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Impact of Land Use/Land Cover Change on Rural Livelihood of Upper Swat, Pakistan

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Abstract

This study aims to investigate the impact of land use/land cover change (LULCC) on rural livelihoods in Upper Swat, Pakistan. It highlights the dynamics of LULCC and its implications for sustainable mountain agriculture and food security. The images from Landsat-5 (1993) and Landsat-8/9 (2023) have been used to determine LULCC. The findings specify prominent shifts in land use and cover from 1993 to 2023, with an increase in forest cover from 14.8% to 23.6% and agricultural land from 2.3% to 6.9% and a decrease in rangelands from 41% to 33.8% and barren land from 27.7% to 19.5%. This change has an impact on food security of mountain inhabitants, the accessibility of regional resources, and possibility for ecotourism. However, issues with infrastructural development and natural resource management are raised by the growth of settlements and the shrinkage of water bodies. Sustainable farming practices are pivotal for preserving food sovereignty and halting soil degradation. In addition, to provide chances for infrastructural development and agricultural diversity, regional farming can also

increase resilience. This study advances knowledge of the complex connections between LULCC rural livelihood and sustainability.

Keywords: Land-use/Land Cover Change, Rural Livelihood, Sustainable agriculture, Food Security, Mountainous Regions, Sustainability

1. Introduction

Globally, mountainous regions are home to 22% people worldwide, which mostly depend on agriculture for their food security, environmental preservation and sustainable development (Romeo et al., 2020). People engaged in mountain agriculture are facing difficulties like, climate change, land degradation and socioeconomic pressure that threaten the means of subsistence livelihood of these rural communities (Gupta et al., 2022). Impassable terrain, fragile ecosystem and limited accessibility are the major characteristics of mountain agriculture (Yesuph, 2020). Mountain agriculture is vital for local food security, income and livelihood (Gauchan et al., 2020). A wide range of high-value indigenous crops are grown by farmers in these areas (Karki, 2020). These crops include staples, vegetables, fruits and nuts (Ali et al., 2022).

The Mountain inhabitants use land as a basic source of livelihood (Chettri et al., 2021). It sustains various activities, such as food production, utilization of natural resources and infrastructural development (Viana et al., 2022). Worldwide, poor management and constant exploitation make land resources scarcer (Maja et al., 2021). Land-cover and land-use (LULC) are two imperative notions in relation to land exploitation (Taye et al., 2023). Land cover is the biophysical condition encompassing, topography, water, soil and anthropogenic features of the earth surface (Chu, 2020). Alternatively, Land-use refers to the ways in which the land is managed for agriculture, urbanization and livestock grazing (Mora et al., 2020). Modification and conversion of land are the main causes of change in land-cover by land-use (Hailu et al., 2020). While the change in land cover refers to more intricate transformations that alter the characteristics of land cover without changing its classification (Zhu et al., 2022). Land conversion is the replacement of one form of land cover with another through agricultural expansion and deforestation (Worku et al., 2021). Changes in land-use and cover are subjective

to a number of human-induced factors, like demographic pressure, technological advancement and economic conditions (Assede et al., 2023). Extensive environmental impacts of these changes are loss of biodiversity, soil degradation and water contamination that endanger food security and vulnerability of the mountainous regions (Muluneh, 2021). Social, economic and environmental factors are the main drivers of the continuous change in land-use and cover (Dibaba et al., 2020). Agro-biodiversity, soil fertility and sustainability of agricultural practices are all negatively affected by the conversion of natural grasslands and vegetation into farmland due to increasing demand for agricultural production (Khan et al., 2022; Maskel et al., 2023).

Change in (LULC) is linked with significant detrimental effects on ecosystem at local, regional, and global level (Sun et al., 2023). The effects of these changes also include high levels of air, water and soil pollution (Emenike et al., 2020). As the land shifts from natural state to intense practice of agriculture and livestock grazing, the biodiversity is decreased (Filazzola et al., 2020). Significant change in (LULC) has had a negative impact on rural livelihoods in Pakistan (Anwar et al., 2024). Consequently, the agriculture expands to the marginal areas due to high population pressures and resource depletion (Ahmadzai et al., 2021).

