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The Assessment of Climate Change Adaptation and Mitigation Strategies among Agrarian Communities in North Kordofan of Sudan

(*Penilaian Adaptasi dan Strategi Mitigasi Perubahan Iklim pada Masyarakat Agraris di Kordofan Utara Sudan*)

Mohammed Hamed Mohammed[1,2*], Salih Omer Tutu[1], Hassan Elnour Adam[1], Alawia Osman Koli[3], & Abdalla Nourain Omer Abdalla[4]

[1]Faculty of Natural Resources and Environmental Studies, University of Kordofan, 51111 Elobeid, Sudan
[2]Institute of Gum Arabic Research and Desertification Studies, University of Kordofan, 51111 Elobeid, Sudan
[3]Faculty of Agricultural Sciences, University of Dalanj, Dalanj, Sudan
[4]Forests National Corporation FNC- South Darfur, Nyala, Sudan
**Email* : hamed1705@yahoo.com

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Adaptation strategies, agrarian communities, climate change mitigation

ABSTRACT

The current study was conducted in Bara Locality - North Kordofan - Sudan to assess climate change adaptation and mitigation strategies among agrarian communities. Data was collected by randomly interviewing 150 respondents from ten villages, using a questionnaire. Descriptive statistics in the SPSS software package and Microsoft Excel were used for data analysis. The results of the study showed that agrarian communities, and due to climate change, have enforced to develop ten adaptation strategies suitable for agriculture in dryland conditions. Most adaptation strategies being used by the agrarian communities are cultivation in different directions locally Sheraik (77%), sowing before rain locally Ramail (77%), and reducing cultivated area as mentioned by 67% of interviewed respondents. In the forestry sector, around 65% of the interviewed respondents have been practiced agroforestry as an adaptation strategy. The interviewees were also able to figure out eight possible mitigation strategies to stave off climate change effects. These strategies are, for example, building capacity of agrarian communities (73%) and provision of early mature as well as the high-yielding and drought-tolerant crops (63%). The study comes out with some suggestions to pave the way for policymakers to tailor suitable future interventions to mitigate the impact of climate change among agrarian communities.

KATA KUNCI
Strategi adaptasi, masyarakat agraris, mitigasi perubahan iklim

INTISARI

Penelitian ini dilakukan di daerah Bara - Kordofan Utara - Sudan untuk menilai adaptasi dan strategi mitigasi perubahan iklim pada masyarakat agraris. Data dikumpulkan melalui wawancara dengan menggunakan kuesioner pada 150 responden yang dipilih secara acak dari 10 desa. Analisis statistik deskriptif dilakukan dengan menggunakan perangkat lunak SPSS dan Microsoft Excel. Hasil penelitian menunjukkan bahwa masyarakat pertanian, karena, terpaksa mengembangkan sepuluh strategi adaptasi yang sesuai untuk pertanian pada kondisi lahan yang kering. Sebagian besar strategi adaptasi yang digunakan oleh masyarakat pertanian adalah

penanaman pada arah yang berbeda di daerah Sheraik (77%), menabur benih sebelum turun hujan di daerah Ramail (77%), dan mengurangi luas area penanaman yang dinyatakan oleh 67% dari responden yang diwawancara. Pada sektor kehutanan, sekitar 65% dari responden yang diwawancara telah mempraktekkan agroforestri sebagai strategi adaptasi. Responden juga mampu mengidentifikasi delapan strategi mitigasi yang mungkin dilakukan untuk mengatasi efek perubahan iklim. Strategi tersebut antara lain peningkatan kapasitas masyarakat agraris (73%) dan penyediaan jenis tanaman early mature atau yang cepat panen dengan produktivitas tinggi dan tahan terhadap kekeringan (63%). Penelitian ini memberikan beberapa saran untuk pembuat kebijakan dalam menyusun intervensi yang sesuai di masa depan dalam rangka mitigasi dampak perubahan iklim pada masyarakat agraris.

