

ASSESSMENT OF THE EFFECTIVENESS OF SOIL CONSERVATION PRACTICES ON HILLSLOPES AND FLAT AGRICULTURAL LANDS IN YORRO LGA, TARABA STATE, NIGERIA.

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Abstract

Soil erosion represents a major constraint to sustainable agriculture, particularly in regions with mixed topography comprising hillslopes and flatlands. This study assessed the soil conservation practices employed by farmers on hillslopes and Flat Agricultural Lands in Yorro Local Government Area (LGA), Taraba State, Nigeria. The study employed a descriptive survey design and data were collected from 400 farm household heads across ten selected villages using a structured questionnaire, complemented by field observations and key informant interviews. The results revealed clear terrain-based patterns in crop cultivation and soil conservation adoption, with hillslope farmlands being more intensively cultivated and managed through structural and biological practices such as contour farming, terracing, and agroforestry, while flat farmlands were dominated by rice cultivation and conservation tillage. Mulching and cover cropping were widely applied across both farmland types, whereas practices like crop rotation and organic manure application were less emphasized. The study concludes that topography strongly influences crop choice, conservation practice adoption, and perceived effectiveness, highlighting the need for terrain-specific agricultural interventions. It is recommended that agricultural extension programs and local government authorities promote terrain-adapted soil conservation practices and provide targeted farmer education and capacity building to enhance sustainable land use and effective soil erosion control.

Keywords: *Soil Conservation, Erosion Control, Hillslope Farmland, Flatland Farm, Yorro LGA, Agricultural Land*

1. Introduction

Soil is a critical natural resource that underpins agricultural productivity, ecosystem services, and environmental sustainability worldwide. Globally, soil erosion is recognized as a major environmental challenge, affecting approximately 33% of the world's arable land and contributing to land degradation, reduced soil fertility, and diminished crop yields (Pimentel et al., 1995; Lal, 2001). In tropical and subtropical regions, high rainfall intensity, steep topography, and unsustainable land use practices exacerbate soil loss, leading to sedimentation of rivers, loss of nutrients, and threats to food security (Morgan, 2005; Montgomery, 2007). Soil erosion also has broader socio-economic implications, reducing farmers' income, increasing vulnerability to climate variability, and undermining rural livelihoods.

Efforts to mitigate soil erosion have led to the development and adoption of diverse soil conservation practices worldwide. These include mechanical methods such as terracing, contour farming, and bunding, as well as biological approaches like cover cropping, agroforestry, mulching, and vegetative strips. The effectiveness of these interventions is context-dependent, influenced by factors such as slope gradient, soil texture, rainfall intensity, and farmer compliance with recommended practices (Lal, 2001; Morgan, 2005). Comparative studies have demonstrated that while some practices perform well on flatlands, they may be

less effective on steep slopes, emphasizing the need for location-specific assessments of erosion control strategies.

In Nigeria, soil erosion has emerged as a pressing environmental concern, particularly in regions with undulating landscapes and intensive agricultural activity. Across the country, hillslope and floodplain farmlands are increasingly susceptible to nutrient depletion, loss of arable soil, and reduced productivity due to poor conservation practices (Obalum et al., 2012). Despite government interventions, research on the effectiveness of soil conservation strategies across different landforms remains limited, particularly in less-studied localities, like yorro region.

The region features a heterogeneous landscape comprising both hillslope and flat lands, subjected to seasonal heavy rainfall and intensive farming. Farmers in Yorro LGA have adopted various soil conservation measures, including ridging, terracing, cover cropping, and mulching, yet there is scant empirical evidence on their actual effectiveness in controlling erosion across different topographies. Most existing studies have focused on generalized soil management approaches without differentiating outcomes between hillslopes and flatlands, limiting the ability of policymakers and extension services to provide targeted guidance.

This study, therefore, seeks to bridge this knowledge gap by assessing the effectiveness and dominant soil conservation practices employed by farmers on the hillslope and flatland farms in Yorro LGA. The vision was to evaluate the effectiveness of the approaches employed by farmers in mitigating soil erosion on hillslopes and flatland farms. The mission was to generate empirical insights that would provide sustainable land management strategies, guide policy interventions, and enhance the design of extension programs for effective erosion control. The objectives of the study were to identify the dominant soil conservation practices used by farmers on hillslope and flatland farms and to assess the effectiveness of these practices in minimizing soil erosion.

