Climate change, salinization and wheat productivity in Uzbekistan

Mashkhura Babadjanova

Abstract - **In recent years, climate change has raised sevaral issues related to agriculture. Its impact led to water scarcity, drought and salinization concerns in the agriculture. On the ongoing condition it is one of main driver for soil salinity, which has great impact on crop growth and one of limiting factor for productivity. Moreover, Uzbekistan is located in the heart of Central Asia, which exists Aral Sea with shrinking water. The Aral Sea shortages often relate to climate change impacts too. As reviewing latest literature shows, there are still gaps to investigate and to analyze the relationships between soil salinity and wheat productivity. This study focuses to analyze relationships between them. The main goal of this paper is to show how soil salinity variable impacts on wheat productivity. The research was conducted using a panel data at the district level during 2010-2017. Fixed Effect Model (FEM) is used to analyze the correlation and the regression estimations.. Soil salinization has significant impact on the crop in the north part of Uzbekistan, which includes data analysis from 2010 to 2017. Findings show, even analyzed period is short, that there is still impact of soil salinity on crop yield. More specifically, p value is significance at 1% of significance level. In the result, coefficient clearly shows negative association between salinity and wheat yield.**

Key Words: soil salinity, wheat production, fixed effects, Uzbekistan

I. INTRODUCTION

Climate Change practice shows that resources have declined in the agriculture over the world. Climate Change hot spotted around Aral Sea basin in Central Asia (World Bank, 2020). To tackle growing demand for food production, climate and soil analysis play crucial role to avoid food insecurity. However, one of Climate Change's consequences is salinization. Rising temperature, lack of water and changeable precipitation are two of main drivers for soil salinity. Irrigated areas depend on freshwater availability provided by meltwater from the Tien Shan and Pamir mountains for the country.

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Water use limits for each surrounded country as following: Amu Darya distributes 0.4 km^3 Kyrgyzstan, 7.44 km^3 Afghanistan, 9.8 km^3 Tajikistan, 21.73 km^3 Turkmenistan, and 38.91 km^3 for Uzbekistan. Syr Darya distributes 2.46km^3 Tajikistan, 4.03km^3 Kyrgyzstan, 12.29km^3 Kazakhstan and 17.28km^3 Uzbekistan (report, 2018-2019).

Since, withdrawal of huge amount of water from main Amu Darya and Syr Darya rivers for agricultural purpose caused Aral Sea disappearance. Water resources loose by poor channel leakage, evaporation and improperly use, which high amount of water withdrawal caused for shortages of the lake. Past decades due to climate warming melted excessive water resources into rivers which provided less amount of water (Punkari et al, 2014). Soil and Water Assessment Tool (SWAT) models projected that water resources dramatic decrease in of the low and average water availability for irrigation scenario due to in the process of Climate Change (Kumar et al, 2021).

Uzbekistan is located in Central Asia and considered as a heart, bordering with Turkmenistan, Kazakhstan, Afghanistan, Tajikistan, and Kyrgyzstan (Figure 1). More than half part of Central Asian population lives in Uzbekistan and the country includes most irrigated cropland in Central Asia (Bekchanov and Lamers, 2016).

The agriculture is important in economy of Uzbekistan and it plays also an important role in food security. Taking into account this, agricultural reforms in Uzbekistan are crucial due to growing population, water scarcity problems and low efficiency of resource use of the sector.

In central and western side of Central Asia, the agriculture is impossible without irrigation (Sommer et al, 2013). The sixty percent of the agricultural land is semi desert by furrow irrigation in Uzbekistan (Ibragimov et al, 2003). To avoid higher salinization in irrigated area, rural people use freshwater for washing up agricultural landThis brings to extra withdrawal of freshwater from rivers, which leads to the lack of water resources to flow to the Aral Sea. Between 2000 and 2010, the share of irrigation in total water withdrawals was observed in Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan about 90% or more (Bekchanov, 2014).

Figure 1. Map of Central Asia.

Source: https://www.worldatlas.com/articles/the-four-regions-of-asia.html

In Central Asia except Kazakhstan, top imported basic food commodity is wheat for other four countries such as Uzbekistan, Kyrgyzstan, Tajikistan, Turkmenistan (FAO, 2012). 41 percent land occupied with wheat in total agricultural area in Uzbekistan (Stat, 2017) (Figure 2). Mostly winter wheat cultivate in irrigated land areas (Table 1).. Table 1 shows wheat productivity by regions. It shows the increase in the wheat productivity over years. Because government is trying to adapt unfavorable climate conditions in different regions and salinization.

