Climate change and the need of adjustments in Tanzanian agriculture

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Abstract
In this study, I tried to find out how residents of different regions of Tanzania perceive symptoms of climate change. I focused on the change of air temperature and the change in the availability of water (precipitations, water flows in the rivers, span of wet/dry season). After that, based on observations and literature, I presented my ideas of how Tanzania should adjust its agriculture to changing climatic conditions.
Keywords: Climate change, Tanzania, agriculture, adjustment

Introduction

Natural climate change is an ongoing process but in the last 150 years the average temperature of the Earth's lower part of the atmosphere has been growing as a result of the greenhouse effect caused mostly by an addition of carbon dioxide to the atmosphere from burning fossil fuels. Many scientists agree that global warming takes place mostly in high latitudes. Figures show that the highest rise of temperature in the period from 1970 to 2014 was in central Asia, Middle East, Northern Africa, South-Western Europe and western part of USA and Canada. Also, it is shown at the figure below, that Western Tanzania experienced higher rise of temperature than the eastern parts of the country. In Western Tanzania the temperatures have risen within this period of about 1 to 2^{o}C, while in Eastern Tanzania about 0.2 to 1^{o}C.

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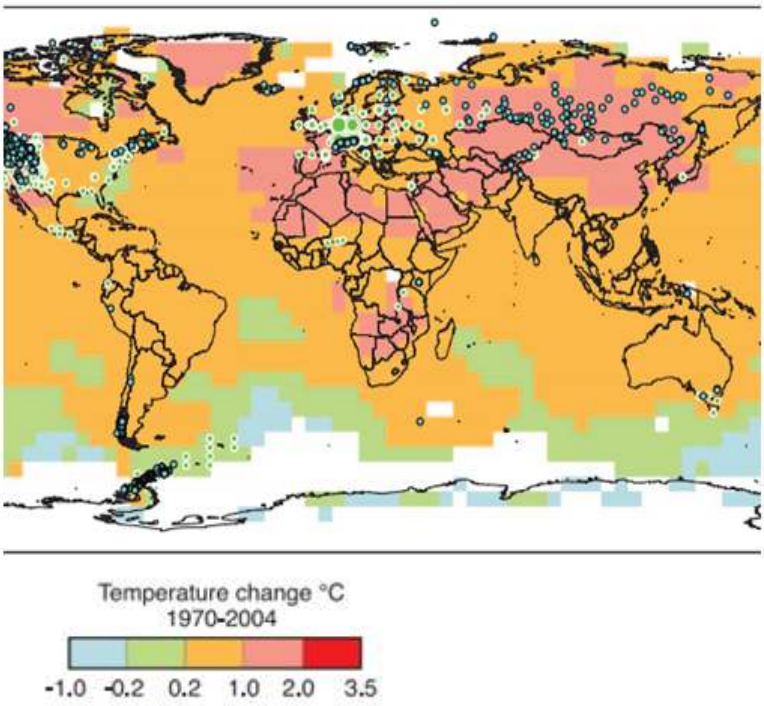
Fig. 1. Changes in surface temperature 1970 - 2004



Source: Intergovernmental Panel on Climate Change (IPCC), 2007

Research methodology

This study of perception of climate change in Tanzania was made through a questionnaire that involved 140 students from the University of Dodoma who were attending my lecture on Climatology. The study took place in 2010 in the middle of the second semester, during the Easter break[2]. Before the break, I discussed with the students in details the content of the questionnaire and each student was given one printed questionnaire. Students were asked to interview their parents and grandparents. My intention was to have elderly people as

[2] In 2013, I repeated the same survey using the same questionnaire to confirm results from the 2010 while at the University of Iringa. I will write about later in the article.

respondents who should have, theoretically, better knowledge about climate change. Each questionnaire contained only three questions that focused on climate changes that have occurred (or not) in the last 30 years in the places of residences of my students, i.e. their respective administrative regions. Responding to a question (on a basis of received answers from relatives) students had a choice of selecting one of the three following options: 1-Yes – changes have taken place, 2-No – changes haven't taken place or 3-I don't know.

