SOIL PHYSICAL PROPERTIES AND PADDY CULTIVATION IN TAUNGDWINGYI TOWNSHIP, MAGWAY REGION (MYANMAR)

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Abstract

Not only such physical features of a particular soil as texture, moisture content and its density determine the different forms of cropping pattern but socio-infrastructural factors like water supply and appropriate land preparation by the farmers also play as major roles for high yield per acre of cultivated crops.Taundwingyi area is well-known since Pre-historic Period due to its irrigated agriculture. Although all physical determinants (relief, climate, soil) are not much favourable for the traditional agricultural system, many intermittent streams which originate on the eastern highland cause the eastern and south-eastern portions of the township as cultivated land with various crops (especially focus on paddy cultivation). Whereas, the western and north-eastern parts of the study area are suitable for dry crop cultivation, mainly due to the sandy soil types. Therefore, the main aim of this dissertation is to find out the relationship between existing soil types and the cropping patterns which are cultivated seasonally. The micro-level emphasis was paid at village tract level for certain sample areas by taking soils. As results, alluvial, meadow alluvial and dry forest cinnamon soils in the study area are well thrived for cultivation of paddy dominated cropping pattern. Sustainability of soil is naturally and traditionally practised with crop rotation system by the local (even by the marginal) farmers. Moreover, scarcity and untimely water supply are the major hindrance for the commercialized farming in Taungdwingyi Township during the study period of 2013-2014 and 2016.

Key words: Soil physical, Cultivation.

Introduction

Soil is the end product of the influence of the climate, relief (elevation, orientation and slope of terrain), biotic activities (organisms) and parent materials (original minerals) interacting overtime. Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Those characteristics, processes, or reactions of a soil that are caused by physical forces can be described by or expressed in physical terms or equations. Examples of physical properties are bulk density, water-holding capacity, hydraulic conductivity, porosity, pore-size distribution and so on.

Cropping Pattern means yearly sequence and spatial arrangement of crops and fallow land on a given area. The cropping pattern used on a farm and its interactions with farm and resources, other farm enterprises and available technology which determine their make-up. In an unit area, different types of cropping patterns are such as inter-cropping, mixed cropping, crop rotation, double or triple or multiple cropping, monoculture, crop combination or association, crop concentration, crop diversification, etc.

Study Area and Field of Study

Taungdwingyi Township is located in the Central Dry Zone of Myanmar. But, its location on the foothill of Bago *Yoma* (Bago Range) makes it to experience tropical savanna climate with the average annual rainfall between 20 inches and 40 inches. Hence, the study area is sometimes out of the Dry Zone Belt of Myanmar. Various types of soil can also favour to grow different crops during three main seasons. Since the ancient Pre-historic Period, the study area is well known for its irrigated agriculture. As a result, the soil condition for seasonal agriculture should be analyzed and some physical properties of soil will be examined for the paddy dominated cropping pattern in the township.

Taungdwingyi Township is situated in the eastern part of Magway Region. Geographically, it lies within the Central Basin of the Dry Zone or at the western foothill of Bago *Yoma*(ranges). Taungdwingyi Township has a total area of 760 square miles or 486,403 acres. It is composed of ten wards in Taungdwingyi Town proper and seventy-two village tracts as shown in Map (1). The relief structure can be divided into three portions (Map-2), namely: The Eastern Bago *Yoma.* The Central Plain or Taungdwingyi Plain. The Western Rolling Land.

The stream from the western part of Bago *Yoma* flows westward and some small streams have disappeared in this area and are known as intermittent streams. All streams enter *YinChaung*(stream). According to Koppen's Climatic Classification, the study area is experienced by Aw (tropical savanna) type of climate.