The term "livelihood" refers to the means by which people and households make a living to satisfy their financial demands and taking advantage of new opportunities (Yang et al., 2021). The human activities determine the living standards attained by households (Jabeen et al., 2020). The resources those are necessary for livelihoods include, workforce as its human capital (Habib at al., 2023). Social capital defines the networks, trust and cooperation that promote cooperation and group activity within a society (Wulandhar et al., 2022). Additionally, financial capital includes income and other financial resources (Jahanger at al., 2022). The foundation for economic activities and production is provided by physical capital, in terms of tools, equipments, and infrastructure (Usman & Wirawan, 2021). Natural capital covers the natural resources and services that sustain life and economic systems such as land, water and forests (Meraj et al., 2021). People and land are interdependent natural resources that are pivotal for sustainable development (Eisenmenger, 2020). Both the human survival and wellbeing of terrestrial ecosystem depend on land and its resources (Liu et al., 2022). Although land is a limited,

immovable and fixed resource but socio-economic and environmental factors continuously influence how land is managed and used (Shijitha, 2021).

2. Study Area

Upper Swat (Tehsil Bahrain) is often referred to as Swat-Kohistan, is an administrative subdivision of District Swat, Khyber Pakhtunkhwa. Upper Swat is the northern region of Swat valley that starts at a distance of (60) kilometres from the city of Mingora. The name Bahrain is of Arabian origin, which means "two rivers" due to its proximity to the confluence of the Swat and Daral Rivers. It is located in the foothills of the Hindu Kush Mountain Ranges, with the Ghizer District of Gilgit-Baltistan to the northeast, the District Chitral to the northwest, the Kandia Valley of Swat-Kohistan to the east, and the Upper Dir, Thal and Lamutai to the west. The tehsil is primarily traversed by the River Swat. Rainfall in this semi-arid temperate zone ranges from 450 to 700 mm per year. Tehsil Bahrain is 2899 square kilometres in size and stretches from 35° 3′ 56" to 35° 54′ 14" North latitude and 72 ° 12′ 29 “to 72° 47′ 2” East longitudes (GoP, 2018). Geographically, Madyan, Bahrain, and Kalam are its three sub-valleys.

Combined mountain agriculture, tourism, fishing, and forest resource utilization are the major source of income for the people of Upper Swat (Khan & Khan, 2009; Sabir, 2014). The uneven terrain has led the farmers to use terracing agriculture techniques (MBA et al., 2022). Additionally, the inhabitants depend on several sources of income to support themselves (Sabir, 2014). Since 1993, the main source of livelihood for many households was a practice mountain agriculture and animal husbandry (Nasir et al., 2024).

