Climate Change Adaptation in Paddy Cultivation: a Case Study of Hinthada Township

Mu Mu Thet[1], Khin Hnin Phyu [2], Pan Ei Phyu [3]

Abstract

The paper tires to present climate change adaptation in paddy cultivation of Hinthada Township located in Ayeyarwady Region known as Myanmar's Granary. Paddy cultivation is major economy due to alluvial soils deposited by Ayeyarwady River and paddy is cultivated not only in monsoon period but also in cool dry period. Like other agriculture activities, effect of climate change is distinct especially in rainfall availability and rainfall variability affects on paddy planting period, varieties choice and cultivation practices. In the study period, rainfall variability such as change in rainy days, amount, etc effect on paddy cultivation and growers planned to adapt by changing planting period, varieties choice and cultivation practices. The objectives of the paper are to examine rainfall variability in Hinthada Township, to explore effects of rainfall variability on paddy cultivation and to find out local growers' perception on rainfall variability. In presenting the paper, time series analysis for rainfall variability was applied and primary data such as farmers' perception, variety choice, changing cultivation period and secondary data such as cultivated area, production, etc obtained from Department of Agriculture Land Management Statistics were applied as well as GIS tools were applied.

Keywords: climate change adaptation, paddy, rainfall availability, paddy planting period, varieties choice, cultivation practices

Introduction

In the first two decades of the 21st century, the impacts of climate change have attracted considerable attention across the world and major concerned are the impacts of climate change on agricultural production and food security as well as socioeconomic development (IPCC, 2014; FAO, 2016; FAO, 2018). Watson et al., 1998 stated that climate variability also indirectly affects the agricultural production by influencing the emergence and distribution of crop pests. Scientific evidences suggest that higher temperatures and changing precipitation levels as a result of the changing climate will cause negative impacts on rural area and rural poverty (Mintiwab et al., 2010). More recently its agricultural production especially in developing countries has been characterized by low productivity due to crop loss caused by climatic irregularity (Agriculture Guide 2019).

The climate of Myanmar is dominated by monsoon wind and about 70% of the total annual rainfall is received during the rainy season between June and September) and the South East Asia region is highly susceptible to climate change (Tangang et al, 2020) and climate change strongly affects the ecological, social, and economic aspects of the country, such as agricultural production and area development (Sein, 2015 & Burki, 2015). Myanmar is greatly susceptible to climate change and natural hazards. Climate change is already resulting in more common and severe disasters such as heavy flooding, storms and storm surges and low productivity in the agriculture sector, among others (https://myanmar.un.org).

Rainfall variability has historically been a major cause of food insecurity and famines in Ethiopia (Pankhurst, 1966; Wood,1977; Degefu, 1987). Changing rainfall trends are often

[1] Tutor, Department of Geography, Hinthada University
[2] Professor and Head, Dr., Department of Geography, Hinthada University
[3] Tutor, Department of Geography, Hinthada University

mentioned as one of the important factors in explaining low productivity of crops and food insecurity (Seifu A., 2004). Irregular rain indirectly affects rural economy through low productivity in agriculture (Deschenes & Greenstone, 2006, Degefu and Bewket, 2014, Goswami et al, 2016). Variation in rainfall pattern may arise threat to agriculture, water resources, and development of an area (Ren et al, 2017 & Lone, 2019).

Agriculture is very important economic activity in Myanmar and it employs 70% of the country's labor force as well as produces 38.2% of its GDP. Paddy is considered both a major food crop and major export food item. The major rice-producing regions of Myanmar are in the delta. Ayeyarwaddy, Bago and Yangon regions make up almost half of the country's harvested rice area. Hinthada Township is located in Ayeyarwady Deltaic area and paddy is extensively grown not only in monsoon soon season but also in summer.

Like other rural areas in Myanmar, Hinthada Township possesses large paddy cultivated area. Although high yield varieties are cultivated, crop loss and low productivity are caused by irregular rain and rainfall variability. To adapt rainfall variability for the purpose of getting high yield and high production, local paddy growers changes paddy varieties, planning time and cultivation methods. In paddy cultivation, broadcasting method is being practiced to reduce growing period. New varieties that need short growing period replace old varieties that take long growing period.

Therefore, Hinthada Township was selected as study area to present "Climate Change Adaptation in Paddy Cultivation" from geographical point of view.

