Assessment of Ecosystem Services by using Decision Tree Approach in the Leimatak River Basin, North East India

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Abstract
Leimatak River basin is witness a degrading trend of watershed ecosystem since 1988 after the agreement signed between the government of Manipur and NHPC for the construction of Loktak Downstream Hydroelectric Project. Many people are migrating in this basin mainly the workers and neighboring villagers in search of developmental programme but there is slow progress in the construction of project. As result, they heavily depend on the environment which have much impact on the ecosystem, now it need a proper watershed management to save the region from the future disaster. Assessment of ecosystem services and the factors that threaten them is an important first step to support watershed management. In this present paper, decision tree approach has been adopted to assess protection, biodiversity, and production services of ecosystem in the study area.
Keywords: watershed, ecosystem, decision tree, biodiversity

Introduction

The ecosystem services and the natural capital stocks that produce them are critical to the functioning of the Earth's life-supporting system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. However, these services are not recognized fully by human societies. The economic valuation of ecosystem service is becoming an effective way to understand the multiple benefits provided by them (Zhongwei Guo , Xiangming Xiao , Yaling Gan , Yuejun Zheng 2001). Assessment of ecosystem services is the first and foremost task for the management and identification of watershed problems. Watershed problems can be estimated base on the ecosystem services such as protection, biodiversity and production. If the level of these three indicators are very low the region has acute problems which need proper management before disaster occur. So in order to estimate the ecosystem services, decision tree method proved to be a suitable and flexible tool for highlighting those areas that need more in-depth research, and for guiding watershed and ecosystem management. Base on the field observation, the study area, Leimatak river basin (554 Sq.km), which is upper catchment area of Irang river, tributary of Barak in North East India has witness a rapid degrading in ecosystem which generated from the haphazard land use system after the formulation of Loktak Downstream Hydroelectric Project. The area has witness a rapid growth of population since 1988 after the agreement signed between the government of Manipur and National Hydroelectric Power Corporation (NHPC) for the construction of Loktak Downstream Hydroelectric Project due to the immigrant of laborers and neighboring villager with the prospects of project related facilities. But there is very slow progress in the construction of project which force the absorbing population to depend on the environment which has much impact on the ecosystem.

Besides, newly troubles has been emerge presently due to construction of Loktak downstream hydroelectricity project by the Government of Manipur. According to the proposed plan, the project envisages construction of 28 meter high barrage and an install capacity of 66 MW (CISMHE, 2011). The constructing Loktak downstream hydroelectricity project which is suppose to harnessing power potential water from Leimatak river and tailrace release of existing Loktak hydroelectric project which is located 23 km upstream from the proposed project which has much impact on the existing land use. The project would affect nearly 211.57 hectares of land including settlement, terrace and shifting cultivation area. Again the project authority proposed a difference catchment area treatment programmes which are new to the local people. Now the effected villagers are dilemma to select a site for new establishment of difference land use such as for settlement, horticulture, shifting cultivation etc, this new establishment will also a lot impacts on the natural functioning of ecosystem. Hence in order to mitigate the project related and earlier existing watershed problems, assessment of ecosystem services will help to identify those area that need more in-depth research and protection which will help in watershed management programme.

In the study area, Leimatak watershed, the author discerned three main ecosystem services that are considered important for integrated watershed resources management: i) ecological protection, referring to the regulation of water supply and soil protection; ii) biodiversity maintenance, referring to the number of species; and iii) the production function, encompassing all tangible products from both forest and agricultural ecosystems (Chongyun Wang, Peter van der Meer, Mingchun Peng, Wim Douven, Rudi Hessel and Chenlin Dang, 2009).

