# AN INVESTMENT BASED APPROACH TOWARDS THE IMPROVEMENT OF IRRIGATION WATER USE EFFICIENCY IN UZBEKISTAN, CENTRAL ASIA

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## Abstract

Uzbekistan's economy depends heavily on agricultural production. As late as 1992, roughly 40 percent of its net material product (NMP) was in agriculture, although only about 10 percent of the country's land area was cultivated. Cotton accounts for 40 percent of the gross value of agricultural production, and approximately for the same percentage of all irrigation water used in Uzbekistan.

According to several reports (ADB, 2006; ADB, 2008; FAO, 2009), about 44 percent of the irrigated land in Uzbekistan today is strongly salinated. Irrigation efficiencies in Uzbekistan are poor; this refers to the distribution of the irrigation water and the infield application thereof. Yields in general, are low.

The key objective of the project is to **improve irrigation efficiency** on farm level through implementing an **investment-based approach**, which is built upon a commercially viable model, via intermediaries to reach out to farmers. This project is different from other previous similar projects (grants and or demonstration projects), since farmers will have to take up loans through intermediaries to pay for new irrigation technology. It is therefore necessary to design an **appropriate financing vehicle** and propose a **supportive institutional framework** for the project.

This paper will give an overview of the problematic of irrigation efficiencies in Uzbekistan and possible interventions to improve efficiencies. The modelling framework which was used will be presented together with an appropriate finance vehicle and a proposed supportive institutional framework to enhance the use of technologies to improve overall water use efficiency.

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## 1. BACKGROUND

Uzbekistan's economy depends heavily on agricultural production. It is estimated that about 44 percent of the irrigated land in Uzbekistan today is strongly salinated. Irrigation efficiencies in Uzbekistan are poor; this refers to the distribution of the irrigation water and the infield application thereof. Yields in general, are low. This, amongst others, contributes to the financial hardship of the farmers of Uzbekistan. In November 2010 the International Finance Corporation (IFC) in Uzbekistan requested Expression of Interests (EOI's) for consultants to advise on the technical and financial/economical aspects of the irrigation farming situation of the country. The key objective of the project is to **improve irrigation efficiency** on farm level through implementing an **investment-based approach**, which is built upon a commercially viable model, via intermediaries to reach out to farmers. This project is different from other previous similar projects (grants and or demonstration projects), since farmers will have to take up loans through intermediaries to pay for new irrigation technology. It is therefore necessary to design an **appropriate financing vehicle** and propose a **supportive institutional framework** for the project.

The study was commissioned by the International Finance Corporation (IFC) which commenced in February 2011 and the final report was presented to the IFC on 31 May 2011. This paper will give an overview of the problematic of irrigation inefficiencies in Uzbekistan and possible interventions to improve efficiencies.

## 2. CONDENSED DESCRIPTION OF THE UZBEKISTAN IRRIGATION SECTOR

Uzbekistan's economy depends heavily on agricultural production. As late as 1992, roughly 40 percent of its net material product (NMP) was in agriculture, although only about 10 percent of the country's land area was cultivated. Cotton accounts for 40 percent of the gross value of agricultural production, and approximately for the same percentage of all irrigation water used in Uzbekistan. But with such a small percentage of land available for farming, **the single-minded development of irrigated agriculture, without regard to consumption of water or other natural resources, has had adverse effects such as heavy salinization, erosion, and water logging of agricultural soils, which inevitably have limited the land's productivity**.

According to the Ministry of Land Reclamation and Water Resources, for example, after expansion of agricultural land under irrigation at a rate of more than 2 percent per year between 1965 and 1986, conditions attributed to poor water management had caused more than 3.4 million hectares to be taken out of production in the Aral Sea Basin alone. According to other reports, about 44 percent of the irrigated land in Uzbekistan today is strongly salinated. The regions of Uzbekistan most seriously affected by salinization are the provinces of Syrdariya, Bukhoro, Khorazm, and Jizzakh and the Karakalpakstan Republic. Throughout the 1980s, agricultural investments rose steadily, but net losses rose at an even faster rate (ADB, 2008).

The total extent of agricultural land of Uzbekistan is 44 million ha. Of these approximately 24 million ha is regarded as arable, of which 4.3 million ha is under irrigation. This is also the area equipped with irrigation infrastructure. Surface drainage systems exist virtually everywhere in the irrigation regions. Very few food crops can be produced in Uzbekistan under rain fed conditions. This is due to the limited raining season, which coincides with the very low winter temperatures. Therefore, almost 100% of all farming in Uzbekistan relies on irrigation. Irrigation farms in Uzbekistan can be divided into 3 categories, namely:

i. Dehkan (household plots) farms, which comprise of less than 35 ha on 12.5 % of the Uzbekistan land.
ii. Private farms averaging approximately 20 ha on 75 % of the land
iii. State farms (Shirkats), mainly large farms comprising 12.5 % of the irrigated farmland in Uzbekistan.

The total annual irrigation water use is 63 billion $m^3$. 4 % of this water is from surface sources, and the balance from ground water. Uzbekistan is among the largest water consumers in the region, and has the highest deficit of water. Irrigation efficiencies in Uzbekistan are poor; this refers to the distribution of the irrigation water and the infield application thereof. Yields in general, are low. This, together with obligations to the farmers by government with regards to the production and supply of cotton and wheat, contributes to the financial hardship of the farmers of Uzbekistan.

Agriculture and the agro-industrial sector contribute about 18% to Uzbekistan's GDP. Cotton is Uzbekistan's dominant crop, accounting for roughly 11% of the country's GDP in 2009. Uzbekistan also produces significant amounts of silk, wheat, fruit, and vegetables. Nearly all agriculture involves heavy irrigation. In 2008, the President signed a decree on enlargement of private farms, which has led to the redistribution of small farmers' land in favor of large farms. Farmers and agricultural workers earn low wages, which the state seldom pays on a regular basis. In general, the government controls the agriculture sector, dictates what farms grow, and sets prices for commodities like cotton and wheat. Most farms grow wheat and cotton to meet the state order, and farmers can face losing their leased land if they do not meet state quotas (US Department of State, 2010).

The crops grown per region (for the four regions forming part of this study) were obtained from the farm survey. Table 2.1**Error! Reference source not found.** shows the relative contribution of crops to the total irrigated land area.

**Table 2.1: Relative contribution of crops to total irrigated area**

| | % of total irrigated land area | | | |
|---|---|---|---|---|
| **Cultivated crops** | **Bukhara** | **Kashkandarya** | **Surkhandarya** | **Khorezm** |
| Cotton | 26.2% | 23.5% | 20.7% | 16.2% |
| Grain | 25.8% | 25.9% | 20.4% | 15.0% |
| Orchards/fruit | 10.4% | 9.4% | 7.8% | 7.4% |
| Vegetables | 10.8% | 7.8% | 14.9% | 16.9% |
| Grapes | 2.9% | 2.4% | 4.9% | 2.7% |
| Gourd | 2.5% | 3.1% | 10.7% | 14.0% |
| Unengaged | 4.7% | 16.1% | 1.3% | 7.4% |
| Clover | 7.2% | 3.1% | 1.6% | 3.2% |
| Maize | 7.5% | 0.4% | 9.1% | 2.5% |
| Oil-bearing crops ( earth-nut, sesame) | 0.7% | 1.2% | 2.3% | 0.7% |
| Rice | 0.7% | 0.0% | 0.0% | 12.7% |
| Legumes (haricot, pea) | 0.4% | 0.8% | 3.9% | 0.0% |
| Mulberry | 0.4% | 6.3% | 2.6% | 1.5% |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

It is clear that there are not significant differences (with the exception of maize and clover production) between Bukhara and Kashkandarya crop patterns. On the other hand the crop patterns in Surkhandarya and Khorezm indicate that there is relatively less cotton and wheat and more vegetables and gourd. Also, Khorezm is the only area with significant rice production.

Since 1995, the quota system has been applied only to cotton and wheat (Khan, 1996 as sited by Abdullaev et.al, 2009). Cotton production is controlled through quotas on area and output as well as related controls on output and input prices and marketing. However, the most malignant aspect of the cotton quota system concerns the designation of particular areas to be sown with cotton, irrespective of their current appropriateness. As a result, **even if farmers fulfil their cotton production quota, they can still be penalized if the area they planted to cotton is less than the requirement**. In effect, this gives farmers **little incentive to increase land productivity** as long as their overall output is sufficient to meet the production quota. The quota system for wheat production is somewhat more flexible than that for cotton. Farmers are allowed to sell 50% of their quota in the open market or to keep it for home consumption. The land to be sown with wheat is also strictly controlled and the same rules are applied as for cotton.

The fixed prices at which cotton and wheat are procured simply do not leave enough money with farmers to pay for WUA services and, as a result, many WUAs are unable to pay for operations and maintenance and are in effect non-operational. The state removed all support, subsidies and credits from rice growing farms in 2003 and, in some water-short areas it even prohibited farmers from growing rice. However, after initial declines in yield and production, production moved back up to 1999 levels. This indicates that if farmers are given the right to grow crops of their choice, they can, at least in some circumstances, maintain yields and production outside the state system.

According to Abdullaev et.al, 2009 the government of Uzbekistan began transformation in 2003. They began to transform the collective farms into individual farms. According to the new policy, priority was given to the development of the individual farms as the major producers of agricultural commodities. Between 2004 and 2006, 55% of the collective farms were to be transformed into individual farms. By 2004, individual farms already occupied 16.7% of agricultural land, hired 765 300 workers and provided 10.5% of the agricultural gross product, including 51.5% of cotton production and 46.2% of grain production. The final transformation related to farm structure was the rise of the so-called dehkan farms, legalized family plots from which most of the Uzbekistan's population earns income (Djalalov, 2010). The state now encourages family plots to be registered as legal entities so that they can acquire credit and benefit from other financial instruments (e.g. leasing). Dehkan farms are allowed to grow any crop except cotton and sell output in the open market. They cannot join the cotton and wheat quota system. Much of the production, primarily fruits and vegetables, grown on dehkan farms is exported to neighboring Russia and Kazakhstan. However, what is most striking about dehkan farms is their large contribution to agricultural GDP, estimated at 25% in 2004, despite their relatively small area (Djalalov, 2010).

By comparison, in spite of its contribution to the GDP, rural employment and income generation, the fruit and vegetable sector have received very little Government focus and support. This has however meant that the sector was relatively free from government interference and has largely been driven by the private sector.

Although the government has established a free market system in the fruit and vegetable subsector and encourage private sector participation in and the commercialization of fruit and vegetable production and agribusiness, the interpretation and implementation of those policies limits their efficiencies and needs to be addressed. There remains, for instance, de facto interference from local and provincial administrations and national Government in production and marketing decisions (e.g. closure of borders for exporters in 2006). To date there has been very little private sector participation in the formulation of policy for the fruit and vegetable subsector (ADB, 2006).

Shirkats and private farms deliver their cotton and wheat quotas to Government controlled purchasing centers. After the crop is delivered and inspected, farmers are paid via account transfers through local banks. In 2002, however, the Government made commitment to liberalize cotton marketing gradually with the aim of developing a competitive market in the procurement, processing, distribution, and export of cotton. In 2002, 20,000 t of cotton were sold through an auction system established by the commodities exchange. The quantities of cotton marketed through this exchange are expected to expand rapidly in the future (ADB, 2003).

Even though the state procurement prices were increased recently to more closely reflect world market prices, and procurement quotas are being relaxed gradually, the current policies are still very restrictive and severely limit a farmer's ability to allocate resources to alternative farm enterprises in a productive and profitable manner. **Farmers who fail to meet production targets can face punishments from local authorities, including lower prices and possible eviction from their land**. Farmers, therefore, have very little incentive to increase their productivity and efficiency under these restrictive pricing and procurement policies (ADB, 2008).