Study Area

Hinthada Township is located in the northern portion of Ayeyarwady Region. It is situated between Ayeyarwady River and Ngawun River. Hinthada Township extends from North latitude 17^{o} 26′ to 17^{o} 48′ and East longitude from 95^{o} 11′ to 95^{o} 33′. This township is made up of 21 wards, 103 village tracts and 820 villages. Being part of Ayeyarwady Region known as Rice Bowl, paddy is widely grown in the study area. In Myanmar, paddy productivity of Ayeyarwady Region is one of the highest due to suitable physical environmental conditions such as low land, monsoon rain availability, meadow soils, high rural population, etc.

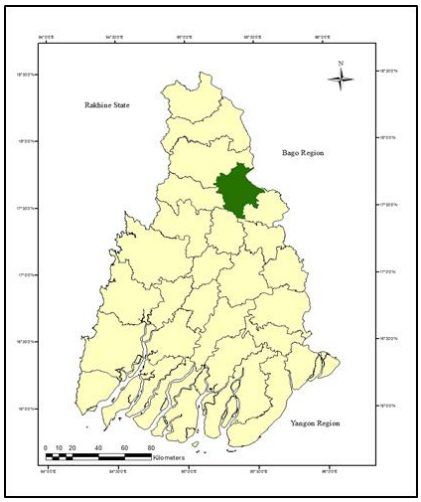


Figure 1. Townships of Ayeyarwady Region
Source: MIMU

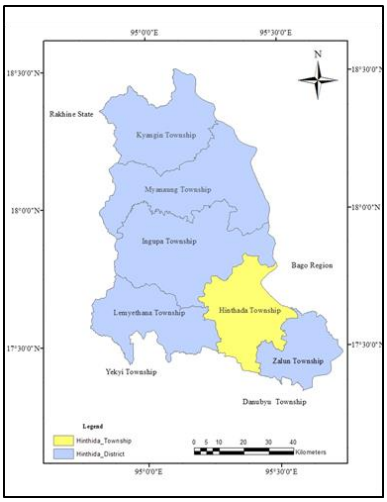


Figure 2. Hinthada District of Ayeyarwady Region
Source: MIMU

Research Questions

How does rainfall variability occur in Hinthada Township?

How do paddy growers adapt rainfall variability effect on paddy cultivation in Hinthada Township?

Objectives

Objectives of the paper are:

- To examine rainfall variability in Hinthada Township
- To explore effects of rainfall variability on paddy cultivation
- To find out local growers' perception on rainfall variability

Data and methodology

To present rainfall variability in Hinthada Township, rainfall data for 22 years were collected from Meteorology and Hydrology Department, Hinthada Township to present time series analysis for rainfall variability. To analyses effects of rainfall variability on paddy cultivation, primary data such as farmers' perception, variety choice, changing cultivation period, etc were collected through field observation, semi structured interviews and questionnaires.

Secondary data such as cultivated area, production, etc were obtained from Department of Agriculture Land Management Statistics. Field observation and data collection were done 3 times (July, August and September, 2022). To get detailed understanding on climate change especially rainfall variability and adaptation measures, focus group discussion was done in village tracts of Hinthada Township in 2022.

Results and Findings

As the rice a staple food of Myanmar, paddy cultivation is also important in Hinthada Township. There are two types of paddy: monsoon paddy (traditional rain fed paddy) and summer paddy (cool dry period paddy). In the rainy season, paddy cultivation depends on available rainfall and monsoon paddy cultivation cost less. Monsoon Paddy cultivated area are more than 50000 ha and it gives major food supply for local people as well as people lived in Myanmar.

Effect of Climate Change: Rainfall Variability

Table 1 Rainfall of Hinthada Township (mm) (2001- 2022)