Introduction

Adaptation is the adjustment in natural or human systems in response to actual or anticipated climatic change or their effects, to reduce harm or exploit beneficial opportunities (IPCC 2007). Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to climate change (Smith et al. 1996). Whether people can adapt, and for how long, depends on the resources available (Gyampoh et al. 2009). Adaptation involves changing processes, practices, or structures, either automatic (regular) or planned, by individuals, households, governments, and other stakeholders. The capacity to adapt depends largely on access to assets (including natural resources; and human, technological, social, physical, and financial capital) and how well these are used (Zakieldeen 2009). An example of adaptation strategy was implemented in arid lands of Bara Province, North Kordofan, Sudan, through the planting of shelterbelts funded project in response to the soil erosion and land degradation consequential from recurrent drought. Some tactical adaptations could be identified in response to an extreme climatic condition (drought), such as the selling of livestock, expanding agricultural lands in response to declining productivity per unit area (at the expense of forest and rangelands), and most widely the use of relief foods (Osman-Elasha et al. 2006). Adaptation in agriculture occurs via a variety of processes and can take many different forms at any given scale or for any stakeholder, considered adaptations according to their administrative, financial, institutional, legal, managerial, organizational, political, practical, structural, and technological characteristics (Adebanjo 2013).

From other sites, mitigation refers to the elimination or reduction of the frequency, magnitude, or severity of exposure to environmental, economic, legal, or social risks, or minimization of the potential impact of a threat or warning (UNISDR 2017). Consequently, it is within the capacity of humans to influence their exposure to change (FAO 2012). Mitigation is also defined in the report for IPCC (2007) as "an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks". Mitigation capacity is a country's ability to reduce anthropogenic greenhouse gas emissions or to enhance natural sinks, where ability refers to skills, competencies, fitness, and proficiencies that a country has attained and depends on technology, institutions, wealth, equity, infrastructure, and information. However, the amount of mitigation that could be – but

is not yet – realized over time is called mitigation potential (IPCC 2007).

North Kordofan State, Sudan is situated within the Sahara-Sahelian zone of Africa and the northern part of it is just locating at the southern periphery of the Sahara desert of Sudan. This geographically described area has experienced recurrent drought spells that started in the 1970s of the past century. Consequently, desertification and desert encroachment have threatened thousands of hectares that are considered productive areas as far as crops, rangelands, and biodiversity aspects are concerned. As a result, a considerable part of the population has been enforced to migrate towards urban areas. Traditional farming, generally small holding areas, is dominant where more than 75% of the state population engages in agricultural activities, including gum Arabic production. For these immigrants to cope with this new situation, are obliged to modify their living pattern and consequently exerted pressure on the nearby forests. The rest of the rural population has enforced to modify their livelihood, become relief-oriented communities, and/or indulge in activities harmful to their surrounding environment. Such activities are like overcutting of trees, overgrazing, and over-cultivation. The prevailed land use patterns in this area depend primarily on subsistent rain-fed farming coupled with pastoral systems on the transhumant basis where camels and desert sheep are the dominant livestock species. The state has been identified by Sudan's National Adaptation Program of Action NAPA (2007) as one of the most five vulnerable areas to climate change and experienced foot insecurity. The agriculture sector is highly vulnerable to climate change than other sectors do. Hence the livelihood of agrarian communities in this state has been affected. Agrarian communities have long been recognized as being particularly vulnerable to the impacts of climate change due to the close connection between their livelihoods and the environment (NAPA 2007; IFAD 2011). With the increase in poverty levels, farmers have enforced to find coping strategies to survive (Mukhala and Chavula 2007). As evidence of climate change impact, agrarian communities in North Kordofan have been practiced different strategies to adapt to climate change. Such activities are livestock and crop diversification, changing planting dates, and mix crops with livestock. On the other side, one could link the conflict between agrarian communities and pastoralists in the Kordofan region with resource scarcity and environmental degradation (IFAD 2011). Since climate change has direct impacts on the livelihoods of agrarian communities they have to find different survival strategies to cope with the changing climate. Scholars in many fields have addressed the issue of climate change within the context of vulnerability, adaptation, mitigation, and resilience of communities (Pokhrel and Pandey 2011; Chinvanno 2012). The objective of the current study is to identify and assess the traditional adaptation strategies which have been adopted by agrarian communities, in North Kordofan-Sudan, and identify the key constraints for mitigation strategies to the targeted communities.