## 3. OBJECTIVE OF THE STUDY

To improve water efficiency in irrigation in cotton, fruits and vegetables sectors on farm level through implementing an investment-based approach, which is built upon a commercially viable model (e.g. by improving productivity, thereby providing payback mechanism), via intermediaries to reach out to farmers. The specific regions to be targeted in the project were Khoresm, Bukhara, Kashkadarya and Surkhandarya.

## 4. METHODOLOGY

The methodology followed was:

i. Literature study of relevant documents and reports. This activity carried on right through the project as more information on previous related became available;
ii. The international consultants' visited Uzbekistan between 28 February 2011 and 18 March 2011. During this period meetings were held with many role players in the four study regions as well as Samarkand and Karakalpakstan, and many sites were visited to observe typical irrigation systems and farming conditions;
iii. From the meetings followed the requesting documents and additional specific regional information. A large number of very useful documents and information sets were received;
iv. Preparation of relevant technical and financial data, making use of purpose made and specialised software models, to produce information to base conclusions on and to make proposals;
v. Calibration of the models;
vi. Analyses of outcome from preferred/selected models, including sensitivity analyses
vii. Compilation of report with findings and proposals

For the sake of brevity only the conceptual model is presented in this paper. However the mathematical model description is available from the authors. Figure 4.1 is a conceptual model of Uzbekistan irrigation agriculture. The model shows that the agriculture sector comprises of individual farms (modelled as typical farms). The typical farms abstract water from the huge canal systems. Due to leakages in the canal system as well as inefficient in-field irrigation systems there is significant water logging and eventually salination and a decrease in the productivity of the land.

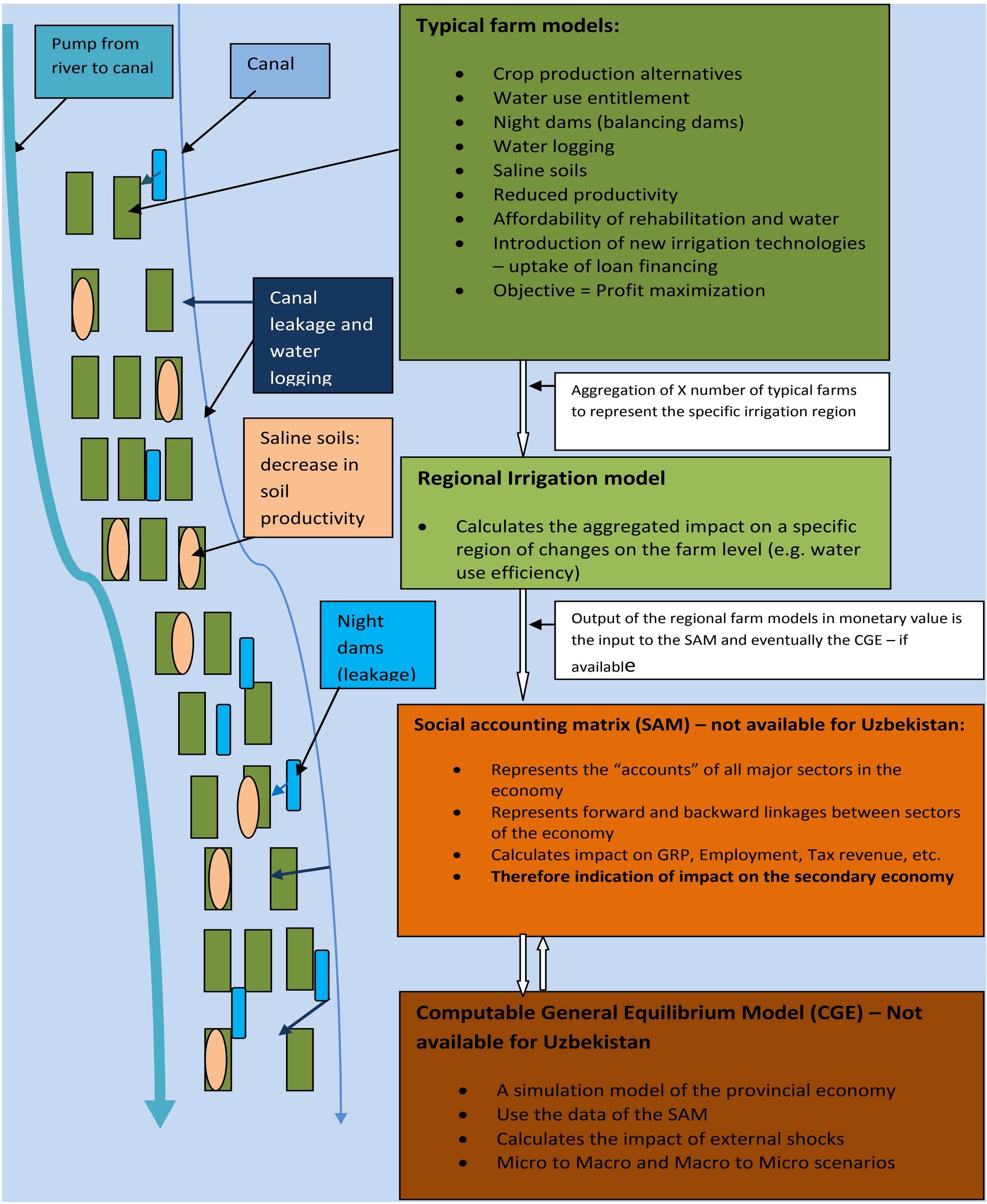


**Figure 4.1: Conceptual model of Uzbekistan irrigation agriculture**

The reduced productivity of soil results in lower yields, reduced profitability and a reduction in the monetary inflow into the regional economy. The result is that the reduced agricultural productivity has a snowball impact on the secondary economic activity which eventually leads to a reduced economic growth rate and a reduction in general welfare.

Since Uzbekistan does not have Social Accounting Matrices (SAM) for the individual provinces, it is not possible to calculate the forward and backward linkages with the rest of the economy. Neither is there a Computable General Equilibrium (CGE) model to test micro-macro and macro-micro scenarios. Within these limitations the consultants estimated the impact of inefficiencies and gain in efficiencies for the four regions which were selected for this project, namely Bukhara, Kashkandarya, Surkhandarya and Khorezm.

A mathematical model (dynamic linear programming) was constructed to simulate irrigation agriculture in four provinces of Uzbekistan (Bukhara, Surkhandarya, Kaskhandarya and Khorezm) with the purpose of analyzing **What if?** scenarios.

## 5. SCENARIOS ANALYSED

For the purpose of this project 6 scenarios were analyzed with the specific objective of pointing out critical elements of the proposed project to the Uzbekistan government. These scenarios are:

**Base:** Current land use, **conventional flood irrigation** only, **only short-term credit** available and restricted to a maximum of about $500 per ha irrigated (the minimum required to make the model feasible). Simulates **business as usual** with **no reduction in yield and or increase in water requirements**.

**Base2:** Same as Base but **gradual reduction of yield with 1%** per annum (20% over a 20-year period) and **gradual increase in water requirement** to flush salinated soils (also with 1% per annum). Only feasible when cotton and wheat production control relaxed with 20% and the total gross water available to the regions in March and April increased with 30-40% (some regions more than others).

**Scen1:** Same as base, but **short-term and long-term credit available** and total loan amount restricted to $2000 per ha. **30% increase in yield for other irrigation technologies** and **40% for micro and drip** - very small deviation in land use from base - **strict land use control**.

**Scen2:** Same as **Scen1**, but **relax control over cotton and wheat with 30% up and down** variation allowed from the observed area under production.

**Scen3:** Same credit available as in Scen1, but **50% subsidy** on capital of new irrigation technology - **same land control as base**

**Scen4:** Same credit available as in Scen1 but **50% subsidies and relaxed control on land use**

**Scen5:** Same as Scen2 but **15% increase in price due** to quality improvement for crops grown with new technology - no subsidy on new technology

**Scen6:** Same as Scen2, but **interest rates on loans 20% higher**

***It is important to note that the results are only for the typical farms (three per region) which were modelled. The amounts will therefore not add up to that for the entire region in the scenarios results which are discussed. It is also important to realise that the relative changes in mathematical models is much more important than the absolute values since it***

***gives an indication of the magnitude of the direction of change compared to the base analysis.***

## 6. THE PRESENT SITUATION

Practically all irrigation in Uzbekistan is done by flood irrigation. Figures quoted for the in-field irrigation efficiencies vary widely (from 30% to 80%). The authors are of the opinion that an average figure of 60% will be appropriate for the flood irrigation systems application efficiency. In practice this means that 40% of the irrigation water supplied to the farm is not used by the crops. In some cases the volume of water which is required to flush the salts in the beginning of the season, is more than the total crop water requirement for the season. Table 6.1 below gives an indication of the level of salinity for the various provinces as indicated by the 320 farmers which were surveyed. It is clear that the level of salinity vary between regions, however, on average (all regions), about 30% of the soils is strongly saline and saline. A further 40% can be regarded as weekly saline. It should be clear that if nothing is done, the percentage strong saline and strong saline will increase over time and all crops productivity will be reduced, including cotton and wheat.

**Table 6.1: Level of salinity for the four regions**

| | *Bukhara province* | | *Kashkadarya Province* | | *Surkhandarya Province* | | *Khorezm Province* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency | *Percent* | Frequency | *Percent* | Frequency | *Percent* | Frequency | *Percent* | Frequency | *Percent* |
| Strongly saline | 5 | *6.25* | 8 | *10* | 2 | *2.5* | 12 | *15* | 27 | *8.4375* |
| Saline | 22 | *27.5* | 11 | *13.75* | 3 | *3.75* | 34 | *42.5* | 70 | *21.875* |
| Weakly saline | 51 | *63.75* | 18 | *22.5* | 33 | *41.25* | 28 | *35* | 130 | *40.625* |
| Non-saline | 2 | *2.5* | 43 | *53.75* | 42 | *52.5* | 6 | *7.5* | 93 | *29.0625* |
| Total | 80 | *100* | 80 | *100* | 80 | *100* | 80 | *100* | 320 | *100* |

To demonstrate the impact the **base scenario and base2** (which simulate a gradual decrease in crop yields and an increase in the volume of water required to flush the soils) are compared in terms of key elements. It is important to note that in order to simulate yield and price risk in the model **randomly generated annual yields and prices are generated which provide for a variation of 10% up and down from the observed base prices and yields.** It is clear from Figure 4.1 that if nothing is done, the total yield of Cotton will be considerably lower (Base 2) compared to the Base (when assumed that nothing will change which is obviously unrealistic). Please note that the total yield in year 1 will not be the same for the 2 Base scenarios, since Base2 had to be modified slightly to be feasible (relaxed cotton and wheat control and more water).

