Analysis of major factors effect on soil erosion in rural agricultural areas in Sri Lanka.

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Abstract: Soil erosion has become major challenge in rural agricultural process in the world. World land resources are declining day by day due to soil erosion. Beside it effect to agronomic productivity. The peg method is one of the most suitable biotechnical construction methods for analysis soil erosion on agricultural lands. Under the judgment sampling method Kandy district, Wewere GND was selected as the study area and the main objective is to analyze how much topsoil has been washed away from an agricultural land. Wewere GND was divided into seven land units according to the most common human activities in the area and the peg method was carried out for 3 months (2nd of November 2018 to 31st of January 2019). Results revealed that the high amount of topsoil washed away from crop cultivation land and it represented as 9.7 mm and the lowest was represented as 0.2mm in scrubs areas. It clearly proved that human activities increase the soil erosion in study area other than scrub areas due to the minimum human activities in the scrub area. Over weeding, maximum tillage, unsuitable cultivation methods, minimum attention of government officers and mismanagement of land are the alarming factors to increase the soil erosion in the Wewere GND. Practice soil bunds and stone bunds, live hedges, Practice cover crops and mulching methods, practice to minimum tillage and selective weed control are some recommendation to decrease the soil erosion in study area. Although conducting awareness programs among villagers are very important. Because soil is the finite and most sensitive layer in the terrestrial system.

Index Terms*: Major factors, Soil erosion, Rural agricultural area*

INTRODUCTION AND BACKGROUND

Soil erosion is the main cause of the decline in global available land resources (Chen et al,2019). Soil erosion has become major challenge in rural agricultural process in the world. World land resources are declining day by day due to soil erosion. Hence this problem has become the main focus of researchers and engineers (Chen et al, 2019).

Although soil erosion is a naturally occurring process, this has been accelerated by human activities such as intensive agriculture, improper land management, deforestation and cultivation on steep slopes (Guo, 2010). Slope, elevation, rainfall, plane curvature, drainage density, lithology, and lineaments are some influencing natural factors of soil erosion (Ouyang et al, 2018).

Increased deforestation and growing agricultural and urban land in the tropical areas influence the intensity of soil erosion. It can intensify as a result of sub-optimal land management, for instance soil compaction, land consolidation, and the use of mechanization inappropriate for local conditions (Petersen and Hoogeveen 2004). An increased soil erosion and sedimentation fills the reservoirs of hydraulic dams, which ultimately decreases the power generation capacity (Sharma, Tiwari & Bhadoria, 2011).

Soil erosion is one of the risks of farmers' efforts to safeguard the productive functions of soils and to maintain ecological functions (Dumbrovsky & Korsun, 2009). It leads to decline in crop yields, hinders global economic development, and poses a threat to food security and human welfare (FAOUN, 2015; Luca, 2015). It also disturbs the agricultural output and aquatic life by polluting water in the rivers. about 2.5 to 4 billion tons of soil is annually eroded worldwide (Chuenchum & Tang, 2020).

According to the study in the Czech Republic about 50% of the area of arable soils are exposed to water erosion risk (Jana et al, 2018). Furthermore, in the Chitral district of Pakistan, it was found out that 4% of the area was under very high erosion risk in the year 2000 which increased to 8% in the year 2020. An increase in agricultural land (4%) was observed in the last 20 years which shows that human activities largely affected the study area (Aslam et al, 2020). Approximately 80% of agricultural areas are facing higher rates of soil loss, and transported sediments severely affect the natural and built environment. Erosion of soil depletes the storage capacity of reservoirs and dams which ultimately decreases the power generation capacity (Aslam et al, 2020).

According to the past research, it has been observed that landscape characteristics are responsible for about 65% to 74% of changes in sediment yield and soil erosion. Changes in streamflow discharge due to land use also increase the intensity of soil erosion. Usually, it is observed that areas with more grassland are less vulnerable to soil erosion, whereas arable lands are more susceptible to soil loss (Ouyang et al, 2018).

A study was conducted by Sharma et al. on the effect of land use and land cover on erosion process in the reservoir from 1989–2004. This study illustrated that a slight increase in mean soil loss was observed. In 1989, it was 12.11 t/ha/y and in 2004 it became 13.2 t/ha/y. Results indicated that deforestation and increased wasteland in higher slopes increased the mean soil loss rate in 15 years (Sharma,Tiwari & Bhadoria, 2011). Another research in the Western Polish Carpathians shows that due to the increase in plantation and a decrease in the rate of cultivation, the rate of eroded soil decreased in the last 160 years (1846–2009). The rate of soil erosion in the year of 1846 was 18.13 tons/ha/y and it decreased to 4 tons/ha/y in the year 2009 (Kijowska-Strugała, 2018).

