Climate change effects on agriculture in Thabaung township, Ayeyarwady region, Myanmar: challenges and perceptions of farmers

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Abstract. In the Thabaung township, Ayeyarwady river delta region, the majority of the farmers derive their livelihood from subsistent farming. With climate change expected to result in increased flooding, the impacts on these poor rural farmers will be significant and since adaptation is not cheap, prioritizing responses by sectors becomes essential. This paper is focused on the impact of flood on agriculture and farmers perceptions and their challenges. The economy of Thabaung Township is largely depends on agriculture but, at the same time, the study area is subjected to floods annually. The paper is based on quantitative and qualitative fieldwork in Thabaung in 2019. First a literature review took place and secondary data (paddy production) was collected from General Administrative Department, Department of Agricultural Land Management and Statistics of Thabaung Township. Within the paper some quantitative methods, common for analyzing (semi-) standardized questionnaires like Likert scale, cluster analysis is used to show the spatial distribution of agriculture condition of flood prone areas were used. Then key actors were asked in qualitative open interviews with local experts (farmers). Finally, a SWOT analysis comes to a comprehensive assessment.

1. Introduction
Agriculture is most disaster affected sector in study area in particularly by flood. Myanmar has many rivers and streams which are the life-blood of the country. The intensity of flood hazards appears in the Ayeyarwady Region in the past decade and increasing the number of coastal floods in study area. Many people settle down in rivers banks and the majority of farmers living in Ayeyarwady delta region. Farmers in Ayeyarwady are particularly vulnerable to natural hazard impacts: these are (i) high hazard exposure (ii) only one rice crop per year (iii) threatens livelihood security of thousands of farmers particularly during the emergency period. In Thabaung township 94% of people living in rural area and 70% depends on agriculture sector for their livelihood. Agriculture sector contributes in GDP 37.8% in 2016 [1].

Floods can also be caused by human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low lying plains prone to flooding leading to alterations in the natural drainage and river basin patterns, deforestation and climate change Myanmar has a high vulnerability towards natural hazards like flood, cyclones and earthquakes. Especially, the Nargis cyclone in 2008 with its disastrous effects (with up to 200,000 fatalities and 2.4 million affected people the third-largest catastrophe worldwide since 1980) but also other disasters like the cyclone Komen in 2015 have resulted in an increasing perceptions in the public related to natural hazards. The...
flooding events of 2004, 2016 and 2019 go down as the worst in Thabaung recorded history. With changing climatic conditions, such flooding events are not only likely to reoccur but with impacts and damages that are more devastating. Thus there is need for systems efficiency and perception studies. According to flooding has the potential to cause social, economic and environmental damage especially on not only agriculture field but also in urban area.

Ngawun River, tributary of Ayeyarwady is crossing inside of Thabaung Township and its most important activity is agriculture. In rainy season, Ngawun River is flooded in the lower elevation area of Thabaung Township. This condition the crops are damaged by flood especially monsoon paddy cultivated area in the the every raining season. Therefore the patterns of agriculture in the study area are also changed by flood.

The settlers along the Ngawun River largely depends on agriculture, although soil can be deposited by flooding, they always face the destruction of cultivated drops. Due to this situation, the British government, to protect paddy cultivation, built Ngawun embankment along the east bank of the Ngawun River from Hinthada to Thabaung in 1876. This embankment is 14.7 miles long. Ngawun embankment was built along the eastern bank of Ngawun River because there is more cultivated area in the east side than western side of the river. Although some areas in the east side of the Ngawun River get protection to some extent, the villages in Thabaung Township that are outside the Ngawun embankment do not get any protection. Moreover, the physical feature of Thabaung Township, except the areas in the west part of the Rakhine Mountain Range, is a very flat alluvial lowland area. The east bank of the Ngawun River is lower than the western bank and more deltaic features are found in the eastern side. Due to these conditions, the village tracts on the eastern bank suffer more flood than those on the western bank. Thabaung Township is one which suffers from flood wrongly along the Ngawun River.

Development of strategic policies and implementation needs to rest on resident’s perception and attitude towards flooding. According to Ologunorisa and Adeyemo, perception studies are essential for responsible planning of flood alleviation schemes and development. Upon this theoretical foundation, the study explores the perception of impacts on agriculture, transportation and water. Based on qualitative data obtained from the semi-structure interviewed to local experts and questionnaires, evaluations of perceived impact extent on selected sectors were analysed. To this end, environmental change information communication process between survey participants and relevant government agencies is evaluated.

