Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 17, Issue 2, 2017
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ADAPTATION ECONOMICS TO CLIMATE CHANGE: KEY VULNERABILITIES OF SMALL-HOLDER FARMS

Serkan GURLUK

Uludag University, Agricultural Faculty, 16059 Nilufer, Bursa, Turkey, Email: serkan@uludag.edu.tr

Corresponding author: serkan@uludag.edu.tr

Abstract

The paper aims to present the key vulnerabilities of small-holder farms while adapting prospective climate change conditions. Natural resources' productivity has declined under climate stress. The natural resources that lose their prolificacy negatively affect small-holder farms. Consequently, the agricultural sector will suffer from climate change impacts. The countries which have small-holder farms should be more careful while designing their rural policies. Indeed, small-holder farms lack capacity in management of agricultural risks. This phenomenon has the potential to trigger rural poverty in the medium-term. Many studies carried out on the African Continent indicates that adaptation costs of climate change account for 250-500 billion USD in the years between 2010 and 2050. Climate change adaptation policies are most effective when they are fully integrated within countries' national development strategies. Furthermore, adequate funding and technology transfer to small-holder farms are important in ensuring success of any climate action and initiative. The current paper will give information related with adaptation costs to climate change in various countries of the world. In addition, the paper discusses the possibility of agricultural adaptation policies coming from developed zones of the world.

Key words: *climate change, adaptation costs, small-holder farms*

INTRODUCTION

Global warming and the expected climate change will have impact different regions and different economic sectors. High-technologies that will prevent the effects causing climate changes are being researched on one side; on the other side, adaptation strategies have gained importance through time.

The agricultural sector is one of the sectors most in need of adaptation because it is intertwined with nature. Therefore, the rural population engaged in agriculture in various parts of the world will be more affected by climate change. However, there are also enterprises in the agricultural sector that have not yet achieved their industrialization process. Small-holder farms, compared to other types of farms, are the most important ones to adapt to climate change. Historically, they have a very poor capacity to manage risks relative to industrial farms. In case of damage that may occur due to climate, their operating capital can be diminished. This has the potential to trigger poverty in the mid-term.Poor people generally come from rural areas, and they earn insufficient income from agriculture throughout the world. The FAO declares that some 1.2 billion humans are extremely poor and are living in rural areas. Olinto et al., (2013) [13] states that about 750 million of them are related to agriculture as small-holder family farmers. Habtemariam et al., (2017) [6] states that the proportion of farms that are negatively affected by climate change ranged between 51% and 78% in the warm regions while the figures are between 10% and 22% in cool regions. Figures justify a special focus on the threats posed by climate change to their livelihoods and their adaptation to approaching climate change conditions.

In order to improve living standards of small-holder farms and rural people, steps taken now and in the future must take climate change policies into account. Potential consequences should be alleviated to the extent that their livelihoods will survive. This study examines the adaptation costs side of climate change management in the context of agriculture in specific regions of the world.

In this context, the paper aimed to present a few considerations regarding the adaptation of economics to climate change: key vulnerabilities of small holder farms.

MATERIALS AND METHODS

The paper is based on the study of literature regarding the climate change and its impact on agriculture performance.

RESULTS AND DISCUSSIONS

Key vulnerabilities of small-horlder farms

Small-holder farms have some critical characteristics that will, in turn, affect themselves with the impacts of climate change. Firstly, they produce relatively small volumes of produce on relatively small plots of land. This causes a weak return to scale issue on their farms. They may produce an export commodity as a main livelihood activity or as part of a portfolio of livelihood activities. They suffer from low financial achievements. They are usually considered to be part of the informal economy (Wiego, 2017) [19]. They are devoid of social protection and have limited records. They may be men or women. They may depend on family labor, but may hire workers. They are often vulnerable in supply chains.