According to the research was conducted by Jayasekara et al. Soil erosion hazard zone maps were developed for each district and for whole Sri Lanka. Results showed that 11.8% of the area in Sri Lanka is under high hazard level of erosion and 4.8% of the area is under very high level of hazard which are intolerable for any land use with respect to the sustainable productivity. Furthermore, six districts namely Badulla (36.5% high erosion hazard), Kandy (32%), Kegalle (38.5%), Nuwara Eliya (40.7%), Rathnapura (38.7%) and Matale (20.3%) showed considerable susceptibility for soil erosion mainly due to the topography and the land use. Four other districts namely, Galle (20% high erosion hazard), Matara (20%), Kaluthara (20%) and Colombo (9%) also showed high tendency for soil erosion due to the land use changes with the urbanization (Jayasekara et al, 2018).

Soil erosion is occurring at an alarming rate not only in central highland but also in lowlands due to changes in land use, removal of vegetative cover and urbanization. Therefore, the assessment of soil erosion of different areas of Sri Lanka is a necessity and apply appropriate conservation methods in each area are requisite.

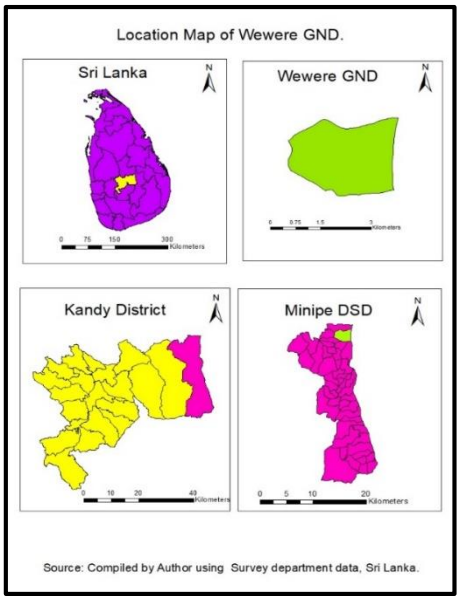
RESEARCH OBJECTIVES

The main objective of the study is to identify the major factors of soil erosion. Besides, identify the most influential human factors on soil erosion and identify the appropriate soil conservation methods in the rural agricultural areas in Sri Lanka and to identify the awareness of farmers on soil erosion are sub-objectives of the study.

DATA AND METHODS

This research is conducted under a human ecological approach and collect qualitative and quantitative data relevant to the study. Wewere Grama Niladhari Division is the study area of this research and it situated in the Minipe Divisional Secretariat and, located in the Eastern part of the Kandy District in the Central Province of Sri Lanka. The absolute location of study area is 7°27'25.17"N - 7°28'46.32"N North latitude and 80°56'37.05"E - 80°58'22.48"E East longitude. The Weware GND is spread over an area of 7.7957 square kilometers and it is a very fertile area.

Map 1



The study area was selected under the judgment sampling method because it was an area with a growing population and a small sloping plain with abundant water sources and a large area of agriculture and various human activities.

Wewere GND was divided into seven land units under the judgment sampling method according to the most common human activities in the area. Accordingly, used simple random sampling method to the field experiment in the study area. Used random sampling method to select 30 villagers and used judgment sampling method to select 5 government officers related to the research.

The month of November was selected for the field experiment, because the study area receives rainfall with the onset of northeast monsoon. As a result, Peg method was conducted among 3 months and the period from 2nd of November to 1st of January. This method was used for this month because the amount of rain that falls in the area.

Under the peg method firstly, demarcated an area of 9 square meters. Thereafter, four equal wooden poles were planted, considering four locations in the demarcated site. Each wooden poles were submerged 5 cm deep into the ground. A line was marked on the place which was touched the ground in 5 cm and studied how much soil particles washed away from the ground due to rain water.

Figure 1
The peg method on 2nd of November 2019
(Before the rain come to the study area.)