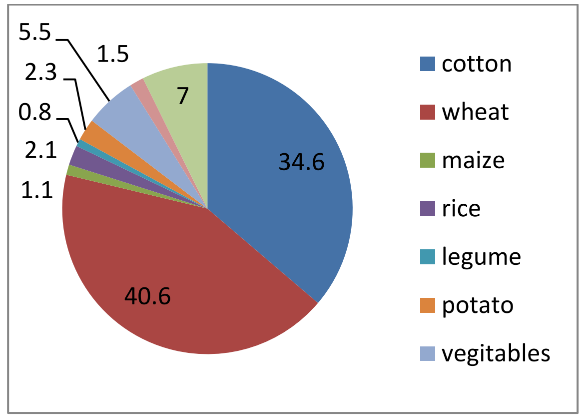

Figure 2. Agricultural land allocation (000/ha) in 2017 in Uzbekistan.

Source: The author's calculation based on Stat 2017

The Ball bonitet is a remainder from the kolkhozes and sovkhozes which shows soil quality (Rudenko et al, 2012). The Ball bonitet played crucial role for the state order policies on wheat and cotton as a main crops in the country. Farmer had a contract to sell their half wheat harvest to the government according to procurement policies (Bobojonov et al. 2013). September, 2019 the sell policy has changed. This farm structure includes taking inputs such as seeds, fertilizer, fuel, pesticides in fixed prices without alternatives to buy cheaper while selling harvest at lower prices. This did not motivate producers to increase yield productivity (World Bank Group, 2019). A half harvest was sold about 50 percent cheaper than market price which individual farmers lost is fulfilled by input subsidy policy (Lombardozzi and Djanibekov, 2021). Ordering policy cancelled due to creating and introducing step by step wheat clusters, government have been trying to improve production process and support producers (The Cabinet of Ministers of therepublic of Uzbekistan, Decree- #806 (24.09.2019).

Table 1. Wheat productivity in 2008-2017 by regions in Uzbekistan№	**Name of regions/years Productivity in kg/ha**	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	Karakalpakstan	2810	4800	3010	3150	2920	3100	3060	3200	3300	3660
2	Andijan	6170	6250	6280	6220	6240	6260	6230	6230	6260	6270
3	Bukhara	6350	6370	6400	5750	5800	5900	6020	6100	6260	5690
4	Jizzah	2450	2560	2460	2550	2550	3480	2900	3030	3040	3070
5	Kashkadarya	3800	4070	4040	4920	4810	4290	4540	4770	5370	5580
6	Navoi	4640	4630	4550	4490	4700	5050	5280	5060	5240	4740
7	Namangan	5010	4900	5050	4860	5190	5860	5890	6030	5930	5960
8	Samarkand	4400	4150	4310	5360	5160	5350	5510	4290	4580	4670
9	Surkhandarya	5030	5410	5130	4890	4990	5060	5070	5110	5140	4920

10	Syrdarya	3870	4120	4300	4000	4720	5000	5430	5210	4500	5300
11	Tashkent region	3490	4780	4510	4770	5130	5200	4880	4350	4170	4190
12	Fergana	5650	5440	5730	4940	5810	5650	6200	5940	5940	6600
13	Khorezm	4690	4520	4800	4220	3500	4200	4470	4470	4780	4770

Source: The author's calculation. Stat.uz

Below figure 3 shows agricultural area's with saline soil distribution, which is near to the Aral Sea Basin. North western part of Uzbekistan Karakalpakstan and Khorezm are hot point of soil salinization. Moreover close regions such as Bukhara, Navoi and Kashkadarya have higher salization than other regions.