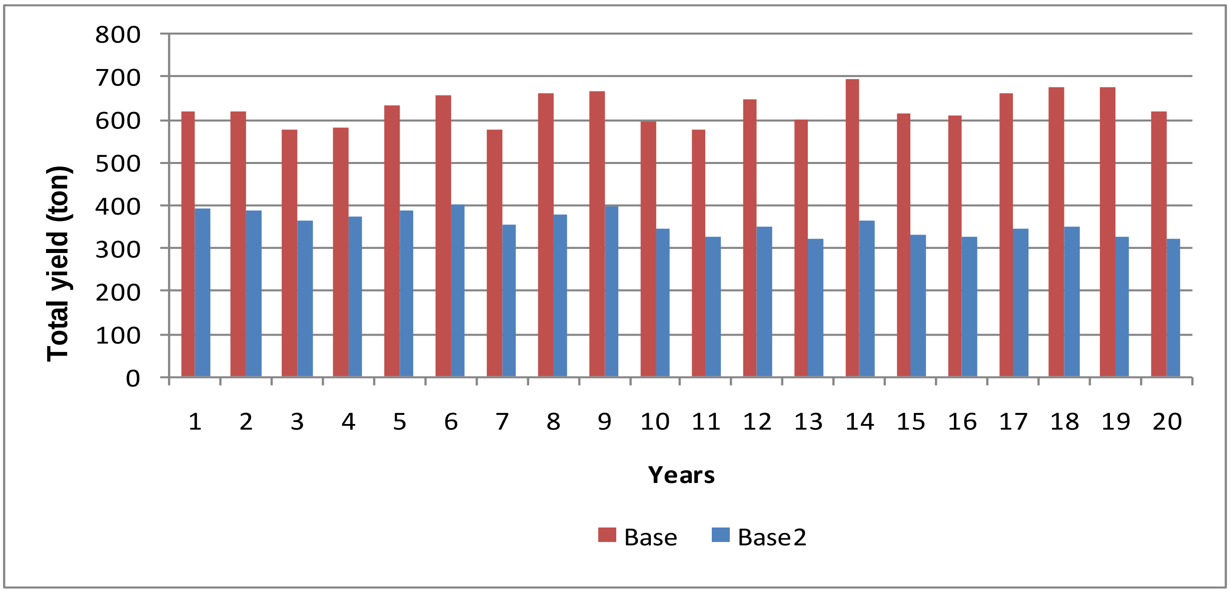


**Figure 6.1: Cotton production Base compared to Base2 (ton)**

Figure 6.2 represents the total wheat production for all regions for the typical farms which were modelled. It is clear that if nothing is done, wheat production will also spiral into a downward trend. ***This is an extremely important result since it shows that if nothing is done, farmers will not be able to produce their production quotas***.

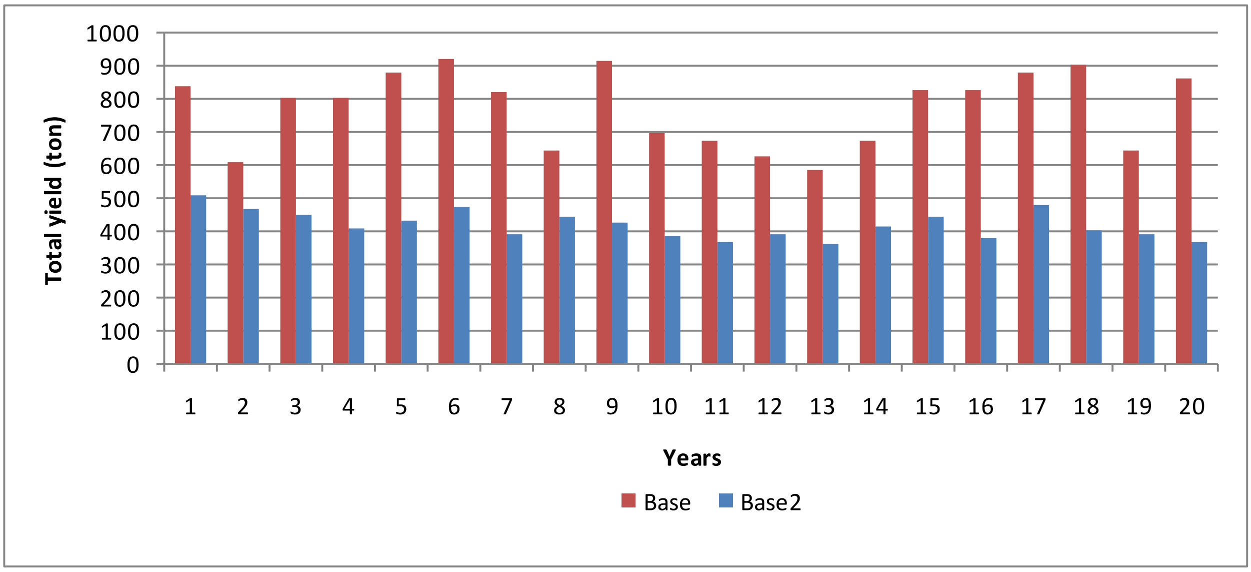


**Figure 6.2: Wheat production Base compared to Base2 (ton)**

Figure 6.3 shows the annual cotton yields over time in the planning model. It is clear that the yield per ha will be significantly lower compared to the current situation if nothing is done. After 20-years the yield is approximately 0.8 tons down from the existing average yield. Similar, Figure 6.4 shows that the yield per ha will eventually (after 20-years), if there is no technological advances, be 1.5-1.6 tons lower compared to the existing average yields.

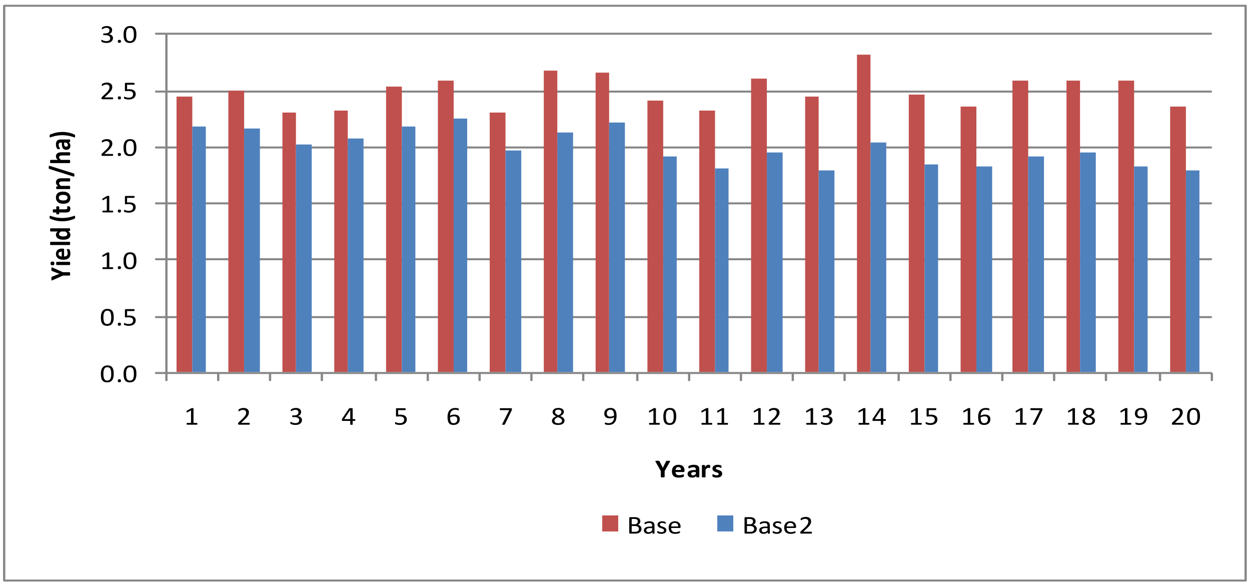


**Figure 6.3: Cotton production per ha base versus Base2 (ton per ha)**

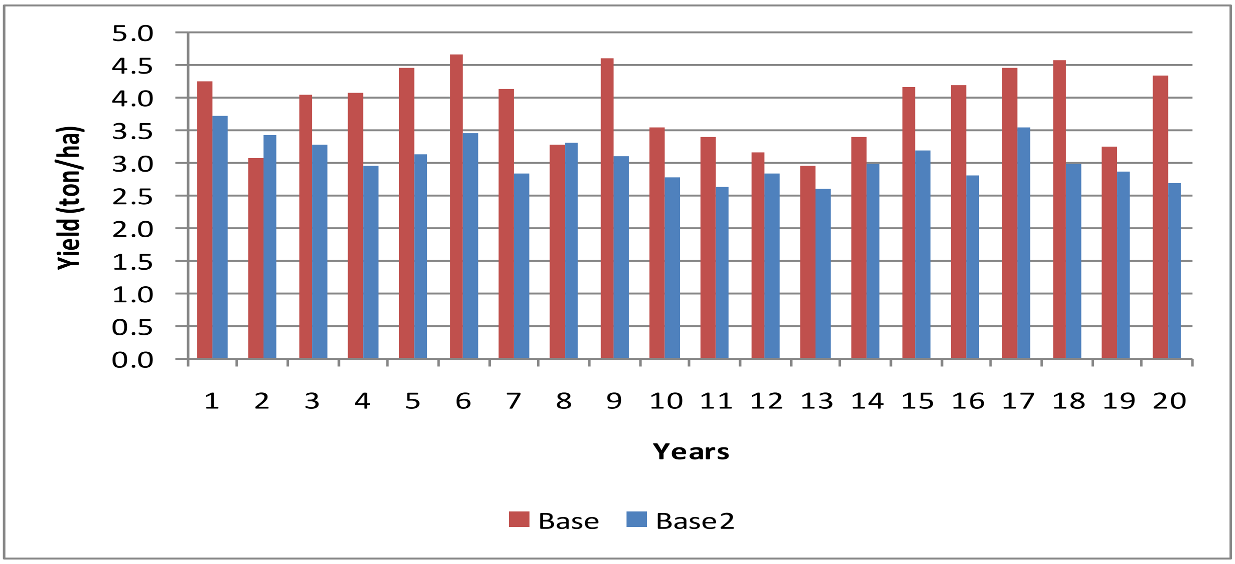


**Figure 6.4: Wheat production per ha Base versus Base2 (ton per ha)**

Figure 6.5 shows the Net Present Value (NPV) of the cumulative cash flow over 20-years. The results indicate that if nothing is done the cumulative cash flow **(aggregated for all regions)**, will be about $USD1 million lower compared to if everything were kept constant over the 20-year period (the Base scenario).

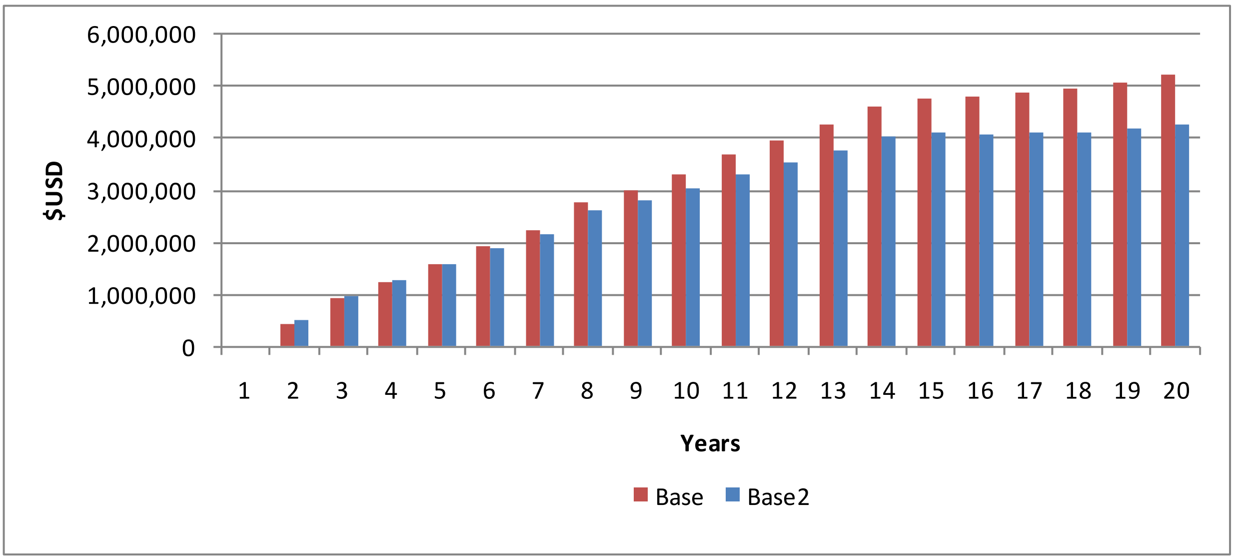


**Figure 6.5: Net Present Value (NPV) of the cumulative cash balance - $USD (all regions)**

It is also important to note that there is a huge increase in the annual total water requirement for the **aggregated typical farms** in each region (see Figure 6.6). The total annual water requirement will increase from about 13 million m$^3$ in the base to about 17-18 million after 20-years.