The phenomenon of vulnerability for small-holder farms in developing areas of the world is a significant factor affecting weakness in the face of climate change impacts. It is defined as a natural resource or social system that is susceptible to sustaining damage from climate change impacts. It depends on exposure, sensitivity, and adaptive capacity (IPCC, 2001) [8]. The exposure to risks is explained by localized weather events and emerging pests and diseases. In regards to economics, those risks can affect the crop productivity and consequently the revenues of the small-holder farms. Likewise, above-average temperatures reduce productivity significantly. Losses should be considered together with on-farm levels and performance losses of natural resources. Water scarcity is one of the main effects that will be given as an example for off-farm levels. It affects the performance of watersheds to meet the small-holder farms' needs. Rationalizing water use in agriculture will greatly facilitate adaptation to climate change in small-holder production systems (Bates et al., 2008) [3].The following figure is remarkable for understanding the significance of water storage investments. Before examining the figure, it is necessary to understand water-related definitions seen in the table below. Seasonal storage index (SSI) indicates the volume of storage needed to satisfy annual water demand based on the average seasonal rainfall cycle. It is calculated as the volume needed to transfer the excess water from wet months to the dry months (Brown and Lall, 2006) [4]. According to the figures, some countries cannot store fresh water in their watersheds because either they do not have enough infrastructure or they experience more dry seasons. Nepal, Sierra Leone, Gambia, and Rwanda are such countries. Another topic is related to the water pricing issues in some regions of the world. Indeed, inappropriate water pricing and subsidized electricity tariffs that encourage the excessive use of groundwater pumping also increases vulnerability to changing climatic conditions (Stern,2006) [17]. In Mexico, for example, 104 aquifers, which are responsible for 60% of the irrigation withdrawals, drain faster than they can replenish themselves.The consequences show the significance of inadequate investment in water-related infrastructure and poor management in resolving the problems with climate change.

Table 1. Seasonal Water Storage Index and Requirements of Selected Countries

Countries	SSI as % of Annual Volume	Current Storage (% of SSI)
India	21	76
Bangladesh	41	33
Ethiopia	10	8
Nepal	47	0
Senegal	40	7
Malawi	34	0
Albania	23	21
Sierra Leone	3	0
Gambia	56	0
Rwanda	9	0

Climate change will affect various regions of the world in diverse fashions. Yet, agriculture will suffer more from those effects. At first glance, Sub-Saharan African Regions may seem to suffer more from climate change because agriculture is inevitably the largest sector on the continent. However, South American and Southern Asian agriculture will also suffer from those effects although the degree of impact is different. It is stated that, by 2100, regions of arid and semi-arid land are expected to expand by 5-8 percent or 60-90 million hectares, resulting in agricultural losses of between 0.4-7 percent of GDP in the Africa (PACJA, 2009) [14]. Of all African countries, 40 percent are expected to lose their self-sufficiency characteristic. In addition, rising sea levels will result in saltwater intrusion into inland freshwater supplies. It may cause crop failure in coastal countries. These crops are exportable production such as mangos, cashew nuts, palm oil, and coconuts in Benin, Ivory Coast, and Guinea (IPCC, 2007) [9]. On the livestock side, it is stated that a temperature rise of up to 5°C from 2006 average global temperatures could benefit some small-holder farms who raise sheep as they are more heat tolerant than other species. The same temperature rise could reduce revenues of large-scale farms because they prefer non-heat tolerant cattle. Decreases of their revenues may account for 35 percent or 20 billion US dollars annually (Seo and Mendelsohn, 2007) [16]. Yet, increased rainfall has the potential to reduce livestock revenue for both large-scale and small-holder farms. In another part of the world, South Asia will suffer from drought and crop quality. Asian countries' agricultural sectors have a share of 20-50% in GDP, and their labor forces depend on agriculture with the same share of 20-50%.India and Bangladesh are important cases in this region. Flooding is one of the major causes of crop devastation in Bangladesh almost every year, and it affectsabout 80% of the land.Reductions in production could potentially be as high as 17%–28% for rice and 31%–68% for wheat (Karim et al. 1999) [10]. A study indicates that irrigated rice in the Western region is likely to change by –11% to +5% dependingon location. Irrigated rice yield in the majority of the region is projected to decline by about 4%. Rainfed rice yields are projected to change in the range of–35% to +35%, with a large portion of the region likely to lose up to 10% of its rice yields.In addition, climate change is likely to reduce yields of maize and sorghum by up to 50%depending upon the region.

Trade-offs of adaptation to climate changes

Adaptation is a key response to reducing vulnerability to the impacts of climate change. Adaptation strategies cannot combat climate change, but it can alleviate its negative effects. It is explained as an adjustment in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007) [9]. We can infer from the definition that two aims gain importance for small-holder farms: to reduce exposure to the risk of damage and to provide stability to cope with unavoidable damage. There are many adaptation strategies in agriculture, which are classified as crop, livestock and other strategies (Table 1).