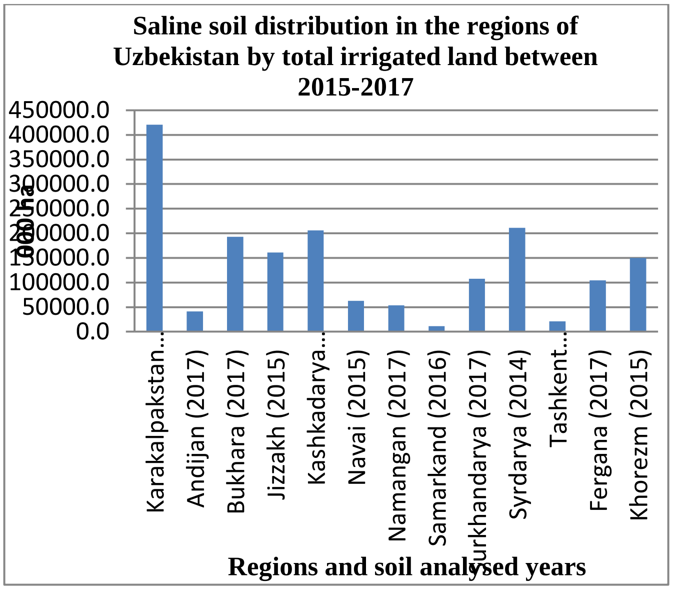

Figure 3. The author's calculation. Source: Center for Soil Composition and Repository, Quality Analysis under the Ministry of Agriculture of Uzbekistan.

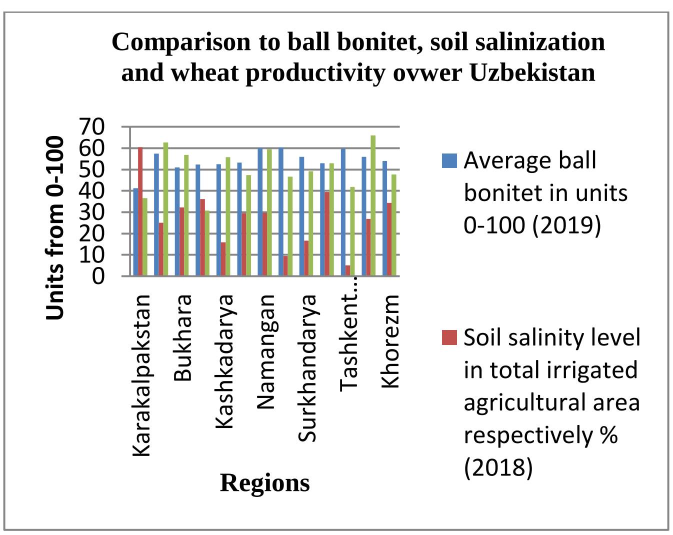

Figure 4. The author's calculation. Source: Center for Soil Composition and Repository, Quality Analysis under the Ministry of Agriculture of the Republic of Uzbekistan

The impact of climate change on wheat productivity has been studied and tested by applying crop models (Sommer at al, 2013), agricultural water use and trade (Abdullaev et al, 2019), Amu-darya's water salinization and its impact to soil salinization which is one of main rivers among two rivers with water fulfilling to Aral Sea (Behzod and Su-Chin, 2013), have evaluated in Central Asian case. However, there are still gaps between soil salinization and crop productivity under climate change by econometric model which crop models cannot calculate economic and physical determinants at the same point. As food insecurity and migration issues are hot pointed in this area. Further, the study evaluates of the impacts of salinity on wheat productivity under farmers' current management in Uzbekistan, where vulnerable to climate change over Central Asia. This study uses collected recorded data in a one panel data and tests at district level across Uzbekistan, in which is around of Aral Sea basin and its spread salt/sandy dusts over other sides.

II. LITERATURE REVIEW

2.1 Connection of soil salinity and crop growth

Agricultural crops are more sensitive to saline soil which directly affects crop growth and development. Salt makes plant thirsty and hungry because osmotic pressure in soil is higher than plant then plant is unable to get water and nutrients within water. Subsequent processes are slower on the uptake and growth, delayed of leaf senescence, diminished tillering or branching, and decreased yield (Schmöckel and Jarvis, 2017).

2.2 Salinization in Central Asia

One of the reason land degradation is soil salinization effects of irrigation which many of researchers have analyzed and tested in Central Asia. Tajikistan and Kyrgyz Republic are upstream countries have lower rate of salinization; however Uzbekistan is located in downstream area and more effected (Bucknall et al, 2017). Salinization is one of factor for yield decline that negatively affects crop productivity (Ahrorov et al, 2012). For wheat crop irrigation is key role which 4-6 times higher yields than rain fed land. Upstream regions in Uzbekistan such as Surkhandarya 66 percent, Navoi 71 percent, Kashkardarya 80 percent (Shenhav et al, 2017) while downstream regions Bukhara, Karakalpakstan, Khorezm 100 percent of total irrigated area depends on pump stations.