	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
2001	0.0	0.0	72.9	0.0	201.2	593.9	500.1	408.4	276.4	186.9	56.1	0.0
2002	0.0	0.0	0.0	5.1	532.1	429.0	469.9	531.4	206.2	184.2	127.0	8.1
2003	20.1	11.9	0.0	0.0	151.6	462.3	579.1	376.2	312.7	134.1	0.0	0.0
2004	0.0	0.0	0.0	67.1	367.3	80.3	354.6	830.1	228.9	76.5	0.0	0.0
2005	0.0	0.0	0.0	9.9	29.0	343.7	424.2	398.5	491.0	140.7	129.0	25.1
2006	0.0	0.0	2.0	283.0	214.9	409.2	772.2	389.1	328.9	151.1	22.1	0.0
2007	0.0	0.0	0.0	0.0	390.4	325.4	1069.8	440.4	465.8	237.0	45.2	0.0
2008	6.1	19.1	0.0	38.1	368.8	426.7	539.0	495.8	207.0	166.4	0.0	0.0
2009	0.0	0.0	6.1	60.7	91.9	472.9	642.9	209.6	281.2	232.4	11.9	0.0
2010	0.0	0.0	0.0	0.0	184.7	321.8	207.8	389.1	428.0	382.0	0.0	47.0
2011	11.9	5.1	70.9	35.1	228.9	792.0	662.7	399.5	461.8	233.4	7.9	14.0
2012	0.0	0.0	0.0	1.0	216.4	617.0	611.1	700.0	174.5	105.2	5.1	1.0
2013	0.0	0.0	0.0	0.0	148.3	391.9	424.7	591.6	256.5	467.9	19.1	1.0
2014	0.0	0.0	0.0	0.0	177.5	455.4	735.6	501.4	144.0	146.1	55.9	0.0
2015	1.0	0.0	14.0	31.0	94.0	637.8	739.9	454.2	223.5	176.3	6.1	0.0
2016	13.0	3.0	0.0	0.0	263.1	608.8	647.2	473.2	254.3	228.3	68.1	0.0
2017	0.0	0.0	0.0	55.9	108.7	514.6	484.1	429.3	240.5	169.4	51.8	0.0
2018	1.0	0.0	0.0	42.9	227.6	543.8	514.6	613.2	146.3	354.8	8.1	2.0
2019	72.9	0.0	0.0	0.0	69.1	394.7	507.0	417.1	380.2	95.0	46.2	3.0
2020	0.0	0.0	0.0	36.8	107.4	478.3	365.0	455.7	267.5	213.1	2.0	0.0
2021	0.0	0.0	0.0	20.1	172.2	596.1	632.7	267.7	302.5	210.1	32.0	0.0
2022	3.0	2.0	25.1	10.2	50.3	342.6	375.9	442.5	319.8	254.0	16.0	0.0

Source: Meteorology and Hydrology Department, Hinthada

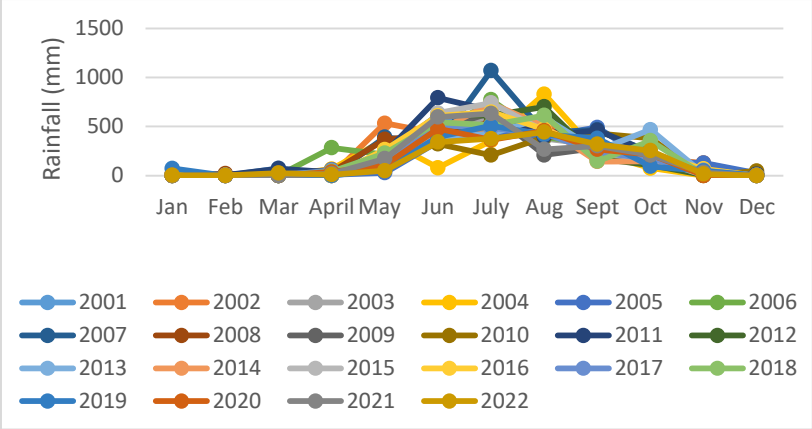


Figure 3. Rainfall of Hinthada Township (mm) (2001- 2022)
Source: Table 1

Effects of climate change especially rainfall changes affecting agriculture particularly on paddy cultivation that needs large amount of rain is distinct in Hinthada Township, like other areas. Between 2001 and 2022, rainfall varies from one year to another. But, in generally, amount of available rainfall for paddy cultivation decreased (Figure 4). In the study period, highest rainfall was 2572.5 mm in 2006 and lowest was 1841.5 mm in 2023.

Change in Total Rainfall

During the study period, rainfall varies distinctly. Highest rainfall was 2559.05 in 2016 and lowest rainfall 1841.5 in 2022.

