**Farm level effects of market integration in Central Asia under climate change**

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**Abstract**

There were several regional trade agreements made amongst Central Asian countries during the transition period. However, the implementation of these agreements remains very restricted which causes limited exchange and flow of agricultural commodities between the countries. The market imperfections caused by state policies, poor market infrastructure and trade restrictions remain the main challenge for small scale producers in Central Asia. This study analyses input and output price differentiations between the countries and discusses the main factors causing those price differences. Furthermore, the paper examines the impact of easing those trade barriers on farm level welfare, especially under different climate change scenarios. Therefore, the paper aims at filling in the gap of knowledge that exists between effects of trade barriers on farm gate prices and farmers’ welfare in Central Asia.

The farm level input-output prices and household consumption patterns are analyzed using the data obtained from farm surveys conducted in Kazakhstan, Uzbekistan, Kyrgyzstan and Tajikistan. Changes in expenditure under trade liberalization among Central Asian countries are estimated. Per capita expenditure changes are estimated for alternative market conditions. The impact of climate change on farm utilities is analyzed using an integrated modeling tool which incorporates the climate change module and crop growth simulation model in the expected utility framework.

The results show significant differences in farm gate prices of many agricultural commodities. Salient differences were also found between the energy and fertilizer prices among these countries. Political disputes between some Central Asian countries are explained to be the main challenge for restricted trade between the countries. Liberalization of trade may create favorable economic conditions for many regions in Central Asian countries. However, potential gains from market integration are very region and country specific. The integrated model results show that easing commodity exchange between the countries may improve the adaptive capacity of the small scale producers especially in Uzbekistan and Tajikistan under different climate change scenarios.

# Introduction

Central Asia covers an area of 400 million hectares, however, only 20% of that is suitable for farming while the rest is composed of deserts and mountainous areas. Nevertheless, agricultural production in this 20% area forms the backbone of Central Asian economies. Agriculture is the main source of export for these countries except for the fossil-fuel-rich Kazakhstan and Turkmenistan. The contribution of agriculture to GDP is lowest at 11% in Kazakhstan and highest at 38% in Kyrgyzstan ([Bucknall *et al.*, 2003](#_ENREF_8)). Cotton exports significantly contribute to the countries’ revenues. For instance, cotton fiber exports accounted for about 18% of the GDP 2004 in Uzbekistan ([CEEP, 2005](#_ENREF_10)).

Agricultural production and commodity exchange between CA countries were implemented according to the plans established by the Soviet Government during the Former Soviet Union (FSU) period. The specialization was mainly identified according to the comparative advantages of FSU states in production of certain crops ([Davis, 1997](#_ENREF_14)). Wheat production was the main agricultural activity in Northern Kazakhstan, Ukraine and Russia. Cotton was considered as the most suitable crop for irrigated lowlands in CA complimented by fruit, vegetable and fodder production. Wheat demand of CA counties was mainly fulfilled by transporting wheat from Russia, Ukraine and Kazakhstan (RUK) and produced cotton in CA also taken to the textile centers in east European states of FSU.

Production was carried out by large scale collective farms known as sovkhozes and kolkhozes (Djanibekov et al., 2012) and farms were not involved in marketing activities. Agricultural trade was mainly carried out by specialized state trade companies. Furthermore agricultural trade outside the FSU was implemented by specialized state organizations which exported products under the instructions of soviet government in Moscow. Exportkhleb (Bread Export), Soyuzplodimport (Fruit Import Union) were the main export and import organizations involved in the external trade. All export and import decision were mainly organized top-down by Ministry for Foreign Trade and countries did not have any involvement beyond the delivering (or receiving) the agricultural products to specialized storage houses.