Students were instructed that it is advisable to select the last option if the questioned person was not sure if the changes did or did not take place. I wanted, in this way, to get information or views about the specific changes that have occurred (or not) in a particular place, rather than getting general knowledge of respondents about the ongoing climate change. Students were instructed that if they selected a positive answer (Yes – changes have taken place) they will have to describe shortly these changes giving concrete examples. The three questions included in questionnaire were:

1. Have you observed any changes in the water levels in lakes?
2. Have you observed any changes in water flows in local rivers/streams?
3. Have you observed any climate changes in relation to precipitations, temperatures, and the span of wet/dry season?

Students came from nearly all administrative regions of Tanzania, but most of the questionnaires were filled in the regions of Iringa, Kagera, Kilimanjaro (respectively 21, 16, and 14 questionnaires). The least represented regions were Lindi, Mtwara, and Tabora (only one questionnaire filled for each region).

Findings

Questionnaires filled out by students provided 420 responses to the three questions. Considering all regions of the country and all of the above three categories of environmental change, 310 responses were positive (Yes - the changes have taken place), which is 73,8% of all responses, 47 negative (11,2%), while 63 responses (15%) were neutral (the responders didn't have any knowledge on the given subjects).

Taking under consideration the whole country (all regions), the first question (regarding changes in the level of water in lakes) was positively answered by

62,9% of respondents, the second (changes in the flow of water in rivers) 72,9%, and the third (changes in climate elements) 85,7%. Table 1 below shows all responses.

Table 1: Comparison of responses to asked questions by administrative regions of Tanzania.

Region	Number of responses to individual questions									**The total number of responses for the region and for a whole country**			
	1			2			3						
	Y	N	?	Y	N	?	Y	N	?	Tot	Y	N	**?**
Arusha (9)	4	3	2	6	1	2	7	0	2	27	17	4	**6**
Dar es Salaam + Pwani (8)	1	7	0	4	2	2	4	3	1	24	9	12	**3**
Dodoma (3)	1	0	2	2	1	0	3	0	0	9	6	1	**2**
Iringa (21)	12	1	8	17	1	3	17	2	2	63	46	4	**13**
Kagera (16)	14	0	2	14	0	2	12	1	3	48	40	1	**7**
Kigoma (7)	5	0	2	6	0	1	7	0	0	21	18	0	**3**
Kilimanjaro (14)	9	1	4	12	0	2	13	1	0	42	34	2	**6**
Lindi (1)	0	1	0	1	0	0	0	0	1	3	1	1	**1**
Manyara (3)	3	0	0	3	0	0	3	0	0	9	9	0	**0**
Mara (6)	6	0	0	5	1	0	6	0	0	18	17	1	**0**
Mbeya (12)	7	2	3	10	0	2	11	0	1	36	28	2	**6**
Morogoro (6)	3	2	1	6	0	0	6	0	0	18	15	2	**1**
Mtwara (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Mwanza (12)	11	0	1	3	4	5	10	1	1	36	24	5	**7**
Rukwa (2)	2	0	0	1	1	0	2	0	0	6	5	1	**0**
Shinyanga (2)	0	2	0	2	0	0	2	0	0	6	4	2	**0**
Singida (4)	4	0	0	2	2	0	4	0	0	12	10	2	**0**
Ruvuma (5)	1	2	2	3	0	2	5	0	0	15	9	2	**4**
Tabora (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Tanga 4	3	1	0	2	2	0	3	1	0	12	8	4	**0**
Zanzibar + Pemba (3)	0	1	2	1	0	2	3	0	0	9	4	1	**4**
Tanzania (140)	88	23	29	102	15	23	120	9	11	420	310	47	**63**

(9) – the number of completed questionnaires in the region
Y – Yes, changes have taken place
N – Non, changes haven't taken place
? – I don't know
Tot – the number of questions asked in the region
(number of completed questionnaires x 6 questions)