2. Materials and Methods

2.1 Study Area

Yorro Local Government Area (LGA) is located in the northern part of Taraba State, Nigeria. Geographically, it lies between latitude 8°42' N and 9°12' N, and longitude 11°20' E and 11°45' E Fig. 1. The study area is characterized by diverse topography, with hill slopes rising sharply in some areas and gently undulating plains in others, providing a mosaic of landforms that influence soil properties, water retention, and agricultural practices. Agriculture forms the backbone of Yorro LGA's rural economy, and farming is predominantly subsistence-based. Farmers cultivate a variety of staple crops, including maize, millet, sorghum, rice, and a range of vegetables, with cropping patterns often determined by soil fertility, slope gradient, and rainfall distribution. Livestock rearing, particularly goats, sheep, and cattle, complements crop production and forms an integral part of the local farming system.

The soils in Yorro LGA are largely ferruginous tropical soils, sandy loam to loamy in texture, with moderate to low natural fertility. On the hill slopes, soils tend to be shallow and more prone to erosion due to runoff, whereas the flatlands feature deeper, more fertile soils that are relatively stable under conventional farming practices. Soil organic matter is generally low, highlighting the need for effective conservation practices to sustain agricultural productivity. Climatically, Yorro LGA experiences a tropical wet and dry climate, with distinct rainy and dry seasons. The annual rainfall ranges between 1,000 mm and 1,500 mm, peaking between

July and September, which can trigger surface runoff and exacerbate soil erosion on vulnerable slopes. Temperatures are generally high throughout the year, averaging between 25°C and 32°C, with the hottest months occurring between March and May. The relative humidity is also elevated during the rainy season, creating conditions favourable for crop growth but also increasing the risk of erosion during heavy downpours.

The study area falls within the Guinea Savannah zone, with scattered trees, shrubs, and grasses dominating the landscape. Indigenous tree species such as *Isoberlinia doka*, *Vitellaria paradoxa*, and *Parkia biglobosa* are common, often interspersed within cultivated farmlands. The natural vegetation plays a role in soil stabilization, reducing runoff, and maintaining ecological balance, but ongoing land clearing for agriculture has led to fragmentation and localized soil degradation.