Planting drought-resistant crops can reduce irrigation water needs. Yet, irrigated-farming means more earnings in many places in the world. Thus, crop diversification can be preferred in suitable lands. High-value crops can be feasible in both irrigated and non-irrigated areas. It is stated that land use conversion, such as the shift from livestock farming to game farming, may provide new opportunities for small-holder farms (Ziervogel et al., 2008) [20]. Changing cropping patterns and using new planting calendars are technical adaptations. This requires better weather forecasts. Yet, changing harvest seasons may cause price fluctuations. Mixed cropping may become another alternative to reducing impacts of climate change. Maize, sorghum, legumes, and nuts may be grown in the same proximity in the field. It can increase the labour costs and harvest losses, while it is beneficial for soil productivity. Mendelsohn et al., (2000) [12] found that planting different varieties of the same crop is one of the most important adaptations. Another way is to reach efficiency in water use. As water becomes a limiting factor, improved irrigation efficiency will always become an important adaptation tool. Conserving soil moisture supports irrigation water efficiency. Contour farming can provide a way to keep moisture in the base level. It refers to field activities such as ploughing and furrowing that are carried out along contours rather than up and down the slope. The contours conserve water by reducing surface run off and encouraging the infiltration of water into the crop area. It requires advanced mechanization and additional labour costs. And finally, agroforestry should be considered together with previously mentioned adaptation techniques. It is a rational land-use planning system that tries to find balance in the raising of food crops and forests (Adesine et al., 1999) [1].

Livestock adaptation strategies are more expensive compared to crop adaptation, and needs additional expertise. A compulsory integration is necessary, linking pasture, livestock-crop management, and pasture management with efficient grazing. Small-holder farms usually lack technology in livestock breeding and agricultural programs (Hoffmann, 2008) [7]. A considerable amount of technology is necessary for and is related to the improvement of local genetics through cross-breeding with heat and disease tolerant breeds. Livestock management systems require some regulations providing lower cost husbandry systems. Yet, small-holder farms have some advantages if they venture to earn their livelihoods from livestock section. This comes from managing the heat stress of animals, because intensive farms' livestock management costs will be higher than that of general farms. A reduction in livestock numbers means more productive animals that will lead to more efficient production. Selection of large animals rather than small can provide advantages in the reduction of heat stress. Agricultural extension education for livestock keepers may increase awareness of climate change adaptations, and the adaptation capacity of a country. Other adaptation strategies are different from live systems, such as crop and livestock adaptation strategies. Labour migration is unique to nomadic societies, and includes migration towards ample water resources. Income diversification concerns non-farm income sources. Off-farm income sources generate opportunities for small-holder farms and accelerate the adaptation to climate change policies implemented by policy-makers in the region.

Table 2. Selected Adaptation Strategies for Small-Holder Farms and Agriculture Sector

Crop Adaptation Strategies	***Livestock adaptation strategies***	***Other adaptation strategies***
*Planting of drought resistant varieties of crops	*Production adjustments	*Labour migration
*Crop diversification	*Breeding strategies	*Income diversification
*Change in cropping pattern and calendar of planting	*Livestock management building	
*Mixed cropping	*Capacity building for livestock keepers	
*Improved irrigation efficiency		
*Adopting soil conservation measures that conserve soil moisture		
*Afforestation and and agro-forestry		

Adaptation is a key response to reduce vulnerability to climate change impacts. In spite of its costs, adaptation offers the opportunity to adjust economic activity in vulnerable sectors and support sustainable development. However, the adaptation costs vary according to region, scenarios, sectors, and also farm size. It is stated that the developing world and consequently small-holder farms endure costs compared to those of large-size farms. The following graphic illustration indicates the differences between small-holder and large-size farms' adaptation costs to climate change. The figure was re-arranged from Stern (2006) [17]. It is stated that small-holder farms' adaptation costs and costs without adaptation will be higher than large-scaled farms. Consequently, costs to government expenditures will be higher in the developing world at the macroeconomic level.