Source: Students' field studies 2010

As to the first question, the most positive responses (over 80%) were in the following regions: Kagera, Manyara, Mara, Mwanza, Rukwa, Singida and Tabora. No positive response was noted in the regions of Lindi, Shinyanga, and Zanzibar, which is likely due to the simple fact that in these regions (i.e. in the districts inhabited by responders), there are no lakes (this was emphasized by respondents in the comment). Those who positively responded to this question (Yes - changes have taken place) mainly emphasized the fact that as a result of intensive irrigation (catching the water from rivers) less water flows in rivers and streams and as a result less water enters into the lakes. Some also pointed out that that may be due to the decrease of precipitations (rainfall) in the last 30 years. Most respondents gave examples of decreased level of water not only in small bodies of water (such as Lake Babati in Arusha region, Lake Ikimba in Kagera region, Lake Jipo in Kilimanjaro region, Mtera in Iringa region), but also in a large-area lakes as Victoria, Tanganyika, Malawi, Rukwa, Manyara.

In Kagera region, 10 respondents (out of 16) noticed a marked reduction of water in Victoria Lake, while in Mara region 2 respondents (out of 6) noticed the same phenomenon in the same Lake (Victoria). Respondents stated that the former lake level is clearly marked on the shore, especially in the quays of the port cities in Bukoba and Mwanza. A similar situation occurred in Lake Tanganyika. Former water level is marked on the quays in ports in Kigoma and Ujiji. Several respondents wrote that on Lake Tanganyika, near the town of Kibirizi, one can see at present some rocks above the surface of the water, where 20-30 years ago one could not see them, and on the Lake Victoria, in the Sengerema district, some offshore islands joined to the mainland.

To the question concerning changes of water flow in rivers, more than 80% of positive answers were in following regions: Iringa, Kagera, Kigoma, Kilimanjaro, Lindi, Manyara, Mara, Mbeya, Morogoro, Mtwara, Shinyanga and Tabora. Only in the regions of Mwanza and Zanzibar positive response rate was less than 50 (respectively 25% and 33%).

As in the case of lakes, respondents gave examples of decreasing water flow in small and big rivers. The main reasons for the decrease in water flow in rivers are irrigations and deforestation. A spectacular example of the decreasing amount of water is the Great Ruaha River. I have had the opportunity to observe personally this phenomenon for several years. Not only does this river carry less water, but it also dries up the swamps in its basin. One of the consequences of the decrease in the flow of water (and drying of smaller streams) is the lowering

of the groundwater level. This phenomenon is especially present in the dry central part of the country (the respondents wrote about the lowering of the water level in wells in Dodoma and its surroundings). See the table (3) below.

Table 3: Rivers and streams in which the respondents observed a change in water flow.

Region	River/stream
Arusha	Rau, and streams near Karatu
Dar es Salaam + Pwani	Mbezi, Msimbazi, Tegeta
Dodoma	Streams in vicinity of Dodoma
Iringa	Great Ruaha
Kagera	Kagera, Ngono, Kabalobi
Kigoma	Muhanga, Mtunguruzi, Kumwambu
Kilimanjaro	Kikafu, Mwanjo, and streams flowing down the slopes of Kilimanjaro
Lindi	Rondo
Manyara	Bubu, streams in districts Babati and Kondoa
Morogoro	Kilombero, Ruhembe
Mwanza	Mwongo
Rukwa	Nzovwe, Kisa, Mtovisa
Shinyanga	Homs
Ruvuma	Ruvuma