Methods

The Study Area

North Kordofan state comprises eight localities including Bara Locality (Figure 1) where the current study was conducted. Bara Locality is situated within the area of the gum belt of North Kordofan, Sudan. It lies between Latitudes 13° 34' and 14° 47' N and Longitudes 30° 05'and 31° 47' E with an area of 11850 km² (Hanno 2003). Based on the average annual rainfall and length of the growing season, North Kordofan State can be divided into three agro-ecological zones (Khatir et al. 2015). These are: 1) semi-desert zone with rainfall ranges from 100 to 200 mm/year and growing season from 30 to less than 60

days, 2) arid zone receives annual rainfall ranges from 200 to 350 mm/year, with the duration of the growing season from 60 to less than 90 days, 3) semi-arid zone with rainfall varies from 350 to 750 mm/year and growing season from 90 to less than 120 days (Figure 1). The impacts of climate change on the vegetation cover, particularly on the gum Arabic belt, are apparent during the last decades where areas famous with gum Arabic production in the past are no longer productive. Food security is mainly determined by rainfall, with more than 70% of Sudan's people directly dependent on climate-sensitive resources for their livelihoods. Bara Locality is generally characterized by gently undulating plains covered with dunes stabilized and disturbed dunes are covering most of the locality. The soils of the study area are various, with sand dominating and generally considered infertile (Khiry 2007). The study area falls in the semi-desert or sand ecological zone with a single rainy season. There is usually a short growth period followed by a dry season with a great reduction in the number of green plant materials. In the eastern part of the study area vegetation is meager dominate by *Acacia tortilis*, *Maerua crassifolia,* and *Leptadenia pyrotechnica*. The sandy rangeland cover with scattered upper story vegetation characterized by grasses such as *Cenchurs ciliaris*, *Chloris gayana*, *Eragrostis spp*, *Panicum turgidum*, *Cyprus spp*, *Dactyloctenium aegyptium,* and *Aristida spp* (Adam and Abdalla 2007; Khiry 2007). The state population is approximately 3.2 million (2008 census), of which approximately 85% is rural and practicing agriculture in addition to the collection of forest products. Agricultural activities have offered the rural population, in Bara Locality, major opportunities to promote food security and improve their livelihoods.

Data Collection

This study was based on qualitative and quantitative data to accomplish the above-mentioned objectives. Qualitative data was based on direct field observations, key informant interviews, and household surveys. However, quantitative data includes household data regarding farm size and millet productivity as a staple food in Bara Locality. The sample size was determined according to Cochran's formula (see equation) for deriving sample size (Cochran 1977). To gather the necessary data, 150