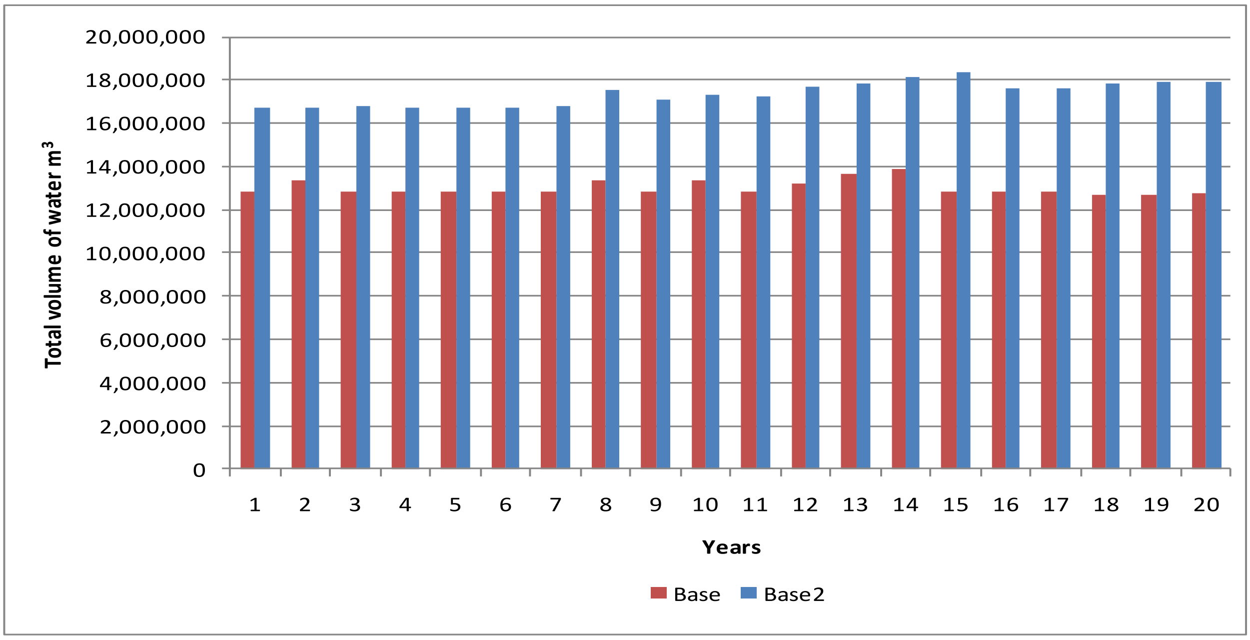


**Figure 6.6: Total annual water requirement (m$^3$) for all regions**

The total crop gross water requirement is also significant higher compared to the current water usage if nothing is done, since water efficiencies will just decrease over time and crop production inefficiencies will increase as the area which is salinated increase (see Figure 6.7).

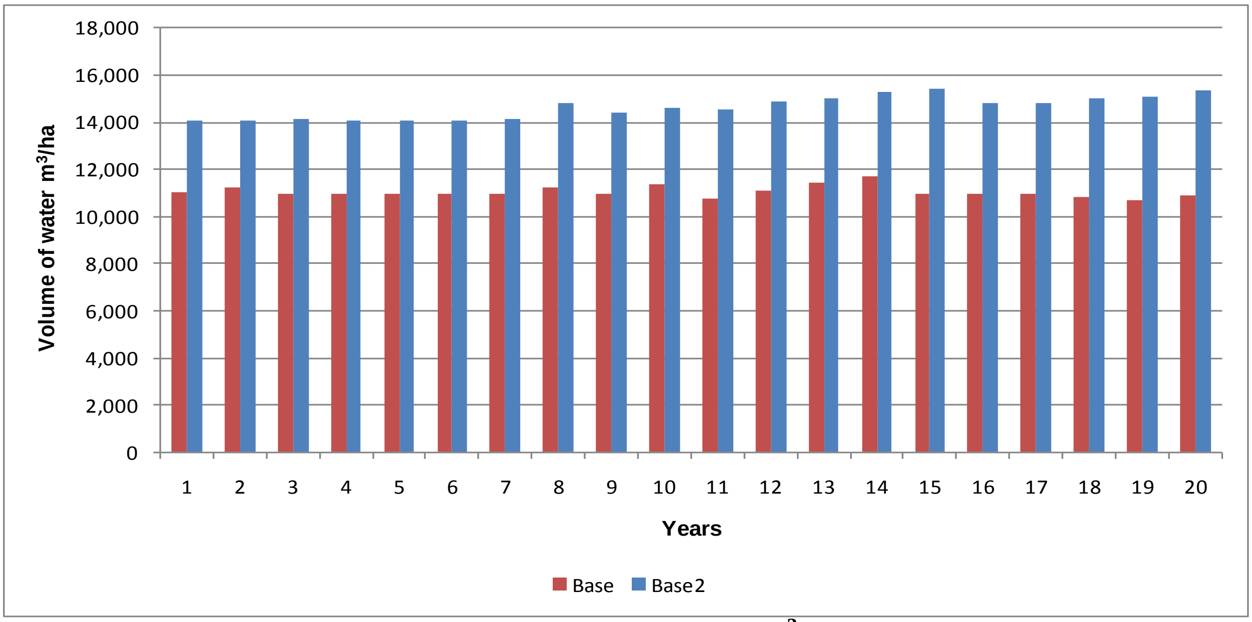


**Figure 6.7: Total gross crop water requirement per ha ($m^3$) – average all regions**

The base analysis is not realistic since it assumes that there will be no further degradation of the soils, decrease in yields and an increase in the volume of water required to flush the soils (to reduce the salt contents). The Base2 scenario is based on very realistic assumptions about a reduction in yield and an increase in water usage. **The analysis clearly illustrated that doing nothing is not an option since it will eventually destroy the agricultural economy of Uzbekistan** and it will bring about tremendous hardship for the rural population.

## 7. RESULTS OF MITIGATION SCENARIOS COMPARED TO BASE2

The objective with the other scenarios (Scen1-6) is to demonstrate the **impact of various potential interventions to mitigate the looming threat** of a down spiralling agricultural economy. A condensed summary of these results are presented in Table 7.1. The following can be concluded:

### 7.1 Impact on conversion rate to new technologies

- In **Scen1** about **74%** of the total irrigated area is converted over a 20-year planning horizon to **lazer and sprinkler** irrigation and to a lesser extent to drip irrigation (6%). On average, the model indicates that **only 26%** of the land will still be irrigated with **conventional** flood over this period.
- In **Scen2** when the control over the cotton and wheat production is relaxed (by allowing a 30% up and down variation on the current area), the conversion to new technologies gain even more field and **only 17%** of the land is still irrigated with **conventional flood**.
- In **Scen3** with **government subsidies of 50%** on the capital investment in the first year are introduced but government production control over cotton and wheat is not relaxed. The result is that **almost 100% of the land is converted** to new irrigation technologies over the 20-year period.
- In **Scen4** where both government subsidies are introduced and control is relaxed, there is **not a significant change compared to Scen3**.
- **In Scen5** the average price of the crops is increased by 15% (due to an expected increase in quality as soil fertility increase and with more efficient irrigation

management). The increase in profitability has a small impact on the introduction of new technology in that lazer is preferred to sprinkler since lazer is relatively less costly and since farmers can probably achieve the same profitability (due to higher prices) compared to sprinkler.

- Finally, the impact of higher interest rates was tested in **Scen6**. The result indicates (which was expected), that if interest rates increase by 30%, it will slow down the conversion to new technologies (compared to scenario 2).

## 7.2 Impact on the loans taken up by farmers

The mathematical model is constructed in such a way that **farmers cannot borrow more money than they can pay back**. Table 7.1 below shows the total loan amount per ha irrigated over the 20-year planning horizon.

- It is clear that **when new technology is introduced there is a significant increase in the loan capital requirement**. The results is significant since it shows that **farmers can take up loans and repay them if an enabling environment** is created where they can increase their yields and product prices and where there is more freedom in the production decisions.
- Even, when state subsidies are introduced, famers will still take up more credit compared to the base (although slightly less compared to Scen1). It is also significant to note that when **production control is relaxed (Scen2), the loan requirement decreases** since farmers have more choice on what they want to produce and this is mainly towards vegetables and fruit which is higher value products.
- It is also obvious that **when the price of the products increases (Scen5), the loan requirement is also reduced** because farms are more profitable and they have more of their own financial sources available.
- Finally, the results also indicate the sensitivity for interest rate hikes. There is a **substantial reduction in the loans taken up by farmers if interest rates increase by 30%**.

## 7.3 Impact on energy requirements on-farm and for bulk water supply

The on-farm energy requirements will increase with the introduction of new irrigation technology since most of these technologies (especially sprinkler, pivot, drip and micro) needs additional energy compared to conventional flood irrigation.

- The modelling results indicates that in Scen1 about **1.2 million kWh** (average of 999 kWh per ha) will be used by the typical farms in the region compared to very little in the base (in the model it was assumed that 100% is conventional irrigation in Base analysis).
- When the control over land cotton and wheat is relaxed, the **energy requirement increases by about 12.8%**.
- In Scen3-5 where almost **100% of the land is converted** to new irrigation technologies, the energy requirement is **more than 60% higher compared to Scen1** (only 75% converted and 35% towards lazer).
- When interest rates increase with 30% the energy requirement is only 9.5% higher compared to Scen1 since a significant smaller area is converted to new irrigation technologies.

### 7.4 Impact on water savings and the resulting impact on energy requirements and costs

- **If nothing is done**, the average crop water usage per ha in these regions will increase **with 32.6% compared** to the present situation (Base2).
- Contrarily, if **new irrigation technology** is introduced the **gross irrigation requirements per ha will decrease by between 10-20%**.
- This may bring about a **huge saving for government** if it is assumed that the farmer is going to pay for energy use on the farm and that government will still subsidise electricity for bulk water delivery. It has been estimated that Uzbekistan uses about 63 billion $m^3$ of water per annum of which about 53% needs some kind of pumping to deliver the water on-farm.
- If there is a saving of say 15% on farm level, the government can reduce bulk water supplies with approximately 3.52 billion $m^3$ at an estimated average energy use of 5.82 $m^3$ per kWh (see **Table 3**), it will save 0.61 billion kWh on the pumped share of the water, resulting in more than $USD30 million saving per annum (assuming $USD0.05 per kWh).