Having similar backgrounds in terms of organization of agricultural production, centrally planned import and export activities, independent states have chosen different approaches in agricultural policies ([Lerman, 2001](#_ENREF_25), [2009](#_ENREF_26)). The differentiation is also seen in their policies in trade with neighboring countries and world market. The main aspects causing the differences in trade policies may seem to be very obviously determined by the comparative advantages of these countries in producing certain crops, geographical location in terms of transport infrastructure as well as the importance of agricultural import and export in the country trade balances as the main economic grounds. Uzbekistan and Turkmenistan boosted own wheat production in order to achieve grain self-sufficiency after their independence but still maintained cotton production in high levels. Tajikistan and Kyrgyzstan have withdrawn their involvement in wheat production and importing wheat from RUK. Uzbekistan and Turkmenistan maintained state involvement in wheat production in irrigated areas against availability of cost effective high quality wheat from the neighbors. These type of policies may be explained by the reduced uncertainty of cereal availability associated with production variation in RUK countries (e.g. export mans in RUK during the period 2006-2011) as well as uncertainties in the external relations between the countries (e.g. ethic and political disputes). These types of uncertainties and trade constraints are not only relevant to the example of grain trade, but also relevant in case of agricultural trade in general. Political and ethnic disputes in the region are causing serious constraints to trade between the countries. Restrictions in commodity trade between the countries thus prevent farmers from planting crops according to their comparative advantages and obtaining increased revenue with the available resources. Furthermore, trade limitation is not only related to agricultural commodities but also limits agricultural input exchange between the countries. Improved commodity exchange between the countries thus could improve productivity not only because of specialization according to comparative advantage but also because of improving input access of smallholders. This type of policy is especially needed in the future due to increasing climate risk and strong need for policy measures to improve the adaptive capacity of agricultural producers. Opportunities and constraints for trade between the countries are often discussed in related literature; however, quantitative analysis of household and farm level gains and losses under market integration has not been undertaken within this specific context. Especially the role of policy measures such as trade liberalization in increasing the adaptive capacity under climate change has not yet been investigated. Therefore, this study investigates how market integration will impact household budgets and farm revenues especially under climate change scenarios.

# Climate change in Central Asia

Irrational water use during the time of the Soviet Union caused several problems in the region including the disappearance of the once fourth largest lake in the world, the Aral Sea ([Glantz, 2005](#_ENREF_20)). Land degradation as an effect of these improper policies is still a major problem in all CA countries where land salinization affected about 12% of the total irrigated area in Kyrgyzstan, 50-60% in Uzbekistan and even more than 90% in Turkmenistan ([Bucknall *et al.*, 2003](#_ENREF_8); [CAREC, 2011](#_ENREF_9)). Reduction of the cropping areas in the irrigated lands has been observed during the last decades, which often occurs due to land degradation ([Kariyeva and van Leeuwen, 2012](#_ENREF_23)). Uncertainties during the transition phase combined with land degradation caused high rates of poverty in most of the regions in Central Asia. More than 90% of the population living in the rural areas is defined as poor (less than 4.30 USD per person per day) according to recent studies ([World Bank, 2009](#_ENREF_38)).

Climate change adds additional dimensions to the problems in the Central Asia region and increases the vulnerability of rural producers ([Lioubimtseva and Henebry, 2009](#_ENREF_27)). Increasing sequences of droughts is causing serious damage to the livelihoods of rural population in semiarid and arid regions of Central Asia ([CAREC, 2011](#_ENREF_9)). Droughts during 2001-2003 and 2007-2008 have shown to be the worst droughts in the history in Central Asia and caused several socio-economic problems ([Lioubimtseva and Henebry, 2009](#_ENREF_27)). For example, droughts in 2001 and 2008 damaged more than a third of the cropping areas in Tajikistan ([Christmann *et al.*, 2009](#_ENREF_12); [CAREC, 2011](#_ENREF_9)). Furthermore, rainfall is becoming heavier and increasing the sequence of floods in mountainous regions of CA and the impact is hitting the poorest population the hardest. Rural populations are already suffering from the increasing sequence of extreme events, and projections show even more changes in the future. According to the Intergovernmental Panel on Climate Change (IPCC) predictions ([IPCC, 2007b](#_ENREF_22)), CA may face declining rainfall during spring, summer and autumn and slight increase or unchanged precipitation during the winter periods. According to IPCC fourth assessment report, the temperature in CA may increase by 3.7 °C on average by the end of the century and this is mainly expected to occur during June, July and August, which are the most important months in the vegetation period. Higher temperatures during the vegetation period may cause higher probability of drought risk and declining productivity of agricultural production ([IPCC, 2007a](#_ENREF_21)).

Existing studies about climate change impacts in CA indicate negative effects of climate change on the livelihoods of small-scale farmers who are currently operating on very narrow profit margin and who lack access to financial resources and technological knowledge in the region ([World Bank, 2009](#_ENREF_38)). There is very limited research available on the impact of climate change on agro-ecosystems and analysis of the adaptation strategies in response to the growing urgency in CA ([Christmann and Aw-Hassan, 2011](#_ENREF_11)). In particular, the impact of market integration on households and farm welfare under conditions of climate change remains an interesting topic for an investigation in the region.