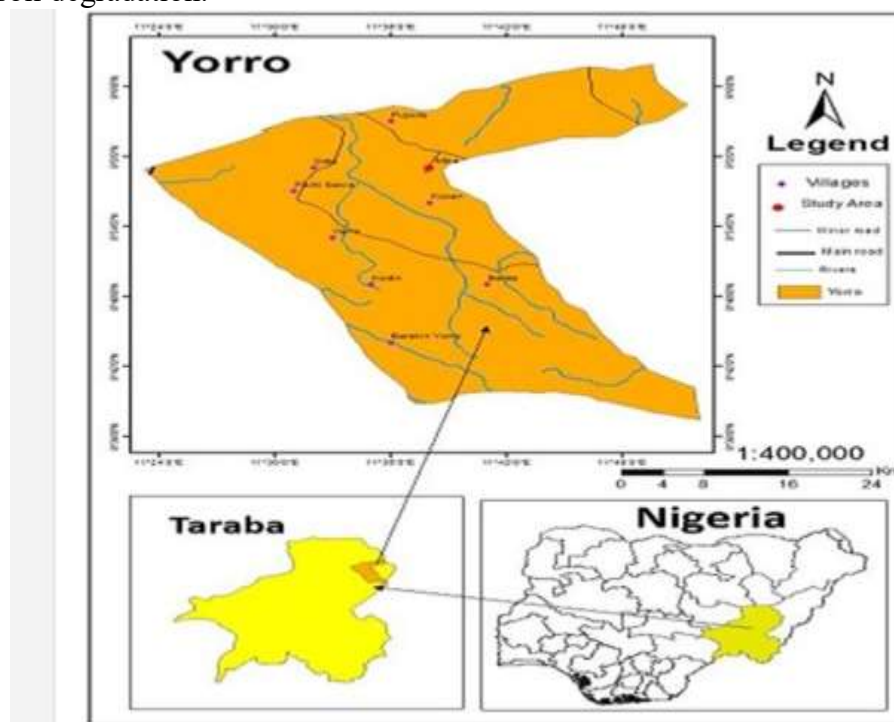


Fig.1: Map of the study area showing sampled villages

2.2 Methods

This study adopted a descriptive survey research design, integrating both qualitative and quantitative approaches to provide a comprehensive assessment of soil conservation practices in Yorro LGA. The target population comprised farmers across ten selected villages within the LGA, and a stratified random sampling technique was employed to ensure representation across land topographies. A total of 400 farm households heads with farm lands located on both the hillslope and flatland sit were randomly selected and use for the study. Data were collected using a combination of structured questionnaires, field observations, and key informant interviews. The questionnaires captured information on farmers' farm sides and perceptions regarding, various soil conservation practices, while field observations were conducted to measure tangible erosion indicators such as rill depth, soil loss, and sediment deposition. Complementary qualitative data were obtained through interviews with extension officers and

local community leaders to provide contextual insights into soil management practices and challenges. Quantitative data were analysed using descriptive statistics converted to percentages.

3 Data presentation and analysis

Table 1: Demographic Information of the Respondents

Variables	Parameter	Frequency	Percentage (%)
Sex	Male	256	65.0%
	Female	138	35.0%
	Total	394	100
Age	18 – 30 years	76	19.3%
	31 – 40 years	121	30.7%
	41 – 50 years	150	38.1%
	51 years and above	47	11.9%
	Total	394	100
Marital Status	Single	78	19.8
	Married	267	67.8%
	Widow/widower	32	4.3%
	Divorced	9	8.1
	Total	394	100
Educational Qualification	No Formal Education	205	52.0
	Primary Education	110	27.9
	Secondary Education	52	13.2
	Tertiary Education	27	6.9
	Total	394	100
Farm Size	Less than 1 ha	93	23.6
	1 – 2 ha	181	45.9
	3 – 5 ha	87	22.1
	Above 5 ha	33	8.4
	Total	394	100.0
Farm Location	Hill-Slope	209	53.0
	Flat Land	185	47.0
	Total	394	100.0

Source: field survey, 2024

Findings from table 1 shows that, 256 respondents (65.0%) were male while 138 (35.0%) were female, this implies higher male dominance in farming in the study area. The age distribution of the respondent indicates that 121 (30.7%) are between the ages of 31–40 years and 150 (38.1%) were 41–50 years, this suggest that most farmers in their prime working years.

Majority of respondents were married 267, (67.8%), and single 78, (19.8%), and had formal education, 205. Most respondents cultivated on small farms site of 1-2hacteres. , with 181 (45.9%) owning 1–2 hectares, while 93 (23.6%) had less than 1 hectare. Concerning farm location, 209 (53.0%) farmed on hill-slopes while 185 (47.0%) on flat lands farms.

Table 2: Distribution of Crops Cultivated by Farmland Type (Hillslope and Flat Farmlands)

Crops Cultivated	Hillslope Farmlands Frequency (f)	Hillslope Percentage (%)	Flat Farmlands Frequency (f)	Flat Farmlands Percentage (%)	Total Frequency (f)	Total Percentage (%)
Maize	48	12.2	39	9.9	87	22.1
Sorghum	44	11.2	26	6.6	70	17.8
Millet	36	9.1	22	5.6	58	14.7
Rice	18	4.6	41	10.4	59	15.0
Yam	33	8.4	21	5.3	54	13.7
Cassava	29	7.4	18	4.5	47	11.9
Vegetables (e.g., tomatoes, pepper, leafy vegetables)	19	4.8	15	3.8	34	8.6
Total	227	57.6	167	42.4	394	100.0

Source: field survey, 2024

Table 2: Distribution of Crops Cultivated by Farmland Type (Hillslope and Flat Farmlands)

Table 2 shows the distribution of crops cultivated by farmers across hillslope and flat farmlands in the study area. The table reveals that out of the total sample size of 394 respondents, 227 respondents (57.6%) cultivate crops on hillslope farmlands, while 167 respondents (42.4%) cultivate crops on flat farmlands. This indicates that crop cultivation is more concentrated on hillslope farmlands than on flat farmlands in the study area.