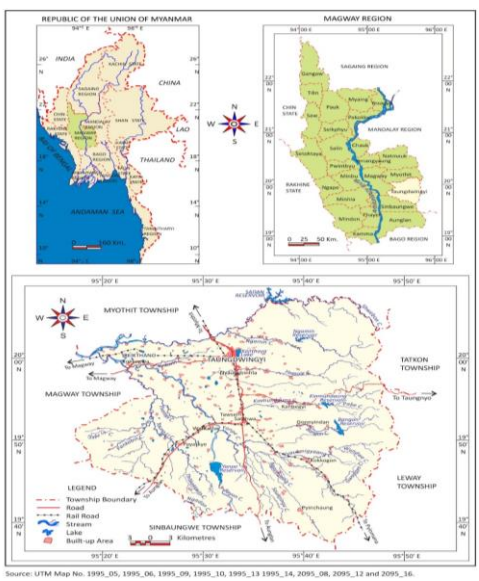


Figure 1. Study area.

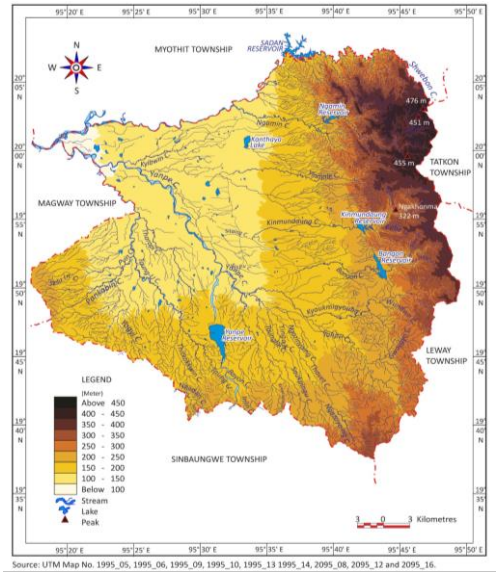


Figure 2. Relief map.

Objectives

To analyze and examine how the physical properties of do existing soils affect on the paddy cultivation and paddy production. To meet the above main aim, the following objectives are planned. To understand how soil texture affects the cultivated crops, To enhance

understanding on what factors are needed to consider for paddy agriculture and its production, and To assess soil erosion its effect on yield of paddy in the study area.

Material and Methods

Some physical properties of soils will be analyzed by various methods. To define the sample sites, secondary data will be collected from UTM map and soil Bureau, Yangon. Some sample plots on which the paddy was thrive commercially were considered. Soil colour were recorded while taking the samples. But, structure of the sample soil may not be assumed or presumed due to the on-site situation of the soil.

Description on Existing Soil Types

The soil of Taungdwingyi Township can be classified as follows and their distribution was shown in Map (3): Meadow Alluvial Soil. Meadow Soil. Dry Forest Cinnamon Soil. Red Brown Savanna Soil. Yellow Brown Forest Soil. Turfy Primitive Soil. Primitive Crushed Stones Soil.

Meadow AlluvialSoil

Meadow alluvial soils are found along the streams of the western part of Bago *Yoma*. The meadow alluvial soils are deposited by running water from the slope. The soils are very thin. Therefore, the surface soil can easily be consumed by ploughing. They have the texture of silty clay loam. Its pH value ranges between 6 and 8 and the average depth of the soil is thick, so that it is quite suitable for crop cultivation. They can be utilized for growing sugarcane, groundnut, sesame, sunflower and vegetables in addition to rice cultivation. Naturally, this soil type possesses a high fertility but due to extensively cultivation, the fertility

This type of soil is found in the southern and northern parts of the township. Soil texture is clay mixture with an average thickness of greater than 40 inches and pH values between 7.0 and 7.5. This soil type is suitable for rice, sugarcane, sunflower,maize and pulses. Theyare most suitable for paddy cultivation becausemost of the soil have clayey texture. In the areas with deficient plant nutrients, they can be used for pulses and vegetables.

Dry Forest Cinnamon Soil

The texture of the soils ranges from light loam to medium loam. Generally, the colour of the soil is grayish. These soilsare suitable for the cultivation of*Ya* crops (dry crops cultivated with only scanty rain fall), like sesamum, groundnut, pulses and corn.

In the study area, this soil type mostly occur on the very gently sloping alluvial-deluvial under mountain plains in the western and of Bago*Yoma*. The pH of the soil is from 7 to 8 and there is little alkalinity. In generally, cinnamon soils develop under the influence of dry forest and consequentlythe soils have a large amount of organic matter. There is a permanent supply of nutrients from surrounding mountains.

