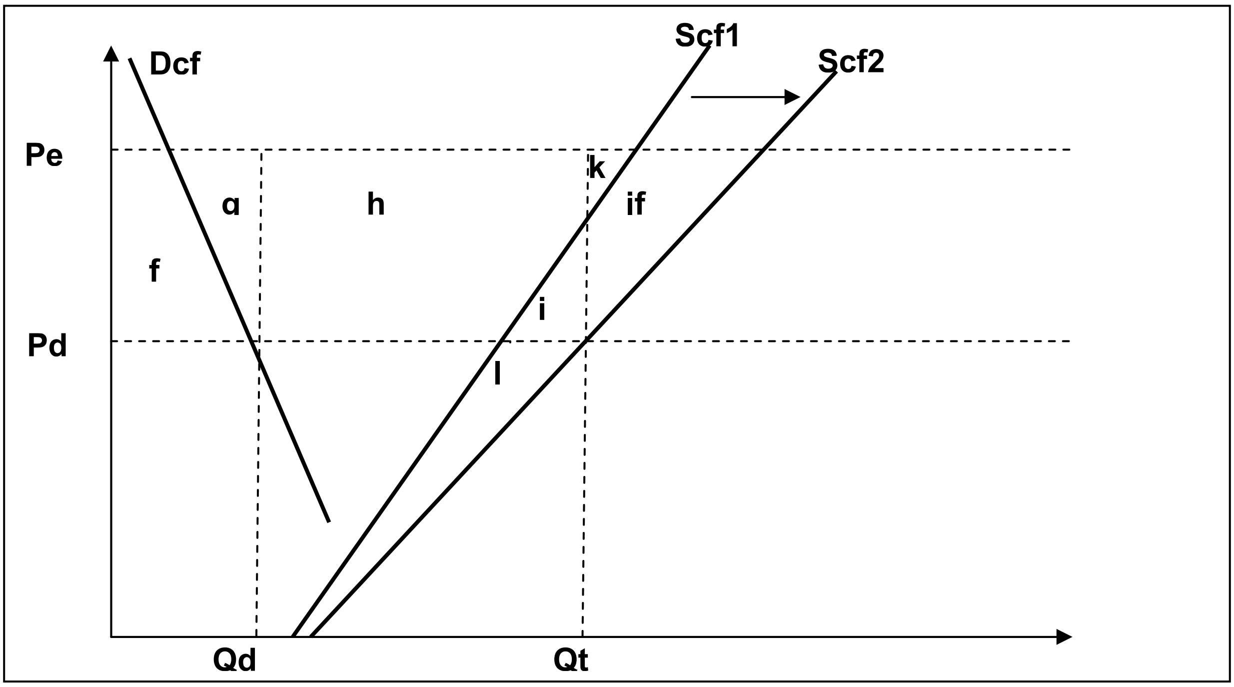
Domestic demand for raw cotton is represented here by the line **Drc** and the initial domestic marginal costs by **Src1**. The domestic market is assumed to be fully competitive and open to the world market, by which the border price **Pb** is determined. When producers are price takers and behave rationally, they will decide to produce an output level of **Qg** in this initial situation. The marginal costs equal the market price (**Pb**) and the total variable costs, represented by the grey shaded area below the marginal cost curve, are covered fully by the market value of the output (**Pb** times **Qg**). Output exceeds the domestic demand and raw cotton would be exported. In order to support the cotton fibre sector, the domestic price is then decreased administratively to **Pg** at which the domestic demand equals **Qg** exceeding now the domestic supply at this price level. To ensure the provision of the fibre producers with domestic raw cotton, a minimum production target is set at **Qg** by the government. Due to this system of regulations, the raw cotton sector loses the areas **a** and **b** as producer surplus compared to the initial situation. The total cost of production (the grey shaded area below the marginal cost curve **Src1** until **Qg**) is the same as in the initial situation. Pg is below the marginal cost and the producers lose additionally **c** and **d**, representing the production costs that are not covered by the earnings from selling **Qg** at **Pg**. The fibre sector gains **a** and **d** as consumer surplus. The total welfare loss by comparing effects on producer and consumer surpluses is the combined area of -c-d. In order to mitigate the burden for raw cotton producers, the government implements a system of input subsidizations (e.g. for water and intermediates), thus shifting the marginal cost curve from **Src1** to **Sr2**. This compensates for the losses **c** and **d** and adds **e** as surplus to the welfare of producers. Demanders are not affected, but the state loses the combined areas of **c**, **d**, and **e** through the payment of indirect subsidies. The net welfare effects on this partial market amount to:

Producers of raw cotton:	**-a**	**-b**			**+e**
Fibre producers:	**+a**			**+d**	
State:			**-c**	**-d**	**-e**
Net welfare change:		**-b**	**-c**		

The net effect is clearly negative on this market, but the considerations above have to be combined with the repercussions on the fibre market as done in the following figure 2.28. The decreased price for raw cotton shifts the marginal cost curve of fibre producers from **Scf1** to **Scf2**. If they could realize the export price **Pe**, which resembles the world market price at the market EXR, they would gain the areas **i**, **j**, and **l** as surplus. However, because of the exchange rate system, they can only realize **Pd**, which is the WMP at the official EXR and lose therefore **f**, **g**, **h**, **i**, **j**, and **k**. Domestic demanders of cotton fibre benefit from this regulations by having access to fibre at the domestic price **Pd** and can increase their surplus by **f** as if compared to a non-distorted foreign exchange market. The government finally gains the areas **h** and **i** through skimming the difference between export value at market and official EXR.
The net welfare effects on this partial market amount to:

Producers of cotton fibre:	**-f**	**-g**	**-h**		**-k**	**+l**
Domestic fibre processors	**+f**					
State:			**+h**	**+i**		
Net welfare effect:		**-g**		**+i**	**-k**	**+l**

Figure 2.28 Partial Market for Cotton Fibre

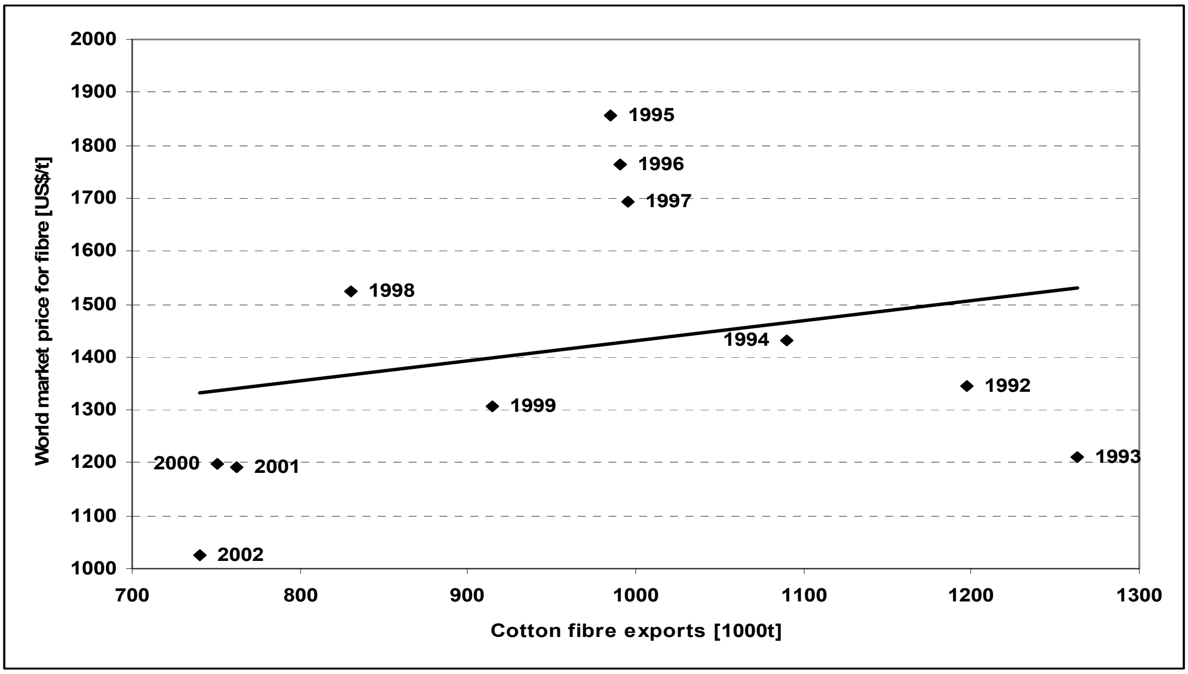


Source: Own presentation, based on Henrichsmeyer and Witzke (1991)

In contrast to the market for raw cotton, the net welfare changes have no clear direction because of the positive (**i**, **l**) and negative (**g**, **k**) terms. However, ROSENBERG (2001) shows a clear net welfare loss on the centralized export markets.

The analysis above was conducted under the assumption, that changes in exported quantity do not affect the export price, thus treating Uzbekistan as a price-taking small country on the international cotton fibre market. Such an assumption might appear counter-intuitive given the fact that Uzbekistan is the second largest exporter of cotton fibre after the USA. There is, however, no empirical indication for effects of Uzbek export quantities on the WMP (ROSENBERG 2001) in the recent years (see also figure 2.29) where a weak positive relation between world market price in US$ and export quantity in 1000 tons is shown for the entire decade before 2002. However, the correlation between Uzbek exports and world market prices was clearly negative between 1992 and 1997 when the share of Uzbekistan in the world-exports of cotton fibre remained between 20% and 18%. This share dropped to 14% in 1998 and declined even further to 12% until 2002 with the apparent consequence that the fibre exports of Uzbekistan had a much weaker impact, if any at all, on the world market. Thus, the treatment of the Uzbek cotton sector as a price-taker is justified for the time since 1998.

Figure 2.29 Uzbek Cotton Fibre Exports and World-Market Prices, 1992 to 2002



Sources: FAOSTAT 2004, USDA 2004

While the export of cotton fibre is a significant source of governmental revenue, domestic wheat production has been pushed since the mid-nineties in order to substitute imports with domestic supply. The set of regulations concerning wheat production are comparable to those of the cotton market. 25% of the targeted production of wheat must be sold to governmental bodies at set prices, another 25% at so called 'negotiated prices' which are still administered, and around 40% can be sold at prices higher than the base state order price. The remainder can be sold freely to local markets. Although there is a private market for wheat in contrast to cotton, the production targets are usually very ambitious and can hardly be fulfilled by the producers. Thus, marketing opportunities beyond the state order are only theoretically existent in most cases (IMF 2000).

Despite the increased domestic production, Uzbekistan is still an importer of wheat. The government supports importers with indirect measures as they tax exporters of cotton. In order to sustain low consumer prices for cereal products, importers can purchase the needed foreign currency under favorable conditions from the central foreign exchange market, e.g. by paying only the official exchange rate in 2001.

2.6 Multiple Exchange Rates

After a period of foreign exchange and trade liberalization from 1995 to 1996, the government of Uzbekistan formally reintroduced a system of multiple exchange rates (MERS) in 1997 that was in some respects abolished again by the end of 2002 (ROSENBERG 2001, EBRD 2003) but not replaced by a fully liberalized exchange rate system. Although it seems that Uzbekistan follows a path to establish a liberalized exchange rate regime in general, it is likely that it will be prevalent for the actors on domestic cotton, gold and wheat markets since these products account for significant governmental budget revenues and expenditures. The 1997-2001 foreign exchange market of Uzbekistan was basically split into three segments.

First, the official exchange market on which the government determines the exchange rate (EXR) at a level well below the market clearing level. Thus, the demand for foreign exchange does exceed the supply and the government has to restrict the access and enforce the supply. Demand at the official market is regulated by the 'Republican Monetary Commission' (RMC) that grants access mainly to importers of capital goods, raw materials, grains and some other selected commodities and services. The supply of foreign exchange is derived from the mandatory surrender of foreign exchange earned mainly from exports of cotton fibre and gold (IMF 2000, ROSENBERG 2001).

The second market for foreign exchange is the commercial bank market, where financial transactions between commercial banks, exchange bureaus, enterprises, and individuals take place. The commercial EXR is also set by the government but at a slightly higher level than the official EXR.[2] Again, demand and supply at this market are subject to several regulations. Individuals, for instance, are only allowed to purchase foreign exchange at this market for a limited number of purposes like studying abroad or pilgrimages[3], but not for international trade transactions. However, supply of foreign exchange at this EXR-level is still lower than the demand and regulated by the government by forcing exporters of products other than cotton fibre or gold to surrender 30% (from 1997 to 1998, 50% from 1999) of their foreign

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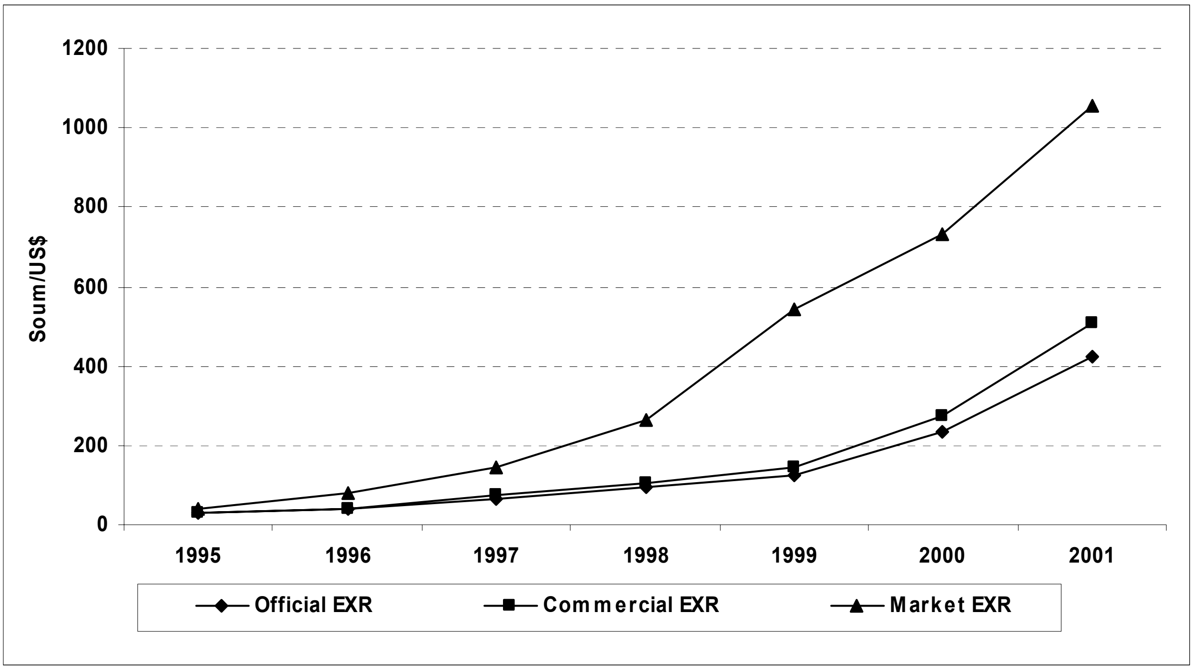
[2] Until 1998, the commercial EXR was restricted to 112% of the official EXR. This margin was adjusted upward to 130% by the end of 2000.

[3] Performing the Hajj; Uzbekistan's population is mainly Muslim.

exchange earnings to the commercial bank market at the commercial EXR (ROSENBERG 2001).

Finally, there is a market for foreign exchange that is mainly determined by the demand that is not covered by the two other markets. The average annual EXR at this unofficial market was 38% higher than the official rate in 1995, the difference rose to 336% of the official EXR in 1999. Starting from 2000 the government adjusted the official EXR such that the gap was narrowed to an average of 149% in 2001 and to 20% by February 2003 (EBRD 2003). Nevertheless, Uzbekistan had not implemented free currency convertibility by 2003 and demanders of foreign exchange do still face a set of administrative restrictions to access the market for foreign exchange. The different annual average exchange rates of the described system are shown in figure 2.30:

Figure 2.30 Average Annual Exchange Rates, 1995-2001 (in Soum/US$)



Sources: ADB 2004, IMF 2000, EBRD 2003

Besides the distortions of the financial markets caused by the MERS, there is a resulting set of implicit export taxes and import subsidies. As described above, exporters of cotton and gold have to exchange their foreign currency earnings at the official rate while other exporters exchange 50% of their foreign currency at the commercial rate. The gap between earnings at the market rate and earnings at the official/commercial rate is very much like a tax on exports and thus a source of governmental revenues. Importers of selected products on the other hand need to pay only the official rate for their exchange requirements and benefit from this regulation as they would from a subsidy on imports.

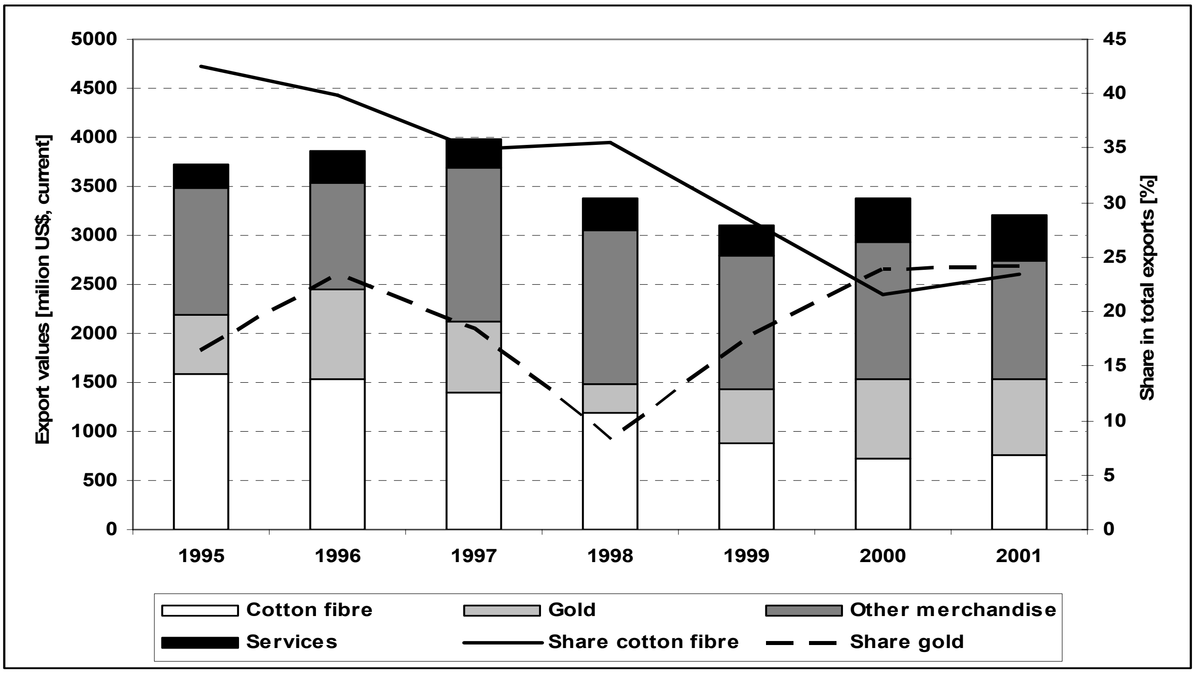
In 2001 for instance, Uzbekistan exported 760 thousand tons of cotton fibre at an average world market price (WMP) of 989 US$ per ton. The value of these exports at the official EXR of 423 Soum per US$ amounted to 292 billion Soum but to 726 billion Soum at the market rate of 1053 Soum per US$. The difference was 434 billion Soum or 10% of the GDP at factor costs (GDPf). In the same year, Uzbekistan imported machinery in a value of 1292 million US$ (WORLDBANK 2002), which was equivalent to 547 billion Soum at the official EXR and 1361 billion Soum at the market EXR. The gap of 814 billion Soum would then be the implicit subsidy on imports for machinery, if the MERS as explained above, applies for all imported machinery and equipment. In this case, the implicit subsidies generated by the MERS would outweigh the corresponding revenues from cotton exports.

The main question arises of whether the MERS causes net-revenues or net-expenditures for the government, and it cannot be answered easily. An in-depth analysis would require detailed information about the exchange rates for trade with different groups of commodities, which was not available to a sufficient extent for this study. Therefore, it will be assumed that both revenues and expenditures will balance each other out and only the average EXR will be used for further computations.

2.7 External Trade

Uzbekistan is not only an important exporter of cotton fibre but also of gold, as can be seen in figure 2.31 below. While cotton fibre contributed to 42% of the total export volume in 1995, its share shrank steadily in the following years to only 23% in 2001. In contrast, the share of gold in total exports rose from 16% to 24% during the same period. The decline of cotton fibre exports is mainly due to the governmental policy of substituting wheat imports by fostering the domestic production on areas formerly used for cotton. By 2000, gold replaced cotton fibre as the most important single commodity in the export-structure of Uzbekistan. This trend appears to continue, according to more recent data from the World Bank (2004). This data indicates a 29%-share of gold in total exports in 2004 as compared to a 21% share for cotton fibre. The group of other merchandise exports does not show any significant trend in the regarded period. Important items in this group are natural gas and oil, about which no further information is available, except data about exported quantities of natural gas (ADB 2004), which increased from 5.6 billion m^3 to 7.0 billion m^3 in 2001. Other exported commodities are crude oil and mining products.

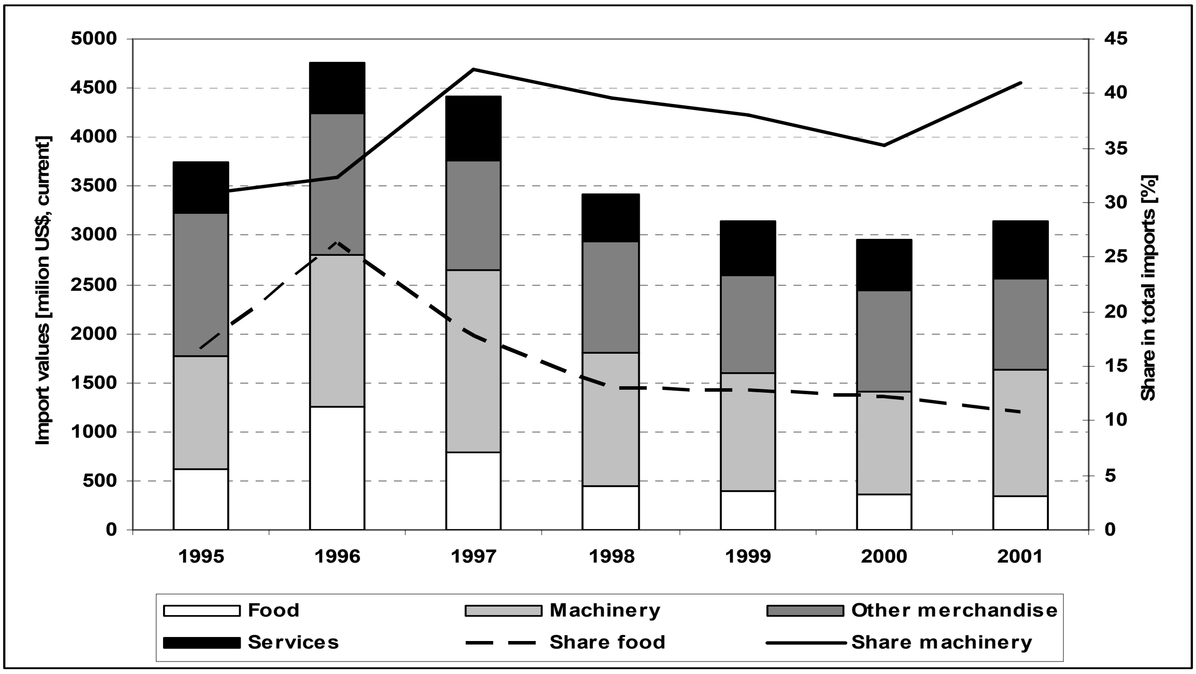
Figure 2.31 Exports of Uzbekistan, 1995-2001 (in million US$, current)



Sources: FAOSTAT 2004, USDA 2004, World Bank 2003, World Bank 2002, IMF 2000

The import side is depicted in figure 2.32. The largest group of imported commodities was machinery and equipment, which accounted for 31% of all imports in 1995 and 41% in 2001.

Figure 2.32 Imports of Uzbekistan, 1995-2001 (in million US$, current)



Sources: WORLD BANK *2003,* WORLD BANK *2002, IMF 2000*

Food imports peaked in 1996 due to a bad harvest but then declined to a share of 11% in total imports until 2001. High shares of machinery imports and declining shares of food imports are an immediate result of the trade-related targets of the Uzbek government, which promotes the import of investment goods in order to modernize and develop domestic industries and decrease the dependency on food imports (IMF 2000). The increased state-ordered production of wheat is also an outcome of this strategy. Earnings from exporting cotton fibre and gold are used to finance the imports of investment goods. Nevertheless, the economic politics of Uzbekistan aim at decreasing the reliance on cotton fibre and at diversifying the export structure (see also figure 2.31). From figures 2.31 and 2.32 appears that the trade related policy targets were achieved during 1995 and 2001.

3 Analytical Framework

The conclusion from the previous chapters is that an appropriate analytical framework for the task at hand has to include the following elements:

- Agricultural production
- Market regulations
- Food and textile industries
- Market interdependencies
- External trade
- Governmental budget
- Household consumption

It would be too narrowly focused to address the question of how to improve the income security of the Uzbek population just by looking at the agricultural sub-sector. A logical consequence is to step from a partial to a general point of view and to employ a general equilibrium approach. A huge advantage in this case is the availability of a blueprint of a computable general equilibrium model (CGEM) from the International Food Policy Research Institute (HARRIS ET AL., 2003). This standard CGEM has already been applied for various countries and research questions. Of particular interest in this context are the works from WEHRHEIM (2003) and KUHN (2001). Both apply a general equilibrium model for Russia and WEHRHEIM, in particular, focuses on the implications of a transforming economy for the modeling procedure. These settings are also of major importance for the analysis of the economy of Uzbekistan and are discussed in the following section.

3.1 General Model Characteristics

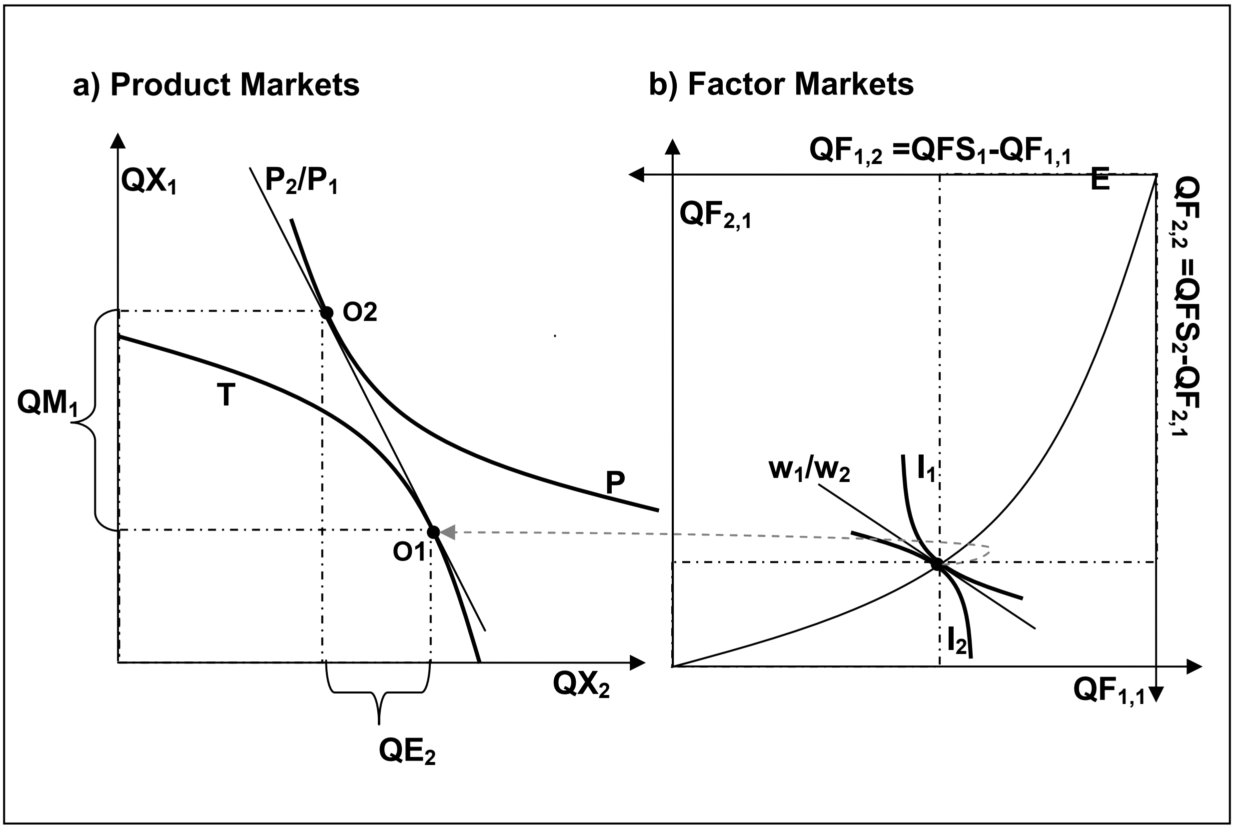
The agents reflected in the structure of the general equilibrium approach are domestic institutions like private households and the government as well as the "rest of the world". In addition, the savings-investment balance and the productive sectors of the economy are taken into account. The decisions of producers and consumers are balanced through simultaneous equlibria on product- and factor-markets. A simplified example in figure 3.1 may illustrate the general structure of such a simultaneous equilibrium.

Consider a model economy with two productive sectors, each producing one output $\mathbf{QX_1}$ and $\mathbf{QX_2}$ respectively. The underlying technology may be described by two continuous production functions $\mathbf{QX_1=f_1(QF_{1,1}, QF_{2,1})}$ and $\mathbf{QX_2=f_2(QF_{1,2}, QF_{2,2})}$, where $\mathbf{QF_{1,i}}$ and $\mathbf{QF_{2,i}}$ refer to two factors of production which are available in the economy and are employed by the i^{th} sector (1 or 2). The total available supply for each factor is here called $\mathbf{QFS_i}$ and all productive activities are constrained by the restriction that the total factor employment must not exceed the factor supply. The place where factor demand and supply come together is the factor market, depicted here in the right diagram **b)** in figure 3.1.