# Opportunities and constraints for market integration

CIS countries have established several regional cooperation organizations in order to develop economic cooperation between these states. There is a very long list of regional organizations and several ones are expected to be established in the future ([Pomfret, 2005](#_ENREF_29); [UNDP, 2005](#_ENREF_36); [ADB, 2006](#_ENREF_1)). The regional cooperation organizations could play an important role in improving economic cooperation and trade between the states. Furthermore, the regional cooperation could also facilitate the cumbersome transit bureaucracy between the countries, which could also increase the trade between non-CIS countries. However, the impacts of these organizations have been minimal in the past two decades and challenges associated with transportation remains unsolved ([ADB, 2006](#_ENREF_1)). The fear that these organizations could become more political was one of the reasons for the failure of a wide number of regional agreements and cooperations ([UNDP, 2005](#_ENREF_36)).

Furthermore, ethnic disputes and political problems between the states have negative impacts on trade of agricultural commodities between the countries. For example, ethnic violence against Uzbeks living in southern Kyrgyzstan that happened in June 2010 had negative impacts not only on food security in the country but also damaged trade relations of the country. The violence has displaced more than 350 thousand people in the country and more than 100 thousand crossed the border to Uzbekistan. The violence which continued for several weeks showed its negative impact on food security for several months ([FAO and WFP, 2010](#_ENREF_18) ). Closing the borders of Kazakhstan and Uzbekistan during this violent period reduced the flour and wheat imports to incredibly low levels and caused extremely high prices in Kyrgyzstan ([Barrows and Gusev, 2010](#_ENREF_3)). The large scale mills and bakeries stopped operations due to the lack of wheat and flour associated with damage to the import infrastructure during the violence. The negative effect continued for several years also due to complications associated with the trade activities transiting Uzbekistan.

In addition to the ethnic disputes, resource related political disagreements also put much pressure on the function of agricultural commodity exchange between the countries. One of the examples could be given in case of Uzbek and Tajik political disputes over construction of the Rogun dam in Tajikistan. Uzbekistan is opposing the construction of the dam since the Uzbek government argues that it will reduce water availability in downstream regions especially during the summer periods ([Eshchanov *et al.*, 2011](#_ENREF_17)). The blockage of construction material transiting though Uzbekistan to Tajikistan has occurred some years which also resulted in negative impacts on trade of agricultural goods. This political dispute reduced the trade potential between these two countries. For example, Uzbekistan exports grain to Azerbaijan and could also export grain to Tajikistan in years when RUK countries have production shortfall or export restrictions if political disputes did not hinder this option. This could also function as risk minimization policy for Tajikistan since production risks are not correlated between Uzbekistan and RUK. [USAID (2011](#_ENREF_37)) discusses complaints of the traders from Tajikistan about the complications of buying grain from Uzbekistan which gives disincentives to the traders.

Trade limitation between the countries has its impact on agricultural producers. One of the assumptions is that it limits agricultural producers’ revenues producing crops according to their comparative advantages. Furthermore, the trade limitations between the countries may distort food prices. However, there is very limited literature available which has investigated the price differentiations and therefore this study contributes to the discussions about the role of market integration in agricultural development in CA.

# Data and methods

The study uses different methodologies in order to investigate the impact of market integration among CA countries on agricultural earnings, household expenses and the role of trade liberalization under climate change. All analysis and modeling work is based on the farm level data obtained from household surveys in four Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan.

* 1. Household surveys

A farm/household survey with total sample of 1591 was conducted in representative provinces for 10 farming systems in CA during the years 2009-2010. The survey covered both subsistence farms with small parcel of land (*households*) as well as commercial farms (*fermer*s). The stratified random selection procedure was applied to select several villages from these representative provinces for the abovementioned 10 agro-ecological zones (AEZ). The number of villages selected from each AEZ was determined by the number of farms and agricultural areas used for crop production by different producer types. After identifying the number of villages per AEZ, random sampling was used to identify the names of the villages from an available list of villages. Collected data included household characteristics and farm level production characteristics (e.g. farm size, fertilizer use, irrigation practices, input use and fertilizer availability) as well as climate change perceptions. This household data was the main information source for the identification of representative farms (Table 1) and bio-economic farm model (BEFM) calibrations.