Source: Students' field studies 2010

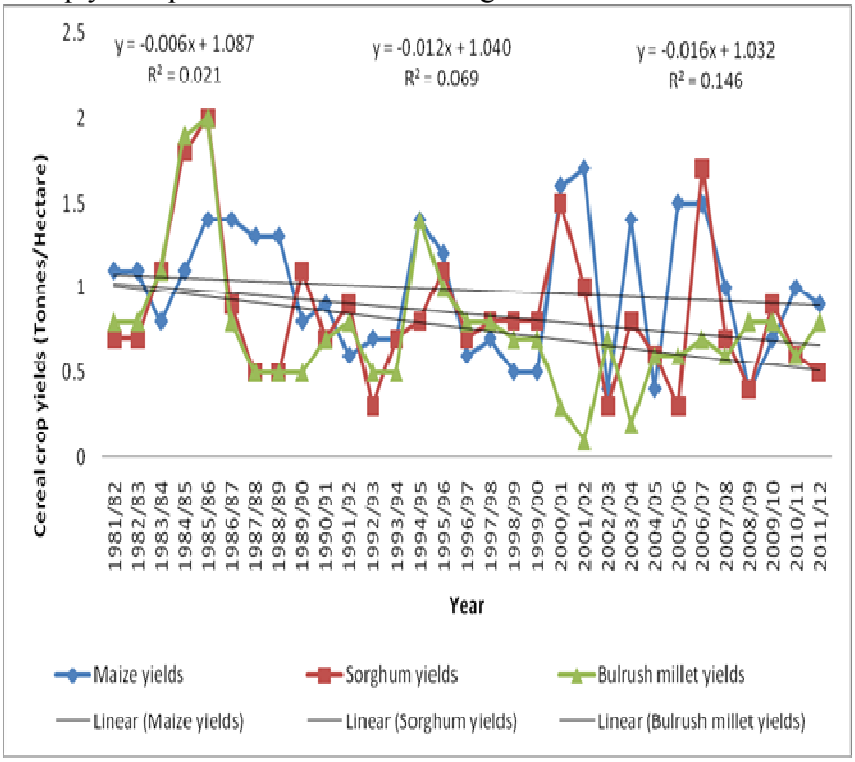
The increase of temperature has also been registered by weather stations. According to the Intergovernmental Panel on Climate Change (2007) the temperature in Africa within the 20th century has risen by 1^{o}C. According to the same source, as it has been mentioned already, in the period between 1970 and 2004 in the eastern part of Tanzania, the increase in temperature was between 0,2 and 1^{o}C, and in western Tanzania between 1 and 2^{o}C (Intergovernmental Panel on Climate Change, 2007). The higher air temperature increase that occurred in the western part of the country has a partial confirmation in respondents' comments to positive answers to the third question. The third

question, regarding the observed climate change, received the most positive responses from all the questions (85.7%). In most regions, the positive responses accounted for over 90% of all responses. However, in the region of Dar es Salaam, there were only 50% of positive answers. In Lindi region, where only one questionnaire was filled, the respondent picked the answer 'I do not know'. The temperature increase is observed especially in higher altitude areas, for example, Iringa, and Mbeya. Respondents wrote that nowadays winter is not as cold as it used to be, and one of the consequences is an increase of mosquitoes, thus an increased incidence of malaria. The increase in the occurrence of malaria was also observed in the regions of Kigoma and Manyara. Projections to 2030 indicate that East Africa will get more rain but will become drier as temperatures rise[3]. For Tanzania, the predicted increase in temperature is between 2.5°C and 4°C (Intergovernmental Panel on Climate Change, 2007). Parts of the country are projected to receive more rainfall, while the rest of the country, including the drought-prone southern areas, will receive less.

According to the respondents, the visible consequences of the decrease in precipitation so far are: decline of yields (Singida), single maize harvest during the year instead of two harvests (Rungwe), replacement of maize with other crops which require a lower amount of water (Songea). The figure (2) below shows decrease of cereal crop yields in Dodoma region in the period from 1981/82 to 2011/12.

[3] According to the respondents there was a rainfall decrease during last 30 years, but according to meteorological data the precipitation remained the same (in general, taking under consideration the whole territory of the country). Higher temperatures, however, intensified the evapotranspiration, and as consequence less water was available. That's why in opinion of respondents there was a rainfall decrease.

Fig. 2. Cereal crop yields per hectare in Dodoma region.



Source: Myeya and Kisanga (2015). Influence of climate change on cereal crop yields in semiarid areas of Dodoma region, Tanzania.

A spectacular consequence of climate change is the gradual melting of the snows on Mount Kilimanjaro and, as mentioned earlier, the reduction of water flow in rivers and streams flowing down its slopes. Several respondents highlighted the fact that the climate is becoming more unstable and unpredictable, for example, droughts (Iringa, Kagera) and floods (Iringa, Morogoro) are more frequent. Despite the fact that the amount of rainfall (per year) in some places remains the same, the shorter rain season causes more torrential rains, which leads to frequent floods. The following table (4) shows the share of positives answers (Yes – changes have taken place) to the three questions in different regions.

Table 4: The percentage of positive answers by administrative regions.