The isoquant-curves ($\mathbf{I_1}$ and $\mathbf{I_2}$) of both technologies are tangent to one another at a point where both factors are fully employed and the marginal rates of technical substitution are equal. The minimum-cost combination is also realized in both sectors as the iso-cost lines with the slope **w1**/**w2** (with $\mathbf{w_i}$: price for the i^{th} factor) overlap one another and are also equal to the marginal rate of substitution. This particular equilibrium is one of a set of possible equlibria which all are located on the expansion-path **E**. Along this path, both factors are fully employed and both productive sectors realize the minimum-cost combinations. The corresponding possible combinations of outputs $\mathbf{QX_1}$ and $\mathbf{QX_2}$ are depicted by the transformation curve **T** in the opposite diagram **a)** in the left part of figure 3.1. Diagram **a)** represents the product market of the model economy.

In the realized point on the transformation curve (**O1**), the marginal rate of transformation equals the output-price ratio $\mathbf{P_2/P_1}$, thus implying the maximization of profits for the producers (HENRICHSMEYER AND WITZKE, 1994). The tangent point **O2** on the indifference curve **P** is also where the marginal rate of substitution equals the price ratio, in which case the consumers reach a maximum level of utility at a given level of income.

Figure 3.1 Stylized General Equilibrium, Base Scenario



Source: Own presentation, based on HENRICHSMEYER AND WITZKE *(1994) and* WEHRHEIM *(2003)*

As the model economy is assumed to be open to external trade and small enough that trade activities would not affect the world-market price, the output prices are exogenous in this case. In this first scenario, domestic supply for product 2 exceeds domestic demand and the surplus $\mathbf{QE_2}$ is exported. On the other hand, in the case of product 1, domestic supply is lower than the demand, which is then satisfied by the imports of product 1, $\mathbf{QM_1}$.

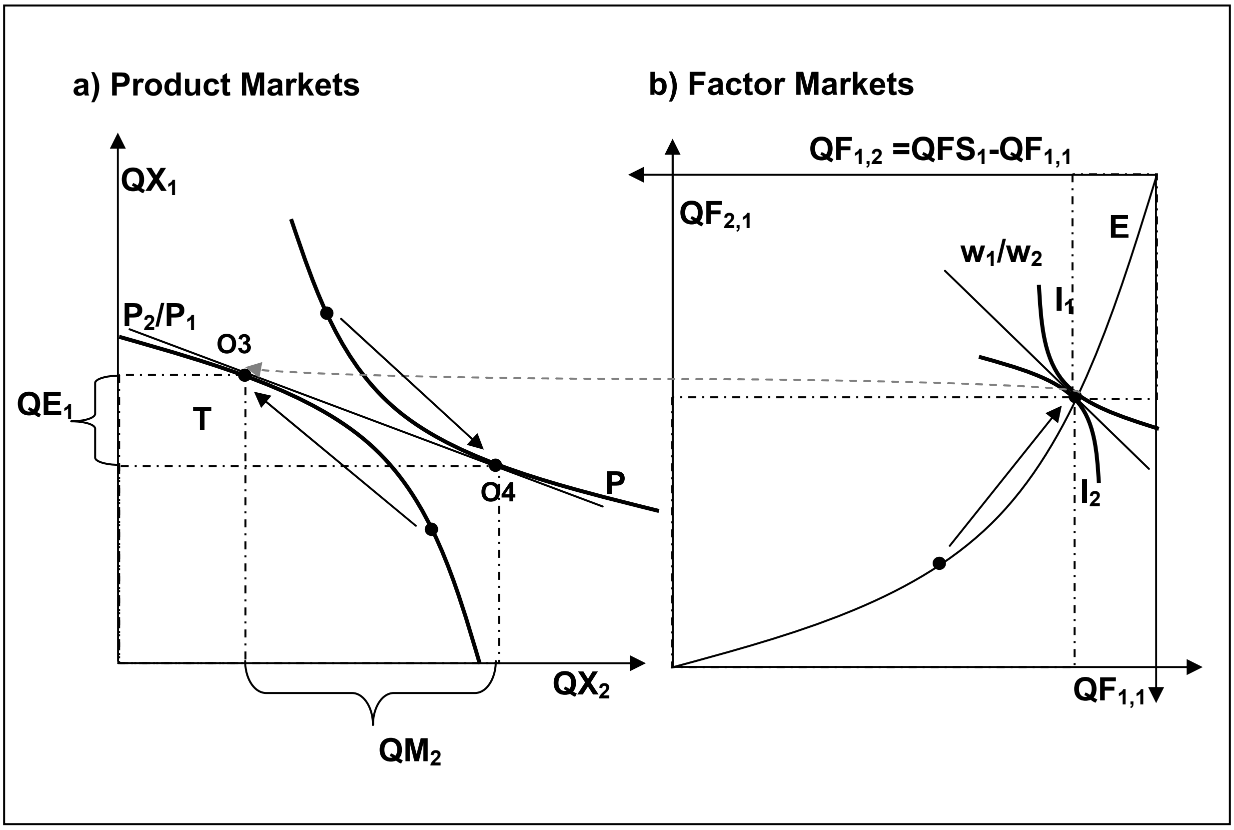
The model economy will now remain on this equilibrium as long as the exogenous determinants do not change. The model economy can be exposed to shocks such as a change in technologies or in the preferences of the consumers as well as changes in the total supply of factors or changes of the world market prices. In order to illustrate the adaptation processes that take place within the model, the relatively simple case of a changing ratio of world-market prices is chosen here as an example and depicted in figure 3.2. The new price ratio $\mathbf{P_2/P_1}$ induces a shift of production and consumption patterns to the new optimal points **O3** and **O4**. In **O3**, the price ratio again equals the marginal rate of transformation, thus fulfilling one necessary condition for a maximum of profit for the producers. The shift along the transformation curve also causes a shift of the factor-market equilibrium along the expansion path **E**. Again, both factors are fully employed and the allocation is realized with the minimum-cost combination, although at a different ratio of input-prices.

The second effect of the price-shock is the realization of a new point on the indifference curve (**O4**). The new factor price-ratio would directly affect the income of the private households, which supply their labor force to the labor markets, and it would indirectly affect their assets of physical capital via the domestic enterprises to the capital markets. Furthermore, the changed price ratios on the product market will also have an income-effect. For the purpose of clarity, the income effects of the new product- and factor-prices are neglected here and only the substitution effect is depicted. The adjusted domestic demand for $\mathbf{QX_1}$ and $\mathbf{QX_2}$ results in inverted trade patterns: The demand for $\mathbf{QX_2}$ now exceeds the domestic supply and the difference $\mathbf{QM_2}$ is imported, whereas $\mathbf{QX_1}$ is produced at a higher level than demanded by the domestic consumers and therefore exported at the level $\mathbf{QE_1}$.

Such a “smooth” reaction of a national economy towards altered world-market prices is, especially in the short run, very unlikely, even in an extremely liberal and market-oriented economy. Domestically produced and imported goods are not necessarily perfect subsidies as implied in figures 3.1 and 3.2. Especially in the case of commodity-aggregates (e.g. “cereals”), the properties of the domestic aggregate may differ from the world-market aggregate (for instance, due to a higher share of coarse grains in the aggregated “cereals” commodity”).

This issue is addressed in the proposed standard CGE model by applying an Armington formulation for the substitution between domestic and foreign commodities. This allows for the treatment of these commodities as imperfect substitutes. Another obstacle for the described smooth reaction is the fact that factors are not necessarily fully mobile between sectors. For example, buildings and machinery cannot be used flexibly in alternative productive activities, and, in general, the employment of labor force in a new sector requires some training.

Figure 3.2 Stylized General Equilibrium, Changed World Market Prices, Flexible Markets

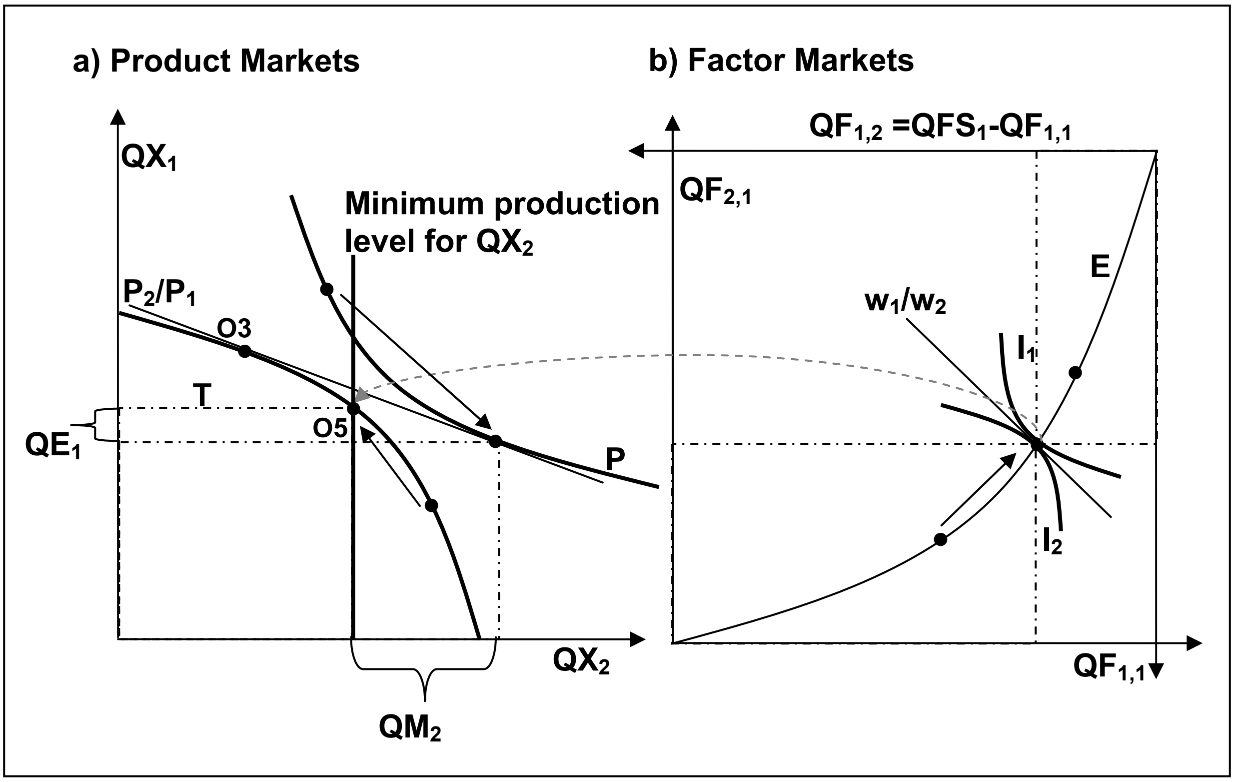


Source: Own presentation, based on HENRICHSMEYER AND WITZKE *(1994) and* WEHRHEIM *(2003)*

In the case of Uzbekistan, the assumption of such flexible product and factor markets is even more questionable. The government has a significant influence on agriculture and other sectors, especially as seen in its use of production targets for items such as cotton, and this imposes serious rigidities on the national economy. For this reason, the standard CGE model has to be adjusted in order to account for these structural rigidities. WEHRHEIM (2003) shows in his analysis of the Russian economy the effects of imperfect factor markets and the implications for analyses with a CGE model. In the case of Uzbekistan, restricted product markets also need to be taken into account, which is illustrated in figure 3.3 below.

The model is again exposed to a changed ratio of world-market prices as in the previous example, but now the national government imposes a minimum production target for product **QX_2**. This target is set at a level below the equilibrium quantity in the base scenario, but still above the level that was realized in the flexible scenario. In this simplified case, the substitution effect along the indifference curve is assumed to be equal to the latter scenario. On the production-side, the set target prevents the model from moving along the transformation curve to the former equilibrium point **O3**.

Figure 3.3 Stylized General Equilibrium, Changed World Market Prices, Restricted Product Markets



Source: Own presentation, based on HENRICHSMEYER AND WITZKE *(1994) and* WEHRHEIM *(2003)*

Instead, **O5** is now realized, in which the optimality condition that the marginal rate of transformation between commodities QX_1 and QX_2 (dQX_1/dQX_2) equals the price ratio P_2/P_1 and the profits of the producers are below the level in **O3**. The new equilibrium on the factor markets is realized at a point in which the factor quantities employed for the production of commodity QX_1 are below the level in the latter scenario, thus showing that production targets for one product affect the structural change of the factor markets. The stable sectoral composition of labor employment in Uzbekistan as discussed in chapter 2.2 gives evidence for the reality of the scenario depicted in figure 3.3. Although the mechanisms explained above differ from those discussed and successfully applied by WEHRHEIM (2003) in the context of rigidities on factor markets in the Russian economy, the overall effects are comparable. The model produces a solution that differs from an optimal solution but still brings the considered markets into equilibrium. Therefore, it appears to be applicable for the economy of Uzbekistan with its structural rigidities, although the model was based on assumptions derived from concepts like maximization of profits or utility.

As a supplement to the above discussion, certain characteristics of the model need to be highlighted:

- Comparative – Static: Different policy options or expected developments can be simulated and compared with the benchmark solution of the base year (i.e. 2001). Hence, dynamic developments of any variable in the Uzbek economy are not taken into account.
- General Equilibrium: The model represents the entire income flow of the Uzbek economy in the base year at a highly aggregated level. Production sectors, consumers and the government are represented separately and interlinked by commodity-markets and by factor-markets for labor and capital. The system is completed by macro-economic equilibrium conditions such as the savings-investment identity, which "closes" the system. Domestic prices and factor cost, such as wages are calculated endogenously.
- Theoretical and empirical consistency: The system of behavioral and general equilibrium equations complies with Walras' law which assures theoretical consistency. All income flows in the economy are based on the double-book-keeping approach of national accounting which assures the empirical consistency of the model.
- Deterministic: Random effects are not covered. This might appear to be a serious shortcoming since the main research question focuses on uncertainty of income. Yet, it is sure that lesser water demand would decrease the risk of scarcity, and that is a deterministic point of view.
- Partly synthetic: Although most parameters (such as share parameters) can be calibrated directly from the base year data (social accounting matrix, SAM), some have to be taken from the literature (for instance trade elasticities).

3.2 A Social Accounting Matrix for Uzbekistan

A Social Accounting Matrix (SAM) is the fundamental dataset for the proposed CGE model. A macro-SAM is a circular flow matrix that captures all income-expenditure relationships in an economy for one year and is based on macro-economic totals, which can be taken directly from the System of National Accounts (SNA). A micro-SAM differs from the (underlying) macro-SAM in so far as it reveals the micro-economic structure of respective macro-totals (e.g. intermediate demand or final demand) by sectors and other subsets of the national accounts. For instance, households can be split based on different criteria (e.g. income groups, regions etc.). The design of the micro-SAM in terms of disaggregation depends on two aspects: (a) the informational needs of the potential users and (b) the availability of the respective data required. The SAM approach constitutes a national data management tool that is theoretically and empirically consistent. This is assured by the reliance on the double-book keeping system where each entry in an individual cell is “booked” as expenditures along the columns and as revenues along the rows. Hence, the row and column totals for each account by definition have to be equal – a situation in which the SAM is called balanced.

For this study, however, a consistent set of micro-economic data was not available from a single source. The data had to be collected from various sources that deviated significantly from one another. In order to compile a well-balanced micro SAM on the desired level of aggregation, a three-step procedure was developed. First, a macro-SAM was constructed based on the system of national accounts. Then, this macro-SAM was disaggregated into a SAM with six productive sectors, called meso-SAM in the following. The accounts of the meso-SAM were chosen in a way that as much information as possible could be used. One example for this choice is the representation of the “construction” sector within an economy. Construction does not produce any commodities for final demand; any payments to this sector are regarded as investments. The trading sectors also do not produce a commodity ready for consumption. The value of “trade” is not consumed directly, but all consumers of any commodity have to pay for the trade mark-ups. Next, the meso-SAM is then further disaggregated into the desired micro-SAM with 20 productive sectors, seven of which are agricultural sectors. Both, micro- and meso-SAM were constructed based on all information available on the respective levels of aggregation, but due to the different

origins of the data used or lack of crucial information, neither of them was balanced after the first compilation. Following the general idea of CATTANEO ET AL. (2000), who employed a cross-entropy approach to update and balance a SAM, a maximum entropy procedure was applied here to balance micro- and meso-SAM.
The three steps will be described subsequently, starting with the system of national accounts.

3.2.1 Macro-SAM and System of National Accounts for Uzbekistan

A macro-SAM consists of the monetary flows within a national economy on a highly aggregated level. The flows are structured according to the regarded accounts, each of which is represented as a row and a column of the matrix. The rows represent the revenues of each account and the columns show the respective expenditures. Table 14 shows the structure chosen for this study. The production account is split into an activity and commodity account. The activities represent the productive sectors within the economy. They consume intermediate inputs (**Ci**), demand people and pay wages (**W**) on the labor market generate surplus (**Yc**) and pay indirect taxes (**Tia**, such as value-added taxes). In addition, they may receive subsidies. The sum of all those expenditures (the column-sum of the activity account (**ACT**) in table 3.1) represents the total domestic output value (**D**) which is available on the domestic commodity markets. Imports (**I**) and indirect taxes on commodities (**Tic**, e.g. sales taxes) add to this, such that the sum of the column of the commodity account (**COM**) equals the total value of commodities available on the domestic markets. This value must match the total consumption within the economy, which is composed of intermediate consumption, household and governmental final consumption (**Ch** and **Cg**), the demand for investment goods (**I**) and finally the demand of the "rest of the world", the exports (**E**).
In addition to the final consumption, households also pay direct taxes (**Td**) on their income as well as chose to save some of it (**Sp**). The income originates from earnings from the supply of labor force to the labor markets (**W**), the capital income from entrepreneurship (**Ych**), transfers paid by the government (**Gt**) such as pensions, and transfers from the "rest of the world" (**Ya**), which might come from citizens which are employed abroad and send money home.

The government receives income from the collection of taxes (**T**) from various sources (**Tia**, **Tic**, **Tf**, **Td**) and from the capital revenues from state-owned enterprises (**Ycg**). These revenues are then used for final consumption (**Cg**) and transfers to households (**Gt**). The difference is the governmental saving (**Sg**).[4] Governmental and private savings (**Sg**, **Sp**) together with the foreign savings (**Sf**) form the revenue-side of the macro-economic capital-account (**S-I**). This corresponds according to basic macroeconomic theory ex post always with the total investment (**I**).

The previously mentioned category of foreign savings (**Sf**) is the difference between expenditures of the "rest of the world" on exports (**E**) and direct payments to domestic institutions (**Ya**, here to the households). Incomes from the balance of payments are imports (**M**) and capital revenues (**Ycf**) from the operating surplus of the domestic activities. The remainder of the operating surplus then goes either to the enterprises or is used for the payment of taxes on physical production factors (**Tf**). For example, these taxes might be based upon the usage of land or water. The enterprises then transfer their revenues (**Yce**) to the respective owners, either private households or the government.

The macro-SAM described above is the framework for the following compilation of a system of national accounts. The main difficulty here is that the data could not be obtained from a single source, such as the national department for macroeconomics and statistics in Uzbekistan. Consequently, the information needed was taken from different sources, like international organizations (IMF, WORLDBANK, etc.) and Uzbek organizations like the Centre for Efficient Economic Policy (CEEP 2003). The first account considered here is the balance of payments, which was relatively easy to obtain.

[4] Governmental savings here is simply the saldo of the governmental current account. Government loans and investments are included in the consolidated budget and governmental capital account. See also further down in chapter 3.3.1.2: Governmental accounts.

Table 3.1 Stylized Macro-SAM

		ACT	COM	LAB	CAP	HHO	ENT	GOV	TAX	S-I	ROW	SUM	
Activities	ACT		**D**									Σ	REVENUES
Commodities	COM	**Ci**				**Ch**		**Cg**		**I**	**E**	Σ	
Wages	LAB	**W**										Σ	
Operating surplus	CAP	**Yc**										Σ	
Households	HHO			**W**			**Ych**	**Gt**			**Ya**	Σ	
Enterprises	ENT				**Yce**							Σ	
Government	GOV						**Ycg**		**T**			Σ	
Taxes	TAX	**Tia**	**Tic**		**Tf**	**Tdh**	**Tde**					Σ	
Savings-Investment	S-I					**Sp**		**Sg**			**Sf**	Σ	
Rest of the World	ROW		**M**		**Ycf**							Σ	
Total	SUM	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ		
		EXPENDITURES											

Legend:

Ci	Intermediate consupmtion by activities
W	Total wages paid by activities
Yc	Operating surplus of activities (capital income)
Tia	Indirect taxes paid by activities (e.g. value-added tax)
D	Domestic production
Tic	Indirect taxes paid on commodity markets (sales tax, import duties)
M	Imports
Yce	Capital revenues for enterprises
Tf	Factor tax (e.g. land tax, water use tax)
Ycf	Capital revenues from (or to) abroad
Ch	Final consumption of households
Tdh	Direct taxes from households (income taxes)
Sp	Private savings
Ych	Capital revenues of households (from entrepreneurship)
Ycg	Capital revenues of the government (from state-owned enterprises)
Tde	Direct taxes from enterprises (profit taxes)
Cg	Final consumption of the government
Gt	Transfers form government to households (e.g. pensions)
Sg	Governmental savings
T	Total tax revenues for the government
I	Total investment
E	Exports
Ya	Household income from abroad
Sf	Foreign Savings

Source: Own presentation

3.2.1.1 Balance of Payments

The main sources of information here were the World Development Indicators (WDI) by the World Bank (WORLD BANK 2003), the Asian Development Bank (ADB 2004) and the International Monetary Fond (IMF 2000). The WDI data concerning the total export- and import- values proved to be preferable because it distinguishes between merchandise and service trade, as shown in table 3.2.

Table 3.2 External Trade of Uzbekistan, 1995-2001 (in million US$)

	1995	1996	1997	1998	1999	2000	2001
Merchandise exports	3475	3534	3695	3048	2790	2935	2740
Service exports	256	328	292	324	309	448	461
Merchandise imports	3238	4240	3767	2938	2587	2441	2554
Service imports	507	527	657	479	557	521	598
Merchandise trade balance	237	-706	-72	110	203	494	186
Net service trade	-251	-199	-365	-155	-248	-73	-137
Average exchange rate [Soum/US$]	30	40	66	91	125	237	437

Source: WORLD BANK 2003

Note: The average exchange rate shown here differs slightly from the official exchange rate as shown in chapter#, which stems from the ADB 2004. In order to maintain the inner consistency of the used data, the EXR shown in the table above will be used for further transformations from US$ into Soum.

The merchandise trade balance is positive in general, except in 1996 and 1997. During these years, the main reason for this negative trade balance was the extraordinary high import of machinery (1542 mio. US$ in 1996 and 1868 US$ in 1997, compared to 1151 million US$ in 1995 and 1352 million US$ in 1998, according to IMF2000). However, the general trend is a decline of the total amount of external merchandise trade, which decreased from 6713 million US$ in 1995 by 21% to 5294 million US$ in 2001. The reason for this trend seems to be the desire of the Uzbek government to become less dependent on the export of cotton fibre and on the import of food products by investing in an own food and textile industry. In contrast to the decline in merchandise trade, the volume of services trade shows an increase of 39% between 1995 (763 million US$) and 2001 (1059 million US$). This change is mainly due to rising exports of services. Detailed information was not available in this context, but one possible explanation might be the rise of tourism to Uzbekistan in the last years. The current account of the balance of payments consists not only of trade but also of other payments from or to the “rest of the world”.

ADB (2004) provides data for net factor income from abroad and direct transfers in local currency units (LCU) rather than in US$ (this doesn't matter for the study because the macro-SAM finally will be shown in LCU). Table 3.3 shows the current account of the balance of payments in billion Soum.

Table 3.3 Current Account of the Balance of Payments of Uzbekistan, 1995-2001 (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Exports[1)]								
Merchandise exports		*103*	*142*	*245*	*276*	*348*	*694*	*1197*
Service exports		*8*	*13*	*19*	*29*	*39*	*106*	*201*
Total exports	**E**	**111**	**155**	**264**	**306**	**386**	**800**	**1399**
Imports[1)]								
Merchandise imports		*-96*	*-170*	*-250*	*-266*	*-322*	*-578*	*-1116*
Service imports		*-15*	*-21*	*-44*	*-43*	*-69*	*-123*	*-261*
Total imports	**M**	**-111**	**-191**	**-293**	**-310**	**-392**	**-701**	**-1378**
Net factor income from abroad[2)]	**Ycf**	**-1**	**-3**	**-11**	**-6**	**-21**	**-49**	**-87**
Transfers from abroad[2)]	**Ya**	**1**	**0**	**2**	**4**	**6**	**3**	**18**
Current account balance	**Sf**	**-1**	**-39**	**-38**	**-6**	**-21**	**54**	**-47**
GDP at market prices[2)]	**GDPm**	303	559	977	1359	2129	3256	4925
Current account balance in percent of GDP		-0.2	-7.1	-3.9	-0.4	-1.0	1.7	-1.0

Sources: 1) WORLD BANK 2003, compare table 3.2
2) ADB 2004

Note: Negative values here will appear as positive entries in the macro-SAM, because of the different style of accounting.

The negative factor income from abroad consists of interest payments for foreign capital (IMF 2000). Consequently, these will be treated as payments from the account of physical capital (**CAP** in the macro-SAM) to **ROW**. The receivers of direct transfers from abroad are not specified in the dataset (ADB 2004), and it is assumed that the transfers will flow directly to the private households. It must be noted that **Ycf** refers to net-factor income, meaning that there might be a fairly high income from Uzbek citizens working abroad or even Uzbek capital used in foreign enterprises. However, the factor payments to **ROW** in 2001 were by 87 billion Soum higher than the revenues.

3.2.1.2 Governmental Accounts

The next institution of interest on the way of constructing a macro-SAM is the government. Information about governmental expenditures and revenues are far more scarce than in the case of the balance of payments. In particular, the sources of taxes and the sinks of governmental expenditures are rarely available. Between 1995 and 1999, the IMF (2000) provides a comparatively detailed consolidated budget, and the Centre for Efficient Economic Policy (CEEP 2003) in Tashkent issued an overview on governmental finance for 2000 to 2002. The compiled consolidated budget is shown in table 3.4. Governmental revenues are booked here as positive entries, expenditures as negatives. In 2001, the government collected 1281 billion Soum from taxpayers and other sources, which amounted 26.0% of the gross domestic product in this year. The largest single components on the revenue-side are value-added and excise taxes (25.3% and 24.0% of the total revenues in 2001), followed by taxes on the profits of enterprises (15.7% of the total revenues in 2001). Custom duties appear to be of minor relevance with a share of only 2.5% of the revenues. Dividing the total annual custom duties by total imports (from table 3.3) yields an average rate of 2.4% in 2001. In addition to custom duties, other taxes on imports include excise and value-added tax, which add to the import price as well as transaction cost resulting from administrative rules that prohibit the import of certain commodities, like cars, for instance (IMF 2000).

Another item worthy of attention is the “other tax and non-tax revenues” component. In this section, the source is unknown and it will be considered income from governmentally owned enterprises (**Ycg**). This decision is justified by the observation that the share of this item within the total revenues dropped from 20.0% in 1995 to 5.8% in 1996, from when it remained at a level of around 5.4% (1998) and 10.4% (2001). This drop coincides with a relatively high share of privatization proceeds to finance the budget’s deficit in 1995 (20.0%) and a much lower level in the following year with only 11.0%. In both years, the contribution to the consolidation of the budget made up 0.8% of the GDP at market prices, while it fell to 0.5% in 1997 and further to 0.05% of **GDPm** in 1998. The peak years for financing from privatization were 1995 and 1996, a period during which the current “other tax and non-tax revenues” declined significantly. Thus, this item will be labeled “revenues from state-owned enterprises” in the following discussion.

Table 3.4 Consolidated Account of the Government of Uzbekistan, 1995-2001 (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Revenues[1),2)]								
Enterprise profit tax	**Tde**	*26*	*55*	*70*	*88*	*109*	*137*	*200*
Individual income tax	**Tdh**	*8*	*20*	*39*	*51*	*78*	*107*	*164*
Value-added tax	**Tva**	*17*	*36*	*73*	*133*	*167*	*232*	*324*
Excise tax	**Txc**	*25*	*56*	*59*	*83*	*140*	*266*	*308*
Resource tax	**Tf**	*4*	*10*	*24*	*53*	*74*	*91*	*118*
Custom Duties	**Tm**	*3*	*3*	*6*	*9*	*7*	*23*	*33*
Other tax and non-tax revenues	**Ycg**	*21*	*11*	*23*	*24*	*37*	*72*	*133*
Total revenues	**TRg**	**105**	**192**	**294**	**440**	**612**	**928**	**1281**
Expenditures[1),2)]								
Education		*-22*	*-41*	*-69*	*-107*	*-171*	*-228*	*-335*
Health and sports		*-11*	*-21*	*-32*	*-45*	*-54*	*-85*	*-133*
Culture, mass media, and science		*-2*	*-5*	*0*	*-10*	*-12*	*-16*	*-30*
Social security and welfare		*-1*	*-2*	*-10*	*-5*	*-4*	*-10*	*-5*
Social safety net	**Gt**	*-10*	*-22*	*-31*	*-45*	*-69*	*-75*	*-103*
Economy		*-13*	*-26*	*-40*	*-55*	*-68*	*-98*	*-113*
State authorities and administration		*-3*	*-6*	*-8*	*-11*	*-14*	*-20*	*-30*
Centralized investments	**Ic**	*-19*	*-40*	*-72*	*-95*	*-122*	*-195*	*-246*
Other expenditure		*-32*	*-39*	*-55*	*-100*	*-120*	*-234*	*-335*
Net lending	**Nl**	*-2*	*-20*	*0*	*-13*	*-21*	*-36*	*-20*
Extrabudgetary funds		*-2*	*-10*	*-2*	*-2*	*0.*	*n.a*[4)]*.*	*n.a.*
Total expenditures	**TXg**	**-117**	**-233**	**-319**	**-487**	**-654**	**-996**	**-1350**
Budget deficit		**-12**	**-41**	**-26**	**-46**	**-42**	**-68**	**-69**
Financing of deficit[1)]								
Domestic banking system		*4*	*38*	*13*	*12*	*13*	*n.a.*	*n.a.*
Treasury bills outside banks		*0*	*1*	*2*	*8*	*11*	*n.a.*	*n.a.*
Privatization proceeds		*2*	*5*	*5*	*1*	*1*	*n.a.*	*n.a.*
Other domestic sources		*0*	*0*	*0*	*3*	*0*	*n.a.*	*n.a.*
External sources		*5*	*0*	*4*	*13*	*17*	*n.a.*	*n.a.*
Unidentified		*1*	*-3*	*2*	*10*	*0*	*n.a.*	*n.a.*
Total financing of deficit		**12**	**41**	**26**	**46**	**42**	**68**[5)]	**69**[5)]
Relations to GDP								
GDP at market prices[3)]	**GDPm**	303	559	977	1416	2129	3256	4925
Revenues in percent of GDP		34.6	34.3	30.1	31.1	28.7	28.5	26.0
Expenditures in percent of GDP		-38.7	-41.6	-32.7	-34.4	-30.7	-30.6	-27.4
Budget deficit in percent of GDP		-4.1	-7.3	-2.6	-3.3	-2.0	-2.1	-1.4

Sources: *1) Account data until 1999: IMF 2000*
2) Account data from 2000: CEEP 2003
3) ADB 2004
4) Data not available, was set to zero
5) Consolidation of the budget requires equality of deficit and financing

n.a.: Data not available

Subsidies paid to productive sectors are not explicitly shown in the consolidated budget. They might be booked under expenditures to the economy, socio-cultural expenditures such as governmental payments for education, or other expenditures. Nevertheless, it is important to identify the amount of these subsidies because of their special characteristics. Subsidies to activities have an impact on the domestic prices of the outputs of the respective sectors, which are not necessarily run by the government itself. It is crucial to differentiate these from activities that are actually run by the government, like education or health-care. ADB (2004) provides information about "indirect taxes less subsidies" (**Ti – Ts**) as shown in table 3.5. The difference between total indirect taxes (**Tva+Txc+Tf+Tm**, see table 3.4) and (**Ti – Ts**) are consequently the subsidies to activities (**Ts**). The derived value of 10 billion Soum in 1995 (rounded; 9853 million Soum) deviates by 2.0% from data released by the Centre for Economic Research (CER) for 1995 (CER 2001). This indicates a total sum of subsidies of 9663 million Soum paid to the aggregated service sector. The difference is treated as accounting error in the following and the figures shown in table 3.5 will be used for the final macro-SAM.