***However, it is extremely important to note that this saving will only be possible if farmers don't use the additional water supplies due to more efficient systems to irrigate more land or other crops with a higher crop water requirement. Since one of the incentives for farmers to invest in more efficient irrigation technologies is to use the additional supplies to expand their operations, government will have to find a way to compensate farmers for this saving. The authors are of the opinion that this is one good argument for government to subsidise new irrigation technologies and to invest in an efficient extension service.***

- The results indicate that the relative increase in energy costs is almost identical to the increase in energy requirement. It is of importance to note that **when interest rates increase with 30% the average energy cost only increases with 8% which is an indication that high interest rates will significantly reduce the conversion** to new irrigation technologies and hence the reduction in energy costs.

### 7.5 Impact on investment cost in new irrigation technology

The reader should note that a relatively small amount (2% of the capital investment) is also included for maintenance. A small amount was also included in the budget for maintenance on conventional irrigation (all reported in NPV terms). **The average capital investment for new irrigation technology ranges between $USD2 600 and $2 900 per ha when there is no subsidies, and approximately $USD1 670 with subsidies.**

### 7.6 Impact on farm profitability

- It is clear that there is a huge potential to increase the profitability of farms with new irrigation technologies.
- The **Net Farm Income increases significantly** for all scenarios where **new irrigation technology** is introduced.
- However, it must be stated that these results **will depend on an efficient extension service and technical backup and by relaxing the production control on cotton and wheat**.

- It is also significant to note that **positive results are also obtainable without government subsidies** (Scen1, Scen2, Scen5 and Scen6).
- It is significant to note that **an increase of 15% in crop prices** will have a **significant impact, larger than that of government subsidies**.
- With the introduction of new irrigation technology in Scen1 the cumulative NPV of the Net Farm Income plus terminal values in year 20 increases by **57% and when control over cotton and wheat is relaxed by 135%.** The reader should note that this is all from a very low base ($6 656 per ha over 20-years in NPV terms).

## Table 7.1: Condensed summary of scenarios results

| Result | **Base**:Current Luse*, only **ST credit max $320/ha** | **Base2**:Current Luse, only **ST credit max $320/ha, 1% /annum decrease in yield, 1% increase in water requirement** | **Scen1**: Current Luse, **ST+LT credit max $2000/ha,30% yield increase other tech, 40% micro, drip** | **Scen2**: Same as Scen1, **relax cotton-wheat control 30%** | **Scen3**: Same as Scen1, **50% subsidy, strict control** wheat/cotton | **Scen4**: Same as Scen1, **50% subsidy, relaxed control** wheat/cotton | **Scen5**: Same as Scen1, relax cotton-wheat control 30%, **15% price increase**, no-subsidy | **Scen6**: Same as Scen1, relax cotton-wheat control 30%, 20% increase **interest rate** |
|---|---|---|---|---|---|---|---|---|
| **Relative contribution of irrigation technologies** | | | | | | | | |
| Conventional | 100.0% | 100.0% | 26.5% | 16.7% | 0.5% | 0.8% | 3.4% | 21.1% |
| Lazer | 0.0% | 0.0% | 34.6% | 27.2% | 29.1% | 26.6% | 36.5% | 27.9% |
| Drip | 0.0% | 0.0% | 5.9% | 5.9% | 8.6% | 8.6% | 8.2% | 5.9% |
| Micro | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Pivot | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Sprinkler | 0.0% | 0.0% | 33.0% | 50.2% | 61.7% | 64.0% | 51.9% | 45.2% |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |
| | | | | | | | | |
| **Average annual loan ammount per ha ($USD)** | 468 | 467 | 4088 | 3658 | 3834 | 3498 | 3550 | 2772 |
| **Relative change (compared to base)** | | **-0.4%** | **773%** | **681%** | **719%** | **647%** | **658%** | **492%** |
| **Relative change (compared to Scen1)** | **-88.5%** | **-88.6%** | | **-10.5%** | **-6.2%** | **-14.4%** | **-13.2%** | **-32.2%** |
| | | | | | | | | |
| **Cotton production all regions (ton)** | **629** | **358** | **1048** | **785** | **1059** | **851** | **909** | **773** |
| Relative change (compared to Base) | 0% | -43% | 193% | 119% | 196% | 138% | 154% | 116% |
| **Wheat production all regions (ton)** | **773** | **420** | **1029** | **711** | **1244** | **870** | **725** | **713** |
| Relative change (compared to Base) | 0% | -46% | 145% | 69% | 196% | 107% | 73% | 70% |
| | | | | | | | | |
| **Gross water requirement (total in m3/ha irrigated)** | 11,032 | 14,630 | 10,014 | 9,632 | 9,245 | 8,990 | 9,478 | 9,640 |
| Relative change (compared to base) | **0.0%** | **32.6%** | **-9.2%** | **-12.7%** | **-16.2%** | **-18.5%** | **-14.1%** | **-12.6%** |
| | | | | | | | | |
| **Total energy requirement (KwH)** | 0 | 0 | 1,203,225 | 1,357,483 | 1,940,522 | 1,970,260 | 1,937,002 | 1,318,098 |
| **KwH per ha irrigated (Kwh /ha)** | | | 999 | 1,127 | 1,610 | 1,635 | 1,607 | 1,094 |
| **Relative change compared to Scen1** | | | | **12.8%** | **61.3%** | **63.7%** | **61.0%** | **9.5%** |
| **Total energy costs ($USD)** | 0 | 0 | 60,161 | 67,874 | 97,026 | 98,513 | 96,850 | 65,905 |
| **On-farm energy costs per ha irrigated ($USD/ha)** | | | 51 | 55 | 82 | 80 | 80 | 54 |
| **Relative cost change compared to Scen1** | | | **0.0%** | **9.0%** | **61.1%** | **57.7%** | **56.6%** | **5.8%** |
| | | | | | | | | |
| **Total investment in new technology ($USD)** | 479,301 | 479,848 | 2,575,097 | 2,719,176 | 2,006,701 | 2,005,048 | 3,033,407 | 2,639,438 |
| **Investment per ha in new technology ($USD)** | 20 | 20 | 2,906 | 2,710 | 1,674 | 1,678 | 2,605 | 2,775 |
| **Relative cost change compared to Base2(%)** | | | **436.6%** | **466.7%** | **318.2%** | **317.9%** | **532.2%** | **450.1%** |
| | | | | | | | | |
| **Cumulative Net Farm Income (NPV 20-years)** | 6,655.8 | 6,016.7 | 10,460.8 | 15,622.2 | 11,974.2 | 17,064.8 | 20,815.8 | 15,254.9 |
| **Relative change** | **0.0%** | **-9.6%** | **57.2%** | **134.7%** | **79.9%** | **156.4%** | **212.7%** | **129.2%** |
| Note: * Luse = Land use | | | | | | | | |

## 8. COSTS AND BENEFITS FOR ROLE-PLAYERS

### 8.1 Water and energy savings

The weighted average energy requirement was calculated (**see** Table 8.1) by assuming the national average pumping height (FAO, 1996). The average volume of water pumped by 1 kWh is 5.82 $m^3$.

**Table 8.1: Weighted average energy requirement for pumping**

| Assumptions | $m^3$ pumped per kWh |
|---|---|
| 66% of water pumped less than 50 meters high | 7.34 |
| 12% of water pumped 50-100 meter | 3.91 |
| 21% of water pumped between 100-150 meters | 2.35 |
| 1% of water pumped more than 150 meters | 1.78 |
| **Weighted average energy requirement ($m^3$/KwH)** | **5.82** |

Table 8.2 shows the estimated value of energy savings in the supply of bulk water if there is a 15% on-farm increase in water use efficiency. It was pointed out earlier that it is assumed that farmers will not use the gains in gross crop water use to irrigate additional land and or to produce other crops with a higher gross crops water requirement.

The total estimated existing gross crop water requirement was calculated from the modelling results from the Base scenario. It was then assumed that a 15% on-farm gain in the average gross crop water requirement will result in 15% less water to be pumped through the bulk water supply system (which is very conservative since no losses were accounted for in the bulk supply infrastructure – if these losses are considered, about 30-40% more water will have to be pumped from the source). Nevertheless the conservative estimate indicates that about 202 million kWh could be saved resulting in a saving of $USD10.08 million in energy costs per annum or roughly $8USD per ha irrigated per annum. These are the savings for the 4 regions in the study area, based on average pumping heads for the country.

**Table 8.2: Estimated value of a 15% on-farm increase in water use efficiency**

| Area | Total Irrigation area (ha) | Etimated existing water use (million $m^3$) | Estimated saving of 15% water with new technology (million $m^3$) | Assumed that 53% (national average) is pumped (million $m^3$ pumped) | Estimated saving in energy to pump bulk water (million KwH) | Estimated cost saving with 15% increase in on-farm efficiency (million $USD) |
|---|---|---|---|---|---|---|
| Bukhara | 264,000 | 2,909 | 436 | 231 | 40 | 1.99 |
| Kashkandarya | 490,000 | 5,489 | 823 | 436 | 75 | 3.75 |
| Surkhandarya | 315,000 | 3,642 | 546 | 290 | 50 | 2.49 |
| Khorezm | 262,000 | 2,718 | 408 | 216 | 37 | 1.86 |
| **Total** | **1,331,000** | **14,758** | **2,214** | **1,173** | **202** | **10.08** |
| **Per ha (Unit per ha)** | | **11,088** | **1,663** | **881** | **151** | **8** |

## 8.2 Estimated cost of new irrigation technologies, estimated efficiencies and yield gains

The estimated capital cost, operations and maintenance (excluding energy costs) and the energy costs of new irrigation technology are shown in Table 8.3. The cost comparison example is for the **Khorezm region for cotton**. All these costs were considered and the Net Present Value (discounted at 12%) for each alternative was calculated to establish which alternative has the lowest cost over a 20-year period. It is clear that the establishment cost of lazer flood irrigation is the lowest compared to the other technologies. Following is sprinkler irrigation, pivot, micro and drip.

**Table 8.3: Cost of new irrigation technology in $USD – Khorezm cotton (Du Plessis, 2011)**

| Cost item | Conventional flood | Lazer | Drip | Pivot | Sprinkler |
|---|---|---|---|---|---|
| Establishment ($USD/ha) | 50 | 1,800 | 4,000 | 3,400 | 2,300 |
| O&M per annum ($USD/annum) | 50 | 36 | 80 | 68 | 46 |
| Energy (KwH) | 0 | 0 | 877 | 1110 | 1700 |
| Energy cost ($USD per annum) | 0 | 0 | 44 | 55 | 85 |
| **NPV (20-years - all costs) - $USD** | **418** | **2,683** | **4,496** | **3,958** | **3,032** |

**Note: Lazer requires an additional $USD686 every five years for maintenance (included in NPV calculations).**

**The authors recommend lazer and sprinkler on short-term crops**, with a slight preference to lazer since it is foreseen that this technology is probably the one that will be implemented due to existing infrastructure and the farming community's knowhow on flood irrigation. However, there is definitely scope for sprinkler irrigation on vegetables, cotton and wheat especially on smaller farming units.

**Drip and micro is the preferred irrigation system on fruit and some vegetables**. However, it is impossible to recommend a specific drip or micro system since it will be very site specific (depending on the soils, climate and crop). Pivots are not recommended within the current security of land tenure system, since it normally involves an investment in immoveable fixed infrastructure.

The authors are of the opinion that farmers will not invest in pivot irrigation unless security of tenure improves.

Table 8.4 show the estimated application efficiencies (with proper management) of the various irrigation systems. It is clear that good lazer flood irrigation can bring about water savings of approximately 20% on border flood irrigation which is very common in Uzbekistan. Simmilar gains are possible with sprinkler irrigation and with micro and drip it is possible to reach efficiencies of up to 95% (35% improvement on conventional flood irrigation).