Region (the number between the brackets indicates the number of respondents/questionnaires per region)	**Question**			**Percentage of positive answers to all questions** (an average of 3 questions)
	1. Lakes	**2. Rivers**	**3. Climate**	
Arusha (9)	44,4	66,7	77,8	**63,0**
Dar es Salaam + Pwani (8)	12,5	50,0	50,0	**37,5**
Dodoma (3)	33,3	66,7	100,0	**66,7**
Iringa (21)	57,1	81,0	81,0	**73,0**
Kagera (16)	87,5	87,5	75,0	**83,3**
Kigoma (7)	71,4	85,7	100,0	**85,7**
Kilimanjaro (14)	64,3	85,7	92,9	**81,0**
Lindi (1)	0,0	100,0	0,0	**33,3**
Manyara (3)	100,0	100,0	100,0	**100,0**
Mara (6)	100,0	83,3	100,0	**94,4**
Mbeya (12)	58,3	83,3	91,7	**77,8**
Morogoro (6)	50,0	100,0	100,0	**83,3**
Mtwara (1)	100,0	100,0	100,0	**100,0**
Mwanza (12)	91,7	25,0	83,3	**66,7**
Rukwa (2)	100,0	50,0	100,0	**83,3**
Shinyanga (2)	0,0	100,0	100,0	**66,7**
Singida (4)	100,0	50,0	100,0	**83,3**
Ruvuma (5)	20,0	60,0	100,0	**60,0**
Tabora (1)	100,0	100,0	100,0	**100**
Tanga 4	75,0	50,0	75,0	**66,7**
Zanzibar + Pemba (3)	0,0	33,3	100,0	**44,4**
Tanzania (140)	**62,9**	**72,9**	**85,7**	**73,8**

Source: Students' field studies 2010

Table 4 above shows that in Tanzania 73,8% of all questions about observed symptoms climate change were answered positively. As can be seen from the table, the most altered regions in terms of climate change (taking into account the percentage of positive answers) are: Manyara, Mtwara, Tabora (100% of positive answers)[4], Mara (over 90 %), and Kagera, Kigoma, Kilimanjaro, Morogoro, Rukwa, Singida (80%). The regions with the slightest changes are: Lindi (33,3%), Dar es Salaam and Pwani (37,5%), Zanzibar and Pemba (44,4% of positive answers).

In 2013, I repeated the same survey using the same questionnaire to confirm previous results from the 2010 while at the University of Iringa. The study involved all 90 students of the Faculty of Science and Education who were attending my lecture on Climatology. As in the case of Dodoma, students were attending my lecture on Climatology, and the study took place during the Easter break. In the meantime, Tanzania had changed the administrative division of the country with two new regions created out of the division of some pre-existing ones. The new regions were taken into consideration. This time, however, questionnaires were filled only in 19 regions. Because of that, we cannot compare the results of 2010 and 2013 surveys in all regions. The results of the 2013 survey are shown in the two tables (5 and 6) below.

[4] It should be noted, however, that in Mtwara and Tabora the only one questionnaire was filled.

Table 5. Comparison of responses to asked questions by administrative regions of Tanzania (students from the University of Iringa)

Region	**Number of responses to individual questions**									**Total number of responses for the region and for a whole country**			
	1			2			3						
	Y	N	?	Y	N	?	Y	N	?	Tot	Y	N	**?**
Arusha (10)	3	1	6	7	3	0	8	1	1	30	18	5	**7**
Dar es Salaam + Pwani (3)	1	1	1	3	0	0	2	0	1	9	6	1	**2**
Dodoma (2)	1	0	1	0	0	2	2	0	0	6	3	0	**3**
Geita (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Iringa (9)	3	4	2	5	0	4	5	3	1	27	13	7	**7**
Kagera (3)	1	0	2	1	0	2	2	0	1	9	4	0	**5**
Kigoma (2)	2	0	0	2	0	0	1	0	1	6	5	0	**1**
Kilimanjaro (8)	4	2	2	7	0	1	7	1	0	24	18	3	**3**
Manyara (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Mara (3)	3	0	0	1	0	2	3	0	0	9	7	0	**2**
Mbeya	13	6	3	18	1	3	18	2	2	6	4	9	**8**