Thabaung Township is one of the twenty six townships of Ayeyarwady Region and located on both sides of Ngawun River. It lies between North Latitudes 16° 53’ 10” and 17° 17’ 17” and East Longitude 94° 33’ 26” and 95° 03’ 20”. It comprises three wards and sixty seven village tracts. It is about 41.4 km (25.75 miles) from the Pathein. This research work deals with the flood hazards of Pathein, Thabaung township along the Ngawun River. Ngawun River is the first and westernmost distributary of Ayeyarwady River and flows from north to south and enters into the Andaman Sea and it is about 317 kilometers long. The western tributaries take their sources from the eastern flank of the Rakhine Yoma and the eastern tributaries take their sources from the slightly higher region. In the southern part of Ngawun River, tidal effect is also experienced. Ayeyarwady delta region, Thabaung township experiences annual floods during the peak monsoon period especially in July and August [2] (See figure.1).
Against this background, this illustrates the dealing with the personal/household level and tries to analyse in more detail the awareness and preparedness of farmers. The main aim of the research is to understand the local farmer perceptions and their challenges by climate change effects on agriculture particular in flood of Thabaung township, in order to achieve the main aim of this paper following objectives have been set up:
1. to search for the best way of reduce the flood risk and preparedness for any risks in the future
2. to analysis that adaptation of their farming method and crops patterns during flooding
3. to examine the local farmers perceptions and their challenges on paddy cultivation by flood.

According to these objectives following guiding research questions have been raised and the paper will try to give answers:
(1) What can we explore the effects of flood on agriculture?
(2) Which impacts can be faced after flooding?
(3) Which suggestions can be given in order to support preparedness actions to local farmers?

2. Methods
The research design is based on a mixed-methods approach which used systematic literature search, secondary data collection, unsystematic talks, in-depth interviews, mapping methodologies and field observations in Thabaung township in order to understand and evaluate the local farmer’s perceptions and their challenges on agriculture. Literature search included reviewed articles, published documents and unpublished studies, as far as it could be retrieved from international libraries. Secondary data include statistical data from the local administration. During the empirical fieldwork, mapping and field observation, 30 unsystematic talks, 25 in-depth qualitative talks with farmers and officers from Agriculture department, in-depth interviews with experts on the paddy cultivation of study area were conducted. Within the paper some quantitative methods, common for analyzing (semi) standardized questionnaires like Likert scale, cluster analysis is used to show the spatial distribution of agriculture condition of flood prone areas were used.
3. Results and discussion

Thabaung Township is divided into four zones by elevation. The levels of flooded prone areas defined by coloured and elevations. The area shown by blue coloured represent the elevation from 1 to 3 metres, purple coloured represent from 3 to 5 metres, yellow from 5 to 10 metres and red represents the elevation of above 10 metres. The red coloured areas are free from flood. According to the figure, the most serious flood prone areas lies in the easternmost part of the Thabaung Township. The village tracts shown by blue and purple will be inundated if the water level reaches the critical level of Thabaung Township (5.152 m). The areas of yellow colour will be inundated only when the water level is between 5 and 10 metres. This area is found mostly in the western alluvial plain and the southern part between the Ngawun River and Daga River. Unflooded areas are on the Rakhine Mountain Range and its spur and in some sporadically area in the alluvial plain (Figure.2).

![Figure 2. Flood prone area in Thaboung Township](image)

Source: DEM 30 meter

Although Thabaung Township is usually flooded during rainy season, there is water shortage problem for summer paddy cultivation in area that is distant from Ngawun River and the other main streams. As a result, monsoon paddy cultivated area is significantly smaller than the summer paddy areas. The main problem founds in Thabaung are the sedimentation in the river and streams. To solve this problem, the sediments deposited at the bottom of the river and streams should be dredged to deepen the stream bed so that the discharge of water can increase. If the dredging sediments carry out, that will reduce the flood intensity to some extent. This erosion is partly due to the deforestation on Rakhine Mountain Range. Thus to reduce the erosion, plants should be grown in the deforested area. Moreover, the main meandering pattern of river the streams cause the decrease of river velocity.

As Thabaung Township is flooded every year and the flood duration is so long that the time is not enough to grow double paddy cultivation in some areas. Thus, the shorter life span and high yield paddy species should be adapted to grow in the deep water area. To solve the water shortage problem, canals should be dug in areas which are distant to the main streams. Moreover, the strength of the Ngawun embankment should be kept carefully.