(Source: Field experiment in the study area,2019)

The study consists of both primary and secondary data, which is used to carry out the research. Primary data collected by using experiments, survey and observation methods including few techniques. Used field experiment, questionnaires, direct interviews as techniques to collect primary data. Officers of related authorities' ideas about the human activities affect to the soil erosion were collected through interviews. Observations were used to investigate the soil types in the study area, types of human activities affect to the soil erosion and identify the slope angle of the study area and prove the survey and experiment data. Further, photographs were used to represent the status of soil erosion where observation was carried out. Secondary data collected through few institutes,

- Survey Department, Sri Lanka.
- Land Use Policy Planning Department, Sri Lanka.
- Natural Resources Management center, Department of agriculture, Kandy.
- District Secretariat office, Kandy.
- Irrigation Department, Minipe.
- Divisional Secretariat , Minipe.
- Department of Agriculture, Minipe.
- Grama Niladhari Division, Wewere

Although research articles, books, reports, magazines, newspapers and the internet were used to collect secondary data.

Collected quantitative and qualitative data were analyzed according to the Statistical data analyze and descriptive data analyze methods. Quantitative data were analyzed using statistical data analysis method and use basic statistical techniques under MS Excel and required charts, graphs, tables obtained. Although descriptive data analyze method used for analyze the qualitative data. Data obtained from field experiments were analyzed using Arc GIS software and used IDW tool to represent spatial data distribution maps.

RESEARCH FINDINGS

The use of plants for soil erosion protection has a long tradition. Old methods with rocks and plants, structures of timber have been used over the past centuries. Recently these old soil conservation techniques have been rediscovered and improved. Biotechnical engineering methods have become part of Geotechnical and hydraulic engineering and have helped bridge the gap between classical engineering disciplines, land use management, landscape architecture and biological sciences. The peg method is one of the most important biotechnical construction methods used for soil erosion protection.

This method was carried out of demarcated sites in the study area among three months. The reason is that the area receives rain during that period. The average rainfall for November was 498mm and for December it was 512mm. Considering these factors, this method was implemented in the study area. Exposed length of planted wooden poles were measured and calculated the average value of exposed.

Figure 2
The peg method on 1st of January 2020
(After the rain came to the study area)

(Source: Field experiment in the study area,2020)

The study area has less than 10^0 slope area. Cultivation and small industries are the main economic functions in Wewere GND. Natural soil erosion process is less in this area, and it was proved by the results.

According to the field experiment the highest exposed value was represented in crop cultivation. It represented as 9.7 mm and the lowest was represented as 0.2 mm in scrubs areas. Vegetable cultivation and home garden also represented high amount of soil erosion. Brick industry represented 2.4 mm and 2.9 mm represented in sand mining industry. The table 1 and map 2 were clearly revealed the results of Peg method.