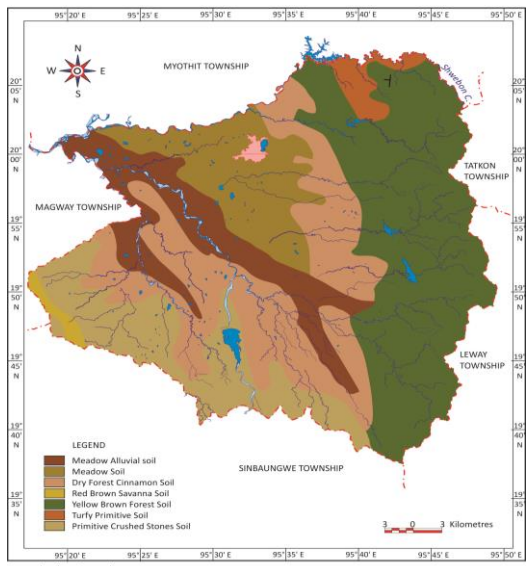
Red Brown Savanna Soil

The colour of the top soil is red and the soil contains much lime. This soil occurs mainly on the gentle slopes and valley in the western part of the township. It is easily eroded by water and wind. These soils are sandy. The accumulation of lime concentration is in the (B) horizon. This soil is best suitable for *Ya* crop because of slight alkalinity. It is slightly acidic and its pH values is between 5 to 6.5. The soil can be mainly used for plantation and afforestation or reforestation.

Yellow Brown Forest Soil

They arefound on well drained hilly regions under forest.They mainly occur in the region of gentle slope of low hill. The colour of the top soil is light brown. Such soils contain more clay. The pH of the soil ranges 4.5 and between 5.5. These soils contain more percentage of clay and humus than the red brown soil.Depending on the slope of the mountains, the depth of the soil varies. Soil texture also varies lightly with relief. It is mostly light loam on hill top and medium loam in the valley and on the slope.

In Taungdwingyi Township, the soiloccurs in the eastern, southern and western parts of the township.Along the hill slope the erosion take places extensively. The great majority of the soils are classified as good garden land. Less amount of area can be used for *Ya* crop cultivation like sesamum, groundnut, pulses and corn.



Source: Landuse Bureau, Yangon.

Figure 3. Map of soil type.

This soil type is mainly found along the slopes of north-eastern part of Taungdwingyi Township. Therefore, its thickness is not deep, i.e not more than 10 inches. Soil texture is fine sandy mixture and soil pH between 6.5 to7.5. This soil ismore suitable for plantation of forest rather than the cultivation of*Ya* crops. But, small patches of this soil is thrived to grow chilly, pigeon pea and corn.

Primitive Crushed Stones Soil

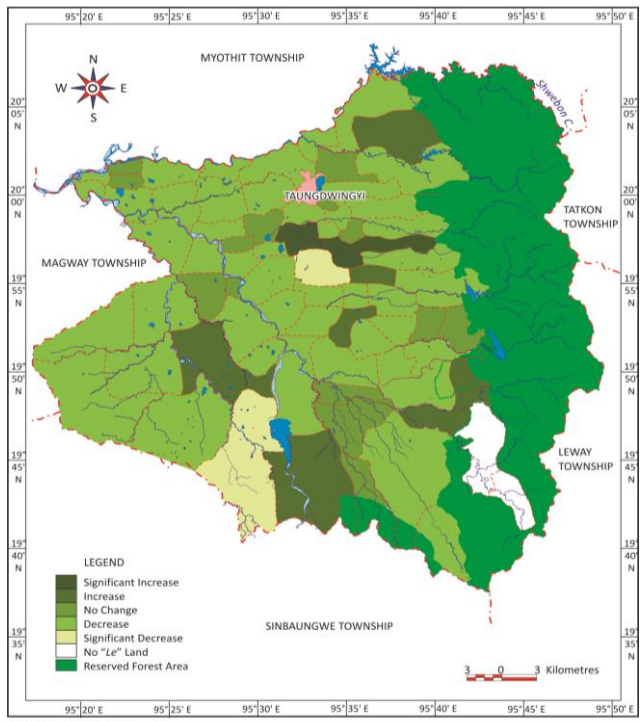
Primitive crushed stone soils are found in the western part of Taungdwingyi Township. The areas with this soil typeare covered with the low shrubs and dry grasses. The surface layer of the soil is just as a mixture of crushed stones, with some quantity ofslightly, fine earth. The soil is totally unsuitable for cultivation and should only be used forforest. Its pH values range between 6.5 and 7.5.