* 1. Household food expenditure changes

In this study a market integration scenario is considered based on the condition that commodity prices between the countries will follow similar pattern. Further limitation is introduced in terms of commodity prices considered in the expenditure change analysis. Only the most important agricultural and processing products such as wheat, rice, vegetables, meat, egg, wheat flour, bread, vegetable oil are considered since those products have the largest share in the household food expenses in rural areas of CA.

Per capita changes of consumption expenses ( ) under the market integration scenario are estimates from the household data:

(1)

where is the vector of current food expenses and is the vector of food expense under market integration conditions. Further analysis is conducted in order to identify the type of households and regions which are winners and losers of market integration as:

(2)

where is a constant, is the matrix of variables describing the household characteristics (household size) and is the matrix of dummy variables to identify the countries.

* 1. Integrated model

A bio-economic farm model (BEMF) is calibrated for 10 representative farm types in four Central Asian countries (Uzbekistan, Kazakhstan, Tajikistan, Kyrgyzstan) with different agro-ecological and socio-economic characteristics (Table 1). We consider the impact of climate change on three main crops which have crucial importance for the rural economies and food security in Central Asia. Cotton is included in this study as it is the main export crop in Uzbekistan, Tajikistan and Kyrgyzstan ([Pomfret, 2007](#_ENREF_30)). Average share of cotton in total crop area in some regions of Central Asia reaches up to 40-50 percent ([Bobojonov *et al.*, 2013](#_ENREF_7)). Potato and wheat are also included due to their importance in food security and farm income. Wheat is the main export crop in Kazakhstan, furthermore also for food security in the whole Central Asian region ([Ali *et al.*, 2005](#_ENREF_2)).

Table 1. Representative farm characteristics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | AEZ | Farm size, ha | Family size | | Fertilizer use per hectare, kg | Land ownership |
| Uzbekistan | arid | 27,1 | 6,7 | | 138,4 | leased |
|  | semiarid | 34,1 | 5,9 | | 120,2 | leased |
| Kazakhstan | arid | 28 | 4,1 | | 134,4 | private |
|  | semiarid | 77 | 5,7 | | 52,3 | private, cooperative |
|  | subhumid | 773 | 6,2 | | 11,3 | private, cooperative |
| Tajikistan | arid | 4,1 | 7,3 | | 119,5 | state, private |
|  | semiarid | 4,6 | 7,8 | | 43,5 | state, private |
|  | humid | 2,1 | 8,2 | | 166,7 | state, private |
| Kyrgyzstan | semiarid | 5,1 | 5,6 | | 136,3 | private |
|  | subhumid | 5,1 | 5,1 | 22,9 | | private |

*Source: Household surveys*

The study considers two representative medium size farms in Uzbekistan, three farm types in Kazakhstan, two farm types in Kyrgyzstan and three farms types in arid, semiarid and humid zones in Tajikistan. Farm sizes are very large in northern Kazakhstan while Uzbekistan has mainly medium size farms and farms in Tajikistan and Kyrgyzstan are small when compared to Uzbekistan and Kazakhstan.

The BEMF model combines climate module, crop simulation and economic models ([see Bobojonov and Aw-Hassan, 2013 for more details](#_ENREF_4)). IPCC (2007) climate change predictions are spatially downscaled to the local levels ([De-Pauw, 2012](#_ENREF_15)). The crop simulation models use these downscaled scenarios. This combination allows consideration of impacts of climate change on the productivity of different crops. These crop simulation models are calibrated with the crop experiment data as well as actual farm management practices collected from farm surveys ([Kato and Nkonya, 2012](#_ENREF_24); [Sommer *et al.*, 2012](#_ENREF_33)). The crop simulation model results were then used in a farm-level stochastic-optimization model in order to identify the climate change impact of farm income volatility and potential of different management options to improve farm income and adaptive capacity of farmers.

# Results

* 1. Household food expenditure changes

Significant differences in food prices are found between the countries. Uzbekistan has a state procurement system for cotton and wheat and those crops cover more than 70 percent of the arable land which leaves less area for fodder crop. This may be the primary explanation for the higher prices of meat in Uzbekistan (Table 2). In contrast, the price of vegetables is significantly low in the country when compared to other CA countries. Most of the vegetables are usually planted as a secondary crop after winter wheat and therefore does not compete for land with state procurement crops. Particularly low vegetable prices are found during the harvest period due to underdeveloped processing, storage and export infrastructure in Uzbekistan ([Bobojonov and Lamers, 2008](#_ENREF_6)).