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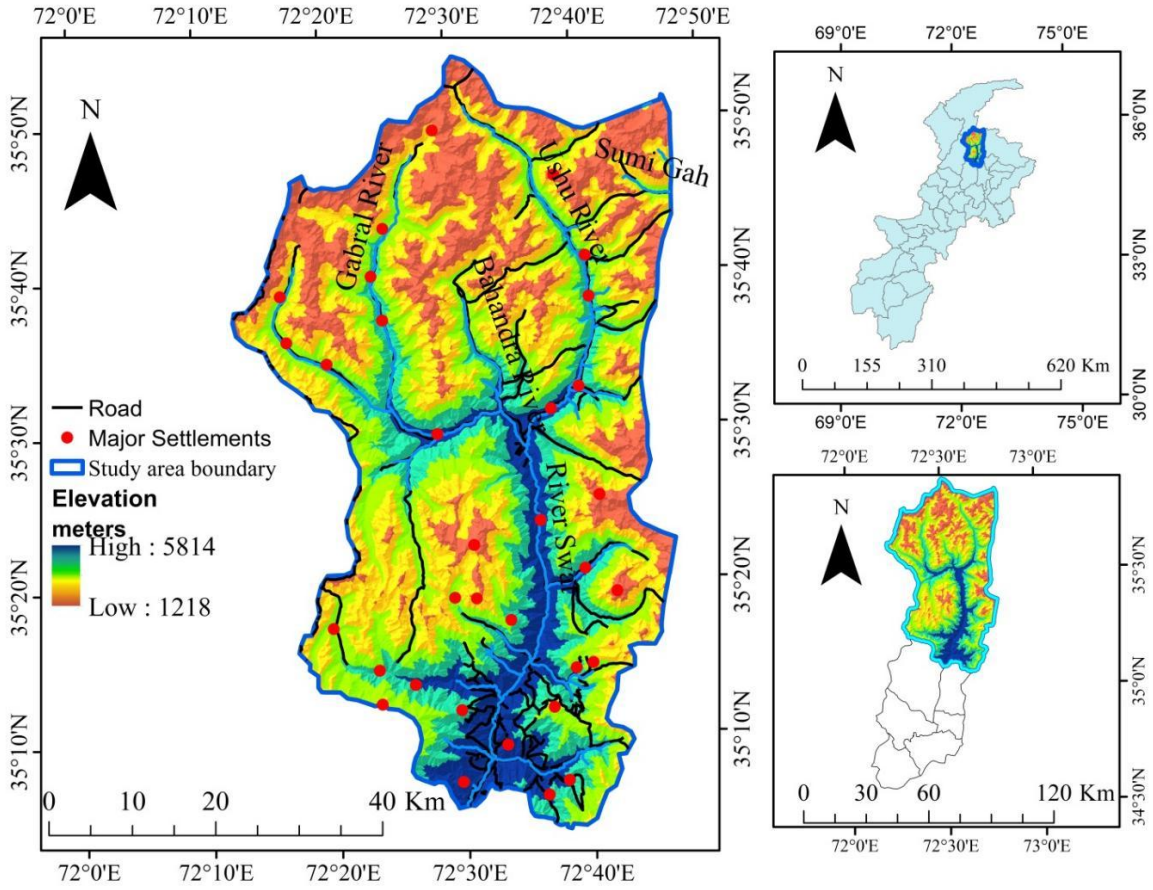

Fig 1. Location of the Study Area

3. Methodology

The mixed- method approach was used to investigate the impact of LULC change on rural livelihood in Upper Swat. In the villages of Madyan, Bahrain, and Kalam, field surveys, observations, interviews and questionnaires were used to collect primary data. To identify spatial changes, satellite images of 1993 and 2023 were classified using supervised methods into five main categories: agriculture, built-up areas, forests, water and barren land. Map accuracy was enhanced by post-classification improvement and local expertise. Furthermore, the socio-economic variables were collected via questionnaires and interviews.

3.1 Field Survey

To examine the impact of change in Land Use/Land Cover (LULC) in Upper Swat a mixed approach of combining both primary and secondary data has been used. A cross-sectional field survey is conducted to collect primary data, employing triangulation using various techniques such as field observations, interviews, questionnaires and satellite image interpretation. The villages of Upper Swat namely, Madyan, Bahrain and Kalam have been selected where these techniques are combined to get a detailed insight of LULC change and livelihood (Fig. 1).

3.2 Acquisition of Satellite Images:

To examine the spatio-temporal change in land use and land cover (LULC) within the study area, satellite images were collected between 1993 and 2023. The (LULCC) map was extracted from Landsat-5 image of 1993 with a spatial resolution of 60 meters, while the (LULCC) map of 2023 was extracted from Landsat 8-9 images with a spatial resolution of 30 meters. Multi-temporal change detection was performed using cloud-free Landsat pictures (Landsat 5-TM and Landsat-8/9) from 1993 and 2023. The USGS Earth Resource Observation System (http://glovis.usgs.gov) provided the data.

3.3 Pre-processing and classifications

To combine the obtained data with biophysical phenomena, the pre-processing of satellite images is needed prior to change detection analysis (Attri et al., 2015). Satellite data is subject to per-pixel signature assignment and classification into five classifications based on Digital Number (DN) values: Agriculture, Built-up area, Forest, Water and Barren land. This is prepared to correct the geometric distortion caused by acquisition system and platform motions. The colour coding and distinct identification set these classes apart. The samples are chosen by defining polygons around representative sites for all land use/cover class and obtaining spectral signatures from pixels within these polygons (Nasiri et al., 2022). The maximum likelihood and supervised classification is used to reduce confusion among mapped land covers.