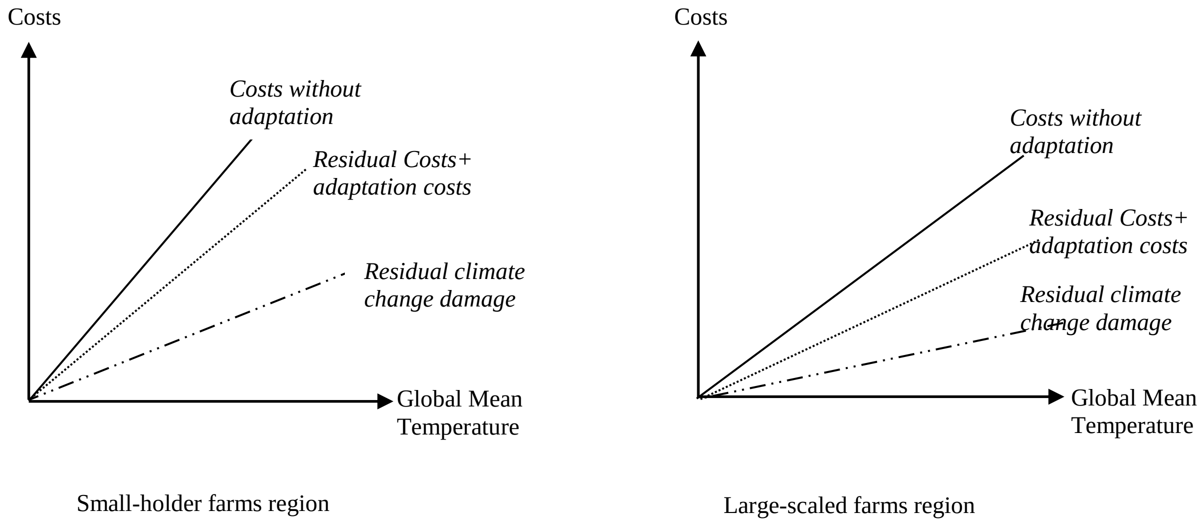

Fig. 1. Changing adaptation costs for small-holder farms and large-scaled farms

Several research projects were carried out in order to calculate adaptation costs at the micro level. Adaptation strategies often require substantial initial investments, but the range of costs can be changeable according to type of strategies followed. McCarthy et al. (2011) [11] estimated costs in some strategies for various countries (Table 3). According to following table, costs change according to the countries examined. Opportunity costs are higher for medium or large-sized farms. One another study carried out by Rosenzweig and Parry (1994) [15] in order to find cereal loss with climate change. It is stated that cereal losses' cost will decrease from 9% to 17% with adaptation costs. Improved seed adoption was found to be highly beneficial to countries. In fact, the net present value of such investments was estimated to range from an average of 203 USD per hectare to 766 USD per hectare in selected countries such as Malawi, Tanzania, Bangladesh, and India (Cacho et al., 2016) [5]. In addition, irrigation and water saving technologies can supply some benefits to small-holder farms. For instance, the benefit of new technology-irrigation is about 226 USD/ha in Bangladesh while it accounts for 7.8 in benefit/cost ratio. Same technology indicates the values of 494 USD/hectares and benefit/cost ratio is 17 in India. Improved grazing management can provide 118 USD/ha net present value over 20 years to small-holder farms.

Table 3. Adaptation costs in selected strategies in changing countries

Strategies	Origin	Investment costs USD/ha	Maintenance costs USD/ ha/ year
Agro-forestry *(Shelter belts, high input system, grass barriers, countour ridging)*	Kenya	160	90
	Togo	376	162
	Indonesia	1,159	80
	Colombia	1,285	145
Soil and Water conservation			
Small-scale conservation tillage	Kenya	0	93
Bench terrace	Ethiopia	2,060	540
Compostproduction, application	B. Faso	12	30
Run off and flood water farming	Ethiopia	383	814
Grazing management			
Grassland restoration	China	65	12
Rotational grazing	S. Africa	105	27

Numbers seem hopeful for relieving the climate change effects. Yet, small-holder farms' financial constraints, existence of public goods, and imperfect information can affect the transition to adaptation policies in the regions where small-holder farms are located [2]. Let's assume adaptation costs are equal for all types of farms. Even if it is equal, the share of adaptation costs in the revenues will be higher for small-holder farms. Financial support is imperative; otherwise industrial agriculture will eradicate the small-holder farms. If we want to make world agriculture sustainable, we need small-holder family farms in a considerable proportion. A qualified dialogue is necessary among all stakeholders to decide what changes in policies and incentive structures are needed. Agricultural extension workshops can provide qualified knowledge to the related regions (Touch et al., 2016) [18].