Maize is the most widely cultivated crop, with a total frequency of 87 respondents (22.1%). Of this number, 48 respondents (12.2%) cultivate maize on hillslope farmlands, compared to 39 respondents (9.9%) on flat farmlands, indicating that maize cultivation is slightly more dominant on hillslope terrains. Sorghum follows with a total of 70 respondents (17.8%), comprising 44 respondents (11.2%) on hillslope farmlands and 26 respondents (6.6%) on flat farmlands, suggesting a stronger association of sorghum cultivation with sloping areas.

Millet is cultivated by 58 respondents (14.7%), with 36 respondents (9.1%) on hillslope farmlands and 22 respondents (5.6%) on flat farmlands, further reinforcing the dominance of cereal crop production on hillslope terrains. Rice cultivation accounts for 59 respondents (15.0%) and shows a contrasting pattern, as it is more prevalent on flat farmlands, where 41

respondents (10.4%) cultivate rice, compared to 18 respondents (4.6%) on hillslope farmlands. This reflects the suitability of flat terrains for rice production due to better water retention.

Yam cultivation records a total frequency of 54 respondents (13.7%), with a higher proportion on hillslope farmlands, where 33 respondents (8.4%) cultivate yam, compared to 21 respondents (5.3%) on flat farmlands. Cassava is cultivated by 47 respondents (11.9%), of which 29 respondents (7.4%) are on hillslope farmlands and 18 respondents (4.5%) on flat farmlands, indicating greater cultivation on sloping lands. Vegetable cultivation records the lowest total frequency of 34 respondents (8.6%), with 19 respondents (4.8%) on hillslope farmlands and 15 respondents (3.8%) on flat farmlands.

Overall, the table indicates that most crops, particularly maize, sorghum, millet, yam, and cassava, are more commonly cultivated on hillslope farmlands, while rice cultivation is more dominant on flat farmlands. This pattern reflects farmers' adaptation to terrain-specific conditions and the suitability of different crops to the physical characteristics of the farmland types in the study area.

Table 3: Distribution of Soil Conservation Practices by Farmland Type (Hillslope and Flat Farmlands)

Soil Conservation Practices	Hillslope Farmlands Frequency (f)	Hillslope Percentage (%)	Flat Farmlands Frequency (f)	Flat Farmlands Percentage (%)	Total Frequency (f)	Total Percentage (%)
Contour farming	56	14.2	26	6.6	82	20.8
Mulching	38	9.6	36	9.1	74	18.8
Cover cropping	34	8.6	32	8.1	66	16.8
Conservation tillage (minimum/no-till, strip-till)	21	5.3	37	9.4	58	14.7
Agroforestry or windbreaks	29	7.4	18	4.5	47	11.9
Stone or soil bunds / ditches	41	10.4	11	2.8	52	13.2
Others (e.g., organic manure, crop rotation)	8	2.0	7	1.8	15	3.8
Total	227	57.6	167	42.4	394	100.0

Source: field survey, 2024

Table 3: Distribution of Soil Conservation Practices by Farmland Type (Hillslope and Flat Farmlands)

Table 3 presents the distribution of soil conservation practices adopted by farmers across hillslope and flat farmlands in the study area. The table shows that out of the total sample size of 394 respondents, 227 (57.6%) practice soil conservation on hillslope farmlands, while 167 (42.4%) do so on flat farmlands, indicating a higher concentration of conservation efforts on sloping terrains.

Contour farming emerges as the most widely practiced soil conservation method, accounting for 82 respondents (20.8%). Of this number, 56 respondents (14.2%) apply contour farming on hillslope farmlands, compared to 26 respondents (6.6%) on flat farmlands, suggesting that contour farming is predominantly associated with sloped terrains where erosion risk is higher. Mulching follows closely with a total frequency of 74 respondents (18.8%), with a relatively balanced distribution between hillslope farmlands, which recorded 38 respondents (9.6%), and flat farmlands with 36 respondents (9.1%).

Cover cropping is practiced by 66 respondents (16.8%), comprising 34 respondents (8.6%) on hillslope farmlands and 32 respondents (8.1%) on flat farmlands, indicating moderate and fairly even adoption across both farmland types. Conservation tillage practices, including minimum tillage, no-till, and strip-till, account for 58 respondents (14.7%). However, these practices are more prevalent on flat farmlands, with 37 respondents (9.4%), compared to 21 respondents (5.3%) on hillslope farmlands.