Table 3.5 Indirect Taxes and Subsidies, 1995-2001 (in billion Soum, current)

		1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Total indirect taxes[1)]	**Ti = (Tva+Txc+Tf+Tm)**							
		50	105	161	278	388	612	783
Total indirect taxes less subsidies[2)]	**Ti - Ts**	40	81	121	203	286	408	584
Subsidies[3)]	**Ts (=-Tia)[4)]**	-10	-24	-40	-74	-102	-204	-199

Sources: *1) See table 3.4: Consolidated Budget*
2) ADB 2004
3) Difference between 1) and 2)
4) Subsidies will appear as negative activity-taxes in the macro-SAM

Having identified the subsidies, it is possible to derive the current account of the government (table 3.6). The revenue-side is divided into direct taxes from households and enterprises (**Tdh**, **Tde**), indirect taxes on commodities (**Tic**, which is the difference between total indirect taxes **Ti** and resource taxes **Tf**)[5], factor taxes and income from state-owned enterprises (**Ycg**). The expenditure-side consists of

[5] It is important to note here that value-added taxes were treated as taxes on commodities. The reason for this is that the **Tva** is levied on commodities rather than on activities in the Uzbek tax system (see IMF 2000)

direct transfers to households (**Gt**), subsidies to activities (**Ts**, treated as negative tax on activities) and the final consumption expenditures of the government (**Cg**).

Table 3.6 Current Account of the Government of Uzbekistan, 1995-2001 (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Current revenues								
Enterprise profit tax	**Tde**	*26*	*55*	*70*	*88*	*109*	*137*	*200*
Individual income tax	**Tdh**	*8*	*20*	*39*	*51*	*78*	*107*	*164*
Total indirect taxes on commodities	**Tic**	*45*	*95*	*138*	*225*	*314*	*521*	*665*
Factor taxes	**Tf**	*4*	*10*	*24*	*53*	*74*	*91*	*118*
Other current revenues	**Ycg**	*21*	*11*	*23*	*24*	*37*	*72*	*133*
Total current revenues	**TRg**	**105**	**192**	**294**	**440**	**612**	**928**	**1281**
Current expenditures								
Transfers to households	**Gt**	*-10*	*-22*	*-31*	*-45*	*-69*	*-75*	*-103*
Subsidies to productive sectors	**Ts**	*-10*	*-24*	*-40*	*-74*	*-102*	*-204*	*-199*
Government consumption	**Cg = TXg -Ic -Nl -Ts -Gt**							
		-77	*-126*	*-176*	*-260*	*-340*	*-486*	*-781*
Total current expenditures		**-97**	**-172**	**-247**	**-379**	**-511**	**-765**	**-1084**
Government current account balance	**Sg**	**-8**	**-19**	**-47**	**-61**	**-101**	**-163**	**-197**

Source: Own results

Cg is calculated by subtracting all non-consumptive expenditures from the consolidated budget, such as governmental investment (**Ic**), net-lending (Nl), direct transfers (**Gt**), and subsidies (**Ts**), from the total expenditures as shown in table 17 (**TXg**). This value represents all payments from the government for governmental services like education, health-care, administration, as well as for public-security. The difference between current revenues and current expenditures is the current savings of the government (**Sg**).

3.2.1.3 Capital Account

Having identified foreign and governmental savings (**Sf** and **Sg**), the savings of the private sector (**Sp**) remain to be calculated. Since the total annual savings (**S**) have (*ex-post*) to equal the realized annual investments (**I**), **Sp** would be equal to **I-Sf-Sg**, as shown in table 3.7. Thus, the revenue-side of the aggregated capital account is completed. The same applies on the expenditure-side. Total governmental investments (**Ig**) are the sum of centralized investments (**Ic**) and net-lending (**Nl**) as shown in table 3.4 (see IMF2000 for this calculation), foreign direct investment (**If**) was taken from IMF (2000) and the World Bank (WORLD BANK 2002). The difference represents private investments (**Ip**). More detailed data about the capital flows between these three institutions are not available, with the exception of the financing-data shown in table 3.4. Therefore, the capital accounts will be merged in the macro-SAM into one aggregated account, the macroeconomic "Savings-Investment" (**S-I**) account.

Table 3.7 Aggregated Capital Account of Uzbekistan, 1995-2001 (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Savings								
Government savings	**Sg**	8	19	47	61	101	163	197
Foreign savings	**Sf**	1	39	38	6	21	-54	47
Private savings[6]	**Sp = S -Sg -Sf**							
		65	70	100	229	242	528	797
Total Savings[1]	**S = -I**	**73**	**129**	**185**	**296**	**364**	**637**	**1041**
Investment								
Government investment[5]	**Ig = Ic +Nl**							
		-20	-60	-72	-107	-144	-231	-266
Foreign direct investment[2), 3), 4)]	**If**	1[7)]	-4	-11	-16	-17	-18	-36
Private investment[6]	**Ip = I -Ig -If**							
		-54	-65	-102	-173	-203	-388	-739
Total investment[1]	**I**	**-73**	**-129**	**-185**	**-296**	**-364**	**-637**	**-1041**

Sources: *1) ADB 2004*
2) IMF 2000 until 1999
3) WORLD BANK 2002 from 2000
4) At average exchange rate, table 3.2
5) See table 3.4
6) Calculated residually
*7) Foreign direct investment (**If**) has an alternated sign in 1995 because of high Uzbek investments in a foreign insurance company in this year (IMF 2000)*

3.2.1.4 Production Account

In 2001, 9.1 million people were officially employed in the national economy of Uzbekistan (see table 3.8). Given an average annual wage of 221 thousand Soum (or 506 US$ at the average exchange rate) in this year, the total wages paid amounted to 2020 billion Soum or 46.5% of the GDP at factor costs.

Table 3.8 Employment and Wages, 1995 to 2001

		1995	1996	1997	1998	1999	2000	2001
Total population [million people][1]		22.9	23.3	23.8	24.1	24.5	24.8	25.1
Labor force [million people][1]	**Pl**	11.1	11.4	11.7	12.0	12.3	12.5	12.8
Employment [million people][1]	**Pe**	8.4	8.6	8.7	8.8	8.9	9.0	9.1
Average annual wage [1000 Soum, current][2), 3)]		13	26	44	65	98	150	221
Total wages [billion Soum, current]	**W**	**108**	**223**	**385**	**572**	**868**	**1347**	**2020**
Other items								
Average annual wages in US$[4]		431	649	670	717	784	634	506
GDP at factor cost [billion Soum, cur.][1]	**GDPf**	263	478	856	1213	1843	2848	4341
Operating surplus	**Yc=GDPf-W**	**155**	**256**	**471**	**641**	**975**	**1501**	**2321**
Wages in percent of GDPf		41.2	46.5	45.0	47.1	47.1	47.3	46.5
Unemployment in percent of labor force	**(Pl-Pe)/Pl*100%**	23.9	24.7	25.6	26.7	27.7	28.0	28.7
Growth rates								
Annual growth rate of population [%]			1.7	2.1	1.3	1.7	1.2	1.2
Annual growth rate of labor force [%]			2.5	2.5	2.9	2.5	1.4	2.8
Annual growth rate of employment [%]			1.3	1.4	1.4	1.0	1.1	1.7

Sources: *1) ADB 2004*
2) IMF 2000 until 1999
3) CEEP 2003 from 2000
4) At average exchange rate, see table 3.2

The operating surplus (**Yc**) for each year is then calculated as the difference between GDP at factor cost (**GDPf**) and the total wages (**W**). These two items allow establishing the production account as shown in table 3.9. Wages and operating surplus plus all indirect taxes less subsidies (**Tic**, **Tf**, **Ts**) add up to the GDP at market prices (**GDPm**). Together with imports (**M**), this makes up the total value of domestically available goods and services (**TP**). This volume is then distributed among exports (**E**) and domestic demand for investment (**I**) and governmental consumption (**Cg**). The remainder is then the final demand of the private sector (**Cp**). One major component is missing, namely, the consumption of intermediate inputs (**Ci**). This item would appear on both sides of the production account, increasing the value of total generation and increasing the total usage by the same amount, and therefore, its inclusion would not change any other value in the account.

Table 3.9 Production Account of Uzbekistan, 1995 to 2001, (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Generation								
Wages[1)]	**W**	*108*	*223*	*385*	*572*	*868*	*1347*	*2020*
Operating surplus[1)]	**Yc**	*155*	*256*	*471*	*641*	*975*	*1501*	*2321*
Indirect taxes[2)]	**Tic**	*45*	*95*	*138*	*225*	*314*	*521*	*665*
Factor tax[2)]	**Tf**	*4*	*10*	*24*	*53*	*74*	*91*	*118*
Subsidies[2)]	**Ts**	*-10*	*-24*	*-40*	*-74*	*-102*	*-204*	*-199*
GDP at market prices	**GDPm=W+Yc+Tic+Tf+Ts**							
		303	**559**	**977**	**1416**	**2129**	**3256**	**4925**
Total imports[3)]	**M**	111	191	293	310	392	701	1378
Total generation	**TP**	**414**	**750**	**1270**	**1726**	**2521**	**3956**	**6303**
Usage								
Investment	**I**	73	129	185	296	364	637	1041
Total exports	**E**	111	155	264	306	386	800	1399
Government consumption	**Cg**	77	126	176	260	340	486	781
Private consumption	**Cp=TP-I-E-Cg**							
		153	341	645	864	1430	2033	3082
Total usage		**414**	**750**	**1270**	**1726**	**2521**	**3956**	**6303**

Sources: *1) ADB 2004*
2) IMF 2000 until 1999
3) CEEP 2003 from 2000
4) At average exchange rate, see table 3.2

It is nevertheless of crucial importance for the social accounting matrix and it will be discussed in the chapter 3.3.2.1. Having derived the total private consumption from the production account, it is possible to establish the current account of the private sector.

3.2.1.5 Current Account of the Private Sector

The private sector is here divided into two parts: The household-side and the enterprise-side. The expenditure side of the current account of households is determined by consumption expenditures (**Cp**), income taxes (**Tdh**) and private savings (**Sp**). These expenditures on the current household budget (**TXp**) are financed by income from wages (**W**), transfer from the government (**Gt**) and transfers from abroad (**Ya**). The remainder stems from entrepreneurial activities (**Ych**).

Table 3.10 Current Account of the Private Sector of Uzbekistan, 1995 to 2001, (in billion Soum, current)

		1995	1996	1997	1998	1999	2000	2001
Households								
Revenues								
Wages	**W**	108	223	385	572	868	1347	2020
Government transfers	**Gt**	10	22	31	45	69	75	103
Tranfers from abroad	**Ya**	1	0	2	4	6	3	18
Revenues from enterprises	**Ych=TXp-W-Gt-Ya**							
		107	186	366	523	808	1244	1901
Total household revenues		**226**	**431**	**784**	**1144**	**1750**	**2668**	**4042**
Expenditures								
Consumption	**Cp**	153	341	645	864	1430	2033	3082
Individual income tax	**Tdh**	8	20	39	51	78	107	164
Savings	**Sp**	65	70	100	229	242	528	797
Total household expenditures	**TXp**	**226**	**431**	**784**	**1144**	**1750**	**2668**	**4042**
Enterprises								
Revenues								
Operating surplus	**Yce**	155	256	471	641	975	1501	2321
Total enterprise revenues		**155**	**256**	**471**	**641**	**975**	**1501**	**2321**
Expenditures								
Profit tax	**Tde**	26	55	70	88	109	137	200
Net factor income from abroad	**Ycf**	1	3	11	6	21	49	87
Payments to households	**Ych**	107	186	366	523	808	1244	1901
Payments to government	**Ycg**	21	11	23	24	37	72	133
Total enterprise expenditures		**155**	**256**	**471**	**641**	**975**	**1501**	**2321**

Sources: *1) ADB 2004*
2) IMF 2000 until 1999
3) CEEP 2003 from 2000
4) At average exchange rate, see table 3.2

3.2.1.6 Macro-SAM

The system of national accounts as discussed in the previous chapters is summarized in the social accounting matrix as shown in table 3.11. Two entries are different from the corresponding values in the system of national accounts:

- Factor taxes (**Tf**) are not paid from activities but rather on from the account for physical capital (**CAP**). Therefore, **Tf** is added to operating surplus in the production account (entry **CAP, ACT**) and then booked as expenditures from **CAP** to **TAX**.

- Capital revenues of the “rest of the world” (**Ycf**) are not paid from the enterprise account but rather from the account for physical capital. Because of this, revenues of enterprises are less than in table 3.10. However, expenditures are as well, and thus, the account is still balanced.

These two changes are made to give a more detailed representation of the market for physical capital.

Table 3.11 Macro-SAM for Uzbekistan in 2001 (in billion Soum, current)

		ACT	COM	LAB	CAP	HHO	ENT	GOV	TAX	S-I	ROW	SUM	
Activities	ACT		4260									4260	REVENUES
Commodities	COM					3082		781		1041	1399	6303	
Wages	LAB	2020										2020	
Operating surplus	CAP	2440										2440	
Households	HHO			2020			1901	103			18	4042	
Enterprises	ENT				2234							2234	
Government	GOV						133		949			1082	
Taxes	TAX	-199	665		118	164	200					949	
Savings-Investment	S-I					797		197			47	1041	
Rest of the World	ROW		1378		87							1465	
Total	SUM	4260	6303	2020	2440	4042	2234	1082	949	1041	1465		
		EXPENDITURES											

Source: Own results

Later on, the factor physical capital will be split further into water, land, and other capital, and it is of major interest for this study to analyze the effects of changes of factor taxes, especially when it comes to the taxation of water.

The macro-SAM shown above represents a consistent overview on the economy of Uzbekistan (here in 2001) and will be the framework for all computations that follow. Having established this framework, the next sections will expand elaborate on this framework. In particular, the number of productive sectors and the types of enterprises has to be considered more specifically, and the process of determining this will be described in the following chapter.

3.2.2 Meso-SAM

The first step in getting a more detailed SAM is the disaggregation of the productive sectors into six categories:

- Agriculture
- Industry
- Construction
- Trade
- Transport and Communication
- Other Services

"Agriculture" and "Industry" are still highly aggregated and will be subject to further processing, whereas "Construction" and the service sectors "Trade", "Transport and Communication", and "Other Services" are already at their final level. This six-sector structure has been chosen here, because it allows characterizing the somehow special sectors "Trade" and "Construction". The main difference between these two compared to other sectors is that they do not produce commodities for final consumption. "Construction"-goods like buildings and infrastructure are investments goods which affect the capital stock in future periods, but they are not consumed by households or as intermediate input as such.

Likewise, "Trade" does not produce goods for final consumption. Revenues of this sector stem from mark-ups on traded commodities, so the consumption of a "Trade"-commodity takes place via consumption of traded commodities that were produced by other sectors before. One major consequence of this view is that "Trade" is neither imported nor exported. In fact, the only service sector whose products are assumed to be traded externally is "Transport and Communication". "Other services" are mainly governmental services, such as education, health-care, or security, which are supplied exclusively to the domestic markets. The only sub-sector within "Other Sectors" that might be traded would be financial services. However, the banking system of Uzbekistan is still mainly state-controlled (IMF 2000), and it represents a relatively small share in the economy with between 4.1% (1995) and 4.5% (2001) of GDP at factor cost.

The considerations above concerning the nature of sectoral outputs will be useful for the computations to come, because they will help to simplify the process of the SAM-compilation.

3.2.2.1 *Activities and Production*

The compilation of the meso-SAM starts with the activity-accounts. Employment and GDP at factor cost is shown in table 3.12 for the six sectors.

Table 3.12 Sectoral Composition of GDP and Employment, 1995-2001

	1995	1996	1997	1998	1999	2000	2001
Nominal GDP at factor cost (in billion Soum, current)[1)]							
Agriculture	85	125	276	380	618	979	1476
Industry	52	100	152	212	305	462	696
Construction	21	46	71	106	143	196	286
Trade	16	39	82	120	192	316	511
Transport and communications	22	38	64	96	147	251	371
Other services	67	130	210	300	438	645	1000
Total	**263**	**478**	**856**	**1213**	**1843**	**2848**	**4341**
Composition of GDP by sectors (percent of total)							
Agriculture	32	26	32	31	34	34	34
Industry	20	21	18	17	17	16	16
Construction	8	10	8	9	8	7	7
Trade	6	8	10	10	10	11	12
Transport and communications	8	8	7	8	8	9	9
Other services	25	27	25	25	24	23	23
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Annual wages by sector (1000 Soum, current)[2), 3), 4)]							
Agriculture	9	14	23	31	39	n.a.	n.a.
Industry	19	37	65	101	160	278	358
Construction	20	43	72	98	141	244	278
Trade	8	18	30	51	72	119	148
Transport and communications	17	36	64	99	133	243	288
Other services	9	20	33	50	77	n.a.	n.a.
Average	**13**	**26**	**44**	**65**	**98**	**150**	**221**
Employment by sectors (million people)[1), 2), 3)]							
Agriculture[1)]	3.5	3.5	3.5	3.5	3.2	3.1	3.1
Industry[1)]	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Construction	0.5	0.5	0.6	0.6	0.6	0.7	0.7
Trade	0.7	0.7	0.7	0.7	0.7	0.8	0.8
Transport and communications	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Other services	2.3	2.3	2.4	2.6	2.9	2.9	3.0
Total	**8.4**	**8.6**	**8.7**	**8.8**	**8.9**	**9.0**	**9.1**

Sources: *1) ADB 2004*
2) IMF 2000 until 1999
3) CEEP 2003 from 2000
4) Wages until 1999 refer to public sector wages

It appears that "Agriculture" has the highest share within the national economy, both in terms of GDPf (34% in 2001) and employment (also 34% in 2001). It is remarkable that the share of this particular sector within GDPf rose slightly from 32% in 1995, while the number of officially employed people declined form 3.5 million people to 3.1 million in the regarded period. However, the decline of employment in agriculture appears to be connected to the acceleration of the creation of private farms that started in 1998.

After this process began, employment dropped from 3.5 million to 3.2 million people. The share of the industrial sectors in GDPf dropped from 20% in 1995 to 16% in 2001 while the employment remained relatively stable (1.1 million people in 1995, 1.2 million in 2001). This observation stands in contrast to the governmental target to develop domestic industries. In fact, the only branch of the national economy with an increasing share is the trade sector (6% of GDPf in 1995, 12% in 2001). Yet, the number of people engaged in trading activities remain at a level of 0.7 million to 0.8 million people, and the average wages are usually lower than the national average. The biggest incline of employment occurred within "other services" which mainly consists of public services; consequently the government is still the largest single employer in Uzbekistan which indicates the slowness of a real transformation from a state-controlled economy to a market-economy.

Table 3.13 Wages and Operating Surplus, 2001 (in billion Soum, current)

FW6[01]		Agriculture **AAGR6[1)]**	Industry **AIND6**	Constructio n **ACON6**	Trade **ATRD6**	Transport and communica tions **ATCM6**	Other services **AOTS6**
Wages	**LAB6[2)]**	677	256	156	172	87	672
Operating surplus	**CAP6**	799	440	131	340	284	327

Notes: *1) Acronyms starting with A denote activities*
2) The cipher "6" at the end of the acronyms denotes the number of productive sectors used at the current stage

Data concerning sectoral wages were taken from the IMF and CEEP. The IMF (2000) provides information about wages in the public sector from 1995 to 1999. CEEP (2003) covers the years 2000-2002 but does not include wages paid in agriculture and "other services". At this stage of the SAM-construction, the wages in this sector are assumed to equal the national averages. Using the data about employment, wages and GDPf, it is possible to compute the first block in the SAM, the sector-specific factor payments for the year 2001 (table 3.13).

This matrix of wages paid to factors, either labor or physical capital, will be called $FW6^{01}_{F6,A6}$ in the following, where "F6" is a set with the elements {LAB6, CAP6}.

The relation to sectoral GDP at factor cost is the same, regardless the year to which it refers:

$$GDPf_{A6} = \sum_{F6} FW6_{F6,A6} \qquad (3.3.1)$$

After having established the payments from activities to the employed factors, the payments for intermediate consumption will be discussed in the following chapter.

3.2.2.2 Input-Output Relations

The macro-SAM in table 3.11 did not include the demand for intermediate consumption of the productive sectors. Information about such input-output relations is scarce in the given context of Uzbekistan. Basically two sources were available: a 125-sector input-output table (IOT) from the WORLDBANK for 1990 (IOT 1995) and a 3-sector IOT for 1995 from the Centre for Economic Research (CER) in Tashkent (CER 2001).

Both tables of input-output coefficients show substantial differences. For example, the 1990's intermediate demand of industry from agriculture was at a level of 128% of the industrial GDPf (light-grey shaded cells in IOC6), while only at a level of 69% in 1995 (light-grey shaded area in IOC3). Service demand from agriculture rose apparently from 3% in 1990 to 19% in 1995 (dark-grey shaded areas). There are two possible explanations for these structural deviations. The first is that the process of independence caused severe changes in the physical input-output patterns. The second explanation stems from changes in price ratios: services for agriculture were cheaply provided from the state authorities and became more expensive during the first five years of independence; agricultural commodities may have received higher prices during soviet times.

Table 3.14 Available Input-Output-Coefficients for Uzbekistan

IOC3 (1995, in percent of sectoral GDPf)[1]

		AAGR3	AIND3	ASER3
Agriculture	**CAGR3**	10	69	11
Industry and Construction	**CIND3**	17	147	48
Services	**CSER3**	19	74	51
GDPf 1995 (in billion Soum, current)		**85**	**73**	**105**

IOC6 (1990, in percent of sectoral GDPf)[2), 3)]

		AAGR6	AIND6	ACON6	ATRD6	ATCM6	AOTS6
Agriculture	**CAGR6**	11	128	0	2	0	1
Industry	**CIND6**	9	94	44	10	8	15
Construction	**CCON6**	0	0	0	0	0	0
Trade	**CTRD6[4)]**	0	0	0	0	0	0
Transport and communications	**CTCM6**	2	12	13	1	3	1
Other services	**COTS6**	1	15	5	10	4	4
GDPf 1990 (in million Roubles, current)		**11402**	**7302**	**3492**	**1371**	**1934**	**10512**

Sources: *1) CER 1995*
2) WB 1994

Notes: *3) The original IOT includes 125 sectors, which were here shrunk to six aggregates.*
4) Trade consumption will be booked on a different account.

While the IOT from 1995 (IOT3) is a preferable source of information because it is more recent, the 1990 IOT (IOT6) allows additional insight into the sector-specific input-output structure. The challenge, therefore, is to combine both sources of information in an efficient manner. One possible approach is to use the sub-totals from IOT3 and the structural data from IOT6 in order to disaggregate IOT3: the payments from "industry and construction" (AIND3) to agriculture would then stem by 100% from "industry" and by 0% from "construction" as there is no such flow indicated in IOT6. Formally, IOT3 has to be expanded for this purpose and IOT6 needs to be reduced in order to determine the share of the flows in IOT6 in the aggregated sub-totals. Two auxiliary matrices are formulated for this purpose, which map the sectors in IOT6 into the corresponding sectors of IOT3 (Table 3.15).

$$IOT3^{95}_{C3,A3} = IOC3^{95}_{C3,A3} \cdot GDPf^{95}_{A3} \qquad (3.3.2)$$

$$IOT6^{90}_{C6,A6} = IOC6^{90}_{C6,A6} \cdot GDPf^{90}_{A6} \qquad (3.3.3)$$

Table 3.15 Mapping Different Levels of Aggregation

MA	**AGR3**	**AIND3**	**ASER3**	**MC**	**CAGR3**	**CIND3**	**CSER3**
AAGR6	1	0	0	**CAGR6**	1	0	0
AIND6	0	1	0	**CIND6**	0	1	0
ACON6	0	1	0	**CCON6**	0	1	0
ATRD6	0	0	1	**CTRD6**	0	0	1
ATCM6	0	0	1	**CTCM6**	0	0	1
AOTS6	0	0	1	**COTS6**	0	0	1

Source: Own results

First, the original **IOT6** is shrunk into a 3X3 matrix:[6]

$$IOT3^{90}_{C3,A3} = \sum_{A6m} \left[\sum_{C6m} MC_{C3,C6m} \cdot IOT6^{90}_{C6m,A6m} \right] \cdot MA_{A6m,A3} \qquad (3.3.4)$$

With:

Indexes (see also table 3.15)

C3, C3m	Index for commodities at the 3-sector level of aggregation
A3, A3m	Index for activities at the 3-sector level of aggregation
C6, C6m	Index for commodities at the 6-sector level of aggregation
A6, A6m	Index for activities at the 6-sector level of aggregation

Variables

$IOT3^{90}$	$IOT6^{90}$ shrunk to 3X3 matrix
MC	Auxiliary matrix for mapping of C3 with C6, see table 3.15
MA	Auxiliary matrix for mapping of A3 with A6, see table 3.15

[6] Equation (3.3.4) can be expressed more elegantly in matrix notation:
$\mathbf{IOT3^{90} = MC' \cdot IOT6^{90} \cdot MA}$
However, most of the following equations are easier to express in standard algebraic notation. For the reason of consistency, this standard is kept.

Then, an auxiliary matrix $IOX6^{90}$ is generated by re-expanding $IOT3^{90}$. This step is necessary to compute the shares of entries in the larger matrix in the sub-totals of the smaller one. IOX^{90} is different from $IOT6^{90}$ since the entries of $IOT3^{90}$ appear in each of the corresponding cells.

$$IOX6^{90}_{C6,A6} = \sum_{A3m}\left[\sum_{C3m} MC_{C6,C3m} \cdot IOT3^{90}_{C3m,A3m}\right] \cdot MA_{A3m,A6} \quad (3.3.5)$$

With:

$IOX6^{90}$ Auxiliary matrix for the 1990 IOT

The shares of the entries in $IOT6^{90}$ (IOS6) in the aggregated values of $IOT3^{90}$ are now calculated by dividing the original $IOT6^{90}$ by the auxiliary matrix $IOX6^{90}$:

$$IOS6_{C6,A6} = \frac{IOT^{90}_{C6,A6}}{IOX^{90}_{C6,A6}} \quad (3.3.6)$$

With:

IOS6 Matrix of shares of entries in the 6X6 IOT in the corresponding entries of the 3X3 IOT

Now, a second auxiliary matrix ($IOX6^{95}$) is generated by expanding $IOT3^{95}$:

$$IOX6^{95}_{C6,A6} = \sum_{A3m}\left[\sum_{C3m} MC_{C6,C3m} \cdot IOT3^{95}_{C3m,A3m}\right] \cdot MA_{A3m,A6} \quad (3.3.7)$$

With:

$IOX6^{95}$ Auxiliary matrix for the 1995 IOT

Finally, an expanded IOT for 1995 is computed by multiplying the elements of $IOX6^{95}$ with the shares in IOS6:

$$IOT6^{95}_{C6,A6} = IOS6_{C6,A6} \cdot IOX6^{95}_{C6,A6} \quad (3.3.8)$$

With:

$IOT6^{95}$ Expanded IOT for 1995

Having done this, one can obtain updated input-output coefficients (IOC^{95}) by dividing IOT^{95} column-wise by the GDPf of the respective sectors (see also table 3.16):

$$IOC6^{95}_{C6,A6} = \frac{IOT^{95}_{C6,A6}}{GDPf^{95}_{A6}} \qquad (3.3.9)$$

With:

$IOC6^{95}$ Input-output coefficients for 1995

$GDPf^{95}$ Sectoral value-added in 1995

Table 3.16 Input-Output Coefficients for Uzbekistan in 1995

IOC6 (1995, in percent of sectoral GDPf)		**AAGR6**	**AIND6**	**ACON6**	**ATRD6**	**ATCM6**	**AOTS6**
Agriculture	**CAGR6**	10	97	0	15	0	13
Industry	**CIND6**	17	169	92	22	19	64
Construction	**CCON6**	0	0	0	0	0	0
Trade	**CTRD6**[4)]	0	0	0	0	0	0
Transport and communications	**CTCM6**	10	34	41	7	16	6
Other services	**COTS6**	8	41	16	57	22	44

Source: Own results

The standard CGE model features a linear-limitational relation between value-added and total intermediate demand of the different activities (HARRIS ET AL. 2001, WEHRHEIM 2003). Therefore, it is consistent within this framework to assume the same input-output relations for the year 2001.

$$IOT6^{01}_{C6,A6} = IOC6^{95}_{C6,A6} \cdot GDPf^{01}_{A6} \qquad (3.3.10)$$

With:

$IOT6^{01}$	IOT for 2001
$GDPf^{01}$	Sectoral value-added in 2001

It is clear that the thus derived IOT for 2001 is a mere guess on the real input-output relations in this year. Nevertheless, it combines all information available in an efficient manner and will be used as long as other data are not at hand.