CONCLUSIONS

All regions will eventually feel the effects of climate change, yet some regions experience those effects more severely. Less-developed regions of the world will have a disproportionally harmful effect in their poor communities, in particular, those who are living at or close to the margins of survival. Also, some sectors will suffer more from those effects. Small-holder farms meet important needs of the world in terms of sustainable farming. The sustainability of small-holder agricultural systems will depend on the ability of small-holders to adopt climate-smart practices and technologies. Global poverty cannot be reduced unless resilience of smallholder farms to climate change impacts are provided. Small-holder farms can adapt to climate change if they, indeed, adopt a diversifying on-farm agricultural production. They mutually depend on natural resources, and consequently, if they have enough support, natural resources can be conserved as well. Finally, it must be recognized that the costs of inaction are much greater than the adaptation costs. Lack of knowledge in the rural areas is a reality for climate change's possible impacts. At least the magnitude of the possible impacts is not known in many rural families. Thus, it is urgently recommended that agricultural extension services in the region are implemented in order to build small-holder farm abilities to better cope with and adapt to climate change.

REFERENCES

[1]Adesina, F. O., Siyambola, W. O., Oketola, D. A., Ojo, L. O., Adegbugbe, A. O., 1999, Potentials of agroforestry for climate change mitigation in Nigeria: Some preliminary estimates. Global Ecology and Biogeography, 8: 163–173.
[2]Akinnagbe, O., Irohibe, I., 2014, Agricultural adaptation strategies to climate change impacts in Africa: A Review. Bangladesh Journal of Agricultural Research, 39: 407-418.
[3]Bates, B. C., Kundzewicz, Z. W., Wu, S., Palutikof, J. P., 2008, Climate Change and water. Technical Paper of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.
[4]Brown, C, Lall, U., 2006, Water and economic development: the role of variability and a framework for resilience. Natural Resources Forum 30: 306-317.
[5]Cacho, O. J., Graham, M. R., Milne, E.,2003, Smallholder agroforestry projects: potential for carbon sequestration and poverty alleviation. ESA working paper 03-06, FAO.
[6]Habtemariam, L. T., Kassa, G. A., Gandorfer, M., 2017, Impact of climate change on farms in smallholder farming systems: Yield impacts, economic implications and distributional effects. Agricultural Systems 152: 58-66.
[7]Hoffmann, I., 2008, Livestock Genetic Diversity and Climate Change Adaptation. Livestock and Global Change conference proceeding. May 2008, Tunisia
[8]IPCC, 2001, Intergovernmental Panel on Climate Change Third Assessment Report, Cambridge, UK.
[9]IPCC, 2007, Intergovernmental Panel on Climate Change Fourth Assessment Report, Cambridge, UK.
[10]Karim, M, Z., Hug, S., Asaduzzaman, M., Mahtab, F., 1999, Vulnerability and Adaptation to Climate Change for Bangladesh. Dordrecht, The Netherlands: Kluwer Academic Publishers.
[11]McCarthy, N. Lipper, L., Branca, G. 2011, Climate Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation. Mitigation of Climate Change in Agriculture Working Paper.
[12]Mendelson, R., Dinar, A., Dalfelt, A. 2000, Climate change impacts on African agriculture. Preliminary analysis prepared for the World Bank, Washington, District of Columbia.
[13] Olinto, P., Beegle, K., Sobrado, C., Uematsu, H., 2013, The state of the poor: where are the poor, where is extreme poverty harder to end, and what is the current profile of the world's poor? Economic Premise No. 125, Washington, DC, World Bank.
[14]PACJA, 2009, Pan African Climate Justice Alliance. The Economic Costs of Climate Change in

Africa.
[15]Rosenzweig, C., Parry, M. L., 1994, Potential impact of climate change on world food supply. Nature, 367: 133-138,
[16]Seo, S. N., Mendelsohn, R. 2007, The Impact of Climate Change on Livestock Management in Africa: A Structural Ricardian Analysis. World Bank Policy Research Working Paper 4279.
[17]Stern, N., 2006,The Economics of Climate Change. American Economic Review 98:2, 1-37.
[18]Touch, V., Martin, R. J., Scott, J. F., Cowie, A., Liu, D.L., 2016, Climate change adaptation options in rainfed upland cropping systems in the wet tropics: A case study of smallholder farms in North-West Cambodia. Journal of Environmental Management 182: 238-246.
[19]WIEGO,2017.http://wiego.org/informal-economy/occupational-groups/smallholder-farmers
[20] Zierwogel, G., Cartwright, A., Tas, A., Adejuwon, J., Zermoglio, F., Shale, M., Snith, B., 2008, Climate change and adaptation in African agriculture. Rockefeller Foundation, Stockholm Environment Institute.