Thabaung Township faces flooding problem in every year. In particularly, flooding effects on the agriculture. As an economy of township is based on agriculture, the farmers suffer on their flood related problems. A total of 3,062 hectares was cultivated in the rainy season and 2,724 hectares were flooded...
in 2016. The level of flood was very high about 22.40’ (Irrigation dept, 2017) in this year. Since the duration of flood is rather long, farmers can grow paddy after water reduce. And the time to grow is very late and insects usually destroy paddy fields. There are many kinds of insects that destroy the crops especially mouse is more danger than others insects. Consequently, the paddy productions rate decreased by insects. Farmers used pesticides than others years to prevent the fall of production rate.

Thabaung Township, situated on both sides of the Ngawun River which floods every year, has good soil suitable for cultivation due to the alluvial depositions that were left over after the flood. Therefore, cultivation is the main economic activities in this township. There is a total of cultivable area of 100,692 hectares (248,622 acres) and 100,423 hectares (247,958 acres) is used for cultivation in Thabaung Township. In Thabaung Township, except Rakhine Mountain Range in the west of the township, the eastern areas are low land plains region which is favourable for cultivation as a means of income. In 2015-2016, there were 57,727 hectares (142,537 acres) of le land, 41,719.8 hectares (103,012 acres) of garden land, 952.6 hectares (2,352 acres) of Kaing land and 269 hectares (664 acres) of virgin land. Le land area is 174.4% of the total cultivated land of 100,692 hectares (248,622 acres). Since the time of the Ngawun River flood, which is usually in July, coincides with the time to cultivate paddy, people cannot grow in time and they have to cultivate only after flood. Besides paddy, other important crops are groundnut, sunflower, chillies, pulses and vegetables.

Thabaung Township, with exception of Rakhine Mountain Range in the west of the township, possessing a plain region, having normal temperature, rainfall and good soil is favourable to grow monsoon paddy. Monsoon paddy is cultivated in almost all the village tracts on the eastern alluvial plain. But paddy fields are damaged due to the flood of the Ngawun River in every year. The time for growing paddy is coinciding with the time of flooding period in June, and July. Therefore, farmers have to grow paddy after the flood is over. The paddy fields grown before the flood are usually suffered damage when the fields are inundated. In 2016, there were 27,544 hectares (68,009 acres) of monsoon paddy cultivation and out of these areas 2,724 hectares (6,725 acres) were grown before the flood came and 24,820 hectares (61,284 acres) were grown only after the flood. The paddy cultivated areas in Thabaung Township is changing due to yearly flood in the area. Monsoon paddy cultivation was 34,531 hectares (65,721 acres) in 2011-2012, 19,760 hectares (48,789 acres) in 2013-2014, 27,584 hectares (68,109 acres) in 2014-2015, 27,544 hectares (68,009 acres) in 2015-2016 and 27,544 hectares (68,009 acres) in 2016-2017 (Table.1). Since the paddy is usually destroyed when the Ngawun River floods, there are changed cultivated acres yearly, yield per acre and total amount of production. The paddy grown in the early rainy season after is suffered damage but it is difficult to cultivate when the flood is over.

| Years       | Monsoon Paddy Cultivated Area (hectares) | Monsoon Paddy Production (basket) | Summer Paddy Cultivated Area (hectares) | Summer Paddy Production (basket) |
|-------------|------------------------------------------|----------------------------------|-----------------------------------------|----------------------------------|
| 2010-2011   | 34,531.1                                 | 6,241,178                        | 34,525.9                                | 7,575,226                        |
| 2011-2012   | 26,617                                   | 4,378,333                        | 26,713.8                                | 5,368,484                        |
| 2012-2013   | 19,759.6                                 | 3,542,080                        | 35,346.8                                | 7,181,942                        |
| 2013-2014   | 21,748.5                                 | 3,910,971                        | 35,071.4                                | 7,157,159                        |
| 2014-2015   | 27,584.2                                 | 5,252,566                        | 33,348.5                                | 6,871,439                        |
| 2015-2016   | 27,543.7                                 | 5,260,496                        | 35,865.2                                | 7,511,320                        |
| 2016-2017   | 27,543.7                                 | 5,770,564                        | 36,743.6                                | 9,068,260                        |

Source: Agriculture Department [1]

Summer paddy is also cultivated in Thabaung Township. Summer paddy cultivated areas are more than those of monsoon paddy cultivated areas. In addition, other crops are cultivated besides summer paddy. In 2018, there were 37,744 hectares (90,725 acres) of summer paddy cultivated area in Thabaung Township. Due to yearly flood, the village tracts on the eastern side of the township grow other crops than summer paddy (Figure.3).
Figure 3. Monsoon and summer paddy cultivated area of Thabaung Township in 2018