Post-classification refinement was used to increase the simplicity and efficacy, as well as to reduce misclassifications and increase accuracy (Zhao et al., 2022). The issue of mixed pixels was handled by visual interpretation. This interpretation significantly enhanced the quality and accuracy of the land use/cover map by refining the results. This refining was also aided by indigenous knowledge and referenced data.

3.4 Analysis of Socio-economic Factors

The socio-economic analysis of the study examines how change in Land Use/Land Cover (LULC) affects livelihood by integrating qualitative and quantitative research techniques. Closed-ended questions were used to collect quantitative data, whereas interviews with heads of households are used to obtain qualitative data.

4. Results and Discussion

This section presents the results that use geospatial approaches to understand the patterns in LULC change within the study area. Five livelihood capitals, each consisting of a distinct set of characteristics, were used to analyse important socioeconomic data pertaining to livelihood interventions. Additionally, graphical representations of the findings of the shift in livelihood activities are provided.

4.1 Land-use and Land-cover in 1993

In 1993, the land-use of Upper Swat was dominated by rangelands, which made up 294,166 acres (41%). The barren land occupied 198,759 acres (27.7%) of the total. The snow-covered area was 93,049 acres (13%), and the forest accounts for 106,536 acres (14.8%). Relatively agricultural land and water bodies made up 17,038 acres (2.3%) and 5,808 acres (0.8%) respectively. The settlement has occupied very little percentage of 1,370 (0.2%) of the land. A total of 716,726 acres of land was examined.

The profusion of rangelands and barren lands in Upper Swat reveals the rough terrain and harsh climatic conditions, which limit agricultural activities and human settlements. However, the extensive forests and the presence of water bodies highlight the ecological value of the region. It sustains biodiversity and offers essential ecosystem services. This balance between natural and human-dominated landscape highlights the need for sustainable land use practices that ensure the long term sustainability and distinctive ecology that support the livelihood of inhabitants.

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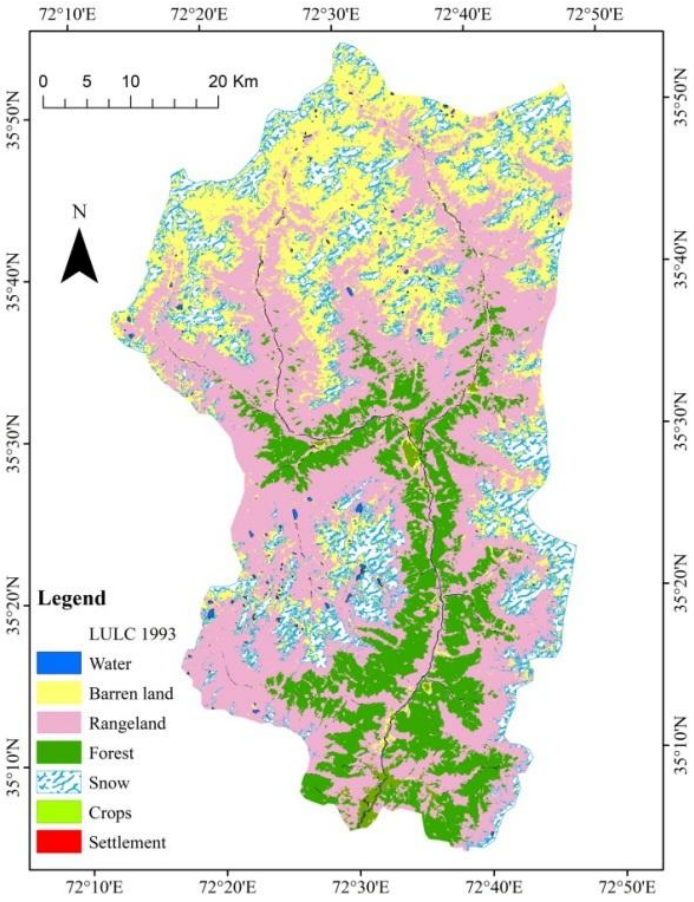
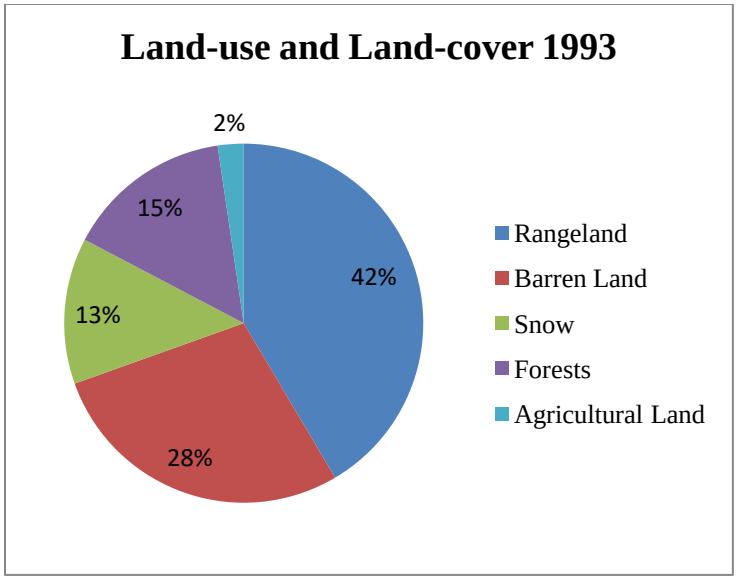