(22)										6	9		
Morogoro (3)	1	1	1	3	0	0	3	0	0	9	7	1	**1**
Mtwara (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Mwanza (4)	3	1	0	4	0	0	3	1	0	12	10	2	**0**
Nyombe (3)	1	0	2	3	0	0	2	0	1	9	6	0	**3**
Rukwa (1)	1	0	0	1	0	0	1	0	0	3	3	0	**0**
Ruvuma (5)	3	2	0	3	2	0	4	1	0	15	10	5	**0**
Shinyanga (2)	0	1	1	0	0	2	2	0	0	6	2	1	**3**
Tanga (7)	4	0	3	7	0	0	6	1	0	21	17	1	**3**
Tanzania (90)	**47**	**19**	**24**	**68**	**6**	**16**	**72**	**10**	**8**	**270**	**187**	**35**	**48**

(10) – the number of completed questionnaires in the region
Y – Yes, changes have taken place
N – Non, changes haven't taken place
? – I don't know
Tot – the number of questions asked in the region (number of completed questionnaires x 3 questions)

Source: Students' field studies 2013

Table 6: The percentage of positive answers by administrative regions (students from the University of Iringa)

Region (number between the brackets indicates the number of respondents/questionnaires per region)	**Question**			**Percentage of positive answers to all questions** (an average of 3 questions)
	1. Lakes	**2. Rivers**	**3. Climate**	
Arusha (10)	30,0	70,0	80,0	**60,0**
Dar es Salaam + Pwani (3)	33,3	100,0	66,7	**66,7**
Dodoma (2)	50,0	0,0	100,0	**50,0**
Geita (1)	100,0	100,0	100,0	**100,0**
Iringa (9)	33,3	55,6	55,6	**48,2**
Kagera (3)	33,3	33,3	66,7	**44,4**
Kigoma (2)	100,0	0,0	50,0	**50,0**
Kilimanjaro (8)	50,0	87,5	87,5	**75,0**
Manyara (1)	100,0	33,3	100,0	**77,8**
Mara (3)	100,0	33,3	100,0	**77,8**
Mbeya (22)	59,1	81,8	81,8	**74,2**
Morogoro (3)	33,3	100,0	100,0	**77,8**
Mtwara (1)	100,0	100,0	100,0	**100,0**
Mwanza (4)	75,0	100,0	75,0	**83,3**
Nyombe (3)	33,3	100,0	66,7	**66,7**
Rukwa (1)	100,0	100,0	100,0	**100,0**
Ruvuma (5)	60,0	60,0	80,0	**66,7**
Shinyanga (2)	0,0	0,0	100,0	**33,3**
Tanga (7)	57,1	100,0	85,7	**80,9**
Tanzania (90)	**51,1**	**75,0**	**80,7**	**68,9**

Source: Students' field studies 2013

Comparison of the results of the research conducted at the University of Dodoma and the University of Iringa (Table 7) gave a fairly similar picture of

climate change. The percentage of positive responses to all questions about environmental change in the whole country was 73,8% for the study of 2010 and 68,9% for the study of 2013. However, slight differences can be seen when comparing the results of the research for the same regions.[5] This is mostly due to the fact that the number of filled questionnaires in each region varied and respondents in many cases came from different, often distant, districts within the same region. Also in both surveys in several regions, only one questionnaire was filled.

Table 7. Comparison of the results of research conducted with students at the University of Dodoma and the University of Iringa

Region	**Percentage of positive responses to all questions about the changes in the region**	
	University of Dodoma	University of Iringa
Arusha	63,0	**60,0**
Dodoma	66,7	**50,0**
Iringa	73,0	**48,2**
Kagera	83,3	**44,4**
Kigoma	85,7	**50,0**
Kilimanjaro	81,0	**75,0**
Manyara	100,0	**77,8**
Mara	94,4	**77,8**
Mbeya	77,8	**74,2**
Morogoro	83,3	**77,8**
Mtwara	100,0	**100,0**
Mwanza	66,7	**83,3**
Shinyanga	66,7	**33,3**
Tanga	66,7	**80,9**
Tanzania	**73,8**	**68,9**

Source: Students' field studies 2010 and 2013.