Known causes of soil salinization were water scarcity or/and improperly water use and management mainly in western north side of Uzbekistan. There are reasons, first is by irrigation water which brings to salt within itself (Rudenko et al, 2012).

Next one is secondary salinization by shallow groundwater. Groundwater influence is predominant in Central Asia and contributes crop water uptake, also it causes secondary salinization (Sommer at al, 2013). Groundwater grows up with dissolved salts in soil by capillary rise (Brouwer and Heibloem, 1985) which is water evaporate in the end; nonavaporable salts stay on the soil surface. Groundwater levels increased between 25 to 35 percent of the total irrigated area during 1990 and 2000 in Central Asia. Salinized area increased by 57 percent in the Amu Darya basin and increased by 79 percent in the Syr Darya basin in the period of 1990-1999 in Uzbekistan. Salinized agricultural land extended equal to 30 percent in Tajikistan and 40 percent in Kyrgyzstan (Ahrorov et al, 2012). 90-94% of the land in Karakalpakstan, Khorezm, and Bukhara Provinces of the country is salinized (Bucknall et al, 2017)

And third reason is salty dust by wind flows from shrinking Aral Sea. It spreads around territory that salt stays on surface of agricultural soil (Rudenko et al, 2012).

III. Conceptual framework

After consideration of related papers and recorded data we created our point of view on the situation. According to our hypothesis climate change is main driver to water shortage and soil salinization in the north western of Uzbekistan. Moreover, due to less snow and rainfall water source shortages. Consequence, in the downstream of two main rivers Amudarya and Syrdarya faces to water scarcity as an example of Aral Sea. In the study our research goals is to analyze that the impact of soil salinity on crop production. There are main three part of the research: first is considering issue, second reviewing all exist data related to the issue then collecting data. Third is analyzing process which is last part of the study.

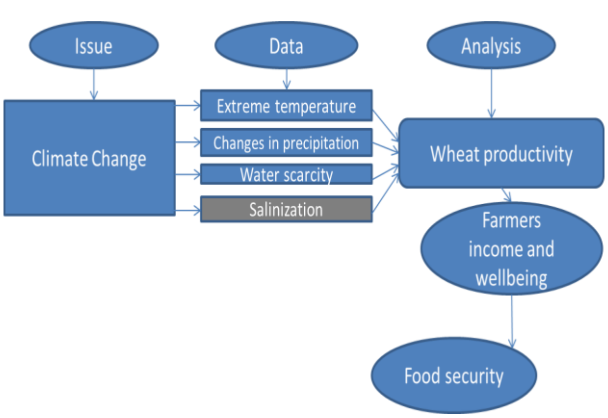

Figure 5. Simplified representation of conceptual framework of the study's hypothesis.

As Figure 5 shows our main goal is food security. Beginning of Independence years the country had to deal with food security. Herewith, the country was producing and more specialized for cotton growth (Djanibekov, 2010).

IV. Emperical framework

4.1 Data

For analysis Panel data created with main output is wheat yield and inputs are used land, labor and fertilizer collected from the state committee on statistics of the Republic of Uzbekistan. Soil salinization (100 centimeter) data are obtained from basin management of irrigation systems and regional ameliorative expedition departments of Ministry of Water resources of Uzbekistan.

4.2 Methods

After reviewing literatures there are three most used models as following: first is cross-section model, which is also known Ricardian model that uses short–term climate data for estimation (Kabubo-Mariara and Karanja, 2007). Second is experimental or agronomic model, which uses data with actual units of study area (Sommer et al, 2013). However, this model cannot include socio-economic issues within. Third, panel model is used wider in the area, as recorded long – term data with socio-economic variables (Mirzabaev, 2013., Ahmad et al, 2014). Dasgupta et al, 2018 describes in their empirical analysis by OLS, FE and RE models in coastal Bangladesh to predict the impact of temperature increases and precipitation amount as a climate variables in soil salinity on high-yielding-variety rice production. As Central Asian case climate change main drivers are likely irrigation, ground water depth (Sommer et al, 2013) and also, soil salinity.