3.2.2.3 Gross Domestic Output

In order to compute the totals of the activity accounts, which represent the total output values for each sector at producer prices, the taxes or subsidies paid or received by the different activities have to be derived as a final component. As indicated in the macro-SAM, the only elements in this category are subsidies (199 billion Soum in 2001), which were in 1995 received by the services-sector only (CER 2001). It has to be noted here that the category "subsidies" refers to direct payments from the government to productive sectors and hence, do not include exemption from taxes which are also a kind of governmental support. Similarly, government support to agriculture is expressed in a set of tax-exemptions and centralized provision with means of production, but not in directly paid subsidies. In the given context, subsidies are perceived as payments to activities which would, at a given quantity of output, decrease the price consumers have to pay for the affected good or service, whereas the factor incomes of the producers are not influenced. The sector which is likely to receive such payments among the service-sectors is the public-services sector, summarized in "Other Services". Consequently, the vector of subsidies received by activities looks as shown below (table 3.17).

Table 3.17 Direct Subsidies to Sectors, 2001 (in billion Soum, current)

$ATX6^{01}$		AAGR6	AIND6	ACON6	ATRD6	ATCM6	AOTS6
Direct subsidies	**SUB6**	0	0	0	0	0	-199

Note: Subsidies are displayed here as negative payments from the activities. A negative payment is revenue.

Total output values can now be computed by summing up factor wages, intermediate demand and activity-taxes (subsidies, respectively):

$$TAV6_{A6}^{01} = \sum_{F6} FW6_{F6,A6}^{01} + \sum_{C6} IOT6_{C6,A6}^{01} + ATX6_{SUB6,A6}^{01} \qquad (3.3.11)$$

With:

$TAV6^{01}$: Total Activity Output in 2001

$ATX6^{01}$: Activity tax in 2001 (see table 3.17)

$TAV6^{01}$ is of particular importance as it reflects the produced value which can enter the commodity markets and is therefore a benchmark for further calculation.

3.2.2.4 Factor Income of Domestic Institutions

The total wages paid by the activities (table 3.13) go straight to the private households (table 3.10) whereas the operating surplus is first booked as revenues of enterprises. Within the enterprise-block in the macro-SAM are the different farm-types that are of major importance for this study. They are engaged in different kinds or agricultural production activities, have different structures of employment and contribute differently to the income of households. Their shares in gross agricultural production are shown in table 3.18.

Table 3.18 Shares of Farm Types in Agricultural Production, 1995-2001

		1995	1996	1997	1998	1999	2000	2001
Share in gross domestic agricultural production value (in percent)[1)]								
Shirkats	**SHR6**	n.a.	n.a.	40.2	35.8	32.9	27.8	26.8
Fermer	**FER6**	n.a.	n.a.	3.2	3.9	4.6	5.5	6.9
Dekhans	**DKH6**	n.a.	n.a.	56.6	60.3	62.5	66.7	66.3
Gross domestic agricultural production (in bilion Soum, current)[2), 3)]								
	TAV_{AAGR6}	125	n.a	n.a	n.a.	n.a.	n.a.	2087
Agricultural value-added (in billion Soum, current)[4)]								
	GDPf	85	125	276	380	618	979	1476

Sources: *1) Spoor 2004*
2) Value for 1995: CER (2001)
3) Value for 2001: NSC (2002)
4) ADB 2004

As seen in this table, the capital incomes generated in the agricultural sector amounted to 799 billion Soum in 2001, which are distributed among the farm types according to their share in gross production. These capital incomes are then subject to profit taxes for enterprises, altogether 200 billion Soum in 2001 (table 3.10). Dividing this total by the total capital revenues of all enterprises yields an average tax rate of 9%.

Without any additional information about the taxes paid by the enterprises, it is assumed that the average rate applies to all enterprises – except Dekhans, which are not subject to taxation. The incomes after taxes are then transferred to the households, again with the exception of direct governmental revenues from state-owned firms (133 billion Soum, see also table 3.10). The resulting flows of factor income among domestic institutions are shown in table 3.19 below.

The fact that households receive capital income from Shirkats is justified by the fact that they are classified as joint-stock companies with their members as shareholders (KANDIOTY 2002).

Table 3.19 Distribution of Factor Incomes in 2001 (in billion Soum, current)

		LAB6	CAP6	HHO6	SHR6	FER6	DKH6	ENT6	GOV6	DTX6
Wages	**LAB6**									
Operating surplus	**CAP6**									
Households	**HHO6**	2020			196	50	530	1125	103	
Shirkats	**SHR6**		214							
Fermer	**FER6**		55							
Dekhans	**DKH6**		530							
Other enterprises	**ENT6**		1435							
Government	**GOV6**							133		364
Direct taxes	**DTX6**			164	18	5	0	177		

Source: Own results

3.2.2.5 Household Consumption and Market Supply

In the macro-SAM, household consumption was booked on the commodity accounts, implying that households consume only marketed goods and services. This implication is questionable, especially in the case of agricultural products. Given the relevance of Dekhans within the agricultural sector, which are only supposed to produce for the needs of the attached households, it is more realistic to assume that at a major portion, if not all, of the output of this structure is consumed directly without entering the markets. It is also likely that parts of outputs generated by industrial sectors are consumed directly, especially from food processing and textile sectors. WEHRHEIM (2003) states in his SAM for Russia in 1994 that 9.8% of the total consumption expenditures were spent for non-marketed agricultural products and 1.9% for industrial goods. CER (2001) does not distinguish between market and non-market consumption and provides a higher share of expenditures for marketed agricultural goods in 1995. However, the production of Dekhans amounted to 66.3% of the total agricultural output value of 2087 billion Soum in 2001 which was with 1384 billion Soum 44.9% of the household's expenditures in this year.

Together with the consumption of marketed agricultural goods, the share rises to 47.8%, indicating that almost half of the expenditures are spent on primary plant and animal products. Given the high share of rural population and the comparatively low average income in Uzbekistan, this value is not totally implausible, although it does not match the data provided by CER (2001) which suggest a total share of expenses for agricultural goods of 18.5% in 1995. If one believes that Dekhans truly are relevant, which is supported by several other studies (SPOOR 2004, BLOCH 2000, POMFRET 2003, KANDIOTY 2002) and also by detailed data for the region of Khorezm (OBLSTAT 2002b), then the information from CER is rejected in favour of the implications of Spoor (2004) as shown in table 3.18. By rejecting the data from CER in this case, the only remaining source of information about consumption patterns of households in a post-soviet environment stems from WEHRHEIM (2003).

The household-consumption patterns for 2001 were computed as follows:

1. Calculation of consumption shares after subtracting consumption of non-marketed agricultural commodities (table 3.20, column 3).
2. Subtraction of gross-production of Dekhans from total household-consumption in 2001.
3. Multiplication of the remainder with the shares from step 1.
4. Division of the sectoral expenditures by total expenditures to obtain the new shares (table 3.20, column 4).

As in the case of the input-output relations, this method of determining the consumption patterns does not necessarily reveal the real patterns, but it makes use of all available information.

Table 3.20 Shares of Household-Expenditures for Marketed and Non-Marketed Commodities (in percent of total Consumption Expenditures)

			Uzbekistan 1995[1)]	Russia 1994[2)]	Russia 1994 w/o AAGR3[3)]	Uzbekistan 2001
			1	2	3	4
Non-Marketed Consumption	Agriculture	**AAGR3**		9.8		44.9
	Industry and Construction	**AIND3**		1.9	2.1	1.2
	Services	**ASER3**		0.0	0.0	0.0
Market Consumption	Agriculture	**CAGR3**	18.5	4.8	5.3	2.9
	Industry and Construction	**CIND3**	65.2	68.9	76.4	42.1
	Services	**CSER3**	16.3	14.6	16.2	8.9
	Total		100.0	100.0	100.0	100.0

Sources: *1) CER 2001*
2) WEHRHEIM 2003

Notes: *3) The given values are the shares of the respective expenditures in total expenditures less expenditures for non-marketed agricultural products*

Although the consumption shares used by WEHRHEIM (2003) are available for 20 sectors, they are displayed here in the 3-sector aggregation in order to compare them with the data provided by CER (2001). In the 6-sector aggregation, as needed for the meso-SAM, household-consumption for 2001 can be found in table 3.21.

By establishing the non-market consumption of households it is now possible to determine the value of marketed output for the different activities:

$$TMS6_{C6}^{01} = \sum_{A6}\left(TAV6_{A6}^{01} - VHHA6_{A6}^{01}\right) \cdot I6_{A6,C6} \qquad (3.3.12)$$

With:

$TMS6^{01}$: Total market supply of domestically produced commodities in 2001

VHHA6: Direct household consumption from activities (table 3.21)

I6: Unity matrix with dimension A6 by C6

Table 3.21 Household Consumption Expenditures in Uzbekistan, 2001 (in billion Soum, current)

				Households HHO6
Non-market consumption	$VHHA6^{01}$	Agriculture	**AAGR6**	1384
		Industry	**AIND6**	36
		Construction	**ACON6**	0
		Trade	**ATRD6**	0
		Transport and communications	**ATCM6**	0
		Other services	**AOTS6**	0
Market Consumption	$VHHC6^{01}$	Agriculture	**CAGR6**	90
		Industry	**CIND6**	1297
		Construction	**CCON6**	0
		Trade	**CTRD6**	0
		Transport and communications	**CTCM6**	22
		Other services	**COTS6**	254
		Total		3082

Source: Own results

3.2.2.6 Import and Export

Trade of goods and services has been discussed in chapter 3.3.1. In order to meet the structure of the meso-SAM, trade with agricultural products has to be extracted from total merchandise trade. FAOSTAT (2004) proved to be a source of detailed information concerning trade with agricultural raw products. This will be discussed in more detail in chapter 3.3.3. For now, only the external trade on the 6-sector level of aggregation is of interest as displayed in table 3.22 for the year 2001.

The main assumption made here is that “other services” do not produce tradable services since this aggregate consists of public services mostly. “Trade” itself is not traded but represented as trade mark-ups on the trade volume. Outputs of “Construction” are neither traded. Although it is possible that Uzbek construction companies work abroad, there is no mentioning of such activities in any of the sources used (IMF 2000, NSC 2002, CEEP 2003).

The values presented here are named in the following:

Imports: $VTM6^{01}_{ROW6,C6}$

Exports: $VTE6^{01}_{C6,ROW6}$

Table 3.22 External Trade in 2001 (in billion Soum, current)

		Imports[2]	Exports
		$VTM6^{01}$	**$VTE6^{01}$**
		ROW6	**ROW6**
Agriculture[1]	**CAGR6**	32	44
Industry	**CIND6**	1084	1153
Construction	**CCON6**	0	0
Trade	**CTRD6**	0	0
Transport and communication	**CTCM6**	261	201
Other services	**COTS6**	0	0
Total		1378	1399

Sources: 1) *FAOSTAT 2005 (at average EXR)*

Notes 2) *The rule that expenditures are booked column-wise is broken in this table. "Imports" will appear row-wise in the meso-SAM*

The low share of agricultural commodities in total trade is remarkable in light of the fact that this sector plays an important role in the national economy. The bulk of agricultural raw products is apparently either consumed or processed within the country – and processing industries have a relatively low share in the composition of GDPf (with the exception of cotton processing). It seems, especially in the context of the importance of the Dekhans, that most agricultural products are consumed or processed by the households directly and not traded at all.

3.2.2.7 Indirect Taxes

Having derived the flows of commodities to domestic and international markets, it is also important to calculate the taxes paid on these markets. The regulations concerning taxation of commodities are rather complex (IMF 2000), and detailed information about which group of commodities is taxed at what rate is not known. In the absence of detailed information, an average rate of indirect taxes is calculated. This is done by adding total imports and domestic marketed production in a first step, thus calculating the value of totally available commodities on the domestic markets:

$$VTD6^{01}_{C6} = TMS6^{01}_{C6} + VTM6^{01}_{C6} \quad (3.3.13)$$

With:

VTD^{01}: Domestically available commodity supply in 2001

The average tax rate is then calculated by dividing total indirect taxes (**Tic** from the macro-SAM) by the total of domestically traded commodities:

$$aitr^{01} = \frac{Tic^{01}}{\sum_{C6} VTD6^{01}_{C6}} \quad (3.3.14)$$

With:

aitr: Average indirect tax rate

This rate is then levied on all traded commodities, either imported or domestically produced. In 2001, the average tax rate was 6.0%, which appears to be too low if compared to a value-added tax rate of 20% as indicated by the IMF (IMF 2000). The reason for this deviation is the huge number of exemptions for all sorts of indirect taxes (value-added tax, excise tax, custom duties). Since the level of aggregation is still very high with six productive sectors, it is possible to assume that the average rate applies for the sectors as a whole. This is not the case within each of the sectors, but at this level of aggregation it can be assumed.

$$ITD6^{01}_{C6} = aitr^{01} \cdot \left(TMS6^{01}_{C6} - VTE6^{01}_{C6} \right) \quad (3.3.15)$$

$$ITM6^{01}_{C6} = aitr^{01} \cdot VTM6^{01}_{C6} \quad (3.3.16)$$

$$ITE6^{01}_{C6} = aitr^{01} \cdot VTE6^{01}_{C6} \quad (3.3.17)$$

With:

ITD6: Indirect taxes on domestically produced and trade commodities

ITM6: Indirect taxes on imported commodities

ITE6: Indirect taxes on exported commodities

The resulting figures are displayed in table 3.23.

Table 3.23 Indirect Taxes by Sectors, 2001 (in billion Soum, current)

Indirect taxes on:		CAGR6	CIND6	CCON6	CTRD6	CTCM6	COTS6
Domestically produced and saled goods	**ITD6**	44	184	43	63	36	126
Imported goods	**ITM6**	2	65	0	0	16	0
Exported goods	**ITE6**	3	70	0	0	12	0

Source: Own results

3.2.2.8 Trade Margins

It has been mentioned earlier that the "trade" sector does not produce a service in a sense that it can be sold or bought directly. As a consequence, there are no direct revenues for this sector from sales to the markets but rather revenues from the mark-ups added to all other traded commodities and services. The average trade mark-up is calculated similarly to the rate of indirect taxes by dividing the total output value of the trade sector ($TMS6_{CTRD6}$) by the total value of commodities less trade-output:

$$atrc^{01} = \frac{TMS6^{01}_{CTRD6}}{\left(\sum_{C6} TMS6^{01}_{C6} - TMS6^{01}_{CTRD6}\right)} \tag{3.3.18}$$

With:

atrc average trade mark-up

The trade mark-ups for the different types of commodities are then calculated by multiplying the average trade mark-up with the respective categories:

$$TRCD6^{01}_{C6} = atrc^{01} \cdot \left(TMS6^{01}_{C6} - VTE6^{01}_{C6}\right) \tag{3.3.19}$$

$$TRCM6^{01}_{C6} = atrc^{01} \cdot VTM6^{01}_{C6} \tag{3.3.20}$$

$$TRCE6^{01}_{C6} = atrc^{01} \cdot VTE6^{01}_{C6} \tag{3.3.21}$$

The results are displayed in table 3.24.

Table 3.24 Trade Margins by Sectors in 2001 (in billion Soum, current)

Trade margins on:		CAGR6	CIND6	CCON6	CTRD6	CTCM6	COTS6
Domestically produced and saled goods	**TRCD6**	82	340	80	0	66	233
Imported goods	**TRCM6**	4	121	0	0	29	0
Exported goods	**TRCE6**	5	128	0	0	22	0

Source: Own results

3.2.2.9 Investment and Government Consumption

As can be seen from the macro-SAM, total investment in 2001 was 1041 billion Soum and governmental consumption was 781 billion Soum. It is assumed here that the government does not spend money other than for governmental services. In some datasets (e.g. CER 2001) the government also has expenditures to other sectors, but the structure chosen here does not allow for this. If a governmental service, such as education, demands agricultural products (e.g. milk for schools), then this expenditure is treated as intermediate demand of this particular sector and not as direct governmental expenditure. Consequently, total government consumption is booked here as payment for “other services” only.

Investment demand for the different sectoral outputs is not as easy to derive. The total output value of the construction sector is definitely placed here (843 billion Soum, including taxes), leaving a remainder of 198 billion Soum. Investment demand for agricultural products can only occur in the form of stock changes and is neglected in this calculation. Consequently, the remaining sum is assumed to be paid for industrial products, i.e. machinery.

3.2.2.10 Balancing the Meso-SAM

All datasets compiled in the previous chapters can now be put together in a social accounting matrix with six activity and commodity accounts, and four types of enterprises. Because of the varying sources (e.g. input-output ratios) of the data used and the simplifying usage of average rates in the context of indirect taxes and trade margins, the resulting meso-SAM (prior SAM or $MESAM^{pr}$ in the following) has imbalanced commodity-accounts. Since the meso-SAM is an intermediate step to a more detailed micro-SAM in the end, it is of major importance to perform the balancing with regard to the reliability of the data put in this SAM and additional available information which has not been used so far because it did not fit into the algorithm expressed in the previous chapters. “Not fitting” means here that data was available only for one or two sectors like the information about total output values for agriculture (table 3.18), but not for all sectors. The challenge now is to estimate a balanced meso-SAM which adds up to the macro-SAM and includes all other information available and accounts for the different levels of reliability of the data fed into it. Formally, this problem can be expressed as follows:

Find a meso-SAM ($MESAM^{bl}_{AC6,AC6'}$) for which applies that the sum of rows equals the sum of the corresponding columns:

$$\sum_{AC6'} MESAM^{bl}_{AC6,AC6'} = \sum_{AC6} MESAM^{bl}_{AC6,AC6'} , \quad \forall AC6 = AC6' \qquad (3.3.22)$$

With:

$MESAM^{bl}$	balanced meso-SAM
AC6, AC6’	Index for accounts in the meso-SAM

The balanced meso-SAM also has to meet a set of other conditions. First, the meso-SAM has to add-up to the known macro-totals. The macro-SAM as presented in table 3.11, which was derived from the system of national accounts, contains neither trade margins nor non-market consumption nor intermediate demand. Hence, it has to be adjusted in two ways:

1. Adding an account for trade margins
2. Deleting household consumption

The resulting adjusted macro-SAM is shown in table 3.25.

Table 3.25 Macro-SAM for 2001, Adjusted for Balancing of Meso-SAM (in billion Soum, current)

MAC^bl		ACT	COM	TRD	LAB	CAP	HHO	ENT	GOV	TAX	S-I	ROW	
Activities	ACT												REVENUES
Commodities	COM								**781**		**1041**	**1399**	
Trade margins	TRD												
Wages	LAB	**2020**											
Operating surplus	CAP	**2440**											
Households	HHO				**2020**			**1901**	**103**			**18**	
Enterprises	ENT					**2234**							
Government	GOV							**133**		**949**			
Taxes	TAX	**-199**	**665**			**118**	**164**	**200**					
Savings-Investment	S-I						**797**		**197**			**47**	
Rest of the World	ROW		**1378**			**87**							
		EXPENDITURES											

Source: Own results

The relation between meso- and this macro-SAM is shown in equation (3.3.23) below:

$$MAC^{bl}_{M,M'} = \sum_{AC6'} \left[\sum_{AC6} MES_{M,AC6} \cdot MESAM^{bl}_{AC6,AC6'} \right] \cdot MES_{AC6',M'} \,, \quad \forall MAC^{bl}_{M,M'} \neq 0 \qquad (3.3.23)$$

With:

MAC^{bl}: Macro-SAM (table 3.35)

MES: Auxiliary matrix for mapping accounts in the meso-SAM with macro-accounts (table 3.36)

M, M': Indexes for accounts of the macro-SAM (see table 3.35)

MES (table 3.26) is an auxiliary matrix similar to MA and MC in chapter 3.3.2.2, in which the dimensions of two different matrices are mapped together.

Table 3.26 Auxiliary Matrix MES

MES	Macro-SAM accounts										
Meso-SAM accounts	ACT	COM	TRD	LAB	CAP	HHO	ENT	GOV	TAX	S-I	ROW
AAGR6	1										
AIND6	1										
ACON6	1										
ATRD6	1										
ATCM6	1										
AOTS6	1										
CAGR6		1									
CIND6		1									
CCON6		1									
CTRD6		1									
CTCM6		1									
COTS6		1									
TRCD6			1								
TRCM6			1								
TRCE6			1								
LAB6				1							
CAP6					1						
HHO6						1					
SHR6							1				
FER6							1				
DKH6							1				
ENT6							1				
GOV6								1			
ITD6									1		
ITM6									1		
ITE6									1		
DTX6									1		
RES6									1		
SUB6									1		
S-I6										1	
ROW6											1

Source: Own results

It is important to note here that the “adding-up” condition applies only for non-zero entries in the macro-SAM. For all other entries, different rules may apply, especially in the context of household consumption, for which the following condition assures that market and non-market demand add up to the macro-total:

$$Ch = \sum_{A6} MESAM^{bl}_{A6,HHO6} + \sum_{C6} MESAM^{bl}_{C6,HHO6} \qquad (3.3.24)$$

With:

Ch Total consumption expenditures of households, see macro-SAM in table 3.11

Furthermore, the finally obtained meso-SAM has to include all known data, such as the information about trade or total output of the agricultural sector. For this purpose, a second matrix is generated which includes only these known values. All other entries are zero. The finally balanced SAM then has to equal all entries in the matrix of known values ($MESAM^{known}$) which are different from zero.

$$MESAM^{bl}_{AC6,AC6'} = MESAM^{known}_{AC6,AC6'}, \quad \forall MESAM^{known}_{AC6,AC6'} \neq 0 \qquad (3.3.25)$$

With:

$MESAM^{known}$ Matrix of known values

In order to avoid the problem that the balanced SAM has entries which are not motivated by the considerations above, all zero-entries in the prior SAM will also be zero in the balanced one.

$$MESAM^{bl}_{AC6,AC6'} = 0 \quad , \forall MESAM^{pr}_{AC6,AC6'} \neq 0 \qquad (3.3.26)$$

Having set the conditions that have to be fulfilled by the balanced meso-SAM, the question now is how to derive it based on the constructed prior SAM ($MESAM^{pr}$). A method that presents itself here is again the maximum-entropy approach which was already employed in chapter 3.2. The particular advantage in this context is that it allows setting support points according to the degree to which one trusts the entries of the prior SAM. This can be done by formulating coefficients of variation (VC6) that define intervals around the prior values which can be more or less narrow. The support points are then defined as follows:

$$MESAM^{max}_{AC6,AC6'} = MESAM^{pr}_{AC6,AC6'} \cdot \left(1 + VC6_{AC6,AC6'}\right), \quad \forall MESAM^{pr}_{AC6,AC6'} \neq 0 \qquad (3.3.27)$$

$$MESAM^{min}_{AC6,AC6'} = MESAM^{pr}_{AC6,AC6'} \cdot \left(1 - VC6_{AC6,AC6'}\right), \quad \forall MESAM^{pr}_{AC6,AC6'} \neq 0 \qquad (3.3.28)$$

With:

$MESAM^{max}$: Maximum allowable entry in the meso-SAM

$MESAM^{min}$: Minimum allowable entry in the meso-SAM

$MESAM^{pr}$: A-priori information about the meso-SAM (prior-SAM)

VC6: Coefficient of variation from the prior-SAM

For instance, the coefficients of variation of the input-output table in the meso-SAM were set to 0.1, which allows for a variation of 10% around the prior value, whereas the variation around the trade margins were set to 0.5 or 50% of possible deviation from the prior.

These support points are then associated with corresponding probabilities which define the values in the final SAM:

$$MESAM^{bl}_{AC6,AC6'} = \sum_{lim} P6^{lim}_{AC6,Ac6'} \cdot MESAM^{lim}_{AC6,AC6'} \qquad (3.3.29)$$

With:

P6: Probability of each entry in the meso-SAM to equal one of the support points

lim: Index for support points, {min, max}

The probabilities have to add up to unity:

$$\sum_{lim} P6^{lim}_{AC6,Ac6'} = 1 \qquad (3.3.30)$$

The objective function is then to maximize the entropy under variation of the probabilities:

$$E = -\sum_{AC6}\sum_{AC6'}\sum_{\mathbf{lim}} P6^{\mathbf{lim}}_{AC6,AC6'} \cdot \mathbf{ln}\left(P6^{\mathbf{lim}}_{AC6,AC6'}\right) \qquad (3.3.31)$$

With:

E: Entropy measure

The maximization is carried out subject to constraints (3.3.22) to (3.3.26) as well as (3.3.29) and (3.3.30).

The balancing model was set up in the general algebraic modeling software GAMS and solved with the non-linear solver CONOPT3. The resulting balanced meso-SAM is displayed in table 40. The relative deviations from the prior amount to -1.1%. On average, the highest deviations can be primarily found in the commodity account for the "transport and communications sector, where, in some cases, they reach the maximum deviation allowed (10% in the context of the input-ouput table, 50% in the context of trade margins and indirect taxes). These deviations, however, nicely demonstrate the way in which the proposed balancing algorithm works: As the commodity account CTCM6 is found to be highly unbalanced, it is possible to increase either the domestic demand or to decrease domestic supply, because import and export values are fixed by equation (3.3.25).

Huge changes of household demand of CTCM6 would collide with equation (3.3.24), and consequently, only intermediate demand can be subject to variation. However, this is limited by the back-and-forward linkages with the other sectors. The only remaining sets of entries which can be changed are trade-margins and indirect taxes, although indirect taxes are in total constrained by equation (3.3.23). Nonetheless, the entries here are relatively small and changes here can be absorbed by minor changes in the larger sector-aggregates industry and agriculture. Therefore, trade margins and indirect taxes of the "transport and communication" sector are decreased to almost the level of the possible limit of 50% of the prior-value. This outcome is also acceptable as the trade mark-ups on services are likely to be less than those on agricultural or industrial commodities, as, for instance, indicated by WEHRHEIM (2003) or MÜLLER and WEHRHEIM (2004) in the case of Russia. The relative decline of indirect taxes paid by CTCM6 is consistent with information from the IMF (2000) which shows that the major part of excise-taxes stem from cotton other merchandise goods rather than from services.

Another remarkable change in the balanced SAM is the smaller value of non-market consumption of agricultural products. In the prior SAM, the total output of Dekhan farms was assumed to be consumed directly, whereas this value declined by 15% during the balancing. This outcome corresponds with findings by KUHN (2001), who also found that household-plots contribute increasingly to the marketed quantity of agricultural commodities. This can also be observed on the local markets in Uzbekistan, where many traders supply parts of the produce of their small plots.

Altogether, the balanced SAM includes not only all information available on the different levels of aggregation (macro- and meso-level), but it also matches the findings of other studies and does not show implausible results. Nevertheless, it is still second-best to a consistent dataset from a single source, preferably a national statistical department. Since such information is not available, it will be used here for the further analysis.

Table 3.27 Balanced Meso-SAM for Uzbekistan, 2001 (in billion Soum, current)

Macro	Name	Meso	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
ACT	Agriculture	AAGR6	1							851											1374														2224
	Industry	AIND6	2								3030										34														3064
	Construction	ACON6	3									728																							728
	Trade	ATRD6	4										1060																						1060
	Transport and communication	ATCM6	5											587																					587
	Other services	AOTS6	6												2056																				2056
COM	Agriculture	CAGR6	7	148	551		75		124												84													44	1026
	Industry	CIND6	8	255	1190	258	113	68	585												1227												189	1153	5038
	Construction	CCON6	9																														852		852
	Trade	CTRD6	10													813	154	156																	1123
	Transport and communication	CTCM6	11	177	311	129	47	59	79												21													201	1026
	Other services	COTS6	12	128	296	46	299	79	441												342					781									2412
TRD	Domestic trade	TRCD6	13							85	352	81		64	231																				813
	Import trade	TRCM6	14							4	121			29																					154
	Export trade	TRCE6	15							5	129			22																					156
LAB	Labor	LAB6	16	677	256	156	172	87	672																										2020
CAP	Operating surplus	CAP6	17	799	440	131	340	284	327																										2321
HHO	Households	HHO6	18																2020			295	84	385	1137	103								18	4042
ENT	Shirkats	SHR6	19																	323															323
	Fermer	FER6	20																	91															91
	Dekhan	DKH6	21																	385															385
	Other enterprises	ENT6	22																	1435															1435
GOV	Government	GOV6	23																						133		498	83	84	364	118	-199			1082
Ti	Indirect taxes	ITD6	24							45	187	43	63	35	125																				498
	Import taxes	ITM6	25							2	65			16																					83
	Export taxes	ITE6	26							3	69			12																					84
Td	Direct taxes	DTX6	27																		164	28	8		165										364
Tf	Factor taxes	RES6	28	40	19	8	14	10	27																										118
Ts	Subsidies	SUB6	29						-199																										-199
S-I	Capital account	S-I6	30																		797					197								47	1041
ROW	"Rest of the world"	ROW6	31							32	1084			261						87															1465
	Total		32	2224	3064	728	1060	587	2056	1026	5038	852	1123	1026	2412	813	154	156	2020	2321	4042	323	91	385	1435	1082	498	83	84	364	118	-199	1041	1465	

Source: Own results

3.3 Micro-SAM

The details shown in the meso-SAM already allow for a certain amount of analysis, but the main topics of interest, especially cotton production and processing have yet to be discussed. Therefore, the sectoral aggregates for agriculture and industry need to be split into smaller sub-sectors. As in the case of the meso-SAM, a set of data is available from various sources, but not with all the necessary details. As before, the information available will be used to construct a prior-SAM, which will be balanced under a set of constraints. Instead of using a macro-SAM as adding-up condition, the meso-SAM as displayed in table 3.27 will be used for this purpose. In a first step, agriculture will be split into seven sub-sectors.

3.3.1 Disaggregation of Agriculture

The first sub-sector to be considered here is animal production, which generated 48.4% of total agricultural production (CEEP 2003). The remaining 51.6% originate consequently from plant production, which is further divided into six crop-categories. While physical output and harvested area are known for these crops (FAOSTAT 2004 on the national level, OblStat 2002b on the regional level), average domestic producer prices are more difficult to obtain. Prices for the main products cotton, wheat, and rice are easily available, although varying from source to source, but it appears that producer prices for vegetable, fruit, and fodder crops are much more difficult to obtain. Obviously, the problem here is to obtain price information for commodities which do not exist as such: "Vegetables" is a category of goods, in which the different items have different prices and thus, different shares in the total output value. Since OBLSTAT 2002b provides the most detailed data on prices among the regarded sources, it is assumed that the price ratios, relative to the cotton price, apply on the national level as well. The price-ratios, multiplied by the total output quantities, are then used to compute the shares of each crop-category in the total value of agricultural production (table 3.28).