The Ngawun River is crossing within the study area and it is a tributary of Ayeyarwady River on the right side. It is needed not only for water transport but also for irrigation of summer paddy cultivation in the township. Although it is useful for these activities, it has some disadvantages like flooding and river bank erosion. There has also deposited by Ayeyarwady river from the Rakhine Mountain Range in the west side of the Ngawun River cause alluvium that makes streams and rivers more shallows. This is a cause of flood in the townships along the Ngawun River. Since the flooding period of the Ngawun River considers with the period of heaviest rainfall in this region, the condition of flood is worse and the flooding duration is long because Ngawun embankment seems to prevent receding of water after flood. The top of the Ngawun embankment in Thabaung Township is 8 metres (26.05 ft) high, the critical water level is 5.1 metres (17 ft) and the danger level is 7.74 metres (25.55 ft). According to the record of Zeepin Kwin water station, during the period of 25 years from 1992 to 2016, the water level exceeded the critical level of Thabaung Township in all year except the year 1992. From 2004 to 2016, during these 13 years, the years in which water level exceeded the critical water level were, 2004, (6.89 m) or (22.75 ft), 2007, (6.5 meters or 21.45 ft, 2015, 6.74 meters or 22.25 ft) and 2016, 6.78 meters or 22.40 ft (Table.2) (Figure 4).

The flood in Thabaung Township usually begins on the third week or last week of July and sometime, on the second week of July. In the year 2004 the flood level was the heighest reaching 6.89 meter (22.75 ft). In that year, water level exceeded critical level on 23.7.2004 5.19 meter (17.15 ft) continued to rise on 7.8, 2004( 6.89) meter (22.75 ft the highest), gradually fall to 3.9 meters (13 ft) on 7.9.2004 and then rise again on the next day and reached 5.9 meters (19.6 ft) on 29.9.2004. The water level fall under danger level on the third of October but rose again to 5.769 meters (18.05 ft) on the last week of October. These data show that there were three times of flood in Thabaung Township in 2004 and the duration of flood lasted for three months.
Table 2. Condition of flood in Thabaung Township (2004-2016)

| No | Year | Highest Water Level |
|----|------|---------------------|
| 1. | 2004 | 22.75'              |
| 2. | 2005 | 18.50'              |
| 3. | 2006 | 18.60'              |
| 4. | 2007 | 22.00'              |
| 5. | 2008 | 20.30'              |
| 6. | 2009 | 18.95'              |
| 7. | 2010 | 18.40'              |
| 8. | 2011 | 19.70'              |
| 9. | 2012 | 21.00'              |
| 10.| 2013 | 20.25'              |
| 11.| 2014 | 19.15'              |
| 12.| 2015 | 22.50'              |
| 13.| 2016 | 22.40'              |

Source: Agriculture and Irrigation Department [1]

Farmers face in cultivation problems by flood in every year. The lowland area, eastern part of the township is difficult to grow paddy because of this area is regularly flood in rainy season (Table 1). According to the Table (2) 47 village tracts, 125 paddy fields, 2,333.2 hectares (5,761 acres) of cultivated land were flooded in 2004-05, but all the 2,333.2 hectares (5,761 acres) damage areas were cultivated after the rainy season. There was no flooded paddy field in Thabaung Township 2005-2006. In 2006-07, 56 village tracts, 131 paddy fields were flooded, 5,998.1 hectares (14,810 acres) were destroyed. A total of 5,998.1 hectares (14,810 acres) of paddy and 1,624.1 hectares (4,010 acres) of Matple and Petisein, were able to recultivated. In 2007-08, 53 village tracts, 129 paddy fields were flooded, 6,664.7 hectares (16,456 acres) were destroyed. All the damage areas were recultivated with paddy 2,496.8 hectares (6,165 acres) and 4,630.9 hectares (10,191 acres) of Matple and Petisein. In 2015-16, 47 village tracts, 138 paddy fields were flooded, there were 1,780 flood victims, 2,942 hectares (7,263 acres) were damaged but recultivated. In 2016-17, 34 village tracts, 107 paddy fields, were flooded and all the damaged 2,724 hectares (6,725 acres) were recultivated.