Study Area

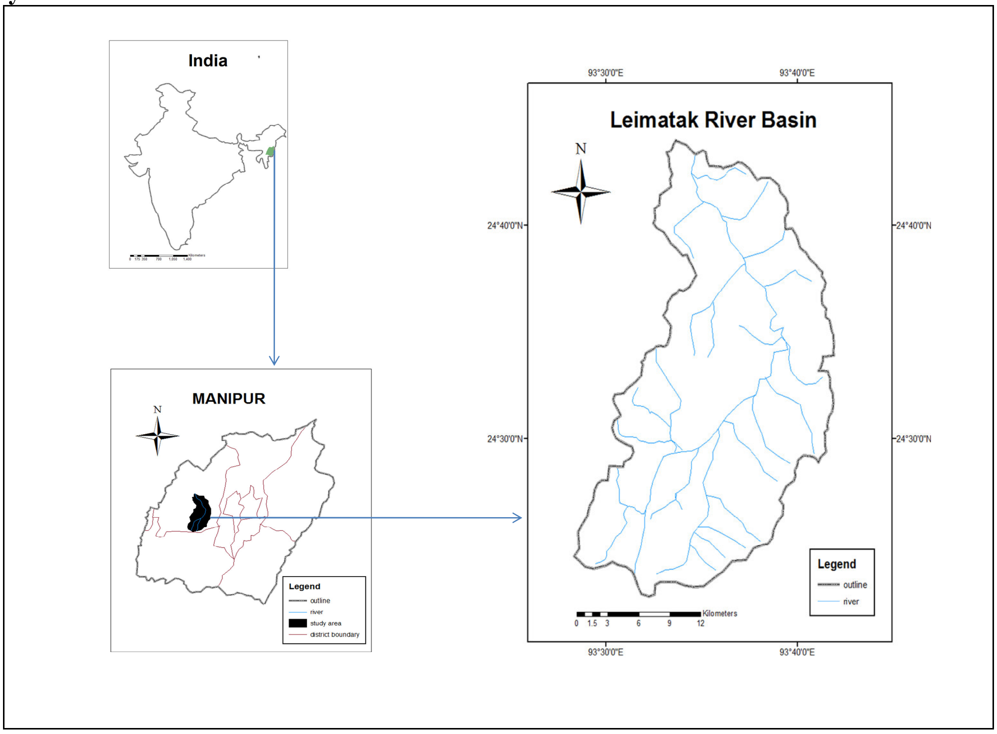

Fig 1 Location Map

Objectives

i) To study the physical and cultural factors affecting the functioning of ecosystem

ii) To assess the ecosystem services

Materials and Methods

For the assessment of ecosystem services, land use and vegetation cover, terrain and slope condition and types of soil are considered as a prime parameters. Land use and land cover mapping was carried out by using standard methods of multi-dated remotely sensed data followed by ground truth and interpretation. Digital image processing and classification of these satellite imageries and the analysis of interpreted maps were carried out by using Arc View 9.2. Soil resource mapping of project area was done from the basic data/ map of soil classification prepared by the National Bureau of Soil Survey and Land Use Planning, (Indian Council of Agriculture Research), Regional Centre, New Delhi (NBSS Publ. 56b, 1996). Spatial database on physiographic features were taken from various sources including Survey of India (SOI) topographic sheets, satellite data and analyzed with Geographic Information System (GIS) tools. A slope model for entire catchment was generated from the contours of Survey of India topographical sheets at 1:50,000 scale, following 20 m contour interval. The contours were traced from the toposheets, scanned and digitized using Arc View 9.2. After acquiring all the information, these three map were used as an input the Decision Tree(DT), after which the values of the three ecosystem functions were calculated in the GIS environment.

Land Use and Vegetation Cover

The knowledge of land use/ land cover is important for planning and management of activities and is an essential tool for modeling and understanding of the Earth feature system. Land use is defined as any human activity or economic related processes associated with a specific piece of land, while the term Land-cover relates to the type of feature present on the surface of the Earth (Lillesand & Kiefer, 2000). Land use and land cover are often used interchangeably however land use is a description of how people use the land and land cover is the actual discretion of land viz.forest water, pasture etc. Land cover/ Land use map shows the spatial distribution of identifiable Earth surface features and provides information regarding description of a given area. Land cover classification or Image classification is the process used to produce thematic maps from satellite imagery. The use of Panchromatic and medium-scale aerial photographs to map land use is an accepted practice since the 1940s. More recently, small-scale aerial photographs and satellite images are being utilized and enhanced for land-use and land-cover mapping. National Aeronautical and Space Administration (NASA) of

USA has made most significant contributions in development of satellite based remote sensing techniques. Since 1972, after the Landsat–1 was launched, remote sensing technology and its application has undergone a tremendous change in terms of sensing development, aerial flights with improved sensors, satellite design development and operations including data reception, processing, interpretation, and utilization of satellite images. All these advancement have widened the applicability of remotely sensed data in various areas, like forest cover, vegetation type mapping, and land cover changes on a regional scale. If this remotely sensed data is judiciously used along with the sufficient ground data, it is possible to develop detailed forest inventories, monitoring of land use and vegetation cover at various scales. The present work is an attempt to make land use and land cover map for Leimatak River Basin.

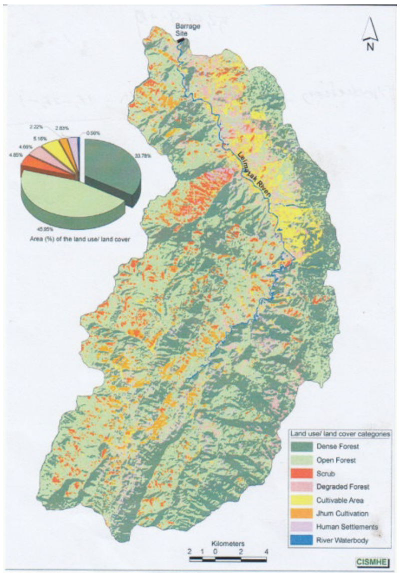

Fig 2: Land Use Map of Leimatak River Basin,2011

Table 1: Area under different land use/ land cover categories in the Leimatak River Basin