**Table 2.** Price difference of main foodstuff, USD kg-1

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | meat | rice | veg | wheat | bread | flour | oil | egg | sugar | butter |
| Kazakhstan | 4,59 | 1,09 | 1,36 | 0,62 | 0,31 | 0,56 | 2,06 | 0,11 | 1,30 | 3,98 |
| Kyrgyzstan | 4,53 | 1,20 | 0,88 | 0,29 | 0,29 | 0,45 | 1,78 | 0,16 | 1,16 | 3,81 |
| Tajikistan | 4,69 | 1,31 | 0,82 | 0,43 | 0,27 | 0,54 | 1,72 | 0,14 | 1,25 | 3,14 |
| Uzbekistan | 5,79 | 1,09 | 0,33 | 0,26 | 0,27 | 0,64 | 2,05 | 0,14 | 1,83 | 3,50 |

Note: price of bread is in USD loaf-1, oil price is in USD liter-1 and egg price is in USD piece-1

The highest prices of vegetables are found in Kazakhstan. Kazakhstan mainly imports fruits and vegetables from different countries around the world which may explain higher prices in the country. The most expensive rice prices are found in Tajikistan. Meat prices are also the second highest in Tajikistan after Uzbekistan.

|  |  |
| --- | --- |
| baseline_cons.tif | market intergartion_cons.tif |

**Figure 1**. Distribution of monthly food expenses per capita

Estimated monthly spending per capita from the survey data was equal to 29.6 USD throughout the sample- including all CA countries. This mainly includes main foodstuff consumed in the household and eating outs are not included. Some change in the mean value is obtained when assuming the integration of markets in CA. Mean per capita consumption expenses increased slightly and became equal to 30.1 USD per month. Some slight changes could be also detected in distribution of expenses in Figure 1.

It might be interesting to look into more details in order to find out households in which countries will be better-off under such market integration conditions. Analysis according to Eq. 2. shows that rural households in Tajikistan and Kazakhstan may benefit from such market integration.

**Table 3.** Regression results

|  |  |  |  |
| --- | --- | --- | --- |
|  | Coef, | t | P>|t| |
| HH size | -0,016 | -0,64 | 0,521 |
| Dhousehold | 0,519 | 3,16 | 0,002 |
| Dkaz | 1,206 | 5,66 | 0 |
| Dkyr | -2,033 | -9,38 | 0 |
| Duzb | -3,366 | -15,9 | 0 |
| Dcons | 0,328 | 1,2 | 0,231 |

Furthermore, rural households with limited land may benefit from such policy reform as it can be seen by the significance of the dummy variable for household type of producers (Dhousehold). In contrast, rural households in Uzbekistan and Kyrgyzstan may have 2 and 3.4 USD more expenses per capita under such market integration conditions.

* 1. Farm gate input output price differences

The difference in input and output prices in CA countries can mainly be explained by differences in trade policies and infrastructure of the countries as well as agricultural policies. For example, farmers in Uzbekistan grow cotton under the state procurement mechanism where farmers are obliged to sell cotton to the government ginneries at fixed prices. Similarly, farmers in Tajikistan also operate under state organized vertical farming and also sell cotton to investors at fixed prices. Therefore, farm gate cotton prices in Uzbekistan and Tajikistan are lower (Figure 2) than in Kazakhstan where there is a competitive market for selling cotton ([Swinnen, 2005](#_ENREF_35)). The case of wheat price in Uzbekistan is quite similar, which is the lowest in CA. Thus state procurement mechanisms in Uzbekistan kept not only farm gate prices low but also consumer prices for wheat and wheat products when compared to other CA countries (Table 2).

**Figure 2.** Farm gate output price differences between the countries

The highest price for fodder crops and rice is received by farmers in Tajikistan. Output price of vegetables and potatoes were in the same range for all countries. However, it is very important to mention the difference between farm gate prices (Figure 2) and consumer prices (Table 2). There is a very narrow gap between those prices in the case of Uzbekistan and Tajikistan but large differences are found in the case of Kazakhstan and Kyrgyzstan. Although, farmers in Kazakhstan receive the lowest price for their wheat, consumers need to pay the highest prices for wheat and wheat products. This might be explained by high purchasing power of consumers in Kazakhstan ([Galiakpar, 2011](#_ENREF_19)) as well as the market power of processing industries in the country. In case of Kyrgyzstan, large differences can be mainly explained by underdeveloped market infrastructure and the impact of ethnic disputes in the country observed in 2010. Those constraints limit trade even between the regions of Kyrgyzstan.