Since Thabaung Township is suffered from flood every year, the village tracts in the lowland area face damage to their agriculture cultivation. Therefore, the Ngawun River flood has more negative effects than the positive ones on cultivation. The data damage of cultivation caused by flood during 13 years from 2004 to 2016 is taken from Agriculture Department, Thabaung Township (Table.2).
Table 3. Paddy destroys and cultivated area of Thabaung Township (2004-2016)

| No | Years       | Village Tracts | Flood Paddy Field | Destroyed Hectares | Recultivated Hectares |
|----|-------------|----------------|-------------------|--------------------|-----------------------|
| 1  | 2004-2005   | 47             | 125               | 2,333              | 2,333                 |
| 2  | 2005-2006   | -              | -                 | -                  | -                     |
| 3  | 2006-2007   | 56             | 131               | 5,998              | 4,374                 |
| 4  | 2007-2008   | 53             | 129               | 6,664              | 2,496                 |
| 5  | 2008-2009   | 45             | 130               | 4,167              | 2,142                 |
| 6  | 2009-2010   | 46             | 106               | 2,155              | 1,367                 |
| 7  | 2010-2011   | 51             | 114               | 2,627              | 2,168                 |
| 8  | 2011-2012   | 22             | 48                | 300                | 196                   |
| 9  | 2012-2013   | 42             | 94                | 3,064              | 3,064                 |
| 10 | 2013-2014   | 38             | 88                | 1,887              | 320                   |
| 11 | 2014-2015   | 45             | 176               | 1,641              | -                     |
| 12 | 2015-2016   | 3              | 138               | 2,941              | 2,941                 |
| 13 | 2016-2017   | 36             | 107               | 2,733              | 2,733                 |

Source: Agricultural Departement, Thabaung Township

The Ngawun River and its tributaries are filled with alluvium and the river depth is being shallow which caused to overwhelming the river banks inundating the settlements and cultivated areas. Moreover, Thabaung Township lies within the monsoon region and receives heavy rains from the southwest monsoon, moist winds and storms occurred in the Bay of Bengal and South China Sea in the rainy season. Out of the total cultivated area of 100,692 hectares (248,622 acres), paddy land is cultivated 57,728 hectares (142,537 acres) which is 57.3% of the total cultivated area. Although there is 57,729.2 hectares, all of this land cannot be used for monsoon paddy every year because of Ngawun River floods. In 2015-2016, monsoon paddy cultivated area is 2,754.4 hectares (68,009 acres), which is only 47.7% of the total paddy land and summer paddy cultivated area is 36,744 hectares (90,725 acres) with 63.7%. When compare the two paddy crops, summer paddy cultivated area is greater significantly than the monsoon paddy. This is because Thabaung Township is flooded during the rainy season which coincides the growing period of monsoon paddy.

Thabaung Township faces the damaging of paddy field especially in deep water area every year. Therefore, farmers have to replace with paddy or pulses in the area of damaged paddy fields when the water level decreases. As a consequence, the cost of growing crops will be double and the time is not enough to grow double paddy crop leading to the decrease of paddy cultivated area. Thus farmers have to adapt the shorter life span paddy or grow other crops like groundnut, pulses and other crops. The damage of paddy fields depends not only on the flooded water level but also on the duration of flood.

In some village tracts of low land areas, farmers put the paddy land uncultivated because of flooding. If the water level increases after growing paddy crop, the paddy field can be inundated and damaged by flood. Farmers frequently suffer the paddy field damaging. Therefore, they avoid the paddy growing in early monsoon and grow paddy when the water level drops entirely. This is known as growing after water level drop cultivation in Thabaung Township. This is a consequence of flood in Thabaung Township.

4. Conclusion

Thabaung Township is located on both sides of the Ngawun River, a distributary of the Ayeyarwady River and 41.4km (25.75 miles) far from Pathein. It lies between North latitude 16° 53' 10" and 17° 18' 20" and between East longitude 94° 33' 11" and 95° 03' 20". There are 3 wards, 67 village tracts and 394 villages in Thabaung Township. It is one of the 26 Townships in Ayeyarwady Region.

The total area of Thabaung Township is 1,989 km2 and that of Thabaung town is 24 km2. This township has a compact shape.
The cultivated land is the most dominant, occupying 49 percent of the Township area. Cultivated land include le land, garden land, kaing land and dani land of which le land is by far the most important which represent 85.5 percent of the cultivated land, followed by garden land with percent.

Thabaung Township is mainly an agriculture township. But, since there is flood every year, with regard to cultivation, the paddy fields in the east bank plain more suffer than those in the west bank. The flood usually begins in July and ends in October and period of flood is long. Therefore, the monsoon paddy cultivation becomes less and less year after year. There were several village tracts that did not grow monsoon paddy in 2016. Depending on weather condition, some people grow paddy and others grow pulses where the flood was over.

Although it is successful to grow paddy in the eastern bank alluvial plain, the crops are damaged due to the flood that comes one to three times a year. The flood condition becomes worse year after year. Therefore, to develop cultivation in the region, the shallow streams, creeks and canals should be renovated.

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