Source: Landsat-5 Image, 1993

Fig. 2: Upper Swat, Land-use and Land-cover, 1993



Source: Extracted from Landsat-5 Image, 1993

Fig. 3: Upper Swat, Land-use and Land-cover, 1993

Table 1: Upper Swat, Land-use and Land-Cover, 1993

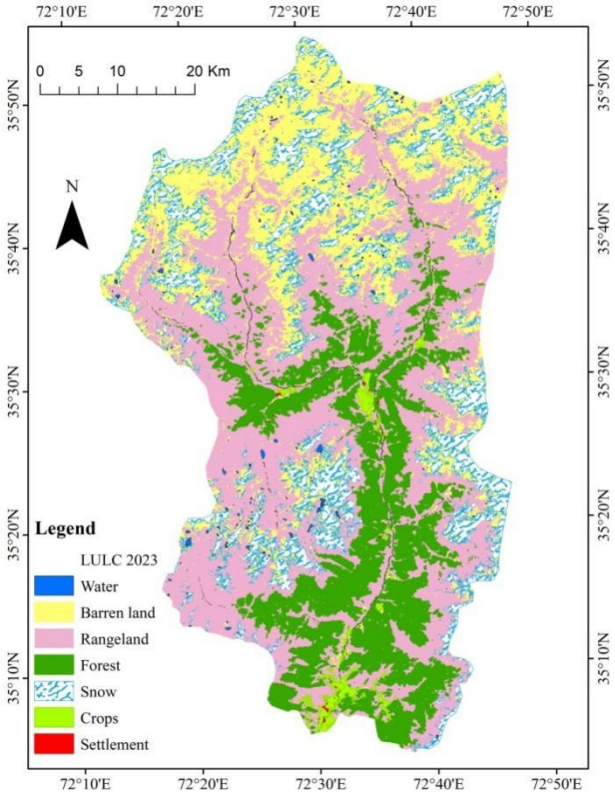
Category	Area (acres)	Percentage (%)	Spatial Distribution
Rangeland	294,166	41.0	Widespread, dominant
Barren Land	198,759	27.7	Scattered, fragmented
Snow	93,049	13.0	High-elevation areas
Water bodies	5,808	0.8	Rivers, streams, lakes
Forests	106,536	14.8	Mountainous regions
Agricultural Land	17,038	2.3	Valley bottoms, plains
Settlements	1,370	0.2	Scattered, rural
Total	**716,726**	**100**	
Source: Extracted from Lansat-5 Image, 1993			

4.2 Land-use and Land-cover in 2023

In 2023, change in land-use and cover of Upper Swat was dominated by rangelands accounting for 242,380 acres (33.8%) of the total area. In addition, barren land accounts for 139,630 acres (19.5%). The volume of land occupied by forests was 168,872 acres (23.6%). The snow covered area was 104,855 acres (14.6%). The water bodies were 5,019 acres (0.7%). The agricultural has occupied 49,873 acres (6.9%). The growth of settlements was 6,097 acres (0.9%).

The shifting LULC also underlines that how ecosystem and human activities are related. The continuous rise in agricultural land and decrease in barren land specify that previously the uncultivated areas are being farmed that improved local food production and economic stability.