**Figure 3: Input price differences between the countries**

The highest input prices in CA are observed in Tajikistan. Especially farmers need to pay very high prices for fuel and fertilizers. High seed prices in Uzbekistan can be mainly explained by the quality differences. Private and governmental seed distribution is well organized and high seed quality may cause equally higher prices in Uzbekistan when compared to other countries.

* 1. Climate change impact

Changes in farm income under climate change scenarios are simulated while considering two Special Report on Emissions Scenarios (SRES) (A1b and A2) for two time horizons (2010-2040, 2070-2100). Since, irrigation plays an important role in CA, we also consider changes in irrigation water availability in the future. Several studies have investigated the water availability under climate change scenarios and magnitude of the changes usually in a range of 5-30% decline in Amu Darya and Syr Darya rivers, the most important irrigation water sources in Central Asia ([Ososkova *et al.*, 2000](#_ENREF_28); [Savoskul *et al.*, 2004](#_ENREF_31); [Chub, 2007](#_ENREF_13); [CAREC, 2011](#_ENREF_9); [Swinnen and Herck, 2011](#_ENREF_34); [Siegfried *et al.*, 2012](#_ENREF_32)). We have considered the maximum level of 30 % reduction predicted by these studies in order to account for predicted water use increase associated with increased water demand (e.g. construction of water dams) in the upstream regions ([Eshchanov *et al.*, 2011](#_ENREF_17); [Siegfried *et al.*, 2012](#_ENREF_32)).

Observed current (mean) income (i.e. baseline scenario) presented in the first column of Table 4 is considered to be 100% and changes of expected income in other scenarios are presented relative to the baseline scenario. The results presented in Table 4 show that the expected income will drop in most of the AEZs under climate change scenarios. A sharp drop in revenue under A2 scenario for the period 2070-2100 (far future) in arid regions of Uzbekistan is expected. Income of farmers in semiarid regions of Uzbekistan may decline in both scenarios in the far future. Reduced irrigation water availability may force farmers to reduce the area of high value water intensive crops and increase the area of crops with less water demand.

Table 4. Percentage changes of expected utilities (revenues) to the baseline scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Baseline, USD ha-1 | A1b (2010-2040) | A1b (2070-2100) | A2 (2010-2040) | A2 (2070-2100) |
| Uzbekistan | arid | 418,2 | 14,7 | 25,5 | 15,1 | -57,5 |
|  | semiarid | 472,9 | 10,7 | -25,5 | 21,2 | -42,6 |
| Kazakhstan | arid | 365,3 | -11,6 | 1,7 | -5,4 | 0,1 |
|  | semiarid | 553,6 | 3,2 | 11,1 | 2,7 | 4 |
|  | subhumid | 129,2 | 38,9 | 77,7 | 47 | 74,5 |
| Tajikistan | arid | 534,1 | -28 | -30,1 | -30,7 | -34,6 |
|  | semiarid | 111,1 | 49,5 | 122,3 | 58,8 | 153,2 |
|  | humid | 372,7 | 17,1 | 29,5 | 13,2 | 30 |
| Kyrgyzstan | semiarid | 512,1 | -14,6 | 7,3 | -14,5 | 11,3 |
|  | subhumid | 662,8 | 5,6 | 24,6 | 14,3 | 22,4 |

There is also some decline observed in the expected utility in arid and semiarid farming systems in Kazakhstan. However, the decline of the expected utility is not as drastic as observed in the case of Uzbekistan. Increased rainfall in the largest part of Kazakhstan may offset the negative impact of reduced irrigation water availability in the future. Expected reduced irrigation water supply should not create much concern in the humid zones of Kazakhstan since the importance of irrigation is very limited due to favorable rainfall conditions.

There will be negative changes in the expected utility under A1b and A2 scenarios in the near future in semiarid regions in Kyrgyzstan. Reduction of irrigation water supply might reduce expected farm utilities about 15 percent under these scenarios. However, there are no negative shifts observed for sub-humid regions due to lower irrigation water demand compared to the semiarid zone. A similar pattern of change is also identified in the arid zone in Tajikistan.