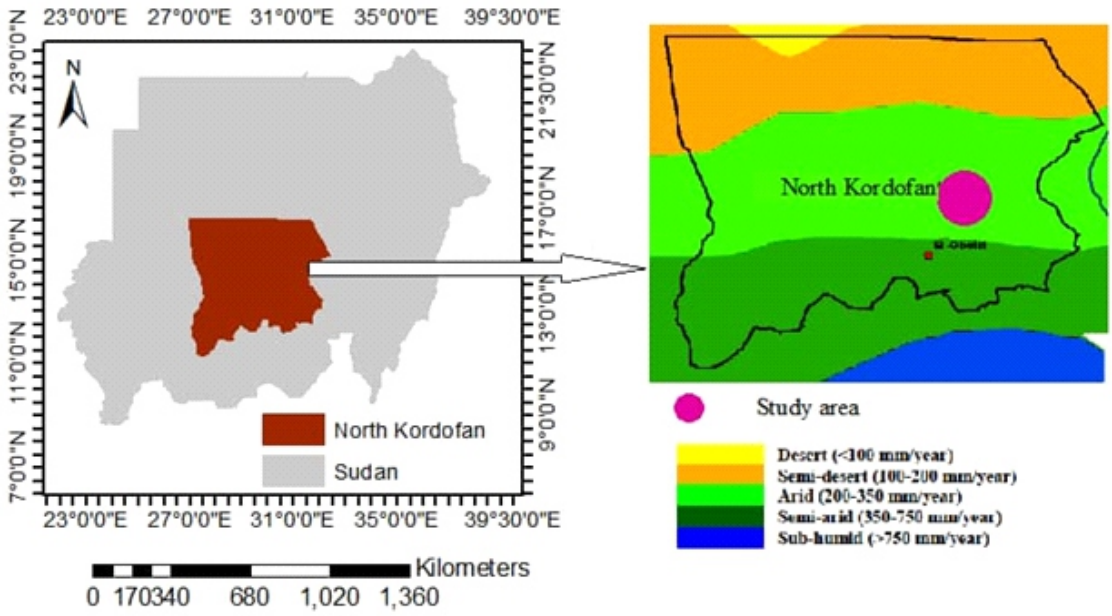

Figure 1. Map shows agro-ecological zones in North Kordofan State (modified from Khatir et al. 2015).
Gambar 1. Peta zona agro-ekologi di Negara Bagian Kordofan Utara (dimodifikasi dari Khatir et al. 2015).

out of 946 households from ten villages commonly considered as agrarian communities, were randomly selected and interviewed during 2016 on issues related to their adaptation strategies and mitigation to climate change. The field survey was supported by key informants' questionnaires to provide insightful data and confidential information that may not be obtained by a household field survey (Kumar 1989). Data was analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS, version 20). Data was subjected to descriptive statistics and correlation analysis to disclose the characteristics and the results were summarized in tables and figures.

$$SS = Z^2 * P(1-P)/C^2$$

Where: SS = sample size; Z is the Z-value = 1.96 at 95% level; P = percentage picking a choice expressed as decimal (0.5 used for sample size needed); C = confidence interval ±0.08.

Results and Discussion

Respondents' Socioeconomic Characteristics

Results of socioeconomic characteristics show that two-third (62%) of the interviewed respondents were female and 38% were male (Table 1). Women actively participate in agricultural production in various regions of Sudan. Women represent 50-90% of agricultural employment in Sudan rural areas, especially in Darfur and Kordofan regions. The contribution of rural women in traditional agriculture, to provide food for their families, maybe due to two reasons: 1) migration of men to search for better job opportunities, and this increases the burden of women inside and outside the home and 2) the decline of social services (education and health) and infrastructure in the countryside. The mean age of respondents was 46 years and 67% of them are above 40 years indicating that a large proportion of the respondents have the knowledge and experienced long-term impacts of climate change over the years. Traditional knowledge as a practice followed and inherited through the generations is either written (documented) or verbal and forms part of the social, historical, or religious context of the people of a certain area. Gyampoh et al. (2009) emphasized that traditional knowledge and practices of indigenous people gained over time through experience and orally passed on from generation to generation – has over the years played a significant part in solving problems, including problems related to climate change and variability.

Table 1. Socio-demographic variables of interviewed respondents (N) in Bara Locality, North Kordofan - Sudan
Tabel 1. Variabel social-demografi dari responden yang diwawancara (N) di daerah Bara, Kordofan Utara – Sudan

Characteristic	Variable	Frequency	%
Gender	Male	57	38
	Female	93	62
Age (years)	< 20	1	1
	20-39	48	32
	40-59	72	48
	60-79	29	19
Educat ion level	Illiterate	79	53
	Basic	5	3
	Intermediated	52	35
	Secondary	12	8
	University	2	1
Occupation*	Farmer	112	75
	Livestock owner	39	26
	Employer	3	2
	Merchant	13	9
	Business	17	11
	Others	40	27

Remark: Sample size = 150 respondents; * Number of participants does not total 150: respondents selected more than one answer.
Keterangan: Ukuran contoh = 150 responden; *Total jumlah responden tidak sama dengan 150: responden memilih lebih dari satu jawaban

Table 2. Adaptation strategies in the agricultural sector as adopted by agrarian communities in Bara Locality, North Kordofan- Sudan 2017
Tabel 2. Strategi adaptasi pada sector pertanian yang diadopsi oleh masyarakat agraris di daerah Bara, Kordofan Utara – Sudan 2017

Adaptation strategies in the agricultural sector	Frequency	%
Cultivation in different directions, *Sheraik*	115	76.7
Sowing before rainy time, *Ramail*	115	76.7
Reducing cultivated areas	101	67.3
Practicing agro-forestry or acacia based system	97	64.7
Migration to other places	96	64
Conducting some agricultural operations like weeding	91	60.7
Changing the time of farming	56	37.3
Store crops for the time of scarcity	72	48
Farming spe cial types like some millet	35	23.3
Smuggling and looting	22	14.7
Others	4	2.7