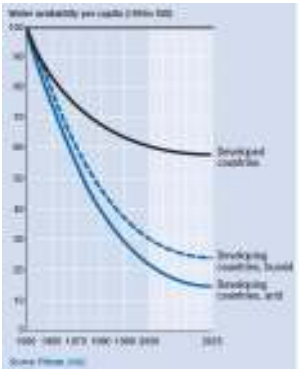
[5] Apart from Kagera and Shinyanga, where differences in results are quite significant, but it should be noticed that in both regions in 2013 the share of the answer – "I don't know" – was very high.

Discussion

The main aim of this study was to get information about how elderly people, who should have theoretically better knowledge about climate change, perceived climate change in Tanzania within the last 30 years. The research showed that around 70% of elderly people perceived various symptoms of climate change, especially the rise of the air temperature, decreased flow of water in rivers and decrease of water level in the lakes. It should be emphasized that the perception presented by respondents about the symptoms of climate change in Tanzania reflects the global climate change patterns.

Globally and locally, irregular rains decrease the amount of accessible water. Global warming will produce significant changes in evaporation and precipitation, and, as a result, the hydrological cycle will be more unpredictable. Higher air temperatures will increase evaporation from the oceans, and evaporation from land, and therefore less water will be available in soils, lakes and rivers. These changes will modify rainfall patterns and will produce more extreme weather events, including floods and droughts. Decreasing amount of accessible water is a phenomenon that the whole world is faced with. It is also connected to the increase of population, which is taking place mainly in poor countries, and with a lack of investments in irrigation and water infrastructure in general, of which Tanzania is an example. The decrease in the amount of accessible water in the world is presented in the following graph (Fig. 3).

Fig. 3. Decrease in the amount of accessible water per person in the group of chosen countries in the years 1950 – 2000.

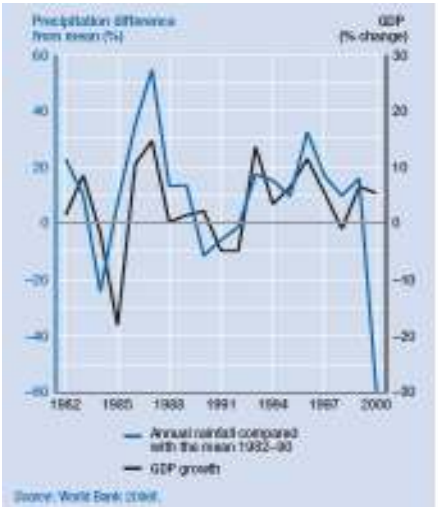


Source: UNDP, 2006

The Human Development Report (2006) foreshadows that the amount of population will lead to increased water scarcity in all the poorest regions of the world. For instance, in 1990 in Sub-Saharan Africa 100 million people lived under conditions of water shortage. In 2005 this amount rose to 300 million but it is estimated that in 2025 it will reach to 750 million.

How, and at which degree, will this water shortage influence development in the world's poorest countries? In African countries with subequatorial climate there is a close relationship between rainfall amount and Gross Domestic Product. This results mainly from the dependence of those countries' economies (which mostly rely on agriculture) on water supply. In Sub-Saharan Africa, only 3% of land under cultivation is irrigated and in Tanzania about 5-10% (UNDP, 2006). The remaining 90-95% of farmland depends merely on climatic conditions. The figure below (4) illustrates the dependence of agriculture in Ethiopia (national economy in general) on the rainfall regime, but the same situation and the same mechanism can be observed in other countries of the Sub-Saharan African region.