Table 3.28 Distribution of Gross Agricultural Product, 2001

		Physical prodcution [1000 t][1]	Relative prices [percent of cotton price][2]	Shares in plant production [percent]	Gross production [billion Soum]	Share in agricultural output [percent]	
Total plant production				**100.0**	**1077**	**51.6**[3]	
Raw cotton	**ACOT20**	3265	100	30.4	327	15.7	**SHR[AGR]**
Grains	**AGRN20**	3988	74	27.4	295	14.1	
Rice	**ARIC20**	68	169	1.1	12	0.6	
Gardening crops	**AGAR20**	4696	53	23.1	249	11.9	
Fodder crops	**AFOD20**	12341	12	14.1	151	7.3	
Other crops	**AOTH20**	849	50	4.0	43	2.1	
Total animal production	**AANM20**				**1010**	**48.4**[3]	
Total agriculture					**2087**[4]	**100.0**	

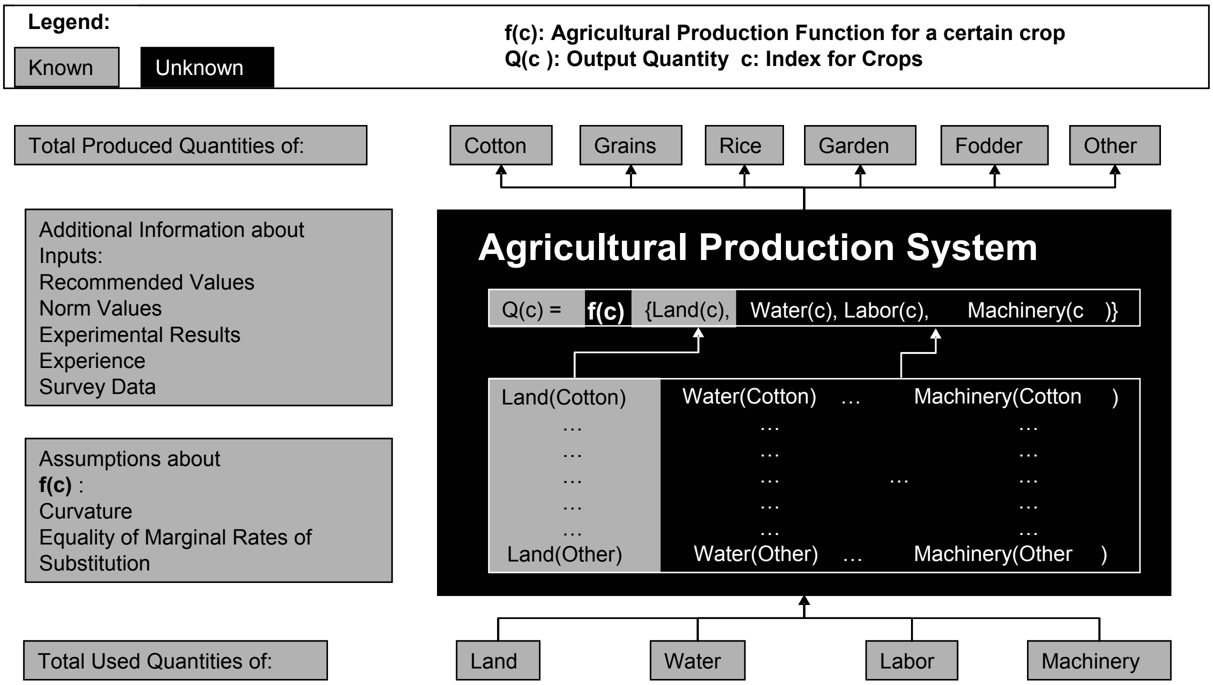
Sources: *1) FAOSTAT 2004*
2) OblStat 2002b
3) CEEP2003
4) NSC 2002

A further dataset required here is the input quantities and input-price ratios. This issue requires some attention because one of the main research questions concerns the value of water. It turns that the issue of input allocation in the crop-production systems is extremely difficult to address. With the exception of land allocated to certain crops, it is hardly possible to assess information about quantities of water, labor, or machinery used for the different crops in the observed agricultural production system. This situation is aggravated by the multitude of government interventions. Additionally, the analysis of input-output relations becomes more difficult because both agricultural input and output markets are distorted, and behavioral patterns of agricultural producers do not follow common assumptions such as profit maximization.

The problem at hand is illustrated in figure 3.29. The produced quantities of crops as well as the total input quantities are known, but the quantities of inputs allocated for the production of specific crops is unknown, with the exception of land. What is known about the input allocations is a set of 'norm' values that were derived during the soviet period and were used to calculate the needed quantities of water, labor-hours and diesel in the framework of a planned economy. These norm values are still in use as 'rules-of-thump' for farmers to calculate their needs for the following cropping period and represent to some extend the knowledge of farmers about their production processes.

Another source of information for the following study comes from assumptions about the functional forms to be estimated and behavioral patterns of the relevant actors. Those assumptions will be discussed in more detail in the following chapters.

Figure 3.4 The Agricultural Black Box



Source: Own results

3.3.1.1 Estimation Method

Since the lack of activity-specific input data is a widely known problem in development economics (and agricultural economics in general), this issue has been addressed already by several authors (e.g. JUST ET AL. 1990 and LENCE AND MILLER 1998). JUST ET AL. (1990) proposes an ordinary least squares (OLS) estimation model for the calculation of input data based on allocated area and dummy variables to capture annual and farm-specific effects. On the other hand, LENCE and MILLER (1998) suggest the use of a maximum entropy (ME) approach to derive not only input data but to estimate parameters of a production function simultaneously. The latter approach appears to match the problem discussed here and, therefore, will be described in some more detail.

LENCE and MILLER (1998) suggest expressing the crop-specific inputs (TCI) as shares (f) of the total quantity of the available inputs (TAI) (Equation (3.3.1)). The shares f have to add up to one (Equation (3.3.2)) and would be implemented in the maximum entropy function according to equation (3.3.3). Equation (3.3.3) reaches its maximum when each crop gets an equal share of the resource in question. In the underlying case, such an assumption is difficult to maintain because the cropping system of the region of interest includes state-ordered cotton production that accounts for around 50% of the irrigated land and consumes the bulk of the available resources. The estimation model developed in this study covers six crops and crop-aggregates, which implies a value of ~0.17 for each f in the maximum of equation (3.3.3). Such an implication is not plausible. Also, this approach does not make use of any other available information on crop-specific input applications such as the results from agronomic studies or recommended values. This consideration leads to a variation of the estimation model proposed by LENCE and MILLER (1998) which will be described in this section. The question is how to incorporate assumptions about the demand of different crops on the inputs in the estimation system.

$$TCI_{i,c,n} = f_{i,c,n} \cdot TAI_{i,n}, \ \forall i,c,n \tag{3.3.1}$$

$$\sum_{c} f_{i,c,n} = 1, \ \forall i,c,n \tag{3.3.2}$$

$$E^{TCI} = -\sum_{i}\sum_{c}\sum_{n} f_{i,c,n} \cdot \mathbf{ln}(f_{i,c,n}), \ \forall i,c,n \tag{3.3.3}$$

With:

$TCI_{i,c,n}$:	Input quantity per crop in respective units
$TAI_{i,n}$:	Total available input quantity in respective units
E^{TCI}:	TCI-related part of the entropy function
$F_{i,c,n}$:	Share of TCI in TAI
c:	Index for crops
i:	Index for inputs
n:	Index for time and regions (n=rt)

3.3.1.2 Support Points

Besides the known aggregated quantities of water, labor and machinery, there are also so-called 'norm' values as a source of information. These norms are a legacy of the soviet era and were the calculative base for the allocation and distribution of inputs in the context of a centrally planned agricultural system. They still serve as a rule-of-thumb for farmers and will be used as prior information in the following (HYDROMODRAY 2003).

The assumption made here is, that the actual application of any input per hectare lies in a symmetric interval around the norm-value as expressed in equation (3.2.4). The range parameter R was chosen in a way that farmers may either not apply the respective inputs at all or they may apply twice as much as the norm recommends.

$$s_{c,i,L}^{CSI} = CSI_{i,c}^{NORM} \cdot R_L \text{ , } \forall c,i,L \qquad (3.3.4)$$

With:

$s_{c,i,L}^{CSI}$:	Prior information about bounds of actual input allocation
$CSI_{i,c}^{NORM}$:	Norm value for input allocation per hectare
R_L:	Range of interval around CSI^{NORM} (0 and 2)
L:	Index for lower and upper bound, {MIN, MAX}

According to GOLAN, JUDGE, AND MILLER (1996), the actual value of the crop specific inputs CSI in each observation point n can be represented by the borders of the respective assumed range s and a corresponding probability p for the variable to equal either the border-values or 'support points' (equation (3.3.5)). For instance, if the probability of both support-points assumes 0.5 the variable equals the norm-value.

$$CSI_{i,c,n} = \sum_{L} P_{c,i,n,L}^{CSI} \cdot s_{c,i,L}^{CSI} \text{ , } \forall c,i,n,L \qquad (3.3.5)$$

The probabilities in each point (i,c,n) have to add up to unity (equation (3.3.6)).

$$\sum_{L} P^{CSI}_{c,i,n,L} = 1, \ \forall c,i,n,L \qquad (3.3.6)$$

With:

$CSI_{i,c,n}$: Actual crop-specific input per hectare

$P^{CSI}_{c,i,n,L}$: Probability of each support point s^{CSI}

In order to ensure that the crop-specific inputs add up to the observed aggregated amounts, equation (3.3.7) is added to the system:

$$TAI_{i,n} = \sum_{c} CSI_{i,c,n} \cdot A_{i,c,n} = \sum_{c} TCI_{i,c,n}, \ \forall i,c,n \qquad (3.3.7)$$

Equations (3.3.4) to (3.3.7) have the same effect as equations (3.3.1) and (3.3.2) with respect to the incorporation of information about total available input quantities, but they also add some additional information about plausible allocations of water, labor and machinery per hectare. The next step is to define an appropriate functional relation between CSI and crop outputs.

3.3.1.3 Functional Crop Production

The total produced quantity of any crop depends on the allocated area and the yield per unit of area. Due to the demand that the yield functions for the different crops should incorporate the three different inputs water, labor, and machinery, it does not appear appropriate to specify them as Cobb-Douglas or CES functions: This would imply an equal elasticity of substitution between all pairs of inputs, which is a highly unrealistic assumption in the given context. However, there is a huge variety of possible formulations of more flexible functional forms with different properties especially concerning their ability to fulfill regularity conditions such as concavity and monotonicity not only locally but globally (e.g. DIEWERT, WALES 1987).

The functional form chosen here is a quadratic one. This decision was made for two reasons: First, a quadratic function can be globally concave (although not globally monotonous). This applies for a McFadden functional form as well (DIEWERT, WALES 1987), but due to the fact that CSI and the parameters of the function have to be estimated simultaneously, a McFadden formulation would increase the complexity of the model to an extent that causes serious difficulties in the numerical solving process. Thus, the second reason for the choice of a quadratic form is its computational simplicity. The major disadvantage of a quadratic function is that it does not imply that certain inputs are essential: It would be possible to get positive output values even if one input value is set to zero, which is a highly unrealistic assumption particularly in the case of labor (no seeding, no harvesting). This property has to be taken into account for the set-up of simulations. The functional form used in this study is specified according to FUSS ET AL. (1978) as follows:

$$Y_{c,n} = \sum_i \beta_{c,i} * CSI_{i,c,n} + \frac{1}{2}\sum_i \sum_{ip} \zeta_{c,i,ip} CSI_{i,c,n} CSI_{ip,c,n} \quad , \ \zeta_{c,i,ip} = \zeta_{c,ip,i} \qquad (3.3.8)$$

$$Q_{c,n} = A_{c,n} * Y_{c,n} \ , \ \forall c,n \qquad (3.3.9)$$

With:

$Y_{c,n}$:	Yield per hectare of each crop
$A_{c,n}$:	Cropped area
$Q_{c,n}$:	Produced quantity of each crop
$\beta_{c,i}$:	Parameter for the linear terms
$\zeta_{c,i,ip}$:	Parameter for the quadratic and cross terms
i, ip:	Index for inputs

3.3.1.4 Theoretical Conditions of Yield Functions

The advantage of flexibility of any functional form comes at the cost that theoretically desirable properties like monotonicity and concavity are not fulfilled automatically and have to be imposed. Restricting the first partial derivatives of Y to be non-negative in all observation points n imposes monotonicity:

$$\frac{\partial Y_{c,n}}{\partial CSI_{i,c,n}} \geq 0 \ , \ \forall i,c,n \qquad (3.3.10)$$

Concavity is imposed according to LAU (1978) by decomposing the Hessian matrix of second partial derivations (**H**) into a lower triangular unit matrix Λ and an upper triangular matrix **U**:

$$\mathbf{H} = \begin{bmatrix} \frac{\partial^2 Y_{c,n}}{\partial CSI_{Water,c,n} \partial CSI_{Water,c,n}} & \dots & \dots & \frac{\partial^2 Y_{c,n}}{\partial CSI_{Water,c,n} \partial CSI_{Machinery,c,n}} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \frac{\partial^2 Y_{cm,n}}{\partial CSI_{Machinery,c,n} \partial CSI_{Water,c,n}} & \dots & \dots & \frac{\partial^2 Y_{c,n}}{\partial CSI_{Machinery,c,n} \partial CSI_{Machinery,c,n}} \end{bmatrix}$$

The matrix above depicts a general case, but it has to be noted here that in the special case of a quadratic function, the Hessian depends on the parameters only. Therefore applies:

$$\mathbf{H} = \begin{bmatrix} \zeta_{c,Water,Water} & \dots & \dots & \frac{1}{2} \cdot \zeta_{c,Water,Machinery} \cdot \zeta_{c,Machinery,Water} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \frac{1}{2} \cdot \zeta_{c,Machinery,Water} \cdot \zeta_{c,Water,Machinery} & \dots & \dots & \zeta_{c,Machinery,Machinery} \end{bmatrix}$$

The decomposition is computed as follows:

$$\Lambda = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \lambda_{i,ip} & 1 & 0 & 0 \\ \lambda_{i,ip} & \lambda_{i,ip} & 1 & 0 \\ \lambda_{i,ip} & \lambda_{i,ip} & \lambda_{i,ip} & 1 \end{bmatrix}$$

$$U = \begin{bmatrix} u_{i,ip} & u_{i,ip} & u_{i,ip} & u_{i,ip} \\ 0 & u_{i,ip} & u_{i,ip} & u_{i,ip} \\ 0 & 0 & u_{i,ip} & u_{i,ip} \\ 0 & 0 & 0 & u_{i,ip} \end{bmatrix}$$

H = $\Lambda \cdot$U

or:

$$\frac{\partial^2 Y_{c,n}}{\partial CSI_{i,c,n} \partial CSI_{ip,c,n}} = \sum_{im} \lambda_{i,im} u_{im,ip}, \ \forall i, ip, im, c, n \qquad (3.3.11)$$

With:

im: auxiliary index for matrix multiplication, alias of i and ip

According to LAU (1978), Q is concave when **H** is negative semi-definite, which is the case, when the diagonal elements of **U** are non-positive.

$$u_{i,i} \leq 0 \qquad (3.3.12)$$

The proposed ME procedure requires the definition of support points for the parameters and their association with respective probabilities (equations (3.3.13) to (3.3.16)):

$$\beta_{c,i} = \sum_{L} P^{\beta}_{c,i,L} s^{\beta}_{c,i,L}, \ \forall c, i, L \qquad (3.3.13)$$

$$\sum_{L} P^{\beta}_{c,i,L} = 1, \ \forall c, i, L \qquad (3.3.14)$$

$$\zeta_{c,i,ip} = \sum_{L} P^{\zeta}_{c,i,ip,L} s^{\zeta}_{c,i,ip,L}, \ \forall c, i, ip, L \qquad (3.3.15)$$

$$\sum_{L} P^{\zeta}_{c,i,ip,L} = 1, \ \forall c, i, ip, L \qquad (3.3.16)$$

With:

$P^{\beta}_{c,i,L}$: Probability for support points of β

$s^{\beta}_{c,i,L}$: Support Point for β

$P^{\zeta}_{c,i,ip,L}$: Probability for support points of ζ

$s^{\zeta}_{c,i,ip,L}$: Support Point for ζ

The support points for the parameters of (3.3.8) were chosen thus that the linear terms β are always positive. The diagonal elements of ζ are forced to be negative and the off-diagonals of ζ may assume any value inside of a range, set by the researcher. This range was pre-determined by calculating the parameters based on the norm values. The symmetry of the off-diagonal terms is imposed by equation 3.3.17:

$$\zeta_{c,i,ip} = \zeta_{c,ip,i}\,,\ \forall c,i,ip,L \tag{3.3.17}$$

For the estimation procedure, equation (3.3.9) was associated with an error term with an expected value of zero. This error term is also defined in an interval between two support points:

$$\varepsilon_{c,n} = \sum_{L} P^{\varepsilon}_{c,n,L} s^{\varepsilon}_{c,L}\,,\ \forall c,n,L \tag{3.3.18}$$

$$\sum_{L} P^{\varepsilon}_{c,n,L} = 1,\ \forall c,n,L \tag{3.3.19}$$

With:

$\varepsilon_{c,n}$: Error term of the yield function

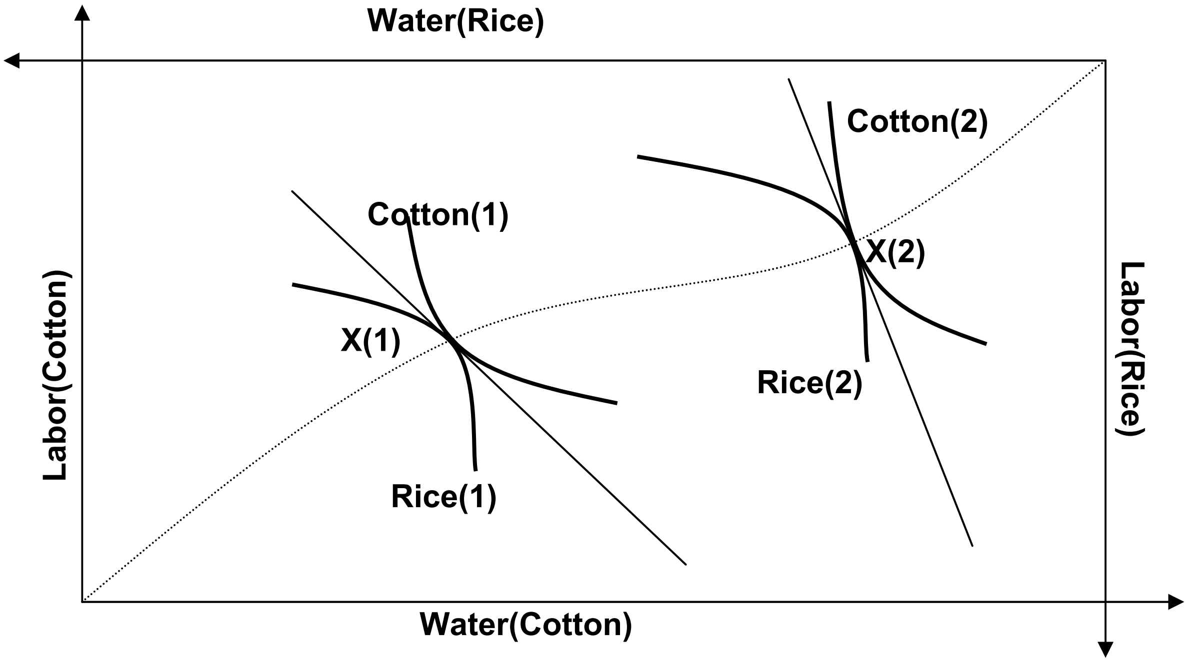
$P^{\varepsilon}_{c,n,L}$: Probability for support points of ε

$s^{\varepsilon}_{c,L}$: Support points for ε

3.3.1.5 Imposing Rationality

The fact that agricultural production in the region Khorezm is subject to a set of governmental regulations and that there are no markets for relevant inputs like water and land and consequently no prices for those inputs, make assumptions about the behavior of the relevant actors in the system rather difficult. They are not profit maximizers in the sense that they can decide about optimal output quantities. But it might be realistic to assume that they produce whatever the state requires them to produce with a minimal cost combination of inputs. Accordingly, in this study we assume that the production is efficient and available resources are not wasted. This assumption is depicted for the simplified two goods, two factor case in figure 3.2 with an Edgeworth Box (e.g. HENRICHSMEYER AND WITZKE 1994).

Figure 3.5 Efficient Production in an Edgeworth Box



Source Own presentation, adopted from HENRICHSMEYER AND WITZKE 1994

It shows arbitrarily chosen isoquant curves for the two products cotton and rice which are produced with two production factors only, water and land. The points x1 and x2 (where the isoquants for both products are tangent to one another) represent possible efficient combinations of input usages: The total available amounts of water and land are used in both cases. Both points also imply that the marginal rates of substitutions are equal for both production functions. This implication is realistic when the prices of land and water are equal for cotton and rice producers. The resulting equalities are summarized in equation (3.3.20). If the input prices are equal for all producers, the negative marginal rate of substitution equals the inverted ratio of input prices.

$$\frac{\frac{\partial Q_{c,n}}{\partial CSI_{i,c,n}}}{\frac{\partial Q_{c,n}}{\partial CSI_{ip,c,n}}} = -\frac{dCSI_{ip,c,n}}{dCSI_{i,c,n}} = -MRS_{i,ip,c,n} = \frac{\mathbf{Pr}[CSI_{i,n}]}{\mathbf{Pr}[CSI_{ip,n}]} \qquad (3.3.20)$$

With:

$MRS_{i,ip,cm,n}$: Marginal rate of substitution between pairs of inputs

Pr[.]: (Unknown) input price

If the condition (3.3.20) holds true for at the level of total production, it also applies on the field level, because the price ratios for inputs may not differ on total production level and on field level. The minimum-cost combination is also assumed to shape production patterns on the field level. If so, then even if the prices are unknown, their ratios can be derived. The condition of equal marginal rates of substitution is imposed in the estimation process according to equation (3.3.21):

$$\frac{\frac{\partial Y_{c,n}}{\partial CSI_{i,c,n}}}{\frac{\partial Y_{c,n}}{\partial CSI_{ip,c,n}}} = \frac{\frac{\partial Y_{cp,n}}{\partial CSI_{i,cp,n}}}{\frac{\partial Y_{cp,n}}{\partial CSI_{ip,cp,n}}}, \quad \forall i \neq ip, c \neq cp \qquad (3.3.21)$$

However, the strict imposition of this constraint is questionable. Agricultural production processes take place within a more or less lengthy period of time and is subject to unforeseen events such as water scarcities during certain phases of the vegetation period, often when the appropriate supply of water is most relevant for quantity and quality of the yield. As a consequence, equation 3.3.21 above may apply for the planning of cost-minimizing input allocation (*ex-ante*) but not necessarily at the end of the production process (*ex-post*). Even if some expenditures have been made at the beginning of the production process (seeds, charges for soil-preparing machinery), the further allocation of inputs during the vegetation period will follow the supply of the scarcest factor. Consequently, not all of the area sown or planted will be harvested if a crucial input was not available when needed. The most appropriate design for an estimation of input allocation would, therefore, be the distinction between phases of the vegetation period less than a year. However, only a small amount of information is available for this period. In order to make use of available data while avoiding the potential inconsistencies of the assumption that equation 3.3.21 applies *ex-ante* but not *ex-post,* this restriction is relaxed by defining and introducing a distortion term in (3.3.21). This distortion term has an expected value of zero. The support points are chosen such that they keep this distortion term as small as possible while maintaining the feasibility of the model. Hence, (3.3.21) is re-formulated as follows:

$$\frac{\partial Y_{c,n}}{\partial CSI_{i,c,n}} * \frac{\partial Y_{cp,n}}{\partial CSI_{ip,cp,n}} = \frac{\partial Y_{cp,n}}{\partial CSI_{i,cp,n}} * \frac{\partial Y_{c,n}}{\partial CSI_{ip,c,n}} + \delta_{i,ip,c,cp,n}, \quad \forall i \neq ip, c \neq cp, n \quad (3.3.22)$$

With:

$\delta_{i,ip,c,cp,n}$: Distortion term

δ is defined between two support points and the associated probabilities.

$$\delta_{i,ip,c,cp,n} = \sum_{L} P^{\delta}_{i,ip,c,cp,n,L} s^{\delta}_{i,ip,c,cp,L}, \quad \forall i \neq ip, c \neq cp \quad (3.3.23)$$

$$\sum_{L} P^{\delta}_{i,ip,c,cp,n,L} = 1 \quad (3.3.24)$$

With:

$P^{\delta}_{i,ip,c,cp,n,L}$: Probability for support points of δ

$s^{\delta}_{i,ip,c,cp,L}$: Support points of δ

Equations (3.3.23) and (3.3.24) complete the system which has to be complemented by an objective (ME) function. This will be described in the following section:

3.3.1.6 Objective Function and Implementation

The objective function contains all probabilities of the variables to be estimated (crop-specific inputs (CSI), parameters of the production function (β, ζ), error term of the production function (ε), and distortion term of the cost-minimization condition (δ)) and is specified as shown below in equation (3.3.25):

Equation (3.3.25) was maximized subject to the constraints (3.3.5) to (3.3.10), (3.3.12) to (3.3.19) and (3.3.22) to (3.3.24). The model was programmed with the software GAMS (General Algebraic Modeling System) and set up as a non-linear optimization problem. It was then solved with the numerical solver CONOPT3.

$$
\begin{aligned}
E = & \\
& -\sum_{c}\sum_{i}\sum_{n}\sum_{L} P^{CSI}_{c,i,n,L} \ln(P^{CSI}_{c,i,n,L}) \\
& -\sum_{c}\sum_{i}\sum_{L} P^{\beta}_{c,i,L} \ln(P^{\beta}_{c,i,L}) \\
& -\sum_{c}\sum_{i}\sum_{ip}\sum_{L} P^{\zeta}_{c,i,ip,L} \ln(P^{\zeta}_{c,i,ip,L}) \\
& -\sum_{c}\sum_{n}\sum_{L} P^{\varepsilon}_{c,n,L} \ln(P^{\varepsilon}_{c,n,L}) \\
& -\sum_{i}\sum_{ip}\sum_{c}\sum_{cp}\sum_{n}\sum_{L} P^{\delta}_{i,ip,c,cp,n,L} \ln(P^{\delta}_{i,ip,c,cp,n,L})
\end{aligned}
\qquad (3.3.25)
$$

3.3.1.7 Estimation Results

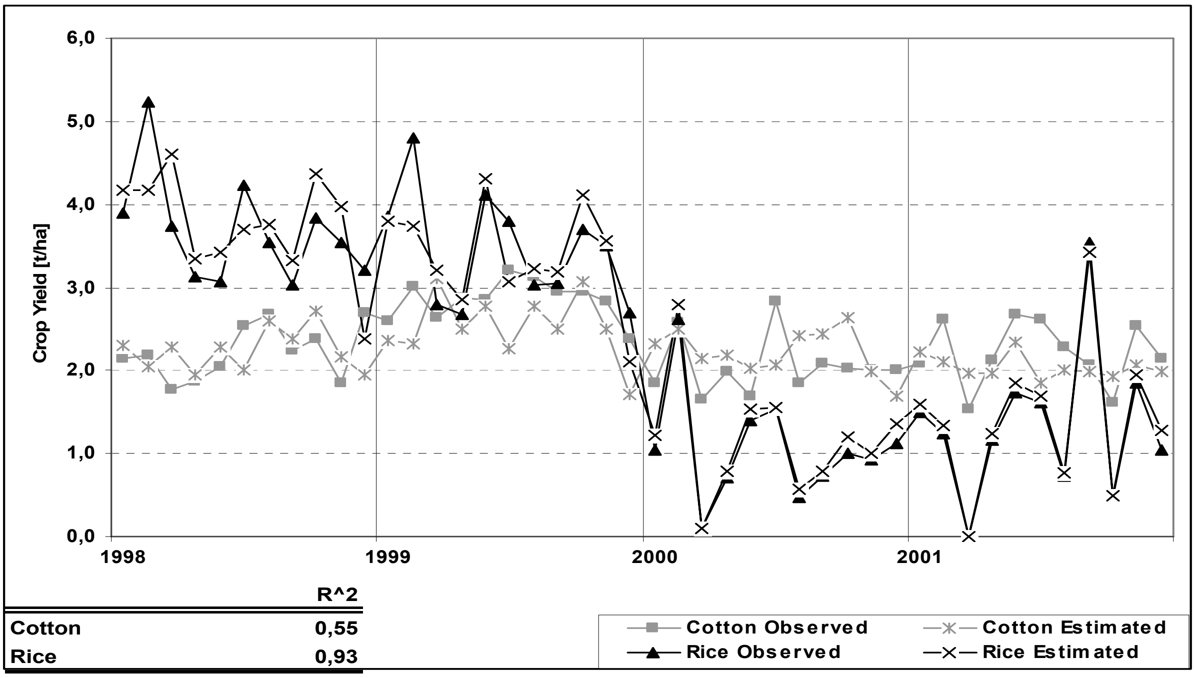
The described model estimates the parameters of the yield functions for each crop and the unknown allocated inputs water, machinery, and labor simultaneously. The accuracy of the model will be measured first according to its ability to replicate the known output quantities with the measurement of determination as indicator. The focus is here on the two main crops, cotton and rice, which together are planted on about 60% of the total crop area in Khorezm. Further relevant indicators to check the plausibility of the model are the estimated input allocations and the estimated price ratios of the inputs.

The Output Side

Figure 3.6 compares the estimated yields for the two main crops cotton and rice with the respective observations. The lines show a different goodness of fit with an R^2 of 0.55 for cotton and 0.93 for rice. The measurements of determination for other crops are not depicted for the sake of readability but are even higher in the case of grains (0.95) and gardening crops (0.94).

Cotton has the weakest result of all crops with the mentioned R^2 of 0.55, which is due to the fact that cotton production is mainly controlled by state regulations and does not respond to variations in total water availability, as other crops do. However, 55% of explained variation from the mean of the observed period still allows some insight into the used technology and can be perceived as an acceptably compatible. Using the fit of the other curves as an indicator for the ability of the model to replicate the observed values, it can be concluded that the model shows a satisfying accuracy.