Remark: Sample size = 150 respondents
Keterangan: Ukuran contoh = 150 responden

Adaptation Strategies in the Agricultural Sector

Results in Table 2 revealed ten adaptation strategies used by agrarian communities to adapt to climate change. As a result of climate change, agrarian communities in Bara Locality have been enforced to develop methods and strategies of agriculture suitable for dryland conditions. The most traditional methods being used by farmers, which are considered as strategies to adapt to climate change, are cultivated in different directions locally *Sheraik* (77%), sowing before rain locally *Ramail* (77%) and reduce cultivated area as mentioned by 67% of respondents.

A household in the agrarian community in Bara Locality has more than one piece of land distributed in different directions of the village due to scarcity and fluctuation in rainfall which varies between 150-450 mm/year with an average of 243 mm/year. As a response to climate change, agrarian communities cultivate small parcels of land, around 3 ha/crop, in more than one direction to avoid crop failure (Figure 2). Reducing cultivated land is prominent, in the same figure, as the area per hectare for many crops decreased since 1970 up to now. As a result of climate change, agrarian communities in Bara Locality can remember that the size of cultivated areas for different crops declined from 1970 to now. The same figure also showed a drop in cultivated areas since the 1970s for staple and cash crops in the study area. Millet and sorghum as the staple crops were decreased at a rate of 47% and 57%, respectively. However, cash crops such as sesame, watermelon, groundnut, roselle, and gum Arabic were dropped by 45.9%, 48.3%, 65.4%, 52.1%, and 81.5%, respectively. These results demonstrate that Bara Locality has been affected by climate change as communities reduced the cultivated areas of crops. Figure 3 demonstrates the impact of climate change in the area cultivated and productivity per unit area. It is indicated that the average annual cultivated land of millet from 1990 to 2019 not exceeds 505,000 ha (CV = 60%) for the whole North Kordofan State. Consequently, productivity per unit area (average 0.14 to/ha) resulting in a high variability (CV = 140%). The steady reduction in cultivated land, as an adaptation strategy, supports what is mentioned by NAPA (2007) that the area is experienced climate change and food insecurity. Another reason for reducing the cultivated area is that the farmer tends to look for options to diversify income for the family livelihood. Sowing before rain or locally called *Ramail* has been practiced by 77% of the agrarian community in Bara Locality as an adaptation strategy, especially when they expect a shortage in rainfall that may not guarantee to sow different farms in a short time or/and family size is smaller. However, sowing seeds before the rain has several disadvantages such as seeds will be susceptible to pests or rotten in case there is no enough rain for seed germination.