**Table 8.4: Estimated application efficiency of irrigation technologies (SAPWAT 2009)**

| Irrigation system type | | Application efficiency |
|---|---|---|
| Flood | Border | 60% |
| | Furrow | 65% |
| | Basin | 75% |
| | Short furrow | 80% |
| | Laser level | 80% |
| Mobile | Centre pivot | 80% |
| | Linear move | 80% |
| | Travelling gun | 70% |
| Static | Sprinkler permanent | 80% |
| | Sprinkler dragline | 75% |
| | Sprinkler hop-along | 75% |
| Micro | Drip - surface | 90% |
| | Drip - subsurface | 95% |
| | Micro sprayers | 85% |
| | Mini sprinklers | 80% |

Table 8.5 shows yields which were reported from the farm survey as well as international best practice.

**Table 8.5: Actual yields recorded from survey and best practices yields**

| Crop | Yield (ton) | | | | | |
|---|---|---|---|---|---|---|
| | Bukhara | Kashkan darya | Surkhan darya | Khorezm | Global Average (2008) | Best Practices (irrigated) |
| Cotton | 3.21 | 2.7 | 2.8 | 2.75 | 2.1 | 6 |
| Wheat | 3.63 | 5.6 | 4.12 | 4.2 | 3.1 | 8 |
| Barley | 3.5 | 4.1 | 3.9 | 4.19 | 2.7 | 7 |
| Maize | 20 | 30 | 15 | 30 | 5.1 | 15 |
| Rice | | | | 4.3 | 4.3 | 6 |
| Millet | 1.4 | 1.6 | 1.7 | 1.3 | 1 | ? |
| Potatoes | 25 | 15.7 | 16.2 | 18.4 | 18 | 75 |
| Tomatoes | 25 | 22 | 35.3 | 24.8 | 28.2 | 100 |
| Cabbage | 20 | 26.5 | 31.5 | 22.4 | 22.3 | 120 |
| Onions | 30 | 23.76 | 26 | 27 | 19.4 | 80 |
| Carrots | 26.5 | 22.6 | 25 | 25.4 | 22.8 | 80 |
| Cucumber | 24.55 | 23 | 23.7 | 18 | 16.7 | 35 |
| Watermelon | 20 | 16 | 15 | 19 | 26.6 | 60 |
| Apples | 15 | 7.39 | 9.7 | 13 | 14.5 | 45 |
| Apricots | 14.9 | 8 | 7.7 | 10 | 7.4 | 30 |
| Grapes | 12 | 7.24 | 6.3 | 12 | 9 | 25 |
| Lucerne | 20 | 21 | 14 | 20 | ? | 25 |

**Source: Farm survey information and various other sources**

It is clear that the yield increase that was assumed in the scenarios analysed (20% to 40%) is still very conservative. In the case of both cotton and wheat it is possible to increase the average yield with best practices with almost 100%. However, the authors are of the opinion that a realistic maximum yield increase in Uzbekistan is probably more in the order of 50% on cotton and wheat.

## 8.3 Subsidies and payback by the community

An analysis was done to estimate the impact of government subsidies and the payback by the community in terms of taxes generated through additional income. All the subsidy scenarios are compared with Scenario 10 (no subsidies and lazer promoted and moderate yield increases of 20%). The “payback” period by the community on government subsidies was estimated by making some assumptions. Since economic multipliers for Uzbekistan agriculture is not available, the production multiplier to the rest of the economy from a $1USD output in irrigation agriculture was estimated at $US3 which compares to estimations that was made in the Northern Cape province of South Africa by Louw & Van Schalkwyk & Grover and Taljaard (2008). The Northern Cape province of South Africa also depends a lot on irrigated agriculture where it makes a contribution of approximately 12% to the GDP. The economic term “**production**” refers to the total turnover (i.e. quantity produced multiplied by the corresponding price) generated by each activity/sector in the economy, which can be measured as the sum of the intermediate inputs plus the total value added by a specific sector. Several scenarios were analysed to calculate the impact of subsidies and the estimated payback by the community based on additional tax income for government. These are:

- Scen10: 20% up and down variation in cotton and wheat area allowed and 50% up and down variation in vegetable/fruit area allowed, run without yield gain for Sprinkler - 20% yield gain for the other irrigation technologies and 30% for drip and micro on long-term crops.
- Scen18: Same as Scen10, but 20% subsidy on the capital cost of irrigation systems
- Scen19: Same as Scen10, but 30% subsidy on the capital cost of irrigation systems
- Scen20: Same as Scen10, but 40% subsidy on the capital cost of irrigation systems
- Scen21: Same as Scen10, but 50% subsidy on the capital cost of irrigation systems

The monetary value of the additional output in NPV terms (12% capitalization rate) was calculated as the difference between Scen10 and the Scen18-21. The average additional output per annum was then calculated and it was assumed that 20% tax is paid on this amount. The total value of the subsidies (in NPV terms) was then divided by the annual estimated tax paid by the community to calculate the estimated payback time (see Table 8.6). The results indicate that it will take approximately 12 years for the community to pay back a subsidy of 20%, 18 years with 30%, 20 years for 40%. It is then interesting to note that with a 50% subsidy, the payback stabilize at approximately 20 years since almost 100% is already converted to new technologies at a 40% subsidy.

**Table 8.6: Estimated payback period by the community on government subsidies**

| Item | Scen10: Relax control, no yield gain Sprinkler, 20% yield gain other | Scen18: 20% subsidy | Scen19: 30% subsidy | Scen20: 40% subsidy | Scen21: 50% subsidy |
|---|---|---|---|---|---|
| **Area converted (ha)** | | | | | |
| Lazer | 541 | 737 | 1002 | 809 | 780 |
| Drip | 55 | 125 | 156 | 209 | 241 |
| Micro | 0 | 0 | 0 | 0 | 0 |
| Pivot | 0 | 0 | 0 | 143 | 143 |
| Sprinkler | 0 | 0 | 0 | 0 | 0 |
| **Government subsidy ($USD)** | | | | | |
| Lazer | NA | 265,215 | 541,141 | 582,357 | 702,167 |
| Drip | NA | 100,136 | 187,000 | 333,657 | 482,251 |
| Micro | NA | 0 | 0 | 0 | 0 |
| Pivot | NA | 0 | 0 | 194,769 | 243,461 |
| Sprinkler | NA | 0 | 0 | 0 | 0 |
| **Total government subsidy ($USD) - Present Value** | | **365,351** | **728,141** | **1,110,782** | **1,427,879** |
| Objective function value over 20-years (Present Value) | 16,979,767 | 17,801,256 | 18,311,466 | 18,816,006 | 19,328,346 |
| Additional output resulting from subsidies (total) | [redacted] | 821,489 | 1,331,699 | 1,836,239 | 2,348,579 |
| Assume value added in secondary industries of 3 | [redacted] | 2,464,467 | 3,995,097 | 5,508,717 | 7,045,737 |
| Average additional output per annum (20-years) | [redacted] | 123,223 | 199,755 | 275,436 | 352,287 |
| Assume say 25% tax paid on additional output per annum | [redacted] | 30,806 | 39,951 | 55,087 | 70,457 |
| **Subsidy payback by community (years)** | [redacted] | **11.9** | **18.2** | **20.2** | **20.3** |

Table 8.7 gives an indication of the amount of subsidy that will be required to convert say 70% of all the irrigation land in these four regions to lazer irrigation with the assumption that there will be a 50% subsidy on the capital expenditure in the first year. The total area to convert will be 931 700 ha and the required subsidy $USD 838.53 million. However, the authors are of the opinion that it will be impossible to convert such a huge area in the short-run. If government consider subsidies it could be spread over a budget period of say 5-10 years to convert such a large area. The subsidies can also be linked to the estimated saving in energy cost which were demonstrated earlier. For example, in Table 8.2 it was estimated that a 15% water saving equals 1663 $m^3$ per water per annum which converts to about 285 kWh (1 kWh pumps on average 5.82 $m^3$). This will result in an energy cost saving for government of approximately $USD8 per ha per annum. In **present value terms** the saving over a 20-year period will be equal to $USD160 which is approximately 9% of the $USD1800 cost to convert to lazer.

It was also pointed out in Table 8.6 that government will recover subsidies through taxes being paid in the rest of the economy through the forward and backward linkages (economic multi-pliers of agriculture).

**Table 8.7: Estimated value of subsidy based on all the regions and on lazer irrigation**

| Area | Total Irrigation area (ha) | Estimated convertion to new technologies (% of total area) | Total area converted (ha) | Average subsidy per ha ($USD) | Total subsidy (million $USD) |
|---|---|---|---|---|---|
| Bukhara | 264,000 | 70% | 184800 | 900 | 166.32 |
| Kashkandarya | 490,000 | 70% | 343000 | 900 | 308.7 |
| Surkhandarya | 315,000 | 70% | 220500 | 900 | 198.45 |
| Khorezm | 262,000 | 70% | 183400 | 900 | 165.06 |
| **Total area (ha)** | **1,331,000** | **70%** | **931700** | 900 | 838.53 |

## 8.4 Summary of costs and benefits to role-players

Figure 8.1 is a conceptual outlay of the proposed institutional model for the project which shows the role of the various stakeholders.

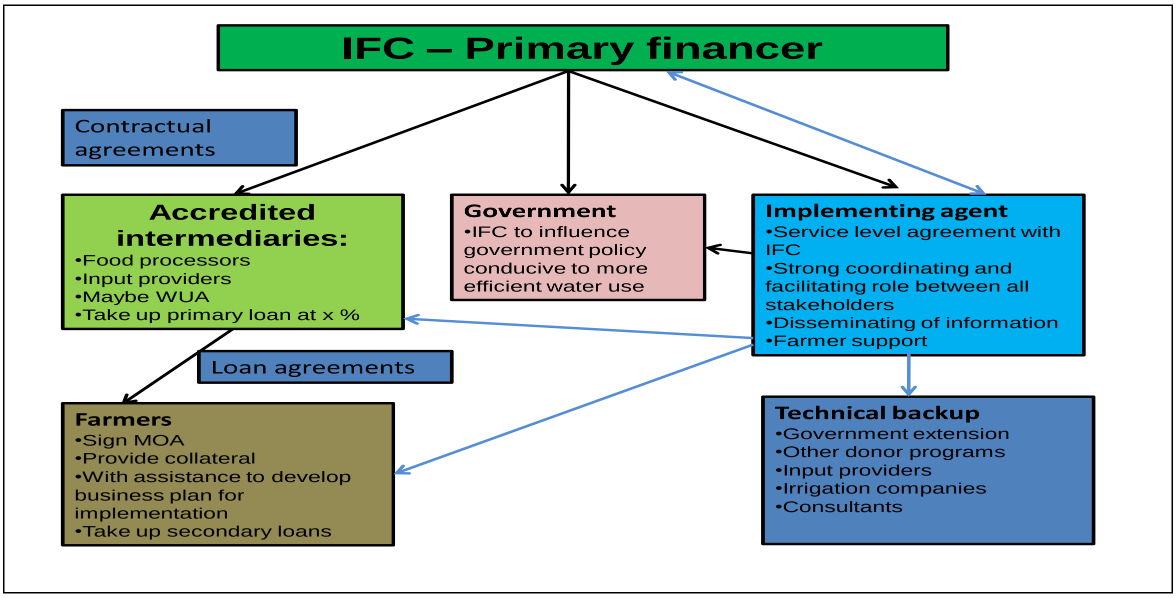


**Figure 8.1: Proposed institutional model for the project**

It should be obvious that there must be benefits for all the stakeholders to make the model attractive for implementation. These, and costs are summarised in section 8.5.