Agroforestry or the use of windbreaks is practiced by 47 respondents (11.9%), with a higher proportion observed on hillslope farmlands (29 respondents or 7.4%) than on flat farmlands (18 respondents or 4.5%). Similarly, the use of stone or soil bunds and ditches is more common on hillslope farmlands, accounting for 41 respondents (10.4%), compared to 11 respondents (2.8%) on flat farmlands, out of a total of 52 respondents (13.2%).

Other soil conservation practices such as the application of organic manure and crop rotation record the lowest level of adoption, with a total of 15 respondents (3.8%), of which 8 respondents (2.0%) are on hillslope farmlands and 7 respondents (1.8%) on flat farmlands. Overall, the table indicates that soil conservation practices are more widely adopted on hillslope farmlands than on flat farmlands, reflecting greater awareness of erosion risks and the need for erosion control measures in sloping areas of the study area.

Table 4: Perceived Effectiveness of Soil Conservation Practices in Reducing Soil Erosion by Farmland Type

Soil Conservation Practices	Hillslope Farmlands Frequency (f)	Hillslope Percentage (%)	Flat Farmlands Frequency (f)	Flat Farmlands Percentage (%)	Total Frequency (f)	Total Percentage (%)
Terracing	52	13.2	17	4.3	69	17.5
Contour plowing	55	14.0	33	8.3	88	22.3
Mulching	39	9.9	37	9.4	76	19.3
Cover cropping	34	8.6	31	7.9	65	16.5

Soil Conservation Practices	Hillslope Farmlands Frequency (f)	Hillslope Percentage (%)	Flat Farmlands Frequency (f)	Flat Farmlands Percentage (%)	Total Frequency (f)	Total Percentage (%)
Conservation tillage	19	4.8	35	8.9	54	13.7
Agroforestry / Bunds	28	7.1	14	3.6	42	10.7
Total	227	57.6	167	42.4	394	100.0

Source: field survey, 2024

Table 4: Perceived Effectiveness of Soil Conservation Practices in Reducing Soil Erosion by Farmland Type

Table 4 presents respondents' perceptions of the effectiveness of various soil conservation practices in reducing soil erosion across hillslope and flat farmlands in the study area. The table indicates that out of the total sample size of 394 respondents, 227 respondents (57.6%) perceived soil conservation practices to be more effective on hillslope farmlands, while 167 respondents (42.4%) perceived them to be more effective on flat farmlands. This suggests that farmers generally associate the effectiveness of soil conservation measures more strongly with sloping terrains where erosion risk is higher.

Contour plowing is perceived as the most effective soil conservation practice, with a total frequency of 88 respondents (22.3%). Of this number, 55 respondents (14.0%) identified it as effective on hillslope farmlands, compared to 33 respondents (8.3%) on flat farmlands, indicating that contour plowing is particularly valued for erosion control on sloped surfaces. Mulching ranks second, with 76 respondents (19.3%), and shows a relatively balanced perception across farmland types, as 39 respondents (9.9%) are from hillslope farmlands and 37 respondents (9.4%) from flat farmlands.

Terracing is perceived as effective by 69 respondents (17.5%), with a stronger emphasis on hillslope farmlands, where 52 respondents (13.2%) reported its effectiveness, compared to 17 respondents (4.3%) on flat farmlands. Similarly, cover cropping records a total of 65 respondents (16.5%), comprising 34 respondents (8.6%) on hillslope farmlands and 31 respondents (7.9%) on flat farmlands, reflecting a fairly even perception of effectiveness across both terrain types.

Conservation tillage is perceived as effective by 54 respondents (13.7%), but its effectiveness is more strongly associated with flat farmlands, where 35 respondents (8.9%) indicated its effectiveness, compared to 19 respondents (4.8%) on hillslope farmlands. Agroforestry and the use of bunds record the lowest perceived effectiveness, with a total of 42 respondents (10.7%), of which 28 respondents (7.1%) are on hillslope farmlands and 14 respondents (3.6%) on flat farmlands.

Overall, the table demonstrates that soil conservation practices are generally perceived to be more effective on hillslope farmlands than on flat farmlands. Practices such as contour plowing and terracing are viewed as particularly effective in sloped areas, while conservation tillage is perceived to be more effective on flat terrains. This pattern reflects farmers' experiences with

erosion dynamics and terrain-specific suitability of soil conservation measures in the study area.