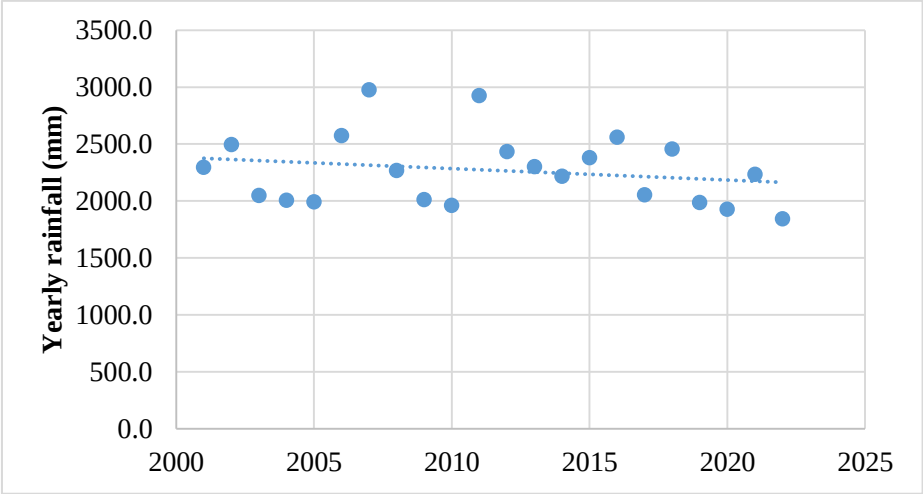


Figure 4. Change in Total Rainfall (2000-2022)

Source: Meteorology and Hydrology Department, Hinthada

Change in rainy day

Change in rainy day per year is found in Hinthada Township. On the other hand, number of rainy day decreased in Hinthada Township in study period. Largest rainy days was 136 found in 2001 and lowest rainy day was 104 in 2005. In figure 5, trend line shows decrease in rainy day in the study period.

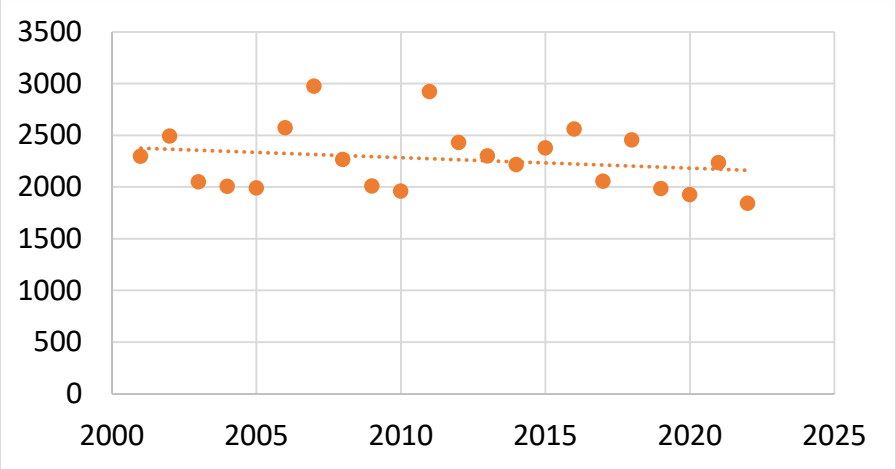


Figure 5. Change in rainy day (2000-2022)

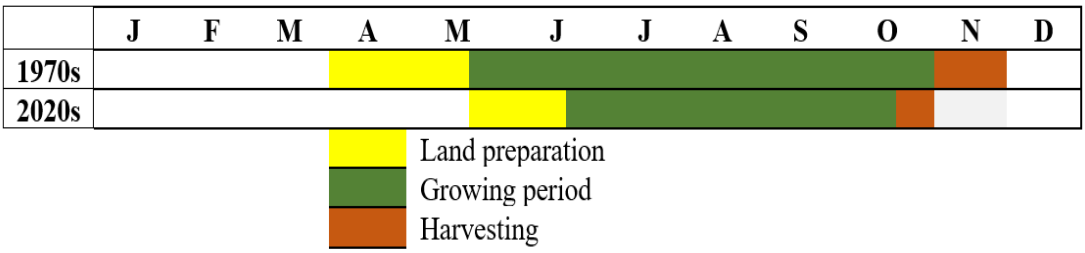
Source: Meteorology and Hydrology Department, Hinthada

Climatic Adaptability in Paddy Cultivation

Changes in climatic conditions especially rainfall play important role in paddy cultivation and change in rainfall is a significant risk for agronomic crops and food security at local, regional, and global level. Ding et al., 2020, said that there are useful strategies, such as moving cropland, shifting planting dates, developing new varieties, and smart management of water and fertilizer to adapt climate change for paddy cultivation.

Change in growing period

In Myanmar, rain started in the end of April and farmers started land preparation for paddy cultivation round about 60 years ago and similarly, farmers in Hinthada Township started land preparation after raining in April known as “Thingyan Lat Say Moe”. Rain fallen in May is sufficient for paddy cultivation. At that time, farmers practiced traditional rain fed paddy cultivation and they planned to cultivate paddy in time of raining.