### 8.5 The costs and benefits and risks for stakeholders

Table 8.8 is a summary of the various costs, benefits and risks for the stakeholders. Some of these are quantifiable whereas others are more of a qualitative nature. The overall result of the analyses shows that no one will lose if the risks are managed properly, therefore a win-win result can be achieved.

**Table 8.8: Summary of the costs, benefits and risks for important stakeholders**

| Stakeholder | Costs | Benefits | Risks |
|---|---|---|---|
| Uzbekistan Government | Not necessarily a cost | Proactive actions to mitigate future regional conflicts over water | Lack of extension services may jeopardize the effort |
| | Maybe subsidies on new irrigation technologies - to convert 70% of area for the four regions to lazer with 50% subsidy - $USD838 million. | Models shows a 50-200% increase in agricultural output which will be the catalyst for economic growth through forward and backward linkages. | Largest risk is to do nothing - agricultural sector will go into downward spiral - political unrest - 40% plus decrease in total cotton and yield production |
| | Costs to participate in establishing an operational extension/research services - depends on the model selected | Increase in tax revenue, increase in the ability of government to supply services - Community pay back to government - 12 to 20 years (in additional tax). | |
| | | Good for the environment by reducing the tempo of salination and potentially turn it around | |
| | | Scenarios do not indicate a decrease in cotton and wheat production with relaxed control - in fact cotton and wheat production increases in all the scenarios even if control is relaxed | |
| | | Energy savings on bulk water supplies - for the four regions estimated at $USD36 million. | |
| Intermediaries | Administrative cost to administer loans to farmers | Secured supply of products (processors) | Failure of farmers to honor loan agreements |
| | Maybe a share of the costs to provide extension services and technical backup | Possible quality improvement (processors) | Failure of a efficient extension service and technical backup - farmers unable to attain full benefits of new technology |
| | | Irrigation input providers if they act as intermediaries can build up a market for their products | Have to pay back loans to IFC in foreign currency - exchange rate fluctuations - needs to convert Soums to forex |
| | | Additional income due to potential to expand operations with secured supply | |
| Farmers | Transaction cost of applying for loans - time | Increase in water use efficiency and turn around of the salination problem (conservatively 15% to 20%) | On-farm fixed investment loss due to insecurity of land tenure |
| | Cost of new irrigation infrastructure - between $1800 and $4000. | Increased soil productivity and yield gains of 20% to 50% possible | Maximum benefits not realized due to government not relaxing control over cotton and wheat production |
| | Cost of learning new technologies - time and possibly additional costs | Overall increase in Net Farm income of up to 200% if all benefits are realized - - model results indicates a increase of up to 200% (albeit from a very low base) | Other market risks (closing of borders) can wipe out all gains in a single season |
| | Increase in energy costs - scenarios results indicates on farm energy costs of between $50-$80 | | Risk of not being able to pay back loans if full or part of the benefits not realized |
| | Increase in production costs - increasing yield, increasing harvesting costs | | Risk of a lack of extension services and technical backup to manage new technology |
| | Increase in marketing costs - new products | | |

Government will be in a position to sustain the existing cotton and wheat production and possibly even increase production. The additional output created by agriculture will spill over to the rest of the economy where it will create more employment opportunity and increase general economic welfare. Intermediaries could potentially be in a better position since they will be able to secure feedstock supplies to their factories and also potentially improve their quality which will put them in a competitive advantaged position. Finally, the farmers will be in a position to increase their Net Farm Income and a better quality of life for rural people.

## 8.6 Mitigating the risks

There is several ways in which the risk to all role-players could be mitigated. However, it was emphasized that the most important factor that will mitigate the risk for all (including government, the IFC, intermediaries and the famers is an efficient education and extension service. Bekchanov et al. (2001) identified the following factors contributing to poor performance of **education and extension services** in Uzbekistan (adapted by the authors in the context of mitigating risks):

- **Form of ownership** – legal entity. Many farmers do not have an appropriate legal entity in which they conduct their business. This is a limiting factor when it comes to credit since financial institutions is often not comfortable if they don't deal with appropriate legal entities.
- **Land tenure** (security and or ownership) – Insufficient security of land tenure and or land ownership is a significant factor which impact on farmer's ability to attract loans (because of their insufficient security). The authors are of the opinion that an improvement in security of land tenure and or ownership will contribute significantly to reduce the risk of all stakeholders. Land tenure security also impacts on the farmers investment decisions. Farmers will not invest in new technologies which require some kind of fixed investment on the farm which they cannot move if they lose the land. It also impact on efficient extension services since extension is not a short-term action. It can take several years for famers to acquire the knowledge to manage new technology optimally. Insecure land tenure result in a short-term vision and is a major obstacle towards human resources development and economic growth.
- **Lack of credit facilities** and access to electronic banking. This is a risk for farmers and for the project since it makes credit transactions difficult for farmers. Electronic banking also contributes to improved financial record keeping and hence a reduced risk for financers.
- **Access to information** (access to email and web information). In today's global village, it is impossible for farmers to be internationally and even nationally competitive without access to email and electronic information. Also, it is much more cost effective to reach famers with electronic information. Improved communication between farmers and the other role-players will also contribute to reduce risks.
- **The availability and prices of inputs**. Similar to the above point. Farmers market risks increases significantly if they do not have access to this information.
- **Inefficient market structures**. Even if there were an efficient extension service, it is not possible to for farmers to maximize farm profitability without efficient market infrastructure. It also place a barrier on what extension services can learn farmers since even if they receive good marketing extension, they will not be able to apply the principles if efficient markets infrastructure is not available. In the Uzbekistan context inefficient marketing infrastructure, especially for perishable product places a restriction on the drive towards higher value fruit and vegetable production and hence the risk that famers will not be able to afford relatively expensive drip and micro irrigation systems.
- **Bureaucratic inefficiency**. The financing model should not be complicated, it must be transparent, there must be advantages for all the stake-holders, it must be institutionalize in such a way that there is a minimum of bureaucracy to reduce transaction costs for farmers. If the transaction cost of applying for a loan is too high, it will erode away all the advantages. However, there is also many other bureaucratic inefficiencies which hamper the movement of goods, services and people in Uzbekistan that places a restriction on investment. Bureaucratic inefficiencies in itself increases the risk of failure for the envisaged project.
- **Deficient program design**. Top down approach leads to failures.
- **Public orientated, staff-intensive information delivery services**. The electronic media and direct linkages to technical input providers can reduce the risk of a lack / failure in information delivery.

- **Top-down approach in technology transfers**. If famers are not involved, there is a risk that they will not implement models and or recommendations.

In addition risks can be reduced by consideration of the following key aspects in project implementation:

- The model indicated that farmers prefer both short-term (one-year) and medium-term loans (five years). Not one of the scenarios resulted in farmers making use of long-term loans. The golden financing rule is to match the loan term with the lifespan of the capital. **Short-term loans should not be used to finance long-term capital**.
- It is therefore proposed that the financing vehicle consists of **both short and medium-term loans**. The medium term loans should be available for the capital to purchase the new technology and the short-term loans to operate the system optimally (including purchasing moisture measuring equipment the maintenance of the system).
- A contract with the terms and conditions should be signed between the intermediaries and the **IFC and between the intermediaries** and the farmers.
- The contract between intermediaries and the IFC should make provision that farmers **are not exploited and that the interest rate is fixed to a maximum level**. It is also proposed that a fixed administration cost be charged which can be capitalized in the loan amount. Experience in South Africa has shown that if administration costs are part of the interest charge, it may result in unfair practices.
- The intermediaries on the other hand should follow a **stringent screening process** (not bureaucratic) to select farmers to qualify for a loan. It is also proposed that the loan agreement between the farmers and the intermediaries make provision for definite management guidelines to be followed. In South Africa the Cooperative Wine Cellars do make for example establishment loans available to farmers under the condition that they must follow a minimum standard of management of these vineyards. This is extremely important to reduce the risk for the farmer, the intermediary and the IFC.
- In support of the abovementioned **minimum management practices**; it is proposed that the intermediaries also play a facilitation role to connect farmers with technical support from irrigation service providers and extension officers and or other experts (which is a scarce commodity in Uzbekistan). If the extent of the loan agreement between the IFC and the intermediaries is large enough it may also make sense for the intermediaries and the IFC to co-finance extension services in a particular region and to capitalize the cost in the interest rate charged. The first price will obviously be if government invests in an efficient extension service in the selected areas as part of the program. It was mentioned earlier in this report that there is a huge return on investment in agricultural extension services.

***The best way to reduce the risks is to create a legal entity where service providers (with international experience), a local team of professionals and a potential processor and or input provider combine forces (in a Pilot Project) to provide a comprehensive intermediary service that will ensure that all the necessary elements for success are addressed:***

- ***Financing***
- ***Facilitating linkages between farmers and extension services and technical backup*** **(room for an enhanced private sector, motivated by profit, sustained by good customer service in a competitive, non-monopolist environment)**
- ***Facilitating the creation of improved market access and more efficient marketing outlets***

- ***Support famers and other stakeholders in their negotiations with government institutions to create a more enabling environment.***

A pilot project where this concept can be refined through experience and with input from all the role-players will be the key to reducing the risk when the project is duplicated in other regions.

### 8.7 Simplified example of farm business case – excel model

Some readers my find mathematical models such as the one that were used in this study intimidating and or experience the results as so-called “black box” results. It was therefore decided to make a very simplified Excel spreadsheet model to illustrate the concept. The complicated large mathematical model does exactly the same kind of calculations but considers many variables simultaneously and then the model calculates an optimal solution to the problem. **Table 8.9** shows the assumptions that were used in this model. The model assumes that the IFC makes $23000 available to an intermediary at 17% interest and the intermediary makes the capital available to the farmers at 20% interest. The farm consist of 10 ha irrigable land with a crop mix of cotton, wheat, grapes, fruit and vegetables. The overhead costs were obtained from the average in the farm survey. The energy requirement for sprinkler (converted to $m^3$ per kWh) is 5.98 $m^3$ per kWh. Energy cost is $USD0.05 per kWh and the water requirement is estimated at an average gross water requirement of 10 000 $m^3$ (net requirement of 7500 $m^3$ per ha).

**Table 8.9: Assumptions used for simplified business case model**

| Assumptions | Value |
|---|---|
| IFC primary loan amount ($USD) | 23000 |
| Loan period - years | 10 |
| IFC loan interest rate (% assumed) | 17% |
| Intermediary loan amount ($USD) | 23000 |
| Annaul payback amount to IFC ($USD) | -4937 |
| Farm loan amount ($USD) | 23000 |
| Farm loan interest rate | 20% |
| Farm loan period- years | 10 |
| Farm payback amount ($USD per $USD1) | -0.239 |
| **Typical farm** | |
| Total irrigated land area (ha) | 10 |
| % under Wheat | 55% |
| % under Cotton | 33% |
| % under Grapes | 2% |
| % under Fruit | 5% |
| % under Vegetables | 5% |
| Total land occupation | 100% |
| Overhead costs per ha ($USD) | 61.5 |
| Energy requirement for sprinkler $m^3$/Kwh | 5.988 |
| Energy costs per KwH ($USD) | 0.05 |
| Gross water requirement $m^3$ | 10000 |

It was also assumed that over time there is a gradual increase in yield (eventually 25%) and also in price because of improved quality of products. However, the assumption was also made that as yield increase and in an effort to improve the quality, the direct allocate able costs (DAC) will also increase. These assumptions are shown in Table 8.10.