Figure 3.6 Observed and Estimated Yields of Cotton and Rice [t/ha]



Source: OBLSTAT *2002b and own results*

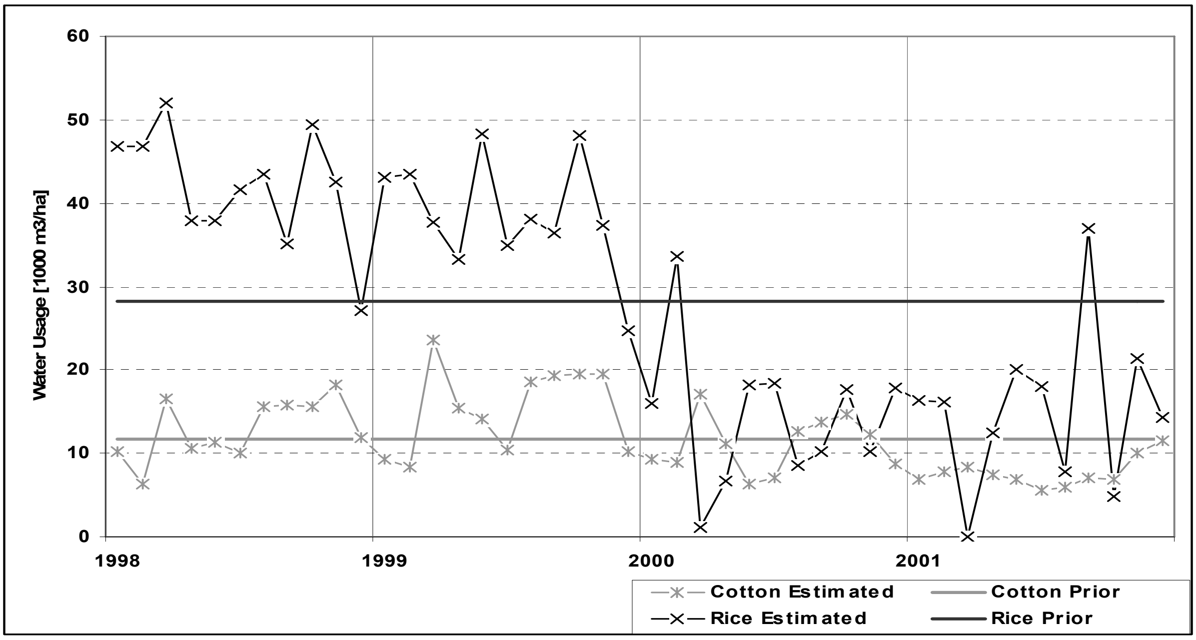
The Input Side

Figure 3.7 depicts the estimated usage of irrigation water per hectare for cotton and rice (thin lines with marks) and the corresponding norm values or priors (bold lines). The prior for rice is 28000 m^3 per hectare and year, for cotton 12000 m^3 per hectare and year. These values were calculated based on norm-values made available by the regional department of the Ministry of Agriculture and Water Resources (OBLSELVODKHOS 2002b), and they include some adjustments for water losses occurring during the transportation from source to field. Effects of poorly prepared field-surfaces due to lack of appropriate leveling and furrow-drawing are also included.

It appears that the estimated values for irrigation water scatter around the prior in the case of cotton. As explained above, cotton production is primarily controlled by the state and thus is seen as a priority crop when it comes to the distribution of water.

Rice production, on the other hand, is not subject to governmental regulations and receives water according to the general availability. The years 2000 and 2001 were drought years and rice producers apparently felt the scarcity by receiving insufficient amounts of water and consequently decreasing yields, as shown in figure 3.7.

Figure 3.7 Water Allocation for Cotton and Rice [1000 m^3/ha]



Source: Own results

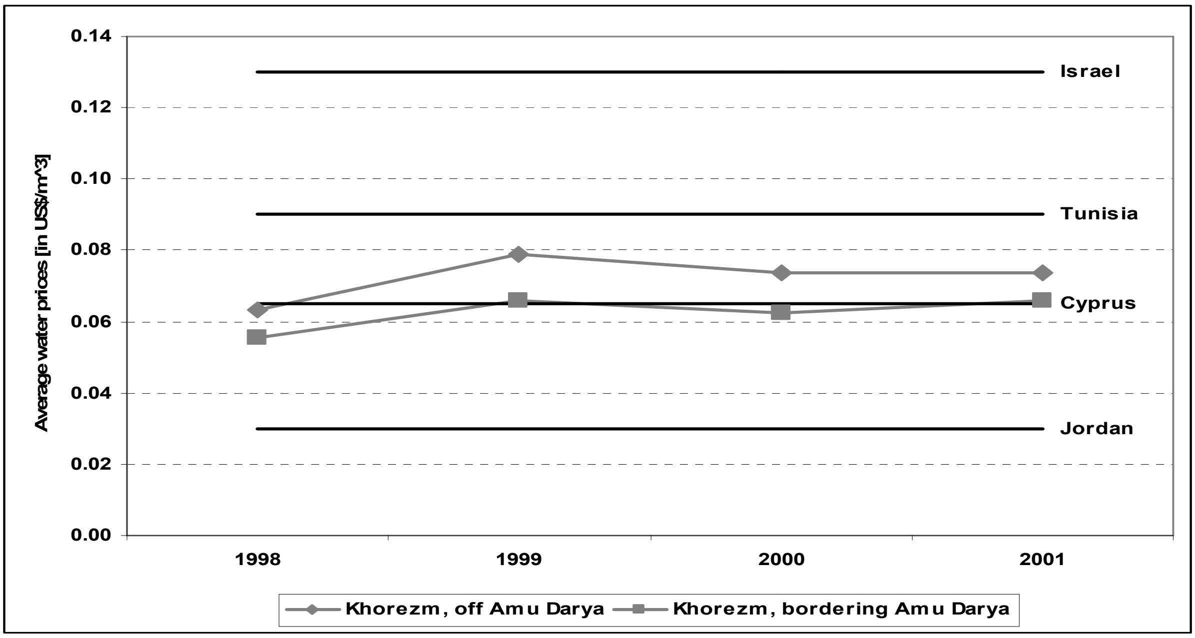
Water Price

The most interesting feature of the estimation above is the potential determination of a price for water. If indeed the price ratios follow equation 3.3.22, then the price per unit of water can be derived at a given average wage per unit of labor input:

$$\frac{\sum_{c} \frac{\frac{\partial Y_{c,n}}{\partial CSI_{water,c,n}}}{\frac{\partial Y_{c,n}}{\partial CSI_{labor,c,n}}}}{\sum_{c} c} \cdot \mathbf{Pr[}CSI_{labor,n}\mathbf{]} = \mathbf{Pr[}CSI_{water,n}\mathbf{]} \qquad (3.3.26)$$

It appears that the ex-post allocations estimated above meet the water-charges in other countries. For example, the charge for each unit of water much higher in Israel, but much less in Jordan. The charges in Tunisia and Cyprus seem to be in the same range as the values Uzbek water consumers might be willing to pay per unit of supplied water.

Figure 3.8 Estimated and Reported Water Prices in different Countries [US$/m³]



Source: CHOHIN-KUPER ET AL 2003, own results

3.3.2 Disaggregation of Industry

The industrial sector is broken up into nine sub-sectors according to data from the Centre for Efficient Economic Policy (CEEP 2003). Unfortunately, the share of the cotton-processing industry is not covered here explicitly. Therefore, it was assumed that it is part of the category “light industry”, which was in 2001 with 20.5% of the total industrial production the largest sub-sector. The share of cotton-processing was calculated by first multiplying the produced quantity of cotton lint (1015 thousand tons in 2001 (CEEP 2003)) with the border price (989 US$/t (FAOSTAT 2004) or 432000 Soum/t at the average exchange rate) which yielded a total value of 439 billion Soum. The share of cotton-processing in the total industry was then determined by dividing this figure by the total industrial production of 2885 billion Soum, resulting in a share of 15.2%. The composition of the industrial sector is shown in table 3.29 below.

Table 3.29 Distribution of Gross Industrial Product

Type of industry		Gross production [billion Soum]	Share in industrial production [percent][1)]	
Power	**APOWE20**	231	8.0	**SHR[IND]**
Fuel	**AFUEL20**	372	12.9	
Metal	**AMETL20**	349	12.1	
Chemical	**ACHEM20**	153	5.3	
Machinery and Equipment	**AMAEQ20**	303	10.5	
Cotton processing	**ACTPR20**	439[2)]	15.2	
Light	**ALGHT20**	152	5.3	
Food	**AFOOD20**	401	13.9	
Other	**AOIND20**	485	16.8	
Total industry		**2885[3)]**	**100.0**	

Sources: *1) CEEP2003*
2) FAOSTAT 2004
3) NSC 2002

3.3.3 Shares and Qualitative Prior

A severe shortcoming of all available datasets, including the very detailed input-output table (125 sectors) from the WORLDBANK (SAM 1995), is that the agricultural sector is split up in animal- and plant-production at best. The micro-SAM desired for this study requires a more detailed representation of the different crops. For this purpose, two auxiliary matrices will be introduced in this chapter. The first one is based on the shares of the agricultural and industrial sub-sectors in their respective meso-totals (tables 3.28 and 3.29). These shares are joined into a vector that includes all activity and commodity accounts of the final micro-SAM (SHR20). This vector is then multiplied with itself in order to achieve a matrix of shares.

$$MICSAM^{shr}_{AC20,AC20'} = SHR20_{AC20} \cdot SHR20_{AC20'} \qquad (3.3.27)$$

With:

$MICSAM^{shr}$:	Share matrix
SHR20:	Vector of shares of elements in the 20-sector aggregation level in the meso-totals
AC20, AC20’:	Index for micro-accounts

The example of the intermediate demand for agricultural products from the industrial sector might illustrate the idea behind this share matrix: The share of food-industry in total industrial production is shown in table 3.29 with 13.9%. In the absence of additional information, the only assumption possible is that this share also applies for the intermediate demand for agricultural goods. Since 14.1% of the agricultural production originates from grain production, the demand from food industry for grains can be obtained by multiplying these shares with the entry in the field [CAGR6, AIND6] in table 3.27.

Following this logic, the shares as shown in tables 3.28 and 3.29 can all be multiplied with each other in order to obtain the share-matrix above, in which then entries would add up to unity and with which the total intermediate demand for agriculture from industry can be split up. Unfortunately, this procedure would indicate for instance demand for fodder crops from the metal-processing industries, which is very unlikely to exist. Because of this reason, an additional matrix is introduced here, which will be called the qualitative prior in the following. This matrix consist of only one and zero-entries; ones where flows are assumed to exist, zeroes where no flows may occur. As an example, the section of intermediate demand from agriculture to agriculture and industry is shown in table 3.30.

Table 3.30 Example for Qualitative Prior Matrix

		Agriculture						
		ACOT20	**AGRN20**	**ARIC20**	**AGAR20**	**AFOD20**	**AOTH20**	**AANM20**
Agriculture	**CCOT20**							
	CGRN20		1					1
	CRIC20			1				
	CGAR20				1			
	CFOD20					1		1
	COTH20						1	
	CANM20							1
Industry	**CPOWE20**	1	1	1	1	1	1	1
	CFUEL20	1	1	1	1	1	1	1
	CMETL20							
	CCHEM20	1	1	1	1	1	1	1
	CMAEQ20	1	1	1	1	1	1	1
	CCTPR20	1						1
	CLGHT20							
	CFOOD20							1
	COIND20	1	1	1	1	1	1	1

Source: Own results

The most important feature of this part of the matrix is that it does not indicate flows between the cropping activities. The only flow allowed here is along the main diagonal, which represents basically the intermediate demand for seeds from each cropping activity. The exception is cotton, which has no demand for its own output. The reason is that the cotton-activity produces raw-cotton, which is entirely processed by the ginneries – here represented as cotton-processing “CCTPR20”. One output of this sector then is seeds, which are transferred back to the cotton producers as indicated by the field [CCTPR20; ACOT20]. The other intermediate demand from agricultural activities to the cotton-processing industry is the demand for oilcake as fodder for animals. This entry indicates that “cotton-processing” does not include only ginning but also milling of the seeds not required for sowing purposes. The reason for merging these sectors lies merely in the lack of data: the share of the cotton industry in total industry had already to be derived from other sources, so that a further splitting would not have been sufficiently supported by the information available.

In order to combine the information in the share-matrix with the qualitative prior and the meso-SAM, an additional matrix that maps the micro- with the meso-dimensions is required (MIC). Its structure is equivalent to the matrix MES as displayed in table 3.26, where macro- and meso-accounts were linked. The following computations combine the relevant matrices:

$$MICSAM^{aux1}_{AC20,AC20'} = MICSAM^{shr}_{AC20,AC20'} \cdot MICSAM^{qual}_{AC20,AC20'} \qquad (3.3.28)$$

$$MESAM^{aux2}_{AC6,AC6'} = \sum_{AC20'} \left[\sum_{AC20} MIC'_{AC6,AC20} \cdot MICSAM^{aux1}_{AC20,AC20'} \right] \cdot MIC_{AC20',AC6'} \qquad (3.3.29)$$

$$MICSAM^{aux3}_{AC20,AC20'} = \sum_{AC6'} \left[\sum_{AC6} MIC_{AC20,AC6} \cdot MESAM^{aux2}_{AC6,AC6'} \right] \cdot MIC'_{AC6',AC20'} \qquad (3.3.30)$$

$$MICSAM^{aux4}_{AC20,AC20'} = \frac{MICSAM^{aux1}_{AC20,AC20'}}{MICSAM^{aux3}_{AC20,AC20'}} \qquad (3.3.31)$$

$$MICSAM^{aux5}_{AC20,AC20'} = \sum_{AC6'} \left[\sum_{AC6} MIC_{AC20,AC6} \cdot MESAM^{bl}_{AC6,AC6'} \right] \cdot MIC'_{AC6',AC20'} \qquad (3.3.32)$$

$$MICSAM^{pr}_{AC20,AC20'} = MICSAM^{aux4}_{AC20,AC20'} \cdot MICSAM^{aux5}_{AC20,AC20'} \qquad (3.3.33)$$

With:

- $MICSAM^{aux1}$: Auxiliary matrix for the primal combination of shares and possible flows
- $MICSAM^{qual}$: Binary matrix for the determination of potential flows between accounts (see table 3.30 for example)
- MIC Binary matrix for mapping meso- and micro-accounts
- $MESAM^{aux2}$: Auxiliary matrix; shrinking micro-SAM into the meso-SAM-dimensions
- $MICSAM^{aux3}$: Re-expended matrix for the calculations of micro-shares in the meso-totals
- $MICSAM^{aux4}$: Shares of micro-SAM in meso-totals
- $MICSAM^{aux5}$: Auxiliary matrix to link micro- with meso-totals
- $MICSAM^{pr}$: Prior information about the micro-SAM

As expressed above, the derived prior does not include all information available. But, in all cases where no other information is provided by any reliable source, $MICSAM^{pr}$ will be used in the following.

3.3.4 Known Values and Meso-SAM

Similar to the balancing process of the meso-SAM, all other information available are included in the model by establishing a matrix of known values. Of particular importance here are trade data, which is the only dataset available for the whole range of the regarded 20 commodities.

$$MICSAM^{bl}_{AC20,AC20'} = MICSAM^{known}_{AC20,AC20'} \qquad (3.3.34)$$

With:

- $MICSAM^{known}$: Matrix of all known entries in the micro-SAM

Furthermore, the sub-totals of the micro-SAM have to be equal to the corresponding entries in the balanced meso-SAM.

$$MESAM^{bl}_{AC6,AC6'} = \sum_{AC20'} \left[\sum_{AC20} MIC'_{AC6,AC20} \cdot MICSAM^{bl}_{AC20,AC20'} \right] \cdot MIC_{AC20',AC6'} \qquad (3.3.35)$$

3.3.5 Balancing the Micro-SAM

Similar to the balancing process described in chapter 3.3.2.10, a set of coefficients which determine the allowable range of deviations from the prior (VC20). Because the entries in the IOT are supported by the 125 sector IOT (WORLD BANK 1995), the values of VC20 were set to 0.1 in this range (10% deviation from the prior), all other entries were allowed to deviate up to 50% from the prior.

$$MICSAM^{\mathbf{max}}_{AC20,AC20'} = MICSAM^{pr}_{AC20,AC20'} \cdot \left(1 + VC20_{AC20,AC20'}\right), \qquad \forall MICSAM^{pr}_{AC20,AC20'} \neq 0 \qquad (3.3.36)$$

$$MICSAM^{\mathbf{min}}_{AC20,AC20'} = MICAM^{pr}_{AC20,AC220'} \cdot \left(1 - VC20_{AC20,AC20'}\right), \qquad \forall MICSAM^{pr}_{AC20,AC20'} \neq 0 \qquad (3.3.37)$$

With:

$MICSAM^{max}$: Maximum allowable entry in the micro-SAM

$MICSAM^{min}$: Minimum allowable entry in the micro-SAM

$MICSAM^{pr}$: A-priori information about the micro-SAM (prior-SAM)

VC20: Coefficient of variation from the prior-SAM

The actual entries in the balanced micro-SAM are then determined by the support points and the corresponding probabilities P20.

$$MICSAM^{bl}_{AC20,AC20'} = \sum_{\mathbf{lim}} P20^{\mathbf{lim}}_{AC20,AC20'} \cdot MICSAM^{\mathbf{lim}}_{AC20,AC20'} \qquad (3.3.38)$$

With:

P20: Probability of each entry in the micro-SAM to equal one of the support points

lim: Index for support points, {min, max}

The probabilities have to add up to unity:

$$\sum_{\mathbf{lim}} P20^{\mathbf{lim}}_{AC20,AC20'} = 1 \qquad (3.3.39)$$

And the totals of rows and corresponding columns have to be equal:

$$\sum_{AC20'} MICSAM^{bl}_{AC20,AC20'} = \sum_{AC20} MICSAM^{bl}_{AC20,AC20'}\ ,\ \forall AC20 = AC20' \qquad (3.3.40)$$

The objective function then is to maximize the entropy under variation of the probabilities:

$$E = -\sum_{AC20}\sum_{AC20'}\sum_{\mathbf{lim}} P20^{\mathbf{lim}}_{AC20,AC20'} \cdot \mathbf{ln}\left(P20^{\mathbf{lim}}_{AC20,AC20'}\right) \qquad (3.3.41)$$

Equation (3.3.41) is maximized subject to constraints (3.3.34) and (3.3.35) as well as (3.3.38), (3.3.39), and (3.3.40). The model is set up in GAMS and solved with the numerical solver CONOPT3.

3.3.6 Adjustment for Cotton Market Regulations

The micro-SAM does not yet include the mechanisms that determine the Uzbek cotton market as discussed in chapter 2.4. Neither state-order price for raw-cotton nor input-subsidies for the producers are regarded by now. The underlying assumption was that subsidies to one sector and taxation of a related sector - as it is the case with raw-cotton production (ACOT20) and cotton-processing (ACTPR20) - would cancel out each other and appear as net-taxation or –subsidization in the governmental budget. Detailed information about the support cotton producers get for the different inputs, be it fertilizer or fuel, is hardly available and would not be too helpful in this context anyway: subsidized inputs, albeit dedicated for the use in cotton-farming, are branched off to grow other crops as well.

Consequently, the subsidies are also spread across the cropping activities and are very difficult to trace as no farmer will know exactly the share of subsidized fertilizer in the total fertilizer-usage for his rice-activity. The approach to book all indirect taxes as commodity-taxes pays off against this background:

Table 3.31 Expenditures of Sub-sectors of the Uzbek Cotton Market, 2001 [in billion Soum, unless otherwise indicated]

Expenditures for:		**Raw cotton production**	**Cotton processing**
Intermediate demand			
Raw cotton production			274
Power		2	4
Fuels		4	
Chemicals		20	1
Machinery		9	2
Cotton processing		15	91
Light industry			2
Other industries		3	2
Transport		11	8
Other services		12	9
Total intermediate demand	**INT**	**76**	**394**
Value added			
Wages		189	14
Operating surplus		144	13
Total value added	**VAD**	**334**	**27**
Total output value at producer prices	**TOVpp=INT+VAD**	**410**	**421**
Other items			
Total raw cotton production [1000t][1]	**Q**	3265	
State order price [Soum/t][2]	**PG**	81330	
Total output value at state-order prices	**TOVgp=Q*PG*(10E-6)**	**266**	
Difference (=subsidy)	**SUB=TOVpp-TOVgp**	**-144**	**0**
Indirect taxes (including export taxes)	**ITX**	**0**	**174**
Trade margins	**TRC**	**9**	**25**
Total expenditures	**TOVmp=TOVpp+SUB+ITX +TRC**	**274**	**620**

Sources: own estimations, except:
1.) FAO 2004
2.) OblStat 2002b

If the input-output relations in the micro-SAM for 1990 are applicable for the situation in 2001 and the share of cotton-production in the total agricultural value-added can indeed approximated by its share in total output, then the column-total of ACOT20 represents the real value of raw-cotton produced in 2001, measured in production cost. This figure is now with 410 billion Soum much higher than the figure obtained by multiplying the total physical production of raw-cotton with the average state-order price, which yields 266 billion Soum (table 3.31).

The difference of 144 billion Soum represents the activity-specific (not input-specific) subsidy the producers of raw-cotton have to receive in order to realize the governmentally set production target at the state price. The raw cotton is then collected and transported to the processing-facilities, for which a mark-up of 9 billion Soum is estimated (table 3.30) whereas indirect taxes are not levied here. The cotton-processing sector is by definition the only demander for raw-cotton and therefore consumes the whole amount. The main difficulty at this stage is that it is not clear from the 125-sector SAM (WB 1995), which physical outputs are produced by the cotton-processing sector. The fact that there is a significant demand from the animal-production sector (table 3.32) implies that ACTPR20 produces oil-cake and therefore includes the milling of cotton seeds.

Table 3.32 Revenues of Sub-sectors of the Uzbek Cotton Market, 2001 [in billion Soum]

Revenues from:	Raw cotton production	Cotton processing
Intermediate demand		
Raw cotton production		*15*
Animal production		*5*
Cotton processing	*274*	*91*
Light industry		*22*
Food industry		*44*
Other industries		*10*
Total intermediate demand	**274**	**187**
Domestic household consumption	**0**	**95**
Exports	**0**	**338**
Total revenues	**274**	**620**

Sources: Own estimations

If so, then the demand of food industries (table 3.32) for products from ACTPR20 refers to cotton-oil and possibly to cotton-seeds as there is no other reasonable input-output relation between those sectors. Intermediate demand from the light-industry sector represents the domestic demand for fibres and the remainder is consequently the domestic consumption demand (for cotton oil) and the export demand from the rest of the world.

After balancing the micro-SAM, the total revenues of exports from CCTPR20 amounts to 338 billion Soum (table 3.32), including the export of cotton-fibre with 329 billion Soum and a small remainder of 9 billion Soum, which represents other cotton outputs such as waste, or the category “carded and combed” (FAOSTAT 2004).

After the adjustments of the micro-SAM for the cotton market, the derived model economy is as close to the real economy of Uzbekistan as the available data allow. It will be used as the base-scenario for the following general-equilibrium analyses.

4 General Equilibrium Analysis

Using the assessment of data and background information in the previous chapters as well as compilation of a social accounting matrix for 2001, it is now possible to set up a general equilibrium model. In turn, this can be used to carry out several experiments in order to analyze the impact of current economy-related policies. It can also be possibly used to identify preferable political strategies to decrease the dependence of the national income on agricultural production, especially irrigated plant production, and foster further growth of private industrial or service activities.
Two sets of experiments will be conducted in this chapter. The first set of experiments will cover reforms of the cotton market. Thus, changes in policies with respect to the production of raw cotton can be linked to changes of policies related to processing and exporting cotton fibers. The second cluster of experiments will address the main purpose of this study, an examination of the impact of further reforms of the agricultural sector, while keeping other branches of the economy unchanged.

4.1 Implementation of the Model

Most of the parameters required are computed by the calibration of the model on the base-year data as represented by the social accounting matrix. There are several parameters that have to be set by the researcher exogenously. These include trade elasticities for the Armington functions as well as elasticities of substitution for the sectoral CES production functions. The data available is not sufficient for a meaningful estimation of these parameters, and consequently, this information must be taken from other sources. WEHRHEIM (2003) compiled a set of the parameters from various publications for the Russian Federation in 1994. MÜLLER AND WEHRHEIM (2004) adapted them for recent years and a more detailed representation of the agricultural sector. Although it may appear questionable to use parameters of a model for the Russian Federation to simulate political measures in Uzbekistan, there are two arguments that support this. First, Russia and Uzbekistan were both part of the Soviet Union and thus subject to the same economic system for the best part of the previous century. Despite more than a decade of independence, the inherited structures and institutions still prevail in both countries, albeit to varying extends.

Second, there were no specific studies for Uzbekistan available at the final stage of this study.

After setting the different exogenous parameters, the model is calibrated such that the model's equilibrium in the base year reflects the observed equilibrium as represented by the social accounting matrix. This fully parameterized model can now be exposed to various exogenous shocks such as changes in world-market prices of major traded commodities, political interventions in markets, or the change of factor assets, such as growth of the population.

4.2 Default Macro-Economic Closures

The model includes three macro-economic balances: the current account of the balance of payments, the savings-investment balance, and the current account of the government (HARRIS ET AL 2001). A set of macro-constraints (or closures) determines the manner in which these accounts are brought into balance (table 4.1). The combination of settings most appropriate for the economy of interest is not entirely evident from the available data and, thus, to some extent based on the assumptions of the researcher. Because the outcome of the conducted experiments depends on the choice of closures, alternative settings can be tested and compared. At any rate, a default setting has to be specified so that other scenarios might be tested against it. The default setting will be discussed in this chapter, whereas alternative settings are described in the subsequent chapter whenever experiments with alternative settings are carried out.

Current account of the government

As can be seen in the first column of table 4.1, the model offers three options for the closure of the current account of the government, which distinguish between two different scenarios. In the first case, governmental savings are flexible and the direct tax rates are fixed (GOV-1). In the second case, the current savings of the government are fixed, but the tax rates are flexible. Here, two possible changes of the tax rates are distinguished: The tax rates may be changed for selected institutions by equal percentage points (GOV-2) or the account is balanced by changing the tax rates at an equal rate for all institutions (GOV-3). In order to identify the most appropriate setting, the relevant information from governmental accounts as shown in chapter 3.3.1.2, together with the current accounts of the private sector (chapter 3.3.1.5) are summarized in figure 4.1 below.

Table 4.1 Alternative Closure Rules for Macro System Constraints[1)]

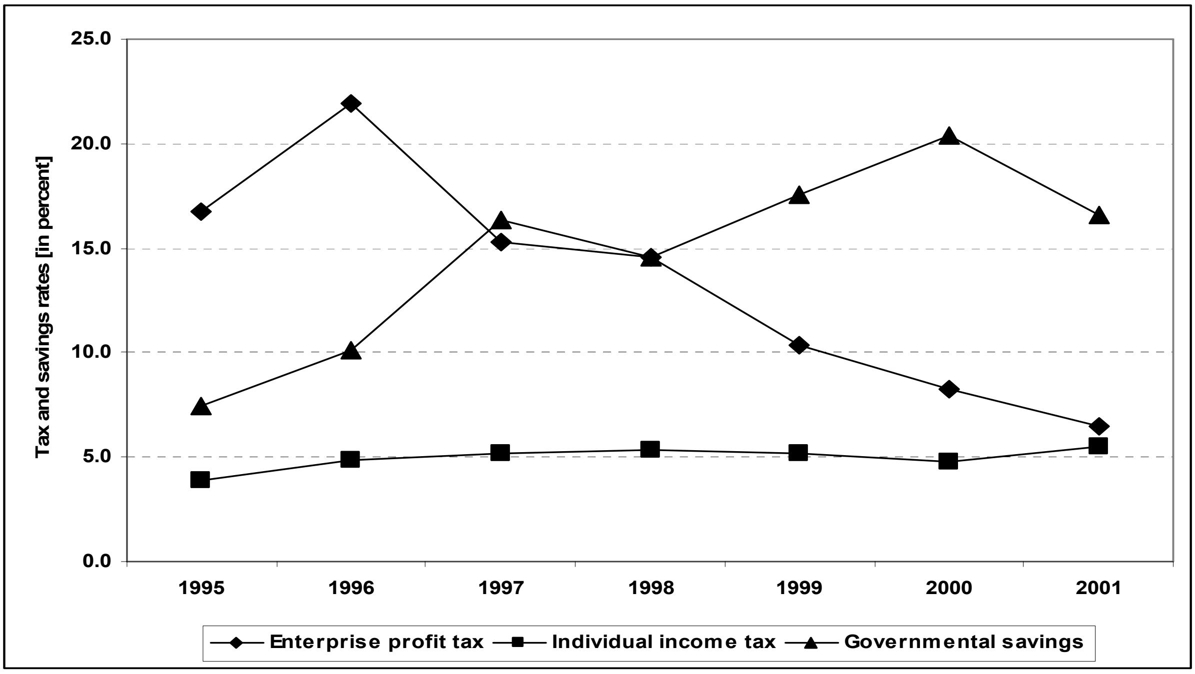
Government	Rest of World	Savings-Investment
GOV-1: Flexible government savings; fixed direct tax rates	ROW-1: Fixed foreign savings; flexible real exchange rate	SI-1: Fixed capital formation; uniform MPS[2)] point change for selected institutions
GOV-2: Fixed government savings; uniform direct tax rate point change for selected institutions	ROW-2: Flexible foreign savings; fixed real exchange rate	SI-2: Fixed capital formation; scaled MPS for selected institutions
GOV-3: Fixed government savings; scaled direct tax rates for selected institutions		SI-3: Flexible capital formation; fixed MPS for all non-government institutions
		SI-4: Fixed investment and government consumption absorption shares (flexible quantities); uniform MPS point change for selected institutions
		SI-5: Fixed investment and government consumption absorption shares (flexible quantities); scaled MPS for selected institutions

Source: HARRIS ET AL 2001

Notes: *1) For the specified closure rules, the choice for one of the three constraints does not constrain the choice for the other two constraints*
2) MPS: marginal propensity to save.

While the individual income tax rate remains comparatively stable at a level around 5.0%, the profit taxes were lowest during 1997 and 1998 when the current account of the Uzbek government showed the highest savings rate. It seems that there is an inverse relationship between these rates, and it can therefore be argued that in times of high savings the government cuts down the taxes levied on enterprises. However, the dynamics shown above do not necessarily lead to the conclusion that there is a functional relationship between those variables as they are subject to numerous other influences. However, the specification of the default model closures can still be based on this observation. Since government savings change over time without a significant trend and the profit tax rates have decreased constantly since 1997, possibly as a result of political decisions, closure GOV-1 appears to be the most appropriate.