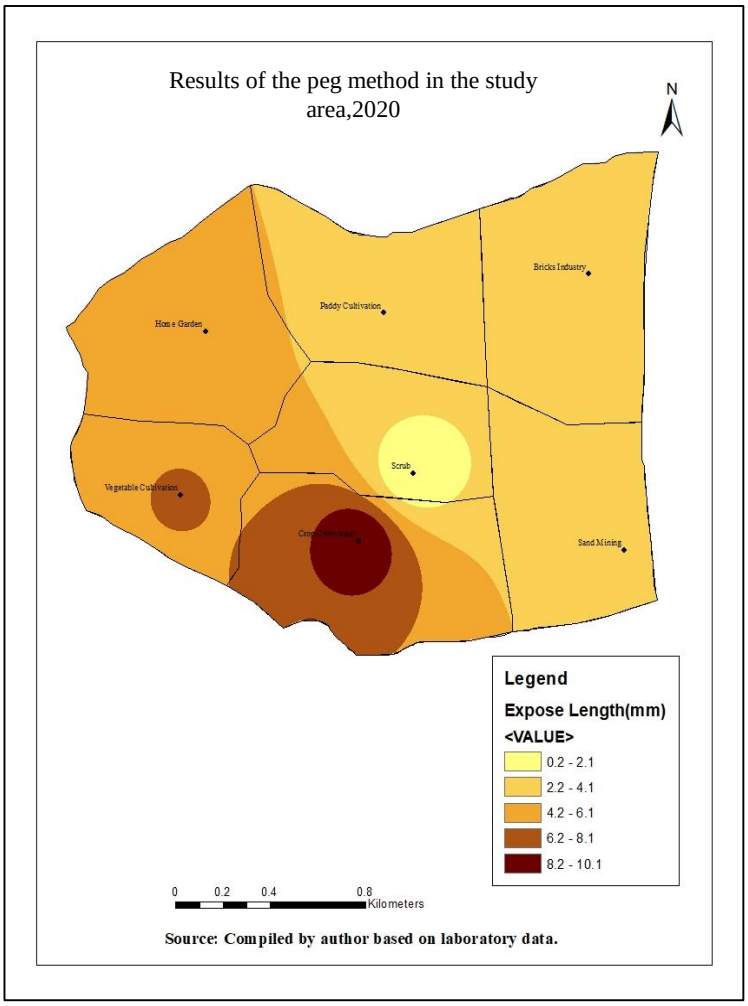
Table 1

Results of the peg method implemented in the study area, 2020

Soil Samples	Pole 1 (mm)	Pole 2 (mm)	Pole 3 (mm)	Pole 4(mm)	Average value(mm)
Scrub	0.1	0.2	0.4	0.3	0.2
Brick Industry	2	5	0.7	2	2.4
Sand mining industry	2	4	0.9	5	2.9
Crop cultivation	10	12	8	9	9.7
Paddy cultivation	6	3	0.9	2	2.9
Home garden	4	7	2	5	4.5
Vegetable cultivation	2	5	10	7	6

(Source: Results of field experiments, 2020)

Map 2



Deforesting, weeding methods, maximum tillage, less use of organic fertilizer, unsuitable cultivation methods are caused to accelerate the soil erosion in study area. Excessive ploughing methods, water supply methods in paddy fields are caused by the high soil erosion in the area. Today, machinery is widely used to reduce time, reduce manpower, and increase yields in the study area. As a result, soil erosion has accelerated.

Overgrazing, use machinery to soil loosening are affected to soil erosion in the brick industry. Soil loosens using different machines in the brick industry. Due to this process, during the rainy season, large water streams are created and soil erosion is increasing in other areas also. In addition, illegal sand mining industry is frequent in the area. And around that the area has been eroded extensively. The banks of the Mahaweli River have been severely eroded. Excessive use of heavy vehicles can damage the topsoil of the area. At present, the topsoil layer is almost unrecognizable. These irregular human activities are increasing the soil erosion in the area.

CONCLUSION AND RECOMMENDATIONS

A number of conclusions can be drawn from the analysis of qualitative and quantitative data obtained from field experiment, observations, and surveys conducted to identify the regulatory factors on soil erosion.

In the Weware Grama Niladhari Division, man plays a powerful role in the performance of the factors affecting soil erosion, along with the development of agriculture and small industries. Agricultural activities such as vegetable cultivation, crop cultivation, paddy cultivation, home garden, small scale industries such as brick and sand mining are major factors on soil erosion in the study area. Although, the soil erosion is minimal in the scrubs areas. This is clearly proved by the experiments, observations and survey results. This has been attributed to the lack of human influence in the area.

There are many recommended methods and ways for soil conservation in an agricultural land. Generally, one of the major conservation methods is the effective use of several other conservation methods, depending on the suitability and requirements. Mechanical measures, biological measures and agronomic measures are major conservation methods.

Soil bunds method can reduce the distance and speed of water flow on the surface of the ground. Also best for slope area less than 10%. Therefore, this method is best suited for the study area. Soil buds can also retain soil and silt on the ground and increase the infiltration capacity also.

Lock and spill drains method is suitable for crops, vegetable and home gardening in the study area. This results in a safe drainage of surface water. Also stone buds and live hedges are suitable soil conservation methods. Soil moisture is protected by using the plant parts as a cover for the soil. *Gliricidia sepium*, *Tithonia diversifolia*, *Adathoda Vasica*, *Calliandra calothyrsus*, *Flemingia macrophylla* are used for live hedges. Although, “Sevandara” and grasses used for this method.

Practice cover crops, selective weed control, minimum tillage, practice mulching are appropriate conservation methods. Leaves, coconut husks, coconut twigs, “Ginisiriya” leaves, straw and grass can be used for mulching method. It also adds organic matter to the soil and enhances microbial activities in the soil.

It is very important villagers aware about the soil erosion. And should practice the soil conservation methods to minimize the soil erosion. Specially training programs, seminar should be conduct in the area. Government officers should give the knowledge about the soil conservation methods. Most of villagers haven’t proper education, so these programs must be conduct in simple language to understand them.

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