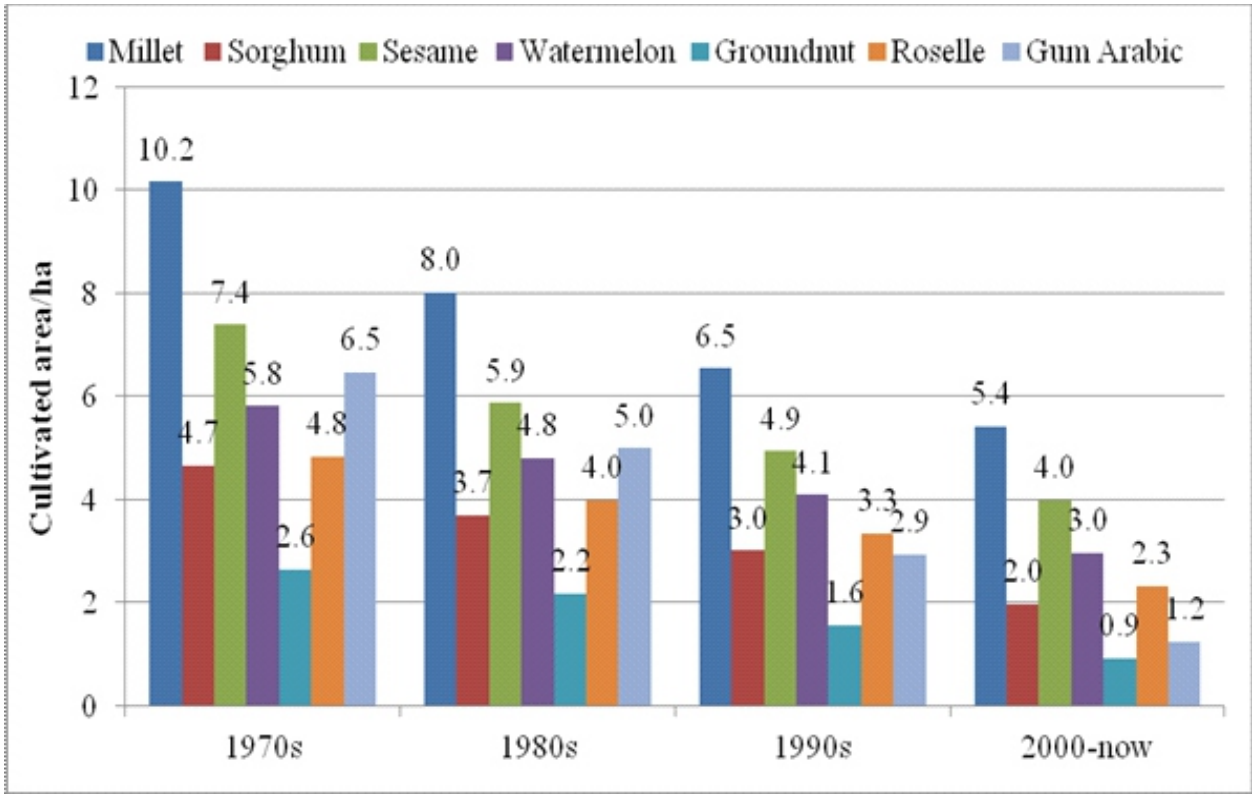

Figure 2. Cultivated areas per hectare for major crops in Bara Locality according to respondents' point of view, 2017
Gambar 2. Area budidaya untuk tanaman utama di daerah Bara menurut sudut pandang responden, 2017