Paddy Cultivation Calendar

Source: interview (2022)

After 2000, effects of climate change become distinct and rainfall pattern changed. Rain fallen in May is insufficient for paddy cultivation and local paddy grower started land preparation in May and started paddy cultivation in June.

Machinery uses in Cultivation and Harvesting

Due to climate change, sufficient rainfall period becomes short and it is available between June and September. To complete paddy cultivation successfully in time, growers

uses agriculture machineries in land preparation. Agriculture machineries produced in China are easily available and it is a cheaper than agriculture machineries made in Japan.

Plate 1. Land Preparation
Source: Field Observation (16.5.2023)

Plate 2. Land Preparation
Source: Field Observation (16.5.2023)

Plate 3. Paddy harvesting
Source: Field Observation (16.10.2022)

Local growers afford to buy agriculture machineries made in China. Paddy growers who have sufficient investment use tractors and who have small investment are hand tractors to reduce cultivation period in Hinthada Township.

Varieties choice

In the 1970s, Pawsan is the most famous varieties that is a hybrid of Ngakywe and Meedon. At that time, a substantial number of high yielding rice varieties (HYV) have been developed and released for rained lowland and irrigated ecologies. During the 1970s and early 1980s, the popular varieties were Shwe War Tun, Kyaw Ze Ya, and Seintaly , Pa Le Thwe, Thi Htat Yin, Shwe Thwe Yin, and Sin Akari which are popular in rice-rice systems. The varieties such as Shwe War Tun, Seintaly , Pa Le Thwe, Thi Htat Yin, Shwe Thwe Yin, and Sin Akari take about 150 days (for 5 months) (https://www.fao.org).

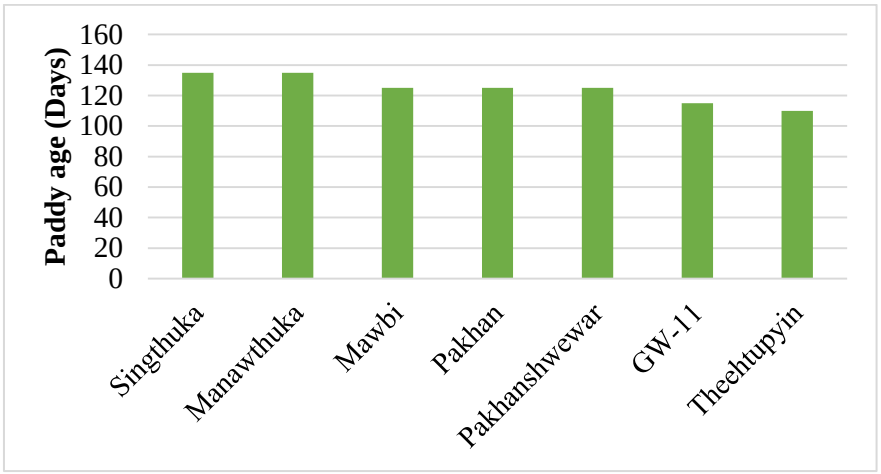


Figure 6. Major Paddy Varieties of Hinthada Township (2022)
Source: Agriculture Department, Hinthada Township

At present, due to rainfall variability as an effect of climate change, local paddy grower chose the paddy varieties that take short growing period. Growers chose to cultivate the paddy varieties such as Manawthukha, Sinthukha, Theehtetyin, Hmawbyi, Pakhan, Pakhanshwewar, GW-11, etc that take shorter growing period and produce 100 baskets per acre. In 2022, most people started growing 90 days paddy variety to complete in short period and to reduce risks caused by climate change such as untimely rain.

Conclusion

The study indicated that effect of climate variability especially rainfall variability as a major determinant of for paddy cultivation. Like other areas, rainfall variability caused by climate change is disturbing agriculture especially paddy cultivation that need much water for successful production. Paddy farmers tries to adapt rainfall variability in paddy cultivation by cultivating climate-smart short lived varieties, by applying agriculture machineries in land preparation and harvesting, and by changing growing period. By cultivation short lived varieties that are new varieties and that are heat resistant and tolerant to climatic variability, labour cost and risks concerning pest also reduced, and less labour cost causes low investment.

In the area, agriculture machinery price is high and that is a major problem for machinery use in the area. Therefore, it is needed to plan for renting agricultural machineries with low rental fee in paddy cultivation. As sufficient availability is also important for farmers, it is necessary for cooperation between farmers for the purpose of getting support from departments concerned as well as private sources. Some farmers in the area are not familiar with the modern technology uses in paddy cultivation, in planting new varieties, and in choosing high yield short lived varieties and rainfall variability become distinct, it is needed to share knowledge on adaptation strategies for paddy cultivation, and ways and means in using modern agriculture technologies to local farmers.