The increase in forests is a sign of efforts to restore natural habitats that lower the risk of soil erosion and floods. This also promotes biodiversity and regulates local climate conditions. Despite, the settlement growth is moderate that indicate increasing population pressures that put a pressure on natural resources.



Source: Landsat-8/9 Image, 2023

Fig. 4: Upper Swat, Land-use and Land-cover, 2023

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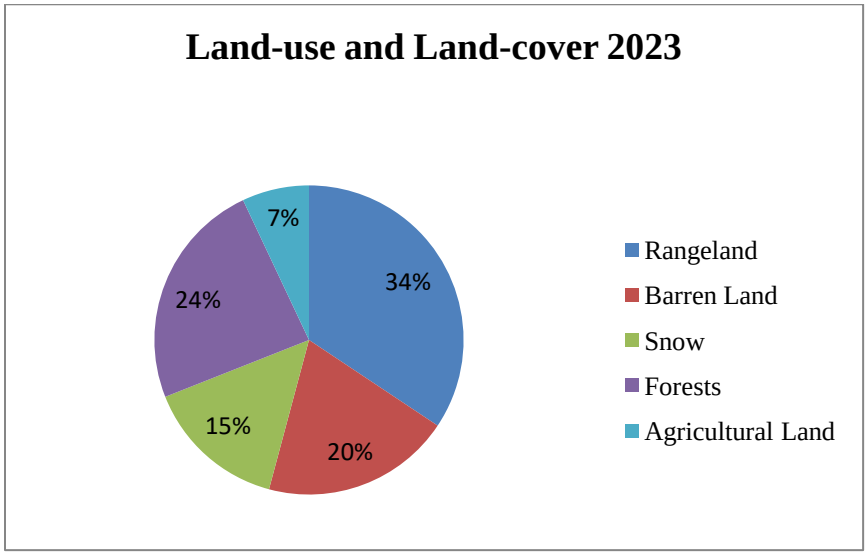

Source: Extracted from Landsat-8/9 Image, 2023

Fig. 5: Upper Swat, Land-use and Land-cover, 2023

Table 2: Upper Swat, Land-use and Land-cover, 2023

Category	Area (acres)	Percentage (%)	Spatial Distribution
Rangeland	242,380	33.8	Widespread, dominant
Barren Land	139,630	19.5	Scattered, fragmented
Snow	104,855	14.6	High-elevation areas
Water bodies	5,019	0.7	Rivers, streams, lakes
Forests	168,872	23.6	Mountainous regions
Agricultural Land	49,873	6.9	Valley bottoms, plains
Settlements	6,097	0.9	Scattered, rural

Category	Area (acres)	Percentage (%)	Spatial Distribution
Total	**716,726**	**100**	
Extracted from Lansat-8/9 Image, 2023			

4.3 Land-use Land- Cover Change

According to LULC maps, from 1993 to 2023, the distribution of land use in the area has significantly changed. The barren land decreased from 27.7% to 19.5%, rangeland declined from 41% to 33.8%. The percentage of snow increased a little from 13% to 14.6%. The land covered by forests increased significantly, from 14.8% to 23.6%. The agricultural land has increased expressively from 2.3% to 6.9%, indicating a stronger focus on mountain farming. The aquatic bodies somewhat decreased from 0.8% to 0.7% and the settlements increased from 0.2% to 0.9%, suggesting population growth.

5. Conclusion

Changes in land- use land-cover in Upper Swat between 1993 and 2023 have significantly impacted mountain agriculture and rural livelihood. The loss of rangeland threatens the food security of pastoral communities who rely on grazing for livestock. Meanwhile, reduced barren land has increased local resource availability, though a slight decrease in water bodies limits access to water for irrigation and fishing. The rise in forest cover boosts ecotourism potential and supports sustainable forestry, while settlement expansion reflects a growing population that places pressure on resources and infrastructure. The notable increase in agricultural land indicates a stronger focus on mountain agriculture, which improves food production and economic stability, though sustainable practices are essential to prevent soil

degradation. These changes also encourage community involvement in regional farming, strengthening food sovereignty, resilience, and opportunities for crop diversification and infrastructure improvements.

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