3.2 Discussion of Findings

The findings of this study reveal clear terrain-based patterns in crop cultivation, the adoption of soil conservation practices, and farmers' perceptions of the effectiveness of these practices in reducing soil erosion. Underscoring the strong influence of topography on agricultural decision-making and land management in the study area. Crop cultivation is more pronounced on hillslope farmlands, suggesting that farming activities have increasingly expanded into sloping terrains, likely as a result of land scarcity and growing population pressure on relatively limited flat arable lands, a trend widely reported across sub-Saharan Africa (Lal, 2015; FAO, 2017).

The predominance of cereal crops such as maize, sorghum, and millet on hillslope farmlands reflects their adaptability to variable soil conditions and their traditional association with upland farming systems in northern Nigeria (Adebayo & Tukur, 2018). In contrast, rice cultivation is more commonly associated with flat farmlands, a pattern that aligns with existing literature emphasizing the crop's preference for level surfaces and improved water retention conditions typical of low-lying terrains (Oyinloye et al., 2020). The adoption of soil conservation practices further demonstrates farmers' responsiveness to terrain-induced erosion risks, with greater emphasis placed on hillslope farmlands where erosion threats are more severe.

Practices such as contour farming, the construction of stone or soil bunds, and agroforestry are more commonly employed on sloping lands, supporting earlier findings that identify these measures as effective in reducing runoff velocity and soil loss on slopes (Morgan, 2005; Nwankwo & Okoye, 2019). Mulching and cover cropping appear to be widely applied across both farmland types, indicating a general perception of their benefits in improving soil structure and protecting the soil surface irrespective of terrain, as noted by Lal (2018). Conversely, conservation tillage is more closely associated with flat farmlands, reflecting its suitability for gentle slopes and its compatibility with mechanized or semi-mechanized farming systems, a pattern consistent with the observations of Hobbs et al. (2008).

The relatively low emphasis on practices such as crop rotation and organic manure application may be linked to constraints related to labour, knowledge, or short-term productivity considerations, as reported in similar agro-ecological contexts (Tekwa & Belel, 2016). Farmers' perceptions of the effectiveness of soil conservation practices further reinforce these terrain-specific patterns, with structural measures such as contour plowing and terracing viewed as particularly effective on hillslope farmlands where erosion is more visible, supporting Morgan's (2005) assertion on the suitability of mechanical measures for steep terrains, while conservation tillage is perceived to be more effective on flat lands due to its operational advantages.

Overall, the findings demonstrate a strong interaction between terrain characteristics, crop choice, conservation practice adoption, and perceived effectiveness, highlighting farmers' adaptive strategies to their physical environment and emphasizing the need for terrain-specific extension services and policy interventions to promote sustainable land use and effective soil erosion control in the study area.

Conclusion

The study concludes that terrain plays a critical role in shaping agricultural practices in Yorro Local Government Area, influencing both crop selection and the adoption of soil conservation measures. Farmers demonstrate a clear awareness of erosion risks associated with different farmland types, with hillslope farmlands being more intensively managed through structural and biological conservation practices such as contour farming, terracing, and agroforestry, while flat farmlands are more suited to crops like rice and conservation tillage methods. The findings highlight the adaptive strategies of farmers in response to physical and environmental constraints, and underscore the importance of aligning agricultural interventions with terrain-specific conditions to promote sustainable land use and effective erosion control. Overall, the study confirms that topography, crop choice, and conservation practices are interconnected factors that shape soil management strategies and influence agricultural productivity in the study area.

Recommendations

1. **Promotion of Terrain-Specific Soil Conservation Programs:** Agricultural extension agencies and local government authorities should design and implement soil conservation programs tailored to farmland topography, emphasizing the use of contour farming, terracing, and agroforestry on sloping lands, while promoting conservation tillage techniques on flat terrains to optimize soil protection and enhance productivity.
2. **Farmer Education and Capacity Building:** Continuous training and awareness campaigns should be organized to educate farmers on the benefits of combining structural, biological, and agronomic soil conservation practices, including crop rotation and organic manure application, to address labour, knowledge, and short-term yield constraints, thereby improving long-term soil fertility and reducing erosion.

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