Agricultural Land & Paddy Cultivation

Myanmar Agricultural Department and Myanmar Land Survey and Land Records Department have defined the agricultural land as the land which is recently occupied by crop

or crops or which is recently left for some period as fallow land. Specifically, MAD (Myanmar Agriculture Department) considered the cropped land which is used for doubled or mixed cropped cultivation is also assumed as the agricultural land. In the study area, the agricultural land was increased for about 20,000 acres after 12 years. It is beneficial not only in the agricultural sector but also for the economic condition of the local farmers.

But, the presence of high land and forested area, less number of perennial water resources, mainly covered by sandy soil are the major hindrances for the development of agriculture especially for the paddy cultivation. Apart from that, scarcity of rain also limits the paddy land just only for once in a year. Wet cultivation (*Le* crops cultivation) could be practised mainly on the western portion of the township where the land area is almost level and the water source is available. But, such wet agriculture is well done during rainy season, while summer paddy cultivation could be sometimes expected with the help of irrigation.



Source: Compiled by Researcher.

Figure 4. PATTERN CHANGE OF "*LE"* LAND IN VILLAGE TRACTS OF TAUNGWINGYI TOWNSHIP

Soil Sampling and Soil Detection

Soil sample were taken during 2016, May. It is intended for soil detection. In this study, soil test and analysis on soil properties could be carried out for the same period. Paddy cultivation is widespread on tropical meadow alluvial soil with irrigation and well drainage. Paddy land should be dry for at least a few weeks every year. It can be easily observed where such soil is covered in the village tracts of the township. The soils for paddy may be true meadow soil with well-drained land. When used for subsistence farming, dry forest cinnamon soil can support for producing a great variety of food crops. This type of soil is rarely found in the study area, where there is highland area and northern parts of the

township. By maintaining or controlling water in the plot naturally or artificially, such land is used to cultivate wet crop like paddy which is defined as *Le* cultivation. For the time span of 12 years from 2001 – 02 to 2013 – 14, 71 village tracts out of 73 had practised *Le* cultivation in the study area. But, their *Le* land use is varied both spatially and temporally, mainly due to the availability of water. It is no doubt that the relief feature and soil condition favoured these village tracts to have more increase of *Le* land than that of others. *Le* land increase was also found in other 7 village tracts but with less amount. While, the decrease of *Le* land was noticed in 46 village tracts. (Map-4) Although there are 4 weirs for *Le* cultivation in the township, the irregularly and scarcity of yearly rainfall could not provide sufficient amount of water not only for cultivation but also into the dam sites.

Analysis on Correlation between Soil Physical Properties and Yield Per Acre of Paddy Cultivation

Meadow-Alluvial soil covered 27 village tracts in the study area. It is clayey and so the water retaining capacity is high. Myanmar Agriculture Department (MAD) suggested that this soil is suitable for cultivation of paddy and sesamum. The village tracts which are mostly occupied by this soil type were used for cultivation of paddy and sesamum during monsoon season. But due to the less facility of irrigation, the respective sown area of paddy was varied during 2016 in the village tracts.The coverage area of such soil type in those village tracts differ from 51 acres in Inywagyi village tract to 4,136 acres in Paybinya village tract. According to the suggestion of the MAD, both paddy and sesamum are cultivated in these village tracts. It is sure that the assured water supply can cause those areas to grow paddy for two times in a year.