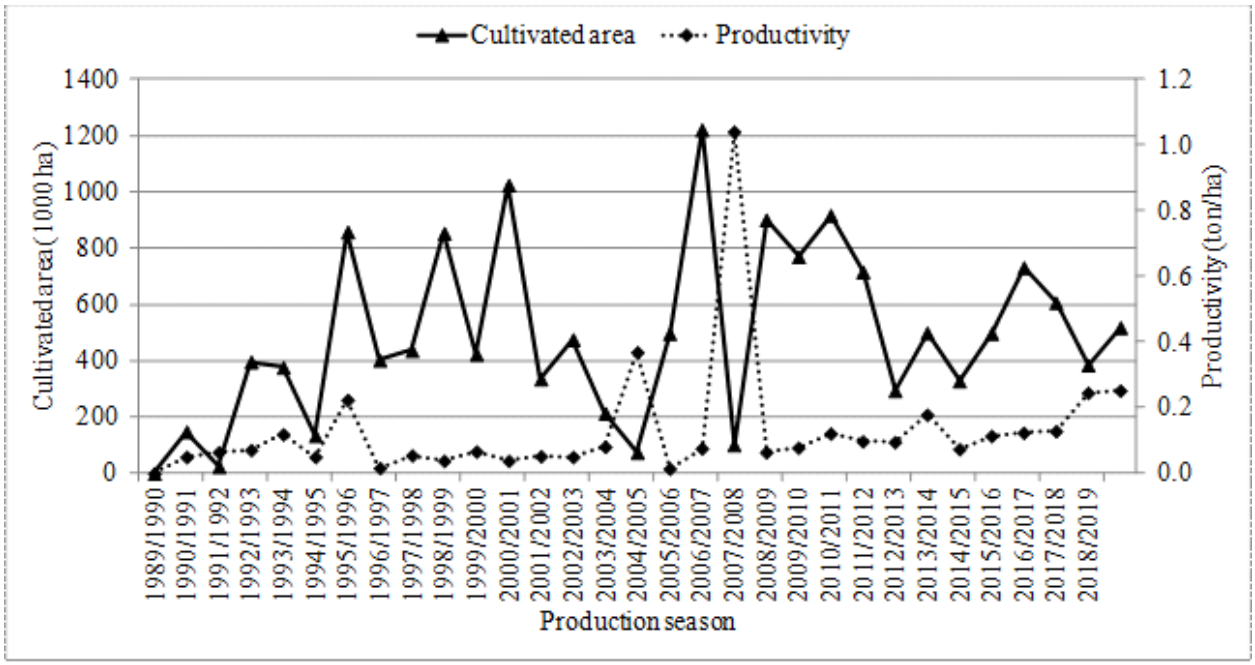

Figure 3. The effect of climate change on millet cultivated area and productivity per hectare in North Kordofan during 1989/1990 to 2018/2019 (adapted from the Ministry of Agriculture 2017)
Gambar 3. Efek perubahan iklim terhadap area budidaya dan produktivitas per hektar dari millet di Kordofan Utara dari 1989/1990 sampai dengan 2018/2019 (diadaptasi dari the Ministry of Agriculture 2017)

Due to climate change, agrarian communities classify the crops yield into four categories according to their viewpoint. These are no yield (NY), low, medium, and high yield (Table 3). The results indicated that 91–97% of the respondents categorize millet as high yield in the 1970s, 1980s, and 2000 up to now. However, in the 1990s only 3.3% of the respondents were mentioned that the yield of millet was high. The situation is similar to other crops (sesame, watermelon, groundnut, roselle and gum Arabic) that yield was low in the 1990s. The importance of using adaptation strategies created by agrarian communities in arid and semi-arid regions stems from the frequency of droughts in this area. These strategies lie in the sustainability of dry environments and the provision of food security.

Table 4 shows the percentage of respondents that cultivated in different directions since the 1970s. Around 28-31% of the interviewees declared that they cultivated millet in four directions (north, east, south, and west) of their village. From the same table, it is clear that respondents have tended not to cultivate some crops such as sorghum, groundnut, gum Arabic, and roselle because of the shortage of rainfall that has been led to frequent failures of these crops in Bara Locality.

Mitigation Strategies in Agriculture and Forests

Agrarian communities (Table 5) can mention eight mitigation strategies, relevant to agriculture and forests, either provided by the government, NGOs, and/or financial institutions. The results showed that 73% of interviewed respondents received training and extension on crop diversification to avoid sole crop failure. This result is confirmed by Gyampoh et al. (2009) who mentioned that in coping with the risk of climate change (fluctuation and low rainfall, drought, and crop failure), local communities grow many different crops and varieties with different susceptibility to drought. The diversity of crops and food resources is often matched by a similar diversity in the location of fields, as a safety measure to ensure

Table 3. Yield categories of some crops based on respondents' point of view in Bara Locality, North Kordofan -Sudan
Tabel 3. Kategori panen dari beberapa tanaman berdasarkan sudut pandang responden di daerah Bara, Kordofan Utara – Sudan

Crop	1970s				1980s				1990s				2000-Now			
	NY	Low	Medium	High	NY	Low	Medium	High	NY	Low	Medium	High	NY	Low	Medium	High
	Respondents (%)															
Millet	3.3	0.0	0.0	96.7	4.0	1.3	4.0	90.7	2.0	2.0	92.7	3.3	2.7	0.7	0.7	96.0
Sorghum	50.0	0.7	0.0	49.3	52	0.7	2.0	45.3	50.7	2.0	46.0	1.3	50.0	49.3	0.7	0.0
Sesame	4.7	0.0	0.0	95.3	6.7	0.7	3.3	89.3	4.7	0.7	89.3	5.3	4.70	88.6	6.70	0.0
Watermelon	26. 7	0.0	0.7	72.6	28.7	1.3	2.7	67.3	26.0	1.3	66.0	6.7	25.3	68.7	4.7	1.3
Groundnut	72.7	0.0	1.3	26.0	73.3	0.0	1.3	25.3	73.3	0.7	25.3	0.7	73.3	26.7	0.0	0.0
Roselle	20.0	0.0	1.3	78.7	23.3	0.7	3.3	72.7	20.0	1.3	70.0	8.7	20.7	71.3	1.3	6.7
Gum Arabic	62.7	0.0	2.0	35.3	63.4	1.3	3.3	32.0	68.0	7.3	24.7	0.0	74.7	25.3	0.0	0.0

Remark: NY denotes for no yield.
Keterangan: NY singkatan dari no yield atau tidak ada panen