To analyse the relationship of soil salinity and crop production, we use the Cobb–Douglas function:

$$Y = f(X_1 + X_2 + X_3 + \ldots\ldots X_n) \quad (1)$$

The model can also be written as following

$$\ln(Y_{it}) = \ln(\beta_0) + \ln(\beta_{1Land\ it}) + \ln(\beta_{2Labor\ it}) + \ln(\beta_{3\mathrm{Fert}\ it}) + \ln\ (\beta_{4\ \mathrm{Soilsal}\ it}) + u_{it} \quad (2)$$

Yit = total wheat production in district i and time t. Land = total wheat sown area in the sampled districts; Labor = used to define total labor cost; Fert = the total cost of used fertilizer; Soilsal – is soil salinity in gr/l; Uit = is the error term. Below Table -1 shows summary statistics and all variables description.

Table 1. Summary statistics

Variables	Discription	Mean	Std.Dev	Min	Max
Wheat yield	Total wheat yield for district tonnes	9.984515	.7904139	6.216606	11.28728
Land	Total land of wheat sown area 000/ha	8.492766	.6598622	5.303305	9.588434
Labour	Total labor cost, mln/uzbek sums	7.163932	.9647618	3.430756	9.048292
Fertilizer	Total used fertiliser cost mln/uzbek sums	7.411498	.8608675	3.091043	9.191983
Soil salinity	gr/l	1.247233	.3778995	.0953102	2.151762

V. Limitation

Data for empirical analysis are very rarely or not reliable in developing countries due to economic or social reasons (Mendelsohn 2008). A panel consists of data across the country, there for collection of full data depends on organizations, regional depertments who has limited time, labor and techniques to analyse soil salinity and do it every three years in some sub-districts. Due to data limitation the soil salinity is calculated and averaged per year in a district. However, soil salinity and ground water level are changeable during seasons when ground water table increase during Irrigation period. Even data should be divided into some seasons. At the time, it was not possible to collect such kind of data.

VI. RESULTS AND DISCUSSION

According to Wooldridge (2010), pooled OLS is employed when a different sample selected for each year/month/period of the panel data. In the analysis using the OLS estimation is simply an OLS technique all individually specific effects are completely overlooked. Differently, RE solves this problem by implementing an individual specific intercept in the model, which is assumed to be random. Since almost every model has some endogeneity issues, the FE-Estimation is the appropriate choice and gives the best consistent estimates but the individual-specific parameters will disappear. As this kind of panel data requires two models such as FE and RE. Fixed effects or random effects are employed when we are going to observe the same sample of individuals/countries/states/cities/etc. Hausman test has applied for the analysis to check which model more fits to hypothesis and the test strongly suggests FE model. Our estimation approach incorporates Fixed Effect. Table 1 shows comparison of estimation results.

Table 1. Main estimation results for wheat crop yield as the dependent variable

	(OLS) lnTOT_YIELD	(FE) lnTOT_YIELD	(RE) lnTOT_YIELD
lnLAND	0.906***	0.692***	0.894***
	(35.17)	(22.47)	(34.18)
lnLABOUR	0.0689***	0.119***	0.0721***
	(4.58)	(8.39)	(4.80)
lnFERT	0.153***	0.331***	0.162***
	(6.90)	(12.40)	(7.23)
lnSOIL_SAL	-0.164***	-0.124***	-0.161***
	(-5.74)	(-4.83)	(-5.65)
_cons	0.868***	0.955***	0.871***
	(5.46)	(6.88)	(5.53)
N	355	355	355
R^2	0.941	0.956	0.949

Model shows that increasing 1ha of land increases 0.90 tonnes production. 1% increase in the soil salinity leads to decline the wheat productivity by 0.16%. Other labor and fertilizer effect positively at 1% of significance level as p value shows.

There are still research gaps, such as relationships between inappropriate irrigation management and water salinization, which leads to land degradation (Hamidov, 2016). However, the research must include crops interaction and development in the saline soil. Soil salinity has taken average per year; actually soil salinity changes in every irrigation and seasons, which is during crop vegetation. Researchers in future must consider this issue while doing analysis.

VII. CONCLUSION

In conclusion, alternative or necessary task innovative technologies such as inoculation with wheat growth promoting bacteria from salinity stress in the saline area (Ashraf, M., 2004; Egamberdieva & Kucharova 2009; Nadeem et al, 2013; Shrivastava, & Kumar 2015; Kaushal & Wani, 2016). Further researches and modeling analysis must integrate in the process of land, water use adaptation and resilience for climate change. Salinization also needs to be calculated by seasonal or vegetation period.

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Over the past years, she participated in several doctoral certificate courses in Germany, conferences and lectures. She had Erasmus Mundus Silk Road Scholarship for master study (2015-2017), ZEF/UNESCO Scholarship for master study (2010-2012).