To get high production in paddy cultivation to get food security and to be higher local economy, further researches on.

Acknowledgements

Firstly, we would like express our thanks to Dr Theingi Shwe, Rector, Dr Yee Yee Than and Dr Aye Lwin, Pro-Rectors, Hinthada University for giving the chance to write this research paper and for their encouragement. We would like to extend our thanks to Professor and Head of the Department Dr Khin Hnin Phyu for her advice and helps in doing this research work.

References

Agriculture Guide, (2019). European Union.

Burki, T., (2015). Floods in Myanmar damage hundreds of health facilities. Lancet 2015, 386, 843.

Degefu, W., (1987). Some aspects of meteorological drought in Ethiopia, in drought and hunger in Africa, Glantz, M. H., Cambridge University Press, Cambridge.

Degefu, W. and Bewket, W. (2014). Variability and trends in rainfall amount and extreme event indices in the Omo-Ghibe River Basin, Ethiopia. Reg. Env. Change, 14, (2), 799-810.

Ding, Y., et al (2000). Adaptation of paddy rice in China to climate change: The effects of shifting sowing date on yield and irrigation water requirement, J. Agrcultural water Management, Volume 228, 20 February 2020, 105890

Deschenes, O. & Greenstone, M., (2006). The economic impact of climate change: evidence from agricultural output and random fluctuations in weather(http://www.econ. ucsb.edu/papers/wp06-04.pdf)

FAO, (2016). "The State of Food and Agriculture: Climate Change, Agriculture, and Food Security." Rome, Italy.

FAO., (2018). "The State of Agricultural Commodity Markets: Agricultural Trade, Climate Change, and Food Security." Rome, Italy.

Goswami, B.N.; Madhusoodanan, M.S.; Neema, C.P.; Sengupta, D., (2006). A physical mechanism for North Atlantic SST influence on the Indian summer monsoon. Geophys. Res. Lett. 2006, 33

IPCC, (2014). "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." Geneva, Switzerland.

Lone, S.A.; Jeelani, G.; Deshpande, R.D.; Mukherjee, (2019). A. Stable isotope dynamics of precipitation in a high altitude Himalayan cold desert and its surroundings in Indus river basin, Ladakh. Atmos. Res. 2019, 221, 46–57

Mintewab, B., Di Falco S., Kohlin, G., (20), Explaining Investment in Soil Conservation: Weather Risk, Rate of Time Preferences and Tenure Security in the Highlands of Ethiopia, London School of Economics and Political Science.

Pankhurst, R., (1966). The great Ethiopian famine of 1888-1892: A new assessment. Journal of History of Medicine and Allied Sciences, 21, 95-124.

Ren, Y.Y.; Ren, G.Y.; Sun, X.B.; Shrestha, A.B.; You, Q.L.; Zhan, Y.J.; Rajbhandari, R.; Zhang, P.F.; Wen, K. M., (2017). Observed changes in surface air temperature and precipitation in the Hindu Kush Himalayan region over the last 100-plus years. Adv. Clim. Chang. Res. 2017, 8, 148–156

Seifu A., (2004). Rainfall Variation and its Effect on Crop Production in Ethiopia. SNNPR State Investment Expansion Main Process (http://www. southinvest. gov.et/news.htm).

Sein, Z.M.M.; Islam, A.R.M.T.; Maw, K.W.; Moya, T.B., (2015). Characterization of southwest monsoon onset over Myanmar. Theor. Appl. Clim. 2015, 127, 587–603

Tangang, F.; Chung, J.X.; Juneng, L.; Supari; Salimun, E.; Ngai, S.T.; Jamaluddin, A.F.; Mohd, M.S.F.; Cruz, F.; Narisma, G.; et al., (2020). Projected future changes in rainfall in Southeast Asia based on CORDEX–SEA multi-model simulations. Clim. Dyn. 2020, 55, 1247–1267

Watson, J., Zinyowera, M.C., Richard Moss, H., (1998). The regional impacts of climate change: An assessment of Vulnerability, Cambridge University Press Cambridge, Cambridge, pp. 13-34, United Kingdom

Wood, C. A., (1977). A preliminary chronology of Ethiopian droughts: In drought in Africa -2, African Environmental Special Report 6.