Figure 4.1 Direct Tax Rates and Government Savings Rate, 1995-2001 (in percent)



Sources: Own results

Notes: Enterprise profit tax rate was calculated as share of paid tax in total revenues of enterprises
Individual income tax rate was calculated as share of paid tax in total revenues of households
Governmental savings tax rate was calculated as share of savings in total governmental revenues

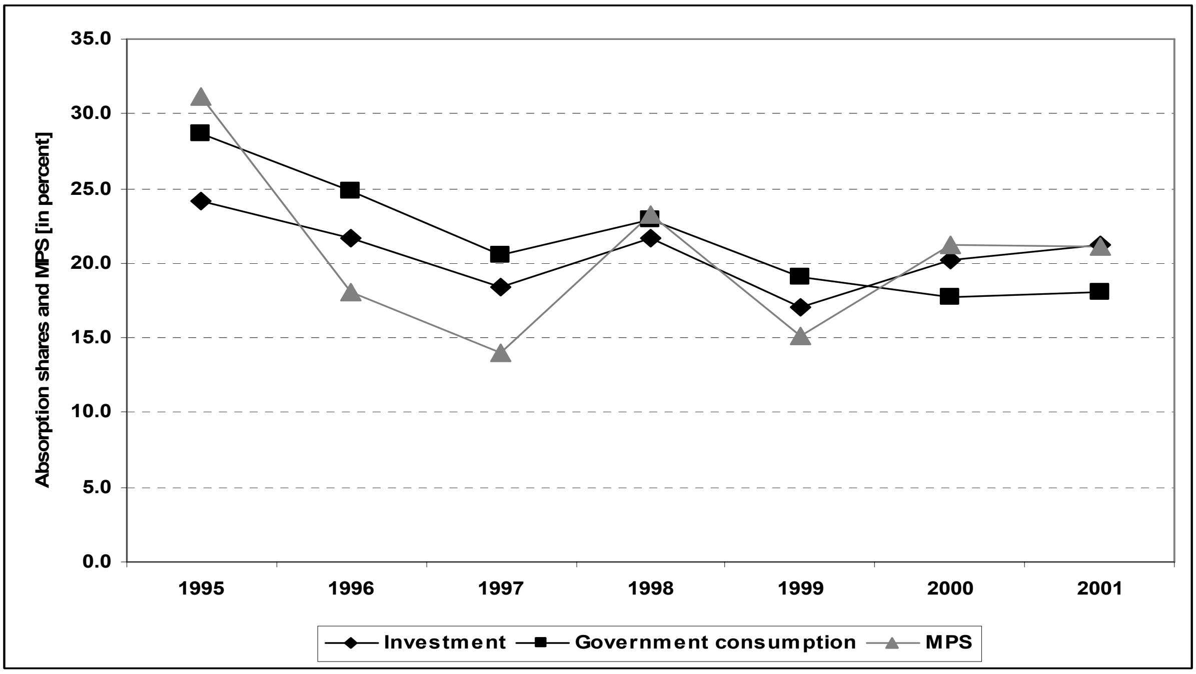
Current account of the balance of payments

In the context of relations with the rest of the world, the standard model offers two different settings: foreign savings are fixed at the initial level and the exchange rate is adapted to balance this account, or the exchange rate is fixed and the foreign savings held flexible. As outlined in chapter 2.6, the Uzbek government had implemented a strict regime on the Soum during 1995 and 2001, and therefore the closure ROW-2 is chosen here as a default setting for the further analysis. Changes in the exchange rate regime will be covered by experiments.

Savings-investment balance

The possible closures for this account can be distinguished by savings-driven and investment-driven settings. The first and second options (SI-1, SI-2) are strictly investment-driven because the capital formation is fixed at the initial level and the marginal propensity to save (MPS) is adjusted for selected institutions in order to meet the demand for total savings. In contrast, SI-3 represents a savings-driven scenario in which total savings are determined by the MPS and total capital formation has to follow the supply of savings. SI-4 and SI-5 are basically investment-driven closures, but with one difference in that in SI-1 and SI-2, the total investments are not fixed at the base-year level but rather computed as fixed share of the total absorption of the model economy. The savings are then adjusted accordingly via the MPS.

Figure 4.2 MPS and Shares of Investments and Governmental Consumption in Total Absorption, 1995-2001 (in percent)



Sources: Own results

Note: Absorption is the sum of domestically produced and imported commodities minus exports.

In order to decide which closure to choose here, it is helpful to decide about the time frame that should be covered by the model. If the analyst wants to run short-run scenarios for a period of only one year, then it is appropriate to fix the investments for this year (HARRIS ET AL 2001) in order to focus on the welfare effects of policy changes in this period and to avoid potentially misleading effects due to changes in investment demand. One question for this study is the effects of changes in factor availability, which occur during two or more periods and it is adequate against this

background to expect changes in investments. Therefore, closures SI-4 and SI-5 are preferable. The specification that absorption shares of investment and governmental consumption are fixed is to some extent supported by the information from the system of national accounts (figure 4.2). Both shares declined from 1995 to 1997 but seem to stabilize around a rate of 20.0% since then. The MPS of households follows the same dynamics but is more volatile in the observed period, which also supports closures SI-4 and SI-5 which allow the MPS to vary for selected institutions.
The question whether the savings rates of the institutions should be adapted by equal percentage points (SI-4) or at a uniform rate (SI-5) is not relevant here, because the household-sector is the only domestic non-governmental institution that saves parts of its income. Consequently, both specifications would yield the same result.

Restrictions of Factor Markets

In addition to the closures related to the macroeconomic accounts, there needs to be consideration of another set of constraints that shapes the markets for primary factors in the model economy. The default setting for factor markets in the model allows factors to move unconstrained between sectors. If the marginal return to capital is higher in agriculture than in industry, then the model will tend to move capital towards agriculture. This will happen with infinite speed due to the static nature of the used model. Given the high degree of governmental influence on the economy of Uzbekistan, the assumption of flexible, fully mobile factor markets is not appropriate, even if the modeled period during which the factors may be re-allocated is sufficiently long to allow even long-term capital goods like buildings to be transferred into other forms of usage. WEHRHEIM (2003) offers a solution for this shortcoming in his application of the proposed CGE model to the Russian economy by restricting the used quantities of factors in some sectors to remain at a specific level. As a consequence, the model will adjust the respective factor wages in order to find a new equilibrium, and this equilibrium differs from the outcome of a pure neoclassical scenario. The default setting for the model is therefore a rigid market for capital, whereas all other factors may move freely from one sector to another. An exception here is the land allocated for cotton and wheat production. These areas are assumed to be subject to governmental regulations and not to individual decisions of producers.

4.3 Simulations

The following simulations will expose the model economy to several shocks that enforce the finding of a new equilibrium. Basically three different types of shocks can be distinguished here:

1. Political: Changes of variables or parameters in the model that are subject to domestic (economy-related) political decisions (tax and tariff rates).
2. Physical/Technological: Changes in available factors of production (decrease of arable land, increase of population) and technological parameters (increase of total factor productivity because of technological progress).
3. External: Changing export- and import-prices, thus changes in terms-of-trade.

Because of the comparative-static nature of the model, it has to be kept in mind that some possible scenarios are related to a shorter time frame than others. An increase in the labor force at a significant level takes place over a couple of years whereas the impact of a decreased tax rate for producers of a certain commodity might be observed without much delay. In order to maintain the comparability of the different experiments, a medium-term setting of four years is chosen for all cases.

All single shocks to which the model economy is exposed will be called ‘items’. The different experiments consist of either none or several items, depending on the aim of the experimental setting. In general, the experiments are carried out in ascending order according to the number of included shocks. The first is always the base scenario, followed by experiments comprising one change from the initial equilibrium (or item). In a third and fourth step, if desired, the cumulative effects of two or more items will be considered.

4.3.1 Cotton Market

The structure of the model allows for the separation of three policies regarding the cotton producing and processing sub-sectors (see also chapter 3.3.3). The first policy is the enforcement of production targets for the producers. The second policy involves the input-subsidies for the producers, which are also a subsidy for the processing sector since they can acquire the raw cotton at a price below the theoretical price that would occur on a non distorted market. Third, the processing sector is subject to export taxes. The following simulations will examine the way which changes of policies related to the cotton market would influence the state of agriculture as a whole, the incomes of the different agricultural enterprises, and finally, the government's budget. Beside political changes, it is important to consider possible future events that will influence the Uzbek cotton sector. This can involve a further increase of investments in the domestic processing industries and also further declines of the world market prices for cotton fibres. These items shape the set-up of the following experiments.

Item 1 Liberalization of the Uzbek cotton market

In this scenario, the subsidies for producers of raw cotton and the indirect taxes paid by the cotton processing industries are reduced by 50%. Production targets are abolished.

Item 2 Increase of capital stock in the light-industrial sectors

According to the United States Department for Agriculture (USDA 2004), domestic processing of cotton fibre increased between 1995 and 2001 by 5.2% p.a. It is not clear to which extend this development was caused by investments in the processing sector, but several authors (e.g. POMFRET 2003 or IMF 2000) point out the attempt of the Uzbek government to foster a larger domestic processing industry via centralized investments. If the assumption of linear input-output relations between intermediate demand and aggregated primary factors is appropriate, then an increase of the domestic intermediate demand for cotton fibre by 5.2% coincides with an equal increase of the stock of primary factors in the light-industrial sector. After the calibration of the model on the base year, the production function of the light-industrial sector has an elasticity of production for the factor capital of 0.66. All else equal, a further increase of the level of the domestic processing of cotton fibre by 5.2 percentage points per year would require an increase of the capital stock by 7.9% p.a., or 16.5% within a time frame of four years. This value is therefore used in the simulations.

Item 3 Further decline of the world market price for cotton-products

Between 1995 and 2001, the world market price for cotton lint declined by 8.7% p.a. Because time series data for the composed commodity produced by light industries is not available, it is assumed that the trend observed on the cotton market applies there, too. Within a medium length time frame of four years, the total decline in both, commodities produced by cotton-processing and light industry, would amount to 30.5% as compared to the base year. These three items are combined as follows:

Table 4.2 Design of Experiments Related to the Uzbek Cotton Market

	Item			
	1. Liberalization of cotton market	**2. Investment in cotton-processing industries**	**3. Decline of world-market prices for cotton products**	**Experiment**
Items in experiment **+: included** **- : not included**	**-**	**-**	**-**	**Base**
	+	**-**	**-**	Exp. 1.1
	-	**+**	**-**	Exp. 1.2
	-	**-**	**+**	Exp. 1.3
	+	**+**	**-**	Exp. 1.4
	+	**-**	**+**	Exp. 1.5
	-	**+**	**+**	Exp. 1.6
	+	**+**	**+**	Exp. 1.7

The major macroeconomic results for these experiments are listed in table 4.3. In order to display an indicator for welfare-changes, the equivalent variation of any of the simulations was calculated. Because consumers' behavior is represented as a linear expenditure system in the model used here (LES, see Appendix 1, Table A4, institution block), the equivalent variation could be computed based on CREEDY AND SLEEMAN (2005) for the case of price- and income variation as discussed in JUST ET AL. (1982). The equivalent variation of price changes is in this case calculated at the terminal income level after the change of the policy and then added to the income change induced by the new policy.

The liberalization of the Uzbek cotton market without any other changes (Experiment 1.1) causes some remarkable effects for the model economy. As a first result, the domestic consumer prices for raw cotton and cotton products increase by 54.5% and 34.5% respectively, which causes a higher level of production in this sub-sector (output quantity of raw cotton increases by 18.3%, cultivated area by 17.2%, employed labor by 31.3%). The marginal valued productivity of water (+10.4%), land (+11.9%), and other physical capital (+36.5%) increases, while the average equilibrium wage for labor declines by -2.9%. As a consequence, the total income of the private sector declines by -2.8%, thus realizing together with changing prices an equivalent variation of -3.5% compared to the initial income level. The revenues of the government on the other hand increase by 3.3%, mainly because of higher incomes from direct taxes and other sources, such as capital income from governmentally owned enterprises. This growth stems from the 2.1 % increased operating surplus, which generates higher profit taxes and higher direct revenues from state owned enterprises, particularly from agricultural enterprises like Shirkats. As a consequence, the benefits of private households from the increased operating surplus are limited, which results, together with declining wages, in a lower total private income. This lowered income of the private sector explains also the declining level of private consumption (-3.7%) and, together with the changed price-ratios, the negative equivalent variation of -3.5%. It must be noted here, that the outcomes of this first simulation are likely to be different if it was carried out with a dataset for years after 2005 when for instance Shirkats were entirely abolished.

Due to declining governmental consumption, the current public savings increase tremendously by 134.5%. It appears that the cotton sector as a whole is not so much a source of governmental income but rather a burden for the governmental budget. The fact that household incomes decline by 2.8% after the liberalization indicates that the subsidies paid to cotton producers have a strong positive impact on the income of the private sector as a whole. The overall impact of such a reform is much more significant then the increase of the capital stock in the cotton-processing industries (Experiment 1.2). The impact of this simulation on the governmental current revenues is zero, whereas the private incomes would benefit to a small extend (0.1% increase of income). In the cumulative scenario (Experiment 1.4) in which both, the liberalization as well as the increase in capital stock take place, the liberalization effect appears to be dominant as the differences of the results are minimal, thus indicating a comparatively small impact of the increased capital stock.

In experiments 1.3 and 1.5, the effects of declining world-market prices for cotton-fibre and textile products are investigated. Exp. 1.3 represents a scenario in which the price change occurs in the context of a regulated cotton market whereas in Exp. 1.5 the market is liberalized. The effect of changing world-market prices for those two groups of commodities is bi-directional in both scenarios. Exports of cotton fibre decline in response to the lower prices, while imports of textile products increase.

Table 4.3 Macroeconomic Results of Experiments Related to the Uzbek Cotton Market

	Base Billion Soum	Exp. 1.1	Exp. 1.2	Exp. 1.3	Exp. 1.4	Exp. 1.5	Exp. 1.6	Exp. 1.7
		change to base [in percent]						
Generation of national income								
Wages	2020	-3.5	0.1	0.2	-3.5	-2.9	0.3	-2.8
Operating surplus	2440	2.1	0.1	-0.1	2.2	2.5	0.0	2.6
Indirect taxes less subsidies	544	-3.8	0.2	3.6	-3.6	2.2	3.7	2.3
Imports	1378	-3.4	0.1	3.8	-3.3	2.7	3.8	2.8
Total	**6381**	**-1.4**	**0.1**	**1.2**	**-1.3**	**0.8**	**1.2**	**0.9**
Distribution of national income								
Investment	1041	-15.2	0.2	17.5	-14.9	13.7	17.7	13.9
Exports	1400	15.7	-0.2	-17.8	15.5	-8.9	-17.9	-9.1
Government consumption	781	-4.2	0.0	4.6	-4.1	3.3	4.6	3.3
Private consumption	3160	-3.7	0.2	3.3	-3.6	0.3	3.5	0.4
Total	**6381**	**-1.4**	**0.1**	**1.2**	**-1.3**	**0.8**	**1.2**	**0.9**
Current revenues of the government								
Indirect taxes less subsidies	544	-3.8	0.2	3.6	-3.6	2.2	3.7	2.3
Other tax and non-tax revenues	405	12.9	-0.2	-18.8	12.8	-6.8	-19.0	-6.9
Total	**949**	**3.3**	**0.0**	**-6.0**	**3.4**	**-1.7**	**-6.0**	**-1.6**
Current expenditures of the government								
Government consumption	781	-4.2	0.0	4.6	-4.1	3.3	4.6	3.3
Transfers to households	104	-21.5	0.7	4.2	-20.9	-14.0	4.9	-13.3
Governmental savings	64	134.5	-1.7	-150.9	133.2	-42.4	-152.2	-43.3
Total	**949**	**3.3**	**0.0**	**-6.0**	**3.4**	**-1.7**	**-6.0**	**-1.6**
Current revenues of the private sector								
Wages	2020	-3.5	0.1	0.2	-3.5	-2.9	0.3	-2.8
Governmental transfers	104	-21.5	0.7	4.2	-20.9	-14.0	4.9	-13.3
Other income	1919	-0.9	0.0	-1.3	-0.9	-2.7	-1.3	-2.6
Total	**4043**	**-2.8**	**0.1**	**-0.4**	**-2.7**	**-3.1**	**-0.3**	**-3.0**
Welfare measure								
Equivalent variation [% of initial income]		**-3.5**	**2.9**	**-1.1**	**-3.3**	**-1.8**	**1.9**	**-4.6**

Source: Own results

Note: The base values displayed here differ to some extend from the values shown in the system of national accounts. The reason is just a different way of accounting in the model.

The domestic consumer prices for textiles drop in both experiments 1.3 and 1.5. In contrast, the domestic prices for cotton fibre decline in experiment 1.3 (-7.8%), while the price increase induced by the market liberalization in experiment 1.5 compensates this effect and causes higher domestic prices for cotton fibre (+20.7%). The differences here show the relevance of the market regulations for the state budget: in the case of declining textile prices, the Uzbek government would realize income losses of -6% while maintaining the current policies and -1.7% when liberalizing the cotton markets, whereas the equivalent variation indicates that the aggregated household would lose -1.1% of its disposable income in the protected scenario, while it loses -1.8% if markets are liberalized. As in experiment 1.1, the increasing operating surplus is partly channeled to the government budget via state-owned enterprises, such that the private households have only a limited advantage.

Also in the final experiment 1.7 in which all three shocks are cumulated, the changing world market prices shape the major part of the model output. The best settings for the private Uzbek households are the non-liberalization scenarios plus investments in the cotton-processing industries (Exp. 1.2 and 1.6). In the case of stable prices, total incomes incline slightly by 0.1%, while declining prices affect the household incomes by -0.3%, which is much less than in all other experiments. From this point of view, it seems that the private households are the beneficiaries of the cotton-market policy within the settings of 2001. As mentioned above, state-owned farming enterprises were abolished after 2005 and the future distribution of capital revenues to either the private or the government sector is subject to the outcomes of the current reforms of the Uzbek economy as a whole.

Another important question in the context of this study are the effects of changing policies on the land and water allocation. The existence of a production target for cotton implies that producers would not opt for this activity if they were not forced to do so. This might be true in the case of the actually low price for raw cotton, but under the settings of Exp. 1.1, the producer price increases by 56.5%. Thus, despite the lower subsidies, the area under cotton increases by 17% and the respectively allocated amount of water by 18% in this case (see tables 4.4 and 4.5 below).

These first experiments indicate that the policies for the cotton sector are not effective in securing governmental revenues but rather to support the incomes of private households.

Table 4.4 Land Allocation in Experiments Related to Uzbek Cotton Market

	Base 1000 ha	Exp. 1.1	Exp. 1.2	Exp. 1.3	Exp. 1.4	Exp. 1.5	Exp. 1.6	Exp. 1.7
		change to base [in percent]						
Crop area								
Cotton	1488	17	0	0	17	-24	0	-24
Grain	1644	-9	0	-2	-9	12	-2	12
Rice	166	-8	0	-5	-8	10	-5	10
Fruit and Vegetable	464	-10	0	1	-10	20	1	19
Fodder	1052	-5	0	-6	-5	6	-6	6
Other crops	80	0	0	0	0	0	0	0

Source: Own results

It has to be noted here, that the potential governmental revenues from the multiple exchange-rate system (MERS) are not included. This system, however, is not only a source of governmental income via centralized exports but also represents a system of import subsidies and it was therefore assumed that both effect compensate each other. Another important observation is that the cotton production in the model economy would be very sensitive to changes of world-market prices if production targets were abolished.

Table 4.5 Water Allocation in Experiments Related to Uzbek Cotton Market

	Base km^3	Exp. 1.1	Exp. 1.2	Exp. 1.3	Exp. 1.4	Exp. 1.5	Exp. 1.6	Exp. 1.7
		change to base [in percent]						
Water usage								
Cotton	4	18	0	-33	18	-25	-33	-25
Grain	4	-8	0	14	-8	10	14	10
Rice	2	-7	0	10	-7	8	10	8
Fruit and Vegetable	1	-9	0	17	-9	18	16	18
Fodder	4	-4	0	9	-4	4	9	4
Other crops	0	-8	0	16	-8	19	16	19

Source: Own results

4.3.2 Agricultural Sector Reforms

Agriculture as a whole is the main source of income for the rural population in Uzbekistan. Therefore it is likely that changes within this sector may have the strongest influence on the current accounts of the private households. For the following simulations it is important to keep in mind that the base year 2001 was a drought year with an extraordinary low supply of irrigation water. Thus, any scenario that helps to improve the situation of the rural population with the severe restriction of water availability will be helpful to develop strategies for the further performance of the Uzbek agriculture. The leading assumption is that other sectors of the economy are not subject to any further change, which also allows maintaining the *ceteris-paribus* setting of the experiments.

As in the previous chapter, the conducted experiments will be constructed based on several items. Again, the first item refers to the liberalization of the cotton market. The second item builds on the observation of low animal productivity. The total factor productivity of the animal producing sector is increased by 10% in order to gain insights into the relative importance of this sub-sector. A contrasting third item will be the improvement of total factor productivity for the main crops cotton, cereals, and rice at the same rate. These items are displayed in table 4.6, the results in table 4.7.

Table 4.6 Design of Experiments Related to the Agricultural Sector

	Item			
	1. Liberalization of cotton market	**2. Improvement of total factor productivity of animal production**	**3. Improvement of total factor productivity of main crops**	**Experiment**
Items in experiment **+: included** **- : not included**	-	-	-	**Base**
	+	-	-	Exp. 2.1
	-	+	-	Exp. 2.2
	-	-	+	Exp. 2.3
	+	+	-	Exp. 2.4
	+	-	+	Exp. 2.5
	-	+	+	Exp. 2.6
	+	+	+	Exp. 2.7

Increases of total factor productivity are here assumed to occur exogenously, thus neglecting the sources of the increase. This simplification was made in order to allow for the comparison of ceteris-paribus scenarios. If, for instance, increased public expenditures for research and development are the source of the higher total factor productivity, the question for financing such expenditure immediately occurs. Consequently, any simulation of increasing productivity would be accompanied with changing governmental expenditures and revenues, which in turn may affect the behavior of the affected agents.

In order to maintain the ceteris-paribus characteristic of the simulations, increases of total factor productivity are assumed to occur exogenously.

Table 4.7 Macroeconomic Results of Experiments Related to Agricultural Sector

	Base Billion Soum	**Exp. 2.1**	**Exp. 2.2**	**Exp. 2.3**	**Exp. 2.4**	**Exp. 2.5**	**Exp. 2.6**	**Exp. 2.7**
		change to base [in percent]						
Generation of national income								
Wages	2020	-3.5	-0.9	0.9	-4.5	-2.1	0.0	-3.2
Operating surplus	2440	2.1	3.6	0.9	5.7	2.6	4.6	6.2
Indirect taxes less subsidies	544	-3.8	2.3	-0.1	-1.5	-4.5	2.2	-2.2
Imports	1378	-3.4	1.9	-0.4	-1.5	-4.4	1.6	-2.5
Total	**6381**	**-1.4**	**1.7**	**0.6**	**0.3**	**-1.0**	**2.3**	**0.7**
Distribution of national income								
Investment	1041	2.5	-3.6	-12.6	-22.3	-1.0	-19.6	2.5
Exports	1400	-0.4	5.2	15.5	23.3	4.7	23.0	-0.4
Government consumption	781	0.1	-1.2	-4.1	-6.3	-1.1	-6.2	0.1
Private consumption	3160	2.8	0.3	-1.1	-3.5	3.1	-0.9	2.8
Total	**6381**	**-1.4**	**1.7**	**0.6**	**0.3**	**-1.0**	**2.3**	**0.7**
Current revenues of the government								
Indirect taxes less subsidies	544	-3.8	2.3	-0.1	-1.5	-4.5	2.2	-2.2
Other tax and non-tax revenues	405	12.9	-1.2	8.0	12.4	20.2	6.8	19.8
Total	**949**	**3.3**	**0.8**	**3.4**	**4.4**	**6.1**	**4.2**	**7.2**
Current expenditures of the government								
Government consumption	781	-4.2	0.1	-1.2	-4.1	-6.3	-1.1	-6.2
Transfers to households	104	-21.5	-0.4	4.9	-22.2	-14.6	4.6	-15.2
Governmental savings	64	134.5	11.6	56.3	150.3	188.8	68.3	205.2
Total	**949**	**3.3**	**0.8**	**3.4**	**4.4**	**6.1**	**4.2**	**7.2**
Current revenues of the private sector								
Wages	2020	-3.5	-0.9	0.9	-4.5	-2.1	0.0	-3.2
Governmental transfers	104	-21.5	-0.4	4.9	-22.2	-14.6	4.6	-15.2
Other income	1919	-0.9	-0.8	-0.2	-1.6	-0.8	-1.0	-1.5
Total	**4043**	**-2.8**	**-0.9**	**0.5**	**-3.6**	**-1.8**	**-0.4**	**-2.7**
Welfare measure								
Equivalent variation [% of initial income]		**-3.5**	**-0.6**	**0.5**	**-7.6**	**0.8**	**-1.5**	**-6.4**

Source: Own results

Table 4.8 Land Allocation in Experiments Related to Agricultural Sector

	Base 1000 ha	Exp. 2.1	Exp. 2.2	Exp. 2.3 change to base [in percent]	Exp. 2.4	Exp. 2.5	Exp. 2.6	Exp. 2.7
Crop area								
Cotton	1488	17	0	0	16	32	0	31
Grain	1644	-9	2	-16	-9	-22	-14	-22
Rice	166	-8	2	-13	-8	-18	-12	-18
Fruit and Vegetable	464	-10	2	0	-11	-9	2	-10
Fodder	1052	-5	4	-1	-4	-4	3	-2
Other crops	80	0	0	0	0	0	0	0

Source: Own results

The equivalent variation for the private households is highest in the case of experiments 2.3 and 2.5, in which the productivity of the main cropping activities was increased by 10%. Higher productivity of the animal producing sector as represented in experiments 2.2, 2.4, and 2.6 is not preferable in any of the examined scenarios. But as in the previous case of cotton-market liberalization, the depicted results originate from a database for 2001 and might not be representative for the years after 2005. The main question to be answered in this experimental setting is whether to promote either plant- or animal production. It appears that promoting plant production is preferable in any case, although the comparatively low level of animal productivity in Uzbekistan might be seen as an indicator that improvements here can be achieved with minor efforts than in the case of plant production. Increasing total factor productivity in both, animal and plant producing sectors (2.6) appears to have the highest contribution to the overall economic performance, thus being an indicator how to follow a possible path of development regardless the institutional background.

Table 4.9 Water Allocation in Experiments Related to Agricultural Sector

	Base km^3	Exp. 2.1	Exp. 2.2	Exp. 2.3 change to base [in percent]	Exp. 2.4	Exp. 2.5	Exp. 2.6	Exp. 2.7
Water usage								
Cotton	4	18	0	11	17	34	10	32
Grain	4	-8	0	-12	-8	-21	-13	-21
Rice	2	-7	-1	-10	-7	-17	-10	-17
Fruit and Vegetable	1	-9	-1	4	-10	-8	3	-9
Fodder	4	-4	1	3	-3	-3	4	-1
Other crops	0	-8	-1	4	-9	-7	3	-8

Source: Own results

5 Conclusions and Outlook

The starting point of this study was the drought during the years 2000 and 2001, which had a serious impact on agricultural production in Uzbekistan in general and on the regions located at the tail end of the Amu Darya River like the district of Khorezm in particular. An analysis of the available information concerning water availability, agricultural production systems, and the related influence of the government, yielded several remarkable conclusions: The per-hectare usage of irrigation water is comparatively high in Uzbekistan and the expansion of the irrigated land since independence in 1992 went along with a significant increase of overall water demand. While the average water supply from the rivers Amu Darya and Syr Darya does not show a declining trend, the variance of the flows is large enough to make water scarcities more likely events in the future years, if the average water demand per unit of irrigated area remains at the observed high level. The issue of water scarcity was discussed in some detail and it turned out that in the observed period the water supply between May and August reveals the highest variance around the monthly mean, which is also the period with the highest demand for irrigation water. Furthermore, the probability in the down-stream located regions of Khorezm of getting a recommended (or "norm") quantity of water per unit of irrigated area during the irrigation period from April to September was calculated to average 74% in 1999 and much less in some districts that are not directly adjacent to the river and which had a probability of less than 64% (chapter 2.4).

The high water demand has two obvious reasons: High water need per hectare and increased irrigated area. Less obvious are the driving forces behind such developments. The rural population in Uzbekistan shows a higher growth rate in the post-independence Uzbekistan than the urban population and the dominant employer remains the agricultural sector. Hence, the share of employment in the industrial sectors decreased to some extend since independence, whereas the residual sector 'other services' shows growing shares of employment (see chapter 2.2). The main sub-sectors within this aggregated 'other service' sectors are governmental services like education and public services, while private service activities play a only a minor role. In the absence of employment opportunities in private, non-agricultural sectors, the rural labor force remains by and large in agriculture, which causes an ever increasing demand for irrigated area. However, the observation that further extension of the irrigated area seems to get closer to a natural constraint underlines that such a form of development is not sustainable. Given the significant influence of the Uzbek government on the current process of economic transformation, it can be concluded that the policies implemented to promote a “gradual” transformation are the very reason for the persisting dependency on and the low resource-efficiency of the agricultural sector. Markets for agricultural inputs and outputs are either severely distorted or not existent, with the consequence that any economic analysis of the given system required detailed information about the related political measures, which was hardly available in most cases. A further difficulty was the fact that agriculture and especially the cotton and wheat producing sub-sectors and the related processing industries play a pivotal role in the overall structure of the Uzbek economy. For instance is the export of cotton fibre a dominant source of foreign exchange earnings and domestic wheat production a tool to decrease the expenditures on food imports. Despite governmental proclamations to shift the structure of the national economy away from agriculture to industrial production, agriculture still is the largest employer and generator of national income. In order to get a better understanding of the impact of the governmental regulations on the markets for raw cotton and cotton fibre, both markets were analyzed on the basis of sequential partial equilibrium analysis in chapter 2.5. It turned out that a clear decision, which sector - raw cotton producers or processor -, benefits more in the Uzbek system could not be made within this analytical framework. This theoretical insight is of particular interest as it is usually assumed that the system exploits the farmers and supports the processing industries. Considering the manifold for- and backward linkages of the cotton-related sectors, it was decided to apply a general equilibrium approach to analyze potential reforms of the national economy. The main properties of this modeling approach are discussed in chapter 3.1. Of particular interest here is the question, whether or not the assumption of a perfectly functioning market-economy equilibrium is appropriate for the analysis of the Uzbek economy. It was shown graphically, that based on a variation of some of the assumptions that constitute the perfect market principle, the impact of governmental regulation would force a hypothetical model economy away from an optimal solution, but nevertheless would find an equilibrium state.