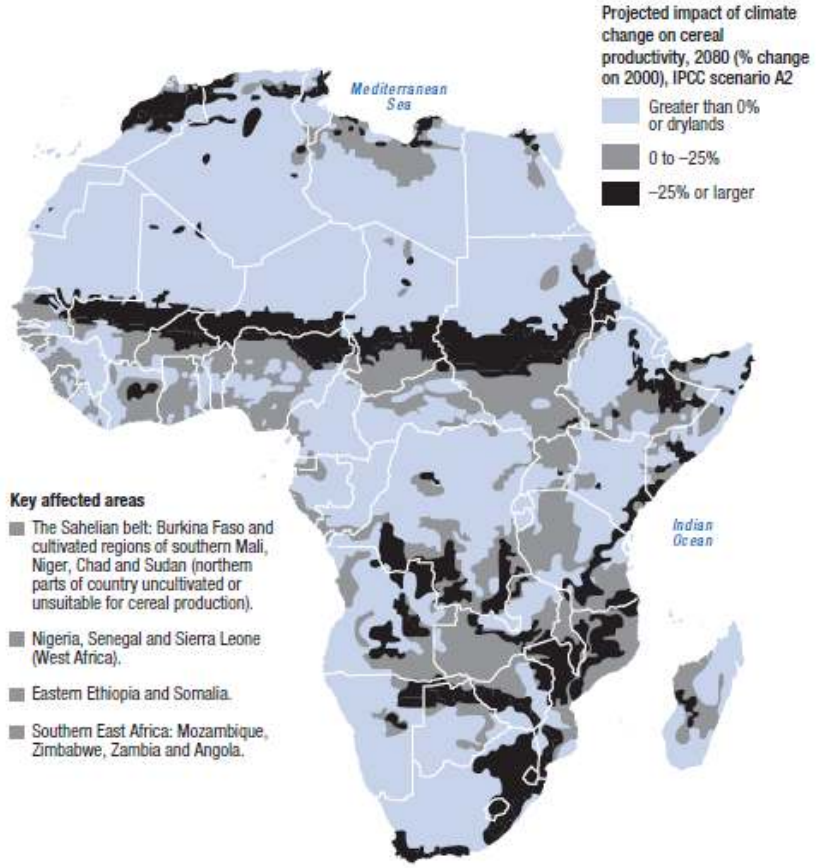
Fig. 4. GDP mirrors rainfall regime in Ethiopia



Source: UNDP, 2006

As stated above, according to the respondents, the main consequences of climate change so far are: decline of yields, single maize harvest during the year instead of two harvests, replacement of maize, which require a bigger amount of water, by other crops with less water needed. The figure below (5) presents the relationship between climate change and cereal productivity in Africa. As can be seen on the map, the most significant fall in productivity in Tanzania, in the period 2000 – 2080, will be in Tanga, Iringa, Njombe and Mtwara regions. The productivity will decrease also in the southeast, west and northwestern parts of the country. Because of the decrease of the available water for crop production, maize productivity is projected to fall in Tanzania by 30% by 2030 (Murray and Orindi, 2005).

Fig. 5. Climate change and cereal productivity in Africa



Source: Fisher et al. (2005) in, UNDP, 2006

Conclusion

Taking the data and other figures under consideration in this article, the following question arises: what should Tanzania do to face the consequences of climate change, or more specifically, the decrease in productivity, and the shortage of food? In my opinion, and depending on my experience and observations, a set of actions should be undertaken. These are: to change/adjust the existing structure of crop production to climatic changes, to improve the

techniques of cultivation, to build well studied irrigation systems, and finally to create functional systems of food storage.

Adaptation of the structure of production to climate change should take place mainly in the areas, where, for various reasons, improved irrigation systems are less likely to be built (for example, for adverse topographical and geological conditions). Plants with less water and soil requirements should replace those with higher requirements (for example, sorghum instead of maize, and cassava instead of potatoes). Appropriate/optimal choice of crops should be carried out with the help of extension officers. With the change of cultivated plants, also production techniques will need change. The most important change will be to reduce evapotranspiration and retain water in the soil. There are many ways of doing that. The simplest and very effective one is a complete coverage (i.e. mulching) of the fields during the growing season with unused parts of crops from the previous harvest (leaves, stems) and increasing the amount of humus in soil which is an excellent water absorbent.

The biggest challenge is the construction of irrigation systems and water retention. All water projects must be coordinated with one another to avoid situations in which one system is running against another, for example, by depriving it of water. This will require not only carrying out the specialized researches/surveys (for example geomorphological and hydrological), but also it will have to take into account the existing technical infrastructure and functioning economic linkages. Finally, the demographic situation must be analysed so that the implementation of the projects does not lead to social conflicts.

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