**Table 8.10: Adjustment factors for yield, price and direct costs**

| Adjustment factor | Base | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yield adjustment factor | 1 | 1.15 | 1.15 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |
| Price adjustment factor | 1 | 1.08 | 1.1 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 |
| DAC adjustment factor | 1 | 1.05 | 1.1 | 1.12 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 |

The financial results of the farm business case are presented in Table 8.11. The analysis shows that with the assumption made the farm can repay the loan at an interest rate of 20% if there is an increase in both the yield and price of products. The farm is feasible at a discount rate which was varied between 6-12% to calculate the NPV and the Internal Rate of Return (IRR) is 18% which is acceptable given the risks involved.

**Table 8.11: Financial results of the farm business case**

| Gross income | Area | Base Yield (ton) | Base Price/ ton ($) | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 5.5 | 2.8 | 358 | 5,582 | 6,933 | 7,061 | 8,024 | 8,024 | 8,024 | 8,024 | 8,024 | 8,024 | 8,024 |
| Cotton | 3.3 | 4.5 | 213 | 3,156 | 3,920 | 3,992 | 4,537 | 4,537 | 4,537 | 4,537 | 4,537 | 4,537 | 4,537 |
| Grapes | 0.2 | 9.8 | 85 | 167 | 208 | 212 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| Fruit | 0.5 | 9.3 | 220 | 1,019 | 1,265 | 1,289 | 1,464 | 1,464 | 1,464 | 1,464 | 1,464 | 1,464 | 1,464 |
| Vegetables | 0.5 | 17 | 175 | 1,488 | 1,847 | 1,882 | 2,138 | 2,138 | 2,138 | 2,138 | 2,138 | 2,138 | 2,138 |
| Loan | | | | 23,000 | | | | | | | | | |
| **Total gross income** | | | | **34,411** | **14,173** | **14,435** | **16,404** | **16,404** | **16,404** | **16,404** | **16,404** | **16,404** | **16,404** |
| | | | | | | | | | | | | | |
| **Direct costs** | **Area** | **Base DAC/ ha ($)** | | **Year1** | **Year2** | **Year3** | **Year4** | **Year5** | **Year6** | **Year7** | **Year8** | **Year9** | **Year10** |
| Wheat | 5.5 | 628 | | 3,451 | 3,624 | 3,797 | 3,866 | 3,969 | 3,969 | 3,969 | 3,969 | 3,969 | 3,969 |
| Cotton | 3.3 | 580 | | 1,914 | 2,010 | 2,105 | 2,144 | 2,201 | 2,201 | 2,201 | 2,201 | 2,201 | 2,201 |
| Grapes | 0.2 | 402 | | 80 | 84 | 88 | 90 | 92 | 92 | 92 | 92 | 92 | 92 |
| Fruit | 0.5 | 450 | | 225 | 236 | 248 | 252 | 259 | 259 | 259 | 259 | 259 | 259 |
| Vegetables | 0.5 | 2,616 | | 1,308 | 1,374 | 1,439 | 1,465 | 1,504 | 1,504 | 1,504 | 1,504 | 1,504 | 1,504 |
| **Total direct costs** | | | | **6,979** | **7,328** | **7,677** | **7,817** | **8,026** | **8,026** | **8,026** | **8,026** | **8,026** | **8,026** |
| **Capital cost on irrigation** | | | | **23,000** | | | | | | | | | |
| **Irrigation maintanence** | | | | **46** | **46** | **46** | **46** | **46** | **46** | **46** | **46** | **46** | **46** |
| Overhead costs | | | | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 | 615 |
| Loan repayment | | | | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 | 5,486 |
| Energy cost per 10 ha | | | | 833 | 833 | 833 | 833 | 833 | 833 | 833 | 833 | 833 | 833 |
| **Total costs** | | | | **36,959** | **14,308** | **14,657** | **14,797** | **15,006** | **15,006** | **15,006** | **15,006** | **15,006** | **15,006** |
| | | | | | | | | | | | | | |
| **Cummulative net cash balance** | | | | **-2,548** | **-136** | **-222** | **1,607** | **1,397** | **1,397** | **1,397** | **1,397** | **1,397** | **1,397** |
| NPV at 6% | 4,005 | | | | | | | | | | | | |
| NPV at 8% | 3,278 | | | | | | | | | | | | |
| NPV at 10% | 2,659 | | | | | | | | | | | | |
| NPV at 12% | 2,131 | | | | | | | | | | | | |
| **IRR** | 18% | | | | | | | | | | | | |

## 9. CONCLUSION AND RECOMMENDATIONS

Following is a condensed summary of the conclusions and recommendations:

- ***In order to encourage more sustainable rotations, it may make sense for government to review their policies on cotton and wheat production control***.
- To date there has been **very little private sector participation in the formulation of policy for the fruit and vegetable subsector** (ADB, 2006). Farmers are unable to provide for rational resource use or efficient farm management and there is a need for support for farmers to adapt. The lack of extension services per se and scarce knowledge is a **contributing factor towards the slow adoption of new irrigation technologies.**

- Independent of the technical support and extension model that eventually evolve it is of paramount importance that it is efficient in supporting the introduction of new irrigation technology and the uptake of loan financing by farmers and that behavior change should be the focus.
- **Efficiency is not only about the hardware (i.e. irrigation systems); management systems and strategies would often yield far greater benefits than switching from one system to another**.
- An **incentive for change is very important** and is a fundamental driving force for improvement of system efficiency. **Reduced costs and increased yields lead to greater profitability for farmers and is regarded as the main incentive for change**.
- In the Uzbekistan situation **where ownership of land is not secure**, this will play an important role in the selection of a more efficient irrigation system. With this in mind the systems that can be considered for Uzbekistan **will rule out expensive infrastructure which a farmer cannot recover or remove**. This applies to the use of centre pivots, linear systems and to some extent also permanent sprinkler systems.
- Uzbekistan probably **had the comparative advantage to produce cotton** (even if there were to be a free market environment). However, with souring **energy costs**, increasing pressure for **ethical trading** (including labor conditions), **climate change**, international pressure to reduce the **carbon footprint**, pressure to reduce the **water footprint** (more crop per drop), huge irrigation areas with **salination problems**, a **ageing irrigation infrastructure**, **outdated irrigation technologies** (low efficiency), and **pressure from the WTO for reduced subsidies to agriculture** the question can rightfully be ask if Uzbekistan has any future comparative advantage whatsoever for cotton production.
- If all the mentioned issues were considered to be addressed in line with international accepted standards, it is quite **possible that there are many other crops** where Uzbekistan may have a comparative advantage.
- For the greater benefit of the Uzbekistan economy, **there should be value added to agricultural produce.** However, there is a **lack of supporting input industries such as new irrigation technology industries, jars, canning factories, and other technical inputs. This is a deterrent to the development of higher value products for exports as well as internal use.**
- The authors is of the opinion that the proposed financing program can make a huge contribution **towards being the catalyst for increased** agricultural output, a more diversified agricultural industry and the development of SME's in the secondary economy if government create an enabling environment for them.
- In general there is definitely **a need for more credit**, farmers will take up credit and they can pay it back only if **all the elements are in place to achieve higher efficiency levels**.
- **It can be concluded, that without technical backup and extension services, which will contribute to the attainment of higher yields, farmers will not convert large areas to new technologies** since they will not reap the full benefit of their investment.
- In general, farmers will change away from conventional irrigation to **sprinkler systems for cotton production and to a lesser extent to laser flood** irrigation.
- When **government control is relaxed**, there is an **increase in fruit and vegetable production in all the regions**.
- A significant result is that **it can be concluded that government fears that cotton and wheat production will be reduced significantly when control is relaxed is not**

**substantiated** since in most of the scenarios, the total yield either increase, or in the case of wheat only a small reduction.

- The results also indicate that as farmers become **more efficient their ability to take up loans increases**.
- **The reader should notice that for the purpose of this report drip and micro should be interchangeable since these technologies capital cost is approximately the same and the crop and soil conditions will determine the decision of which one to use**.
- It can be concluded from the results that **subsidies will make a huge contribution towards the introduction of new irrigation technologies.**
- The results indicate that **it will take approximately 15 years for the community to pay back a subsidy of 20%, 18 years with 30%, 20 years for 40%**.
- Amongst others it is also concluded that **intermediaries should follow a stringent screening process (not bureaucratic) to select farmers to qualify for a loan**. It is also proposed that the loan agreement between the farmers and the intermediaries make provision for **definite management guidelines** to be followed
- It is also concluded that the financing vehicle **must be supported by efficient technical backup and extension services**.

Most of the abovementioned conclusions could benefit from specific actions to impact positively on the future of the Uzbekistan agriculture. The **following recommendations** are regarded to receive priority consideration in the process to improve the infield irrigation efficiencies of the farmers of Uzbekistan:

- There is a lack of knowledge about efficient micro irrigation systems under the farmers and even the authorities of Uzbekistan. **Greater awareness and knowledge about these systems are much needed.**
- Care must be taken to **ensure that there is a responsibility on the irrigation engineer / technician selling the system to the farmer**. It is not just about ‘selling pipes’; there should be a service that goes with it which includes: A sound system design, transfer of knowledge, training and monitoring. If not done correctly right from the start there is a possibility that a good concept and technology will fail after implementation, which will cause mistrust of the technology by fellow farmers, and eventually it will be rejected for the wrong reason.
- Efforts must be made to **discourage the use of equipment of poor or inferior quality**.
- Training alone (extension officers and farmers) in the use of micro irrigation systems will be insufficient for successful implementation. **Experienced technical people (which may include farmers) from countries where these technologies are used will have to be consulted for a period**. Irrigation companies (opening in Uzbekistan) will bring with them much knowledge and experience, but it may take a long time before there is sufficient business (a critical mass) in the country to attract many of these companies.
- The **implementation of more efficient infield irrigation systems** must go hand in hand with **implementation and/or restoration of effective drainage systems**.
- The **WUA’s must be assisted and empowered** to play the role they are tasked with. Training programs elsewhere in Uzbekistan showed that with the necessary assistance to build capacity they can grow to be much more effective (doing the right things) and efficient (doing the right things right).

- An **enabling environment should be created** for farmers to increase their productivity and their profitability. **This is probably the most difficult since it will require a political will to relax the current control on the cotton and wheat industry and to PROMOTE the production of higher value crops**. However, it was pointed out in this report that the fears of government are unsubstantiated and that it is possible to produce and even grow the current cotton and wheat output with a smaller area with increases in productivity.
- The government of Uzbekistan should **seriously consider the introduction of subsidies on on-farm irrigation infrastructure and new technologies**. Not only is the current irrigation unsustainable but it is also places a cap on the maximum growth potential of the agricultural industry.
- It is recommended that the **financing model be implemented in those areas with the highest level of technical support**. If it is not possible for implementation in all the regions, the **Khorezm region** is preferred due to reasons that were already discussed earlier.
- Finally, the authors recommend that a **workshop be held with all the proposed stakeholders to refine the proposed financial model and the program of implementation**.

***Finally, the best way to reduce the risks is to create a legal entity where service providers (with international experience), a local team of professionals and a potential processor and or input provider combine forces (in a Pilot Project) to provide a comprehensive intermediary service that will ensure that all the necessary elements for success are addressed:***

- ***Financing***
- ***Facilitating linkages between farmers and extension services and technical backup*** **(room for an enhanced private sector, motivated by profit, sustained by good customer service in a competitive, non-monopolist environment)**
- ***Facilitating the creation of improved market access and more efficient marketing outlets***
- ***Support famers and other stakeholders in their negotiations with government institutions to create a more enabling environment.***

A pilot project where this concept can be refined through experience and with input from all the role-players will be the key to reducing the risk when the project is duplicated in other regions.

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