Paddy Yield Per Acre of more than 80 baskets

Although almost all village tracts cultivated paddy during 2016, the yield per acre was totally different from one to another. Only 9 village tracts have been found where there had high yield per acre of paddy with 80 and above in baskets. Among them, only Wetshangan village tract could produce 100 baskets per acre in 2016. The remaining village tracts have been found with the yield per acre of paddy with the range of (51-79) baskets.All these village tracts are not located on the same soil type. That is the one reason for the highest yield per acre of paddy. As these soil types have sandy loam and clayey texture with thick soil depth, such physical properties cause to produce high yield of paddy although it is not comparable to that of other irrigated regions in Myanmar. Moreover, plain character of landform of these village tracts favour to be having high yield of paddy.

Paddy Yield Per acre with Medium Range (51-79) baskets

Medium yield per acre of paddy in 2016 was (51 - 79) baskets and which was noticed in 46 village tracts. The medium range of paddy yield was found in most of the village tracts with 8 different types of soil or the combined types of these soils. There are two levels of yield: one is medium high (i.e 70 baskets and above) and another one is medium low (i.e less than 60 baskets but more than 50). Even the dry forest cinnamon soil is suitable for forest land and orchard land although they were covered by paddy cultivation with medium high yield per acre. The reason was that the sufficient supply of water by Kyaukmechaung weir. The remaining 58 village tracts have been found with medium low yield per acre of paddy in 2016. The yield was between 50 and 60 baskets per acre. These village tracts have been found with varied soil types with different physical properties. It was due to the reason of lack of irrigated water in some village tracts even though the physical properties of soil can

support for high yield of paddy. In the village tract of Gonnyindon, most of the land area was used for sugarcane as commercial crop. So, they have less interest and less amount of inputs for paddy cultivation. The different reasons for Pwinthlagyi village tract were that late water supply from Zidaw dam and silting along the irrigation canals. In addition, very little attention for soil preparation before cultivation and after harvesting paddy are the main reasons for low paddy yield in Chaungnet village tract where the supply water is available. The same problem was also found in Sugaukkyi village tract even though where supply water is available, the village tract is located on the transition soil types of meadow alluvialand dry forest cinnamon. Dry forest cinnamon soil, primitive crushed stone soil, red brown savanna soil cover the 22 village tracts. Apart from the reason of in-appropriate soil type for paddy cultivation, sandy texture, medium or thin cover of soil led them to produce lesser yield per acre than that of other soil types (especially meadow and meadow alluvial soil types). Irrigated water is available in 11 village tracts, but the respective yield per acre of paddy was medium-low level. It is prominent that such soil types as dry forest cinnamon, primitive crushed stone and red brown savanna soils do not favour the sufficient moisture capacity of paddy cultivation. Therefore, such soil physical property determines the cropping patterns as well as crop production.

Table 1. Soil Types and Paddy Yield Per Acre in Village Tracts of Taungdwingyi Township (2016)

Dominant Soil Types	**Village Tracts where paddy dominated with respective yield per acre of :**		
	Low ≤ 50 baskets	**Medium low 51 - 79baskets**	**Medium high ≥ 80 baskets**
Meadow Alluvial Soil	Kywegan, Teldaw (1) Kokkogwa	Nyaunggon, Inywagyi, Ohnhnedon, Thitpokkon, Sugaukkyi, Taunglyaung	Pyadu, Wetshangan, Ingon
Meadow and Meadow Alluvial Soil	Letpanshe, Kyakatkan	Ingyigon	Teldaw (2)
		Hingayaw, Satthwa, Kyanzu	Lelthar (1)
Meadow Alluvial and Dry Forest Cinnamon Soil	Yagyidaw, Paybinya	Talokegon, Hmokshe	Yeway
		Kobin, Gyochaung, Sitta	
Dry Forest Cinnamon Soil	Gonnyindon, Kokkogon	Aungzu, Simihtun, Zidaw, Kyetsha	Kan-U, Kinmundaung
		Thirimingala, Wetkathe, Lelthar (2), Panthwingyi, O-bauk, Teikpwe, Letpanbu, Kanpay	
Primitive Crushed Stone Soil and Red Brown Savanna Soil	Lettet, Yaedwingaung	Wathonbyu, Leiktaik, Lettet	-
Meadow Soil	Thila, Panthwinlay	Tayokekaw	Kalagan
		Shangaing, Kinde, Pandawnge, Bogon, Pwinhlagyi, Chaungnet, Pyinnyin, Nyagamoe, Paukywa, Nyaungbinhla, Ye-U	-
Meadow and Dry Forest Cinnamon	-	Taungdwingyi, Thitya, Pintaing,	-
Dry Forest Cinnamon and Primitive Crushed Stone Soil	-	Patlegyi, Hlebwegyi, Payatkye, Nyadaw, Kantha	-