Table 4. Directions of cultivated areas as indicated by agrarian communities in Bara Locality, North Kordofan- Sudan 2017
Tabel 4. Arah area budidaya seperti yang diindikasikan oleh masyarakat agraris di daerah Bara, Kordofan Utara – Sudan

Crop	1970s					1980s					1990s					2000-Now				
	N	E	S	W	NC	N	E	S	W	NC	N	E	S	W	NC	N	E	S	W	NC
	Respondents (%)																			
Millet	25.3	11.3	39.2	46.7	3.3	24.7	16.7	33.4	42.7	6	19.4	18.7	20.1	52.6	3.3	14	18.6	26.7	60.6	4.7
Sorghum	8	4.6	22	24	52.7	8	10.6	16	19.3	57.3	8	11.3	12.1	23.3	55.3	4.1	9.3	11.4	30	54.7
Sesame	20.7	12	48	40.7	3.3	19.3	25	40.7	37.4	8	14.6	22.6	28	51.9	4	8	22.6	27.9	57.3	5.3
Watermelon	16	10.7	39.4	30	27.3	16.7	14.1	34.8	26	30.7	11.3	21.3	22	39.3	26.7	6.7	20.6	22.0	44.7	26.7
Groundnut	7.4	2	14	9.4	74.7	7.4	4	12.7	7.3	76	4	5.4	7.4	11.3	74.7	2	6.7	7.4	13.3	76
Roselle	14.7	9.3	36	36.7	21	14.7	14.7	29.4	31.4	27.3	2	20.7	18.7	44.7	22	4.7	19.3	18	51.3	22
Gum Arabic	16.6	5.4	28	6.7	62.7	13.3	8	23.3	6.1	64.7	4.7	16.6	6.6	15.3	70	1.4	15.3	4.7	18.6	73.3

Remark: NC = no cultivation; N, E, S, and W denote for north, east, south, and west directions, respectively.
Keterangan: NC = tidak ada budidaya; N, E, S, dan W adalah arah Utara, Timur, Selatan, dan Barat secara berturut-turut.

Table 5. Mitigations strategies in agriculture and forestry mentioned by respondents in Bara Locality, North Kordofan-Sudan 2017
Tabel 5. Strategi mitigasi pada sector pertanian dan kehutanan seperti disebutkan oleh para responden di daerah Bara, Kordofan Utara – Sudan 2017

Mitigations strategies in agriculture	Frequency	Percentage	Provided by
Training and ex tension to cultivate different crops	110	73.3	Government
Early mature varieties	97	64.7	Research institutes
Drought -tolerant varieties	96	64	Research institutes
High -yielding varieties	91	60.7	Research institutes
Using agro -forestry	86	57.2	Research in stitutes
Using fertilizers	50	33.3	Government/research institutes
Financial loan	39	26	Financial institutes
Construction dams and excavation for water catchments	4	2.7	Government/financial institutes

Remark: Sample size = 150 respondents
Keterangan: Ukuran contoh = 150 responden

that in the face of extreme weather some fields will survive to produce harvestable crops. Early mature and drought-tolerant varieties as mitigation strategies were both mentioned by 65% of the respondents. The development of new varieties that tolerate drought and varieties with the short growing season is paramount important as the study area (Bara Locality) has been experienced drought-prone since the 1980s (NAPA 2007). On the other hand, the application of agroforestry practices by agrarian communities (57% of the respondents) is becoming great essential. For the sake of overcoming climate change impacts, many rural communities in the drylands of Sudan have been used agroforestry as an adaptation and mitigation strategy. As part of other land use, agroforestry can be considered as an adaptation and mitigation strategy since it adds a level of diversity within agricultural lands in terms of production and ecological services. From the respondents′ viewpoint, the acacia-based system has the most valued services that can mitigate climate change impacts as it reduces the probability of agriculture crop failure.

Conclusion

Climate change has impacted not only the environment but also socioeconomic activities, especially for rural communities as their livelihoods directly depend on agriculture. Since already Bara Locality has been classified as the vulnerable area to the negative impacts of climate change, agrarian communities have to adjust their livelihood to adapt to the changing climate. Cultivation in different directions and sowing before rain are the top two adaptation strategies being practiced by agrarian communities in Bara Locality.

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