One major obstacle for the implementation of a general equilibrium model was the lack of a consistent dataset. This issue was addressed in four steps. First, a system of national accounts was compiled (chapter 3.2) from various sources and assembled into a social-accounting matrix at a highly aggregated level (macro-SAM). This macro-SAM was in a second step used as the framework of a more detailed meso-SAM. The a-priory entries in this meso-SAM were calculated based on available data, but the resulting SAM was unbalanced. In order to estimate a balanced meso-SAM, a maximum entropy approach was chosen that used the unbalanced SAM as prior information and the macro-SAM as constraint. The thus balanced meso-SAM was then used as constraint for the finall micro-SAM, which was complied in a third step. A major task here was the disaggregation of agricultural inputs and the computation of hypothetical prices for the major inputs, e.g. water or machinery. The hypothetical price of water was of particular interest here because no such prices do exist yet at the time being in Uzbekistan. The estimated results for a water price in Uzbekistan were validated by comparing them with water prices in different countries. It turned out that the estimated price ranged between charges for irrigation water in Cyprus or Tunisia.

These results were, among others, used to establish a unbalanced micro-SAM that includes 20 productive sectors, seven of which in agriculture, nine in industry, and four service sectors. This micro-SAM was then balanced in a fourth step by imposing the meso-SAM as adding-up constraint. This process yielded a micro-SAM which includes systematically all available information. It is, nevertheless, only a second-best option and the acquisition of a SAM from one single source would be preferable. A standard version of a general equilibrium model was then calibrated on this micro-SAM and used to carry out several simulations in chapter 4. These simulations cluster around the Uzbek market for cotton at three stages within the value-added chain: Production of raw cotton, processing of raw cotton and processing of cotton fibre in the textile industry. All discussed changes were always related to this core element. The conducted general equilibrium analyses yielded one major insight: In all experiments that abolished the cotton market regulations, the consequence was increasing revenues for the government and lower revenues for the private sector. This unexpected result is of particular interest, because it is usually assumed that the combination of production targets and the low prices for raw cotton allow the government of Uzbekistan to transfer significant resources out of agriculture. But as already indicated by the partial market analyses (chapter 2.5), the net-effect of the regulations as a whole is not necessarily disadvantageous for farmers. Input-subsidies for agricultural producers offset to some extent the negative effects of low output prices and production targets. In addition, the low prices for raw cotton are also a subsidy for the processing industry and as such, an additional burden for the governmental budget. It has again to be mentioned that this result is based on a compiled database and therefore subject to some uncertainty. Nevertheless, these general equilibrium results are consistent with the theoretical considerations in chapter 2.5.

The negative consequences of a liberalization of the Uzbek cotton market for the agricultural producers occur because of the abolishment of input subsidies. This decrease of indirect revenues could be partly offset by improving the total factor productivity of main crops and animal production activities. While a higher efficiency of main crop production yielded better results in the general equilibrium framework, the scope for improvements here might be limited when it comes to real-world applications. Enhancement of the productivity of plant production might require significant investments, which would require the existence of a functioning credit system. This issue was not addressed here, but in the context of the banking system of Uzbekistan, severe adjustments appear to be necessary before farmers can be provided with affordable credits. But given the low productivity of livestock in Uzbekistan, even small improvements might cause remarkable effects. Here, a more detailed study of the animal producing sectors would help to derive applicable recommendations for animal farmers.

Another important issue is the further development of industrial sectors. Given the declining trend of world-market prices for cotton fibre and textiles, investment in the domestic textile industries might not be an optimal decision. A more detailed analysis of the comparative advantages of industrial activities in Uzbekistan would be desirable in this context. Especially the agro-processing industries besides the fibre-industries might be worthwhile to be considered here, as they can take advantage from the high level of agricultural production in Uzbekistan.

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Appendices

Appendix 1: Algebraic Model Description

Table A1: The parameters of the model

Parameter	Name of parameter
	Parameters other than tax rates
α^{a}_{A}	shift parameter for top level CES function
α^{ac}_{C}	shift parameter for domestic commodity aggregation fn
α^{q}_{C}	shift parameter for Armington function
α^{t}_{C}	shift parameter for CET function
α^{va}_{A}	shift parameter for CES activity production function
$\beta^{h}_{A,C,H}$	marg shr of hhd cons on home com c from act a
$\beta^{m}_{C,H}$	marg share of hhd cons on marketed commodity c
$cwts_{C}$	consumer price index weights
δ^{a}_{A}	share parameter for top level CES function
$\delta^{ac}_{A,C}$	share parameter for domestic commodity aggregation fn
δ^{q}_{C}	share parameter for Armington function
δ^{t}_{C}	share parameter for CET function
$\delta^{va}_{F,A}$	share parameter for CES activity production function
$dwts_{C}$	domestic sales price weights
$\gamma^{h}_{A,C,H}$	per-cap subsist cons for hhd h on home com c fr act a
$\gamma^{m}_{C,H}$	per-cap subsist cons of marketed com c for hhd h
$ica_{C,A}$	intermediate input c per unit of aggregate intermediate
$int\,a_{A}$	aggregate intermediate input coefficient
iva_{A}	aggregate value added coefficient
$icd_{C,CP}$	trade input of c per unit of comm'y cp produced & sold dom'ly
$ice_{C,CP}$	trade input of c per unit of comm'y cp exported
$icm_{C,CP}$	trade input of c per unit of comm'y cp imported
$mps01_{INS}$	0-1 par for potential flexing of savings rates
$mpsbar_{INS}$	marg prop to save for dom non-gov inst ins (exog part)
$qdst_{C}$	inventory investment by sector of origin
$qb\,arg_{C}$	exogenous (unscaled) government demand
$qbarinv_{C}$	exogenous (unscaled) investment demand
ρ^{a}_{A}	CES top level function exponent

ρ_C^{ac}	domestic commodity aggregation function exponent
ρ_C^{q}	Armington function exponent
ρ_C^{t}	CET function exponent
ρ_A^{va}	CES activity production function exponent
$shif_{INS,F}$	share of dom. inst'on i in income of factor f
$shii_{INS,INSP}$	share of inst'on i in post-tax post-sav income of inst ip
$supernum_H$	LES supernumerary income
$\vartheta_{A,C}$	yield of commodity C per unit of activity A
$tins01_{INS}$	0-1 par for potential flexing of dir tax rates
$trnsfr_{INS,AC}$	transfers fr. inst. or factor ac to institution ins
	Tax rates
ta_A	rate of tax on producer gross output value
te_C	rate of tax on exports
tf_F	rate of direct tax on factors (soc sec tax)
$tinsbar_{INS}$	rate of (exog part of) direct tax on dom inst ins
tm_C	rate of import tariff
tq_C	rate of sales tax
tva_A	rate of value-added tax

Table A2: The sets of the model

Set	Name of set
	a. model sets
AC	global set for model accounts - aggregated microsam accounts
$ACNT_{AC}$	all elements in AC except TOTAL
A_{AC}	activities
$ACES_A$	activities with CES fn at top of technology nest
$ALEO_A$	activities with Leontief fn at top of technology nest
C_{AC}	commodities
CD_C	commodities with domestic sales of output
CDN_C	commodities without domestic sales of output
CE_C	exported commodities
CEN_C	non-export commodities

CM_C	imported commodities
CMN_C	non-imported commodities
CX_C	commodities with output
F_{AC}	factors
INS_{AC}	institutions
$INSD_{INS}$	domestic institutions
$INSDNG_{INSD}$	domestic non-government institutions
H_{INSDNG}	households
	b. calibration sets
$CINV_C$	fixed investment goods
CT_C	transaction service commodities
CTD_{AC}	domestic transactions cost account
CTE_{AC}	export transactions cost account
CTM_{AC}	import transactions cost account
	c. report sets
$AAGR_A$	agricultural activities
$ANAGR_A$	non-agricultural activities
$CAGR_C$	agricultural commodities
$CNAGR_C$	non-agricultural commodities
EN_{INSDNG}	enterprises
$FLAB_F$	labor
$FLND_F$	land
$FCAP_F$	capital

Table A3: The variables in the model

Variable	Name of variable
CPI	consumer price index (PQ-based)
DPI	index for domestic producer prices (PDS-based)
DMPS	change in marginal propensity to save for selected inst
DTINS	change in domestic institution tax share
EG	total current government expenditure
EH_H	household consumption expenditure

EXR	exchange rate
FSAV	foreign savings
GADJ	government demand scaling factor
GOVSHR	govt consumption share of absorption
GSAV	government savings
IADJ	investment scaling factor (for fixed capital formation)
INVSHR	investment share of absorption
MPS_{INS}	marginal propensity to save for dom non-gov inst ins
MPSADJ	savings rate scaling factor
PA_{A}	output price of activity a
PDD_{C}	demand price for com'y c produced & sold domestically
PDS_{C}	supply price for com'y c produced & sold domestically
PE_{C}	price of exports
$PINTA_{A}$	price of intermediate aggregate
PM_{C}	price of imports
PQ_{C}	price of composite good c
PVA_{A}	value added price
PWE_{C}	world price of exports
PWM_{C}	world price of imports
PX_{C}	average output price
$PXAC_{A,C}$	price of commodity c from activity a
QA_{A}	level of domestic activity
QD_{C}	quantity of domestic sales
QE_{C}	quantity of exports
$QF_{F,A}$	quantity demanded of factor f from activity a
QFS_{F}	quantity of factor supply
QG_{C}	quantity of government consumption
$QH_{C,H}$	quantity consumed of marketed commodity c by household h
$QHA_{A,C,H}$	quantity consumed of home commodity c from activity a by household h
$QINT_{C,A}$	quantity of intermediate demand for c from activity a
$QINTA_{A}$	quantity of aggregate intermediate input
$QINV_{C}$	quantity of fixed investment demand
QM_{C}	quantity of imports
QQ_{C}	quantity of composite goods supply

QT_C	quantity of trade and transport demand for commodity c
QVA_A	quantity of aggregate value added
QX_C	quantity of aggregate marketed commodity output
$QXAC_{A,C}$	quantity of ouput of commodity c from activity a
TABS	total absorption
$TINS_{INS}$	rate of direct tax on domestic institutions ins
TINSADJ	direct tax scaling factor
$TRII_{INS,INSP}$	transfers to dom. inst. insdng from insdngp
WALRAS	savings-investment imbalance (should be zero)
WALRASSQR	Walras squared
WF_F	economy-wide wage (rent) for factor f
$WFDIST_{F,A}$	factor wage distortion variable
YF_F	factor income
YG	total current government income
$YIF_{INS,F}$	income of institution ins from factor f
YI_{INS}	income of (domestic non-governmental) institution ins

Table A4: The equations of the model

Name of equation	**Equation**
	Price block*
domestic import price	$PM_C = pwm_C \cdot (1+tm_C)\cdot EXR + \sum_{CT} PQ_{CT} \cdot icm_{CT,C}$
domestic export price	$PE_C = pwe_C \cdot (1+te_C)\cdot EXR + \sum_{CT} PQ_{CT} \cdot ice_{CT,C}$
dem price for com'y c produced and sold domestically	$PDD_C = PDS_C + \sum_{CT} PQ_{CT} \cdot icd_{CT,C}$
value of sales in domestic market	$PQ_C \cdot (1+tq_C)\cdot QQ_C = PDD_C \cdot QD_C + PM_C \cdot QM_C$
value of marketed domestic output	$PX_C \cdot QX_C = PDS_C \cdot QD_C + PE_C \cdot QE_C$
output price for activity a	$PA_A = \sum_{C} PXAC_{A,C} \cdot \vartheta_{A,C}$
price of aggregate intermediate input	$PINTA_A = \sum_{C} PQ_C \cdot ica_{C,A}$
value-added price	$PA_A \cdot (1-ta_A)\cdot QA_A = PVA_A \cdot QVA_A + PINTA_A \cdot QINTA_A$
consumer price index	$CPI = \sum_{C} cwts_C \cdot PQ_C$

domestic producer price index	$DPI = \sum_{CD} dwts_{CD} \cdot PDS_{CD}$

Production and trade block

CES aggregate prod fn (if CES top nest)	$QA_A = \alpha^a_A \cdot \left[\delta^a_A \cdot QVA_A^{-\rho^a_A} + (1-\delta^a_A)\cdot QINT_A^{-\rho^a_A}\right]^{-\frac{1}{\rho^a_A}}$
CES aggregate first-order condition (if CES top nest)	$QVA_A = QINTA_A \cdot \left(\frac{PINTA_A}{PVA_A}\cdot\frac{\delta^a_A}{1-\delta^a_A}\right)^{\frac{1}{1+\rho^a_A}}$
Leontief aggreg intermed dem (if Leontief top nest)	$QINTA_A = inta_A \cdot QA_A$
Leontief aggreg value-added dem (if Leontief top nest)	$QVA_A = iva_A \cdot QA_A$
CES value-added production function	$QVA_A = \alpha^{va}_A \cdot \left(\sum_F \delta^{va}_{F,A}\cdot QF_{F,A}^{-\rho^{va}_A}\right)^{-\frac{1}{\rho^{va}_A}}$
CES value-added first-order condition	$WF_F \cdot wfdist_{F,A} = PVA_A \cdot (1-tva_A)\cdot QVA_A$ $\cdot \left(\sum_{FP}\delta^{va}_{FP,A}\cdot QF_{FP,A}^{-\rho^{va}_A}\right)^{-1} \cdot \delta^{va}_{F,A}\cdot QF_{F,A}^{-\rho^{va}_A-1}$
intermediate demand for commodity c from activity a	$QINT_{C,A} = ica_{C,A}\cdot QINTA_A$
production function for commodity c and activity a	$QXAC_{A,C} + \sum_H QHA_{A,C,H} = \vartheta_{A,C}\cdot QA_A$
output aggregation function	$QX_C = \alpha^{ac}_C \cdot \left(\sum_A \delta^{ac}_{A,C}\cdot QXAC_{A,C}^{-\rho^{ac}_C}\right)^{-\frac{1}{\rho^{ac}_C}}$
first-order condition for output aggregation function	$PXAC_{A,C} = PX_C\cdot QX_C\cdot\left(\sum_{AP}\delta^{ac}_{AP,C}\cdot QXAC_{AP,C}^{-\rho^{ac}_C}\right)^{-1}$ $\cdot\delta^{ac}_{A,C}\cdot QXAC_{A,C}^{-\rho^{ac}_C-1}$
CET function	$QX_C = \alpha^t_C\cdot\left(\delta^t_C\cdot QE_C^{\rho^t_C} + (1-\delta^t_C)\cdot QD_C^{\rho^t_C}\right)^{\frac{1}{\rho^t_C}}$
domestic sales and exports for outputs without both	$QE_C = QD_C\cdot\left(\frac{PE_C}{PDS_C}\cdot\frac{1-\delta^t_C}{\delta^t_C}\right)^{\frac{1}{\rho^t_C-1}}$
export supply	$QX_C = QD_C + QE_C$
composite commodity aggregation function	$QQ_C = \alpha^q_C\cdot\left(\delta^q_C\cdot QM_C^{-\rho^q_C} + (1-\delta^q_C)\cdot QD_C^{-\rho^q_C}\right)^{-\frac{1}{\rho^q_C}}$

first-order condition for composite commodity cost min	$QM_C = QD_C \cdot \left(\frac{PDD_C}{PM_C} \cdot \frac{\delta_C^q}{1-\delta_C^q} \right)^{\frac{1}{1+\rho_C^q}}$
comp supply for com's without both dom. sales and imports	$QQ_C = QD_C + QM_C$
demand for transactions (trade and transport) services	$QT_C = \sum_{CP} \left(icm_{C,CP} \cdot QM_{CP} + ice_{C,CP} \cdot QE_{CP} + icd_{C,CP} \cdot QD_{CP} \right)$

Institution block

factor incomes	$YF_F = \sum_{A} WF_F \cdot wfdist_{F,A} \cdot QF_{F,A}$
factor incomes to domestic institutions	$YIF_{INSD,F} = shif_{INSD,F} \cdot \left[(1-tf_f) \cdot YF_F - trnsfr_{row,F} \cdot EXR \right]$
total incomes of domest non-gov't institutions	$YI_{INSDNG} = \sum_{F} YIF_{INSDNG,F} + \sum_{INSDNGP} TRII_{INSDNG,INSDNGP}$ $+ trnsfr_{INSDNG,gov} \cdot CPI + trnsfr_{INSDNG,row} \cdot EXR$
household consumption expenditures	$TRII_{INSDNG,INSDNGP} = shii_{INSDNG,INSDNGP}$ $\cdot (1-MPS_{INSDNGP}) \cdot (1-TINS_{INSDNGP}) \cdot YI_{INSDNGP}$
transfers to inst'on ins from inst'on insp	$EH_H = \left(1 - \sum_{INSDNG} shii_{INSDNG,H} \right) \cdot (1-MPS_H) \cdot (1-TINS_H) \cdot YI_H$
LES cons demand by hhd h for marketed commodity c	$PQ_C \cdot QH_{C,H} = PQ_C \cdot \gamma_{C,H}^m + \beta_{C,H}^m$ $\cdot \left(EH_H - \sum_{CP} PQ_{CP} \cdot \gamma_{CP,H}^m - \sum_{A} \sum_{CP} PXAC_{A,CP} \cdot \gamma_{A,CP,H}^h \right)$
LES cons demand by hhd h for home commodity c fr act a	$PXAC_{A,C} \cdot QHA_{A,C,H} = PXAC_{A,C} \cdot \gamma_{A,C,H}^h + \beta_{A,C,H}^h$ $\cdot \left(EH_H - \sum_{CP} PQ_{CP} \cdot \gamma_{CP,H}^m - \sum_{AP} \sum_{CP} PXAC_{AP,CP} \cdot \gamma_{AP,CP,H}^h \right)$
fixed investment demand	$QINV_C = IADJ \cdot qbarinv_C$
government consumption demand	$QG_C = GADJ \cdot qbarg_C$
total government expenditures	$YG = \sum_{INSDNG} TINS_{INSDNG} \cdot YI_{INSDNG} + \sum_{f} tf_F \cdot YF_F + \sum_{A} tva_A \cdot PVA_A \cdot ($ $+ \sum_{A} ta_A \cdot PA_A \cdot QA_A + \sum_{C} tm_C \cdot pwm_C \cdot QM_C \cdot EXR$ $+ \sum_{C} te_C \cdot pwe_C \cdot QE_C \cdot EXR + \sum_{C} tq_C \cdot PQ_C \cdot QQ_C$ $+ \sum_{F} YIF_{gov,F} + trnsfr_{gov,row} \cdot EXR$

total government income	$EG = \sum_{C} PQ_C \cdot QG_C + \sum_{INSDNG} trnsfr_{INSDNG,gov} \cdot CPI$

System constraint block

composite commodity market equilibrium	$\sum_{A} QF_{F,A} = QFS_F$
factor market equilibrium	$QQ_C = \sum_{A} QINT_{C,A} + \sum_{H} QH_{C,H} + QG_C + QINV_C + qdst_C + QT_C$
current account balance (of RoW)	$\sum_{C} pwm_C \cdot QM_C + \sum_{F} trnsfr_{row,F} = \sum_{C} pwe_C \cdot QE_C$ $+ \sum_{INSD} trnsfr_{INSD,row} + FSAV$
government balance	$YG = EG + GSAV$
direct tax rate for inst ins	$TINS_{INSDNG} = tinsbar_{INSDNG} \cdot (1 + TINSADJ \cdot tins01_{INSDNG})$ $+ DTINS \cdot tins01_{INSDNG}$
marg prop to save for inst ins	$MPS_{INSDNG} = mpsbar_{INSNDNG} \cdot (1 + MPSADJ \cdot mps01_{INSDNG})$ $+ DMPS \cdot mps01_{INSDNG}$
savings-investment balance	$\sum_{INSDNG} MPS_{INSDNG} \cdot (1 - TINS_{INSDNG}) \cdot YI_{INSDNG} + GSAV$ $+ FSAV \cdot EXR = \sum_{C} PQ_C \cdot QINV_C + \sum_{C} PQ_C \cdot qdst_C + WALRAS$
total absorption	$TABS = \sum_{C} \sum_{H} PQ_C \cdot QH_{C,H} + \sum_{A} \sum_{C} \sum_{H} PXAC_{A,C} \cdot QHA_{A,C,H}$ $+ \sum_{C} PQ_C \cdot QG_C + \sum_{C} PQ_C \cdot QINV_C + \sum_{C} PQ_C \cdot qdst_C$
investment share in absorption	$INVSHR \cdot TABS = \sum_{C} PQ_C \cdot QINV_C + \sum_{C} PQ_C \cdot qdst_C$
government consumption share in absorption	$GOVSHR \cdot TABS = \sum_{C} PQ_C \cdot QG_C$
Objective function	$WALRASSQR = WALRAS \cdot WALRAS$

*Notational convention inside equations:

*Parameters and "invariably" fixed variables are in lower case.

*"Variable" variables are in upper case.

Appendix 2: Aggregation Scheme

Meso-SAM	Micro-SAM	Worldbank
Agriculture	Raw cotton Cereals Rice Fruit and vegetable Fodder crops Other plant products	104-Agricultural crops, 107-Forestry
	Animals	105-Animal husbandry
Industry	Electric power	1-Power
	Fuel industry	2-Oil products, 3-Refineries, 4-Gas & gas products, 5-Coal, 6-Combustible shales, 7-Peat
	Metal industry	8-Ferrous ores, 9-Ferrous metals, 10-Coking products, 11-Fire resistant materials, 12-Metal products, 13-Non-ferrous ores
	Chemical industry	15-Mineral chemistry, 16-Basic chemicals, 17-Chemical fibres, 18-Synthetic resins, 19-Plastic products, 20-Paints & lacquers, 21-Synthetic paints, 22-Synthetic rubber, 23-Organic chemicals, 24-Tires, 25-Rubber & asbestos, 26-Other chemical products
	Machine building	27-Energy & power equipment, 28-Hoisting technology, 29-Mining , 30-Transportation, 31-Railway equipment, 32-Electrotechnical , 33-Cable products, 34-Pumps & chemical equipment, 35-Machine tools, 36-Forging/Pressing, 37-Casting, 38-Precision instruments, 39-Synthetic diamonds, 40-Tools & dies, 41-Autos & parts, 42-Bearings, 43-Tractors & agricultural, 44-Construction , 45-Communal , 46-Light industry , 47-Processed food , 48-Trade & dining , 49-Printing 50-Household appliances, 51-Sanitary equipment, 52-Shipbuilding, 53-Radio electronics, 54-Other industries , 55-Metal construction, 56-Metal products, 57-Repair
	Cotton processing	73-Cotton products
	Light manufacturing	74-Flax products, 75-Wool products, 76-Silk products, 77-Hosiery/Knitwear, 78-Other textile products, 79-Sewn goods, 80-Leather
	Food industries	81-Sugar, 82-Bread & baked products, 83-Confections, 84-Vegetable oils, 85-Perfume oils, 86-Distilleries, 87-Wines, 88-Fruit/Vegetables, 89-Tobacco, 90-Other food, 91-Meat products, 92-Dairy products, 93-Fish products, 94-Microbiology, 95-Flour & cereals, 96-Animal feed

	Other industries	58-Logging, 59-Sawmills & lumber, 60-Plywood, 61-Furniture, 62-Paper & pulp, 63-Wood chemistry products, 64-Cement, 65-Asbestos products, 66-Roofing & insulation, 67-Prefab concrete, 68-Wall materials, 69-Construction ceramics, 70-Linoleum products, 71-Other construction materials, 72-Glass & porcelain, 97-Pharmaceuticals, 98-Medical equipment, 99-Medical products, 100-Other products, 14-Non-ferrous metals
Construction	Construction	102-Construction
Trade	Trade	115-Trade Markup
Transport and communication	Transport and communication	108-Transport cost, 109-Road services, 110-Communication
Other services	Other services	106-Agricultural services, 111-Information processing, 112-Other prod. sectors, 114-Transport Markup, 116-Distribution, 117-Procurement, 122-Housing Communal, 123-Non-productive transport, 124-Non-productive communication, 125-Education, 126-Culture, 127-Health & recreation, 129-Science, 130-Banking & insurance, 131-State administration, 133-Defense & other

Appendix 3: Balanced Micro-SAM for Uzbekistan

(2001 in billion Soum, current)

Part 1 of 3

	ACOT20	AGRN20	ARIC20	AGAR20	AFOD20	AOTH20	AANM20	APOWE20	AFUEL20	AMETL20	ACHEM20	AMAEQ20	ACTPR20	ALGHT20	AFOOD20	AOIND20	ACON20	ATRD20	ATCM20	AOTS20
CCOT20													274							
CGRN20		4					24								25			22		34
CRIC20			1												4			6		6
CGAR20				7											20			45		59
CFOD20					4		103													
COTH20															3			3		4
CANM20							10							11	175			2		28
CPOWE20	2	1		1			4	5	18	2	7	6	4	1	4	28	6	22	16	29
CFUEL20	4	2		2	1		6	70	77	2	4	2			1	12	7	8	32	36
CMETL20										168	2	69				18				
CCHEM20	20	11	2	9	4	1	1	2	12	3	64	12	1	2	1	14	12	2	3	71
CMAEQ20	9	6	1	5	3	1	15	4	4	3	4	56	2	1	1	16	63	57	10	467
CCTPR20	15						5						91	22	44	10				
CLGHT20							1			1	1	2	2	50	1	6				
CFOOD20							100								147	1				
COIND20	3	2		2	1		13	2	1	1	3	3	2		4	87	173	24	4	24
CCON20																				
CTRD20																				
CTCM20	11	22	4	21	9	2	88	42	54	3	7	13	8	3	20	106	127	39	58	63
COTS20	12	17	3	16	7	2	69	43	19	6	7	50	9	7	45	100	46	294	74	439
TRCD20																				
TRCM20																				
TRCE20																				
LAB20	189	43	12	93	13	10	316	25	43	3	9	28	14	13	56	66	156	172	87	672
ARE20	14	15	2	5	9															
WAT20	17	15	9	6	18	1														
CAP20	113	101	11	32	45	5	425	47	80	7	11	45	13	24	107	125	139	354	292	355

	ACOT20	AGRN20	ARIC20	AGAR20	AFOD20	AOTH20	AANM20	APOWE20	AFUEL20	AMETL20	ACHEM20	AMAEQ20	ACTPR20	ALGHT20	AFOOD20	AOIND20	ACON20	ATRD20	ATCM20	AOTS20
HHO20																				
SHR20																				
FER20																				
DKH20																				
ENT20																				
GOV20																				
ITD20																				
ITM20																				
ITE20																				
DTX20																				
RES20																				
SUB20	-144																			-199
S-I20																				
ROW20																				

Part 2 of 3

	CCOT20	CGRN20	CRIC20	CGAR20	CFOD20	COTH20	CANM20	CPOWE20	CFUEL20	CMETL20	CCHEM20	CMAEQ20	CCTPR20	CLGHT20	CFOOD20	COIND20	CCON20	CTRD20	CTCM20	COTS20
ACOT20	266																			
AGRN20		72																		
ARIC20			14																	
AGAR20				161																
AFOD20					100															
AOTH20						16														
AANM20							195													
APOWE20								240												
AFUEL20									309											
AMETL20										198										
ACHEM20											118									
AMAEQ20												286								
ACTPR20													421							
ALGHT20														118						
AFOOD20															641					
AOIND20																586				
ACON20																	729			
ATRD20																		1049		
ATCM20																			576	
AOTS20																				2086
TRCD20	9	9	2	7	4	1	58	7	35	3	7	23	8	36	169	95	81		33	224
TRCM20		4						3		2	11	87		2	24				15	
TRCE20				4		1		21	13	2	4	7	17		7	64			12	
LAB20																				
ARE20																				
WAT20																				
CAP20																				
HHO20																				
SHR20																				

	CCOT20	CGRN20	CRIC20	CGAR20	CFOD20	COTH20	CANM20	CPOWE20	CFUEL20	CMETL20	CCHEM20	CMAEQ20	CCTPR20	CLGHT20	CFOOD20	COIND20	CCON20	CTRD20	CTCM20	COTS20
FER20																				
DKH20																				
ENT20																				
GOV20																				
ITD20	0	5	1	3	2		28	4	20	2	6	16	9	18	80	49	44	64	18	126
ITM20		2						2		2	8	44		1	12				10	
ITE20				3				10	7	3	2	4	165		4	30			8	
DTX20																				
RES20																				
SUB20																				
S-I20																				
ROW20		32						26		144	172	569		22	150				261	

Part 3 of 3

	TRCD20	TRCM20	TRCE20	LAB20	ARE20	WAT20	CAP20	HHO20	SHR20	FER20	DKH20	ENT20	GOV20	ITD20	ITM20	ITE20	DTX20	RES20	SUB20	S-I20	ROW20
ACOT20																					
AGRN20								167													
ARIC20								31													
AGAR20								36													
AFOD20								12													
AOTH20								5													
AANM20								984													
APOWE20																					
AFUEL20																					
AMETL20																					
ACHEM20																					
AMAEQ20																					
ACTPR20																					
ALGHT20								14													
AFOOD20								18													
AOIND20								3													
ACON20																					
ATRD20																					
ATCM20																					
AOTS20																					
CCOT20																					
CGRN20								15													
CRIC20																					
CGAR20								9													39
CFOD20																					
COTH20								2													6
CANM20								56													
CPOWE20								19													142
CFUEL20								30													88
CMETL20																					101
CCHEM20								44													38

	TRCD20	TRCM20	TRCE20	LAB20	ARE20	WAT20	CAP20	HHO20	SHR20	FER20	DKH20	ENT20	GOV20	ITD20	ITM20	ITE20	DTX20	RES20	SUB20	S-I20	ROW20
CMAEQ20								66												187	55
CCTPR20								95													338
CLGHT20								133													
CFOOD20								784													54
COIND20								138													337
CCON20																				854	
CTRD20	811	148	154																		
CTCM20								30													201
COTS20								390					781								
TRCD20																					
TRCM20																					
TRCE20																					
LAB20																					
ARE20																					
WAT20																					
CAP20																					
HHO20				2020					196	50	530	1125	103								18
SHR20					20	46	148														
FER20					5	11	39														
DKH20					3	7	519														
ENT20							1435														
GOV20												133		493	81	235	364	118	-343		
ITD20																					
ITM20																					
ITE20																					
DTX20								164	18	5		177									
RES20					15		103														
SUB20																					
S-I20								797					197								47
ROW20							87														