Paddy Yield Per acres of less than 50 baskets

There are two types of soil: meadow alluvial and dry forest cinnamon, in the village tracts of Yagyidaw and Paybinya. The yield per acre of paddy was quite low as most farms had to rely only on rainfall as well as less application of fertilizer. The soil texture of these soils is mostly sandy and clayey with silt, so that the water retain capacity is low and insufficient supply water caused to less than 50 baskets per acre of paddy yield.

Primitive crushed stones soil and red brown savanna soil mostly cover two village tracts: Lettet and Yaedwingaung. Although soil texture is composed of silt and clay, it is composed of coarse grain size due to the component of small size of gravel and coarse sand. Although these soil types are not recommended to grow. These soils are recommended to leave for forest land by MAD. The yield per acre of paddy for each village tract with respective soil types are tabulated in Table (1)

Results from Economic Point of View

In the area of irrigated agriculture on meadow soil and dry forest cinnamon soil (e.g. in Kinmundaung, Panthwinlay, Panthwingyi, Nyadaw, Hmokeshe, Talokegon village tracts), the cultivated cropping pattern of (Summer paddy- Monsoon paddy or Pre-monsoon sesamum, monsoon paddy) could provide better return for the farmers.

In paddy cultivation consumes paidmuch more attention the soil fertility rather than other crops. If there is a continuous cultivation of paddy for two-times in a year, the soil can be exhausted and it also can affect pest for the next time summer paddy cultivation. To prevent such condition, natural fertilizers like cow dung and organic residues should be applied.

Results from Crop Calendar (2016) It can be clearly observed that 52 village tracts out of 73, had been cultivated the same cropping pattern by leaving one cropping season (i.e. pre-monsoon period). It is mainly due to the choice of farmers who expect the rain for successful growing of monsoon paddy. Moreover, the supply water from the dam sites was not sufficient and not in time provision. As a result, those farmers could grow monsoon paddy, starting from mid-July up to end of November or beginning of December for harvesting. But in the winter season, various types of beans were grown. In the table, the winter crops which dominated in these 52 village tracts were same.

Results for Soil Conservation (Naturally)

Crop rotation pattern can conserve the fertility of soil naturally. It is found in almost all of the village tracts. It is also suitable for tilling when the soil is dried. It can reduce pest and weed effects as the ploughed land is burnt under the sun heat. After reaping the grains (paddy), the land used to be ploughed up again for re-fertilizing of soil. Such natural soil conservation system was observed in 50 village tracts of the study area. There is an effective consequence that caused to prevent the increase of pest population. Growing lentils at least once in a cycle of crop rotation system can conserve the nitrogen component in the soil. But, the leaves of gram can acidify the soil.

Results for Soil Conservation (Artificially)

Applying of chemical fertilizers should be checked with not only the type of soil but also with the level of productivity. For example, for 1 acre of paddy field, such chemical inputs as Urea for (50 or 40 kg), T.Super for (25kg or 35kg) and Potash for (15kg) are mostly used by the farmers. But the clayey soil and sandy soil have different texture so that the amount and types of inputs of fertilizer differ from each other. The loam soil is applied by the chemical fertilizers of Urea (40kg) and T. Super (25kg) per acre of paddy land. The farmers answered that the cultivation of sesamum, gram and mung bean need less amount of investment, but provides more profitable than that of paddy cultivation.

