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THE ESTIMATION OF THE EROSION-THREATENED LANDS USED FOR COCOA CROPS IN SAN LORENZO CANTON, ESMERALDAS PROVINCE, ECUADOR

©*Kravchenko R.*, ORCID:0000-0003-0474-5555, Ph.D., Universidad UTE,
Quito, Ecuador, roman.kravchenko@ute.edu.ec

©*Pelaez M.*, ORCID:0000-0002-1043-7893, Quito, Ecuador, mayreasco@gmail.com

©*Granda R.*, ORCID: 0000-0002-3702-5864, Ph.D., Universidad UTE,
Quito, Ecuador, roberto.granda@ute.edu.ec

ОЦЕНКА СОСТОЯНИЯ ЭРОЗИОННО ОПАСНЫХ ЗЕМЕЛЬ, ИСПОЛЪЗУЕМЫХ ДЛЯ ВОЗДЕЛЫВАНИЯ КАКАО-КУЛЬТУР В КАНТОНЕ САН-ЛОРЕНСО ПРОВИНЦИИ ЭСМЕРАЛЬДАС, ЭКВАДОР

©*Кравченко Р. А.*, ORCID:0000-0003-0474-5555, канд. геогр. наук, Университет УТЕ,
г. Кито, Эквадор, roman.kravchenko@ute.edu.ec

©*Пелаез М.*, ORCID:0000-0002-1043-7893, г. Кито, Эквадор, mayreasco@gmail.com

©*Гранда Р.*, ORCID: 0000-0002-3702-5864, Ph.D., Университет УТЕ,
г. Кито, Эквадор, roberto.granda@ute.edu.ec

Abstract. The soil condition on the slopes used for the cocoa crops has been analyzed. The investigated territory lies in the equatorial plains of South America at the Pacific Coast. The field investigations and the soil samples were taken in the cocoa crops zones. The sites with 3° and 8° inclination angle of slopes were chosen for the analysis. It was found that the higher inclination angle provokes more intensive soil degradation processes and the organic content loss. The organic matter content range in the plow layer decreases from 9.74% to 3.26%. The main degradation factor is the erosion, namely, the sheet erosion of the surface soil. The linear erosion forms are insignificant. The slopes with no more than 3° inclination angle are characterised by less organic content loss caused by the sheet erosion and appear to be more suitable for the cocoa crops in the investigated zone.

Аннотация. Исследовано состояние почв на склонах, используемых для возделывания какао-культур. Изученная территория расположена на равнинах в экваториальной части Южной Америки, близ Тихоокеанского побережья. Полевые исследования земель и анализируемые образцы почв приурочены к зонам возделывания какао-культур. Сравнивались участки склонов с крутизной 3° и 8°. Установлено, что процессы деградации почв, и прежде всего потеря органического вещества наиболее интенсивно проявляется при большем уклоне поверхности. Наблюдается падение содержания органического вещества с 9,74% до 3,26% в пахотном слое. Основным фактором деградации — это эрозионные процессы, а именно плоскостной смыв верхнего горизонта почв. Линейные эрозионные формы развиты незначительно. Для возделывания какао-культур в исследуемой зоне склоны не превышающие наклон в 3° являются благоприятными и не приводят к существенной потере плодородия в результате смыва.

Keywords: erosion, cocoa, soils, slop, farmland.

Ключевые слова: эрозия, какао, почвы, склон, сельскохозяйственные земли.

The Republic of Ecuador is one of the producers and exporters of cocoa. The greater part of the plantings lays the Province of Esmeraldas cultivated mostly by small-scale farmers.

Cocoa crops on sloped areas eventually leads to the soil degradation caused by water erosion processes.

The research was focused on the estimation of the lands with different slope angle inclination used to cultivate *Theobroma cacao* L.

A number of previous research papers have dealt with the problem of the soil degradation process in Ecuador caused by agricultural activity [1–3] and others.

The authors carried out the investigation in Esmeraldas province, San Lorenzo canton, Ecuador in 2017–2018. The key-site is located in the district of Tululbi–Ricaurte (a plain area at the Pacific coast of Ecuador), 10–60 meters above sea level. Nevertheless, the slopes of different inclination provoke erosion processes. The location in the equatorial area at the latitude of 1°15' determine the main climat characteristics of the territory. According to the data of *The National Institute of Meteorology and Hydrology of Ecuador* the mean temperature is 25° C, slightly varying through the months. The average annual precipitation for the region exceeds 2500 mm. January is the wettest month and in September the precipitation rates decrease. The precipitation rates are changeable throughout the year. The humid period lasts from January to the mid-summer. The monthly average rate from January to April is 300 mm. The dry season falls on the period of August–December.

The forms of linear erosion are not prevailing in the investigated area: rare cases of gully erosion, rain gulleets and furrow erosion.

It should be noted that the research was held within one farm with the identical agricultural methods and cultivation period of this agricultural crop.

The field-investigations were carried out in the agricultural areas used for cocoa crops (Figure).



Figure. Sloped areas with cocoa crops.

The comparative analysis was carried out for two key-sites situated on the slope with 3° inclination angle in its upper part and 8° in the middle. The data is presented in the Table. The soil sampling analysis was carried out at the laboratory of *Agrocalidad*, Quito.

Table.

THE PARAMETERS OF THE KEY-SITES' SLOPE SOILS

<i>Parameters</i>	<i>Key-site 1 Cacao. (slope angle 3°)</i>	<i>Key-site 2 Cacao. (slope angle 8°)</i>
Organicmatter (%)	9.74	3.26
Nitrogen (%)	0.49	0.16
Phosphorus (mg/kg)	3.5	3.5
Potassium (cmol/kg)	0.07	0.55
Calcium (cmol/kg)	1.95	3.7
Magnesium (cmol/kg)	0.36	1.22
Iron (mg/kg)	295.3	534.2
Manganese (mg/kg)	8.47	16.85
Copper (mg/kg)	8.18	4.7
Zinc (mg/kg)	3.44	3.11
pH	5.39	5.34

The particular attention is to be attracted by the changing percentage of the soil organic content. The amount of organic matter loss increases dependable the inclination angle (9.74% at 3° slope to 3.26% at 8° slope). Such dramatic three time drop is caused by intensive linear erosion and fast soil fertility decline.

Also, the soils of steeply inclined areas reveal the three times decrease of nitrogen parameter in comparison with key-site 1. The phosphorus indicators are the same for both of the compared sites. However, these parameters (3.5 mg/kg) are lower than the average amounts for the coastal area of Ecuador: according to "Agencia Ecuatoriana de Aseguramiento de Calidad Agro" they appear to be 11.0–20.0 mg/kg. The investigated agricultural lands were not applied with phosphate fertilizers. And therefore, the sheet wash could not influence the decrease of the phosphorus amount in the analyzed soils.

The high concentration of iron and manganese in the soil from the steeply inclined slope could be explained by the soil formation conditions in the area.

On this basis we conclude that the intensity of the soil degradation of the lands used for cocoa crops depends on the inclination angle of the slope. It is not recommended to plant cocoa crops on the slopes of more than 8° inclination angle to avoid fast soil degradation and soil fertility decline.

The slopes with no more than 3° inclination angle do not suffer greatly from soil degradation and appear to be more suitable for the cocoa crops in the investigated zone. The soils on the steeply inclined slopes are more liable to erosion.

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