The results under scenario simulation show that farmers in arid regions are very vulnerable to risk associated with irrigation water availability. Climate change may cause significant decline of farm level revenues in the future. There are several technical measures recommended by international and national research organizations in order to improve the adaptive capacity of agricultural producers. However, most of those technological solutions are not implemented due to the lack of supporting policy measures in the regions. Market integration could provide a policy environment for improving the efficiency and economic efficiency of agricultural producers. Improving the export potential of farmers could be one of the important policy measures in CA to improve the adaptive capacity of agricultural producers. Most of the agricultural products are produced for local consumption or traded at fixed prices which are usually lower than the world market prices. Very limited regional trade between these countries exists. In the following scenario, we analyze the impact of climate change under the assumption of better market links between the CA countries.

In this scenario, we analyze climate change impact under conditions of similar prices for inputs and outputs among all CA countries. All input and output price are assumed to be equalized to their average observed in CA. Only the price of cotton is treated differently in the simulations. The price levels observed in Kazakhstan is used for Uzbekistan and Tajikistan in the case of cotton as considered in similar studies ([Bobojonov *et al.*, 2010](#_ENREF_5); [Djanibekov *et al.*, 2013](#_ENREF_16)). Because it is very unlikely that market integration causes cotton trade between the countries which is usually sold to the world market. Prices in Uzbekistan and Tajikistan are below the world market prices due to the state procurement in those countries.

**Table 5.** Changes of expected utilities (revenues) under market integration to the baseline scenario, in percentage

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | A1b (2010-2040) | A1b (2070-2100) | A2 (2010-2040) | A2 (2070-2100) |
| Uzbekistan | arid | 327,5 | 339,4 | 324,5 | 122,5 |
|  | semiarid | 229,3 | 106,6 | 258,3 | 65,7 |
| Kazakhstan | arid | 10,6 | 24,7 | 17,2 | 23,2 |
|  | semiarid | 2,7 | 9,1 | 2,1 | 1,8 |
|  | subhumid | 63,7 | 105,3 | 72,4 | 101,7 |
| Tajikistan | arid | 199,6 | 190,4 | 190 | 178,1 |
|  | semiarid | 61,8 | 116,4 | 69 | 139 |
|  | humid | 44,5 | 43,4 | 21,3 | 36,3 |
| Kyrgyzstan | semiarid | 17,1 | 18,9 | 14,8 | 18,6 |
|  | subhumid | 22,7 | 43,5 | 31,1 | 41,7 |

The results show that farmers in Uzbekistan and Tajikistan will particularly benefit from such policy in the future. Thus income gains from market integration will offset negative impacts of climate change. There were no large gains observed in Kazakhstan and Kyrgyzstan since farmers already receive competitive market prices in those countries. However, some gain was still observed which has offset income decline under climate change.

# Conclusions

Analysis of the household level data has shown that there are some differences in food prices among CA countries. Highest meat price is found in Uzbekistan as well as lowest vegetable prices. The highest price of rice is paid by households in Tajikistan. Significant utility gains for rural households in Tajikistan and Kazakhstan may be obtained under conditions of market integration among CA countries.

There are also some significant differences in agricultural commodity prices received by farmers. In general, farmers in Uzbekistan and Tajikistan receive lower prices for their commodities when compared to Kyrgyzstan and Kazakhstan. There is a very low difference between farm gate and consumer prices in Uzbekistan and Tajikistan, while very large differences are found in Kazakhstan and Kyrgyzstan. Those high differences could be explained by higher purchasing power of household in the case of Kazakhstan and constraints in market infrastructure in Kyrgyzstan. Salient differences also found between the energy and fertilizer prices among these countries.

The analysis of climate change scenarios show that farmers in arid zones of Uzbekistan and Tajikistan will have very significant revenue losses, especially in the far future scenarios. Similarly, farmers in arid regions of Kazakhstan and semiarid regions of Kyrgyzstan also may face income declines in the near future. The modeling results have shown that market integration option provides very good opportunities to agricultural producers to overcome negative effects of climate change. In particular, agricultural producers in Uzbekistan and Tajikistan will mostly benefit from such policy measures since output prices received by farmers are well below the regional averages.

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