Problems Faced by the Farmers

In the irrigated area, insufficient water supply and late/early water supply systems are the major hindrances for the farmers. If the weather condition is not normal the crop output might fail and it can also cause loss to the investment etc.

The seasonal phase was the problem of labour shortage as young adults (men) had gone abroad for various share jobs. Hence, the expense for hiring labour has been higher and higher gradually. Machines can be replaced, if their prices are affordable by the farmers. Although the price of chemical inputs has been increased, the amount of chemical inputs are increasingly applied and as a consequence the quality of product has been declined and it can also lead to get less price. In the study area, some farmers would like to continue growing summer paddy as soon as harvesting mung bean which caused to lose the soil fertility. Paddy after paddy cultivation-pattern can also cause the boggy land when the plots always have water.

Soil Erosion

Generally two types of soil erosion could be found in the study area: washed out erosion by surface running water and wind erosion. As shown in Map (2), dendritic drainage pattern of streams, streamlets, their braided nature and the sandy character of the channel beds caused them as intermittent streams. Most of the streams are originated from the eastern *Bogo Yoma.* Therefore, the streams flow from east to west or northwest. Along their channel, they used to erode surface soil and even gravels from the mountain area. Their erosion rate is high. The rate of weathering is also very intensive, as the study area lies in the Dry Zone of Central Myanmar with high temperature changes. As a result, the eroded gravels and debris are carried and deposited along the channel beds. Although the velocity and discharge rate of the streams are strong while raining, the water has been disappeared as soon as the rain stopped. Hence, fine particle of the surface soil could not be carried for far distance. Only the alluvium could be carried by long distance and are deposited. As a result, meadow alluvial soil in the study area could be observed as a narrow stripe along *Yape* stream.

Wind erosion can take place in hot and pre-monsoon season. When the monsoon wind shifts from the sea to the continent, the wind speed has been gradually stronger and it used to be at maximum rate from the month of April to September /October. Throughout the study area, there is no wind breaker for the cultivated land. If the systematic ploughing method (i.e the furrows should be perpendicular to the wind direction) should be adopted by the farmers. For that purpose, some farmers have that knowledge to avoid the wind erosion. But, for the study area, the wind erosion rate could not be calculated as lack of instrument.

Discussion and Recommendation

About two-thirds of the township is characterized by plain or rolling plain. But only Taungdwingyi plain is suitable for crop cultivation. Although there are a number of streams and streamlets, water supply is not much reliable as they are of intermittent nature.Some area of forest land were already encroached by different activities of local people. The significant increase of land use types such as uncultivated land, virgin land and cultivatable waste land was the major drawback of agricultural land use and its consequences for crops production. Only 37% of total area of the township was used for crop cultivation during the study period. Not only has the rugged terrain in the eastern part, but also having sandy soil limited the cultivated area. As a consequence, *Ya* cultivation is more dominant than that of *Le* cultivation.

Out of 7 major soil types, not more than 3 soil types are favourable for crop cultivation.Many number of physical properties of different soil types are understood and it could be observed that different physical properties could be analyzed by relating with the crop cultivation or crop yield. Due to many constraints, only grain size detection could be done for the entire

study area. But, there is very less chance to do specific examination on physical effects of soil properties on cropping pattern or agriculture. Hence, based on the soil types, certain physical properties and yield per acre of paddy of the study area were presented.

As a result, the fertility rate of any type of soil and the availability of water supply have much problemsand difficulties which have been solved by human endeavours in the past periods or years. It is still not yet resolved for some cases about soil conditions at micro-level (i.e plotwise) in some particular area.

According to the agriculture calendar, paddy could be grown for two times in a year but in very limited village tracts where irrigation water is available. Growing of pulses is benefitted for the farmers as the market has been opened. Diversified cropping pattern could be observed, but it is mainly for the family needs and local markets. As the agriculture of the study area is heavily dependent on the rainfall only, the cultivated areas of various crops differed in one village tract to another. Although paddy is most preferred by the farmers, mung bean, gram and maize have been popular as cash crops for the marginal farmers, because the income from such crops could be reliable before harvesting paddy.

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