Land use/ land cover	**Area (Ha)**	**Percentage**
Dense Forest	18,529.74	33.78
Open Forest	25,208.47	45.95
Scrub	2,658.17	4.85
Degraded	2,553.96	4.66
Cultivated Area	2,830.97	5.16
Jhum	1,217.40	2.22
Settlement	1,551.83	2.83
River	308.90	0.56
Total	**54,859.44**	

The total catchment area of the proposed project up to the barrage site is about 54859.44 ha.The catchment area includes Leimatak river and its major tributaries like the Tuipin Lui, Talai Lui and Nabil Lui, etc. The land use/land cover of the catchment area consists of 8 categories (Table 1and Fig.1), out of which the maximum area of about 25208.47 ha is under open forest lands. Dense forest covers 33.78% of land, scrub and degraded forest are about 9.51% (4.85% and 4.66%) of the total catchment area. Human settlements and cultivation land covers contribute 10.21% in the catchment and river/ water body contribute about 308.90 ha of the total catchment area.

Terrain and Slope Condition

In the present study, various physiographic parameters were analyzed through remote sensing and GIS techniques. A database of different aspects was formulated for Leimtak river catchment. Secondary sources like Survey of India (SOI) toposheets and satellite data were utilized in preparation of different thematic maps. Analysis and interpretation of this spatial database were achieved by using GIS techniques. The results were cross checked by field surveys for ground truth collection. The outcome of this study has been discussed in the following sections.

Physiographically, the area is hilly and rugged mountainous terrain with narrow intermontane valleys.

The tract forms a part of tertiary mountains and comprise of high hills with varying altitude. These tightly folded hills constitute parts of Barail, Manipur and Lushai hill ranges. The ridges have sharp summits and steep slopes. The hills are running northeast to south east in general.

The slope has a great influence on the soil and water loss from the area and influences the land use capacity. The percentage of slope determines the erosion susceptible of the soil depending on its nature. The slope model for Leimatak River Basin area was generated from the contours of Survey of India toposheets at 1:50,000 scale following a 20 m contour interval. The toposheets were scanned and the contours were digitized using Arc GIS 9.2

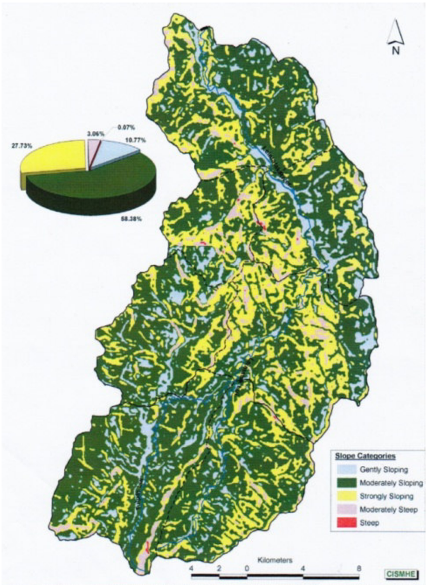

Fig 3: Slope Map of Leimatak River Basin

Table 2: Slope class with area in hectare and per cent of Leimatak River Basin

Slope Class	Degree	Area (Ha)	Per Cent
Gently Sloping	> 10	3373.88	6.15
Moderately Sloping	10-15	25177.57	45.89
Strongly Sloping	15- 20	21066.69	38.40
Moderately Steep	20-25	4869.82	8.88
Steep	25-30	367.48	0.67
Very Step	30-35	3.99	0.01

The Catchment area of Leimatak River has a total area of 54859.44 hectares. The same was divided into six slope classes. As indicated in the map (Fig. 3) and Table 2, moderately sloping and strongly sloping classes are dominant in the catchment area. The moderately sloping class accounts for the largest area coverage in the catchment and this slope class accounts for 25177.57 hectares of land i.e., 45.89% of the total area of the catchment. It is prevalently spread along the banks of Tuipin lui and on the right bank of Leimatak river before the barrage site. The second prominent slope class in the catchment area is strongly sloping class, which covers an area of 21066.69 ha of land i.e. 38.40% of the total catchment area. Strongly sloping class is proportionately spread over the entire catchment but is prevalent on the right and left bank of the Leimatak river, after the confluence of Tuipin Lui and Talai Lui. Other slope classes accounts for less area as compared to former two classes. Moderately steep covers an area of 4869.82 ha i.e., 8.88% of the total catchment area. This slope class is prevalent along the higher reaches of Nabil Lui, Salbol Lui and Tingpi Lui streams on the right bank of the Leimatak river and along the higher reaches of Pakol Lui, Thop Lui and Simui Lui along the left bank of Leimatak river. Gently sloping class has an area of 3373.88 ha which is 6.15% of the total catchment and is typically prevalent along the tributary valleys of Leimatak river and the main channel but is spatially spread on the either banks of Leimatak river from Khengjang village to barrage site. The other two slope classes are very sparsely distributed with areas of 367.48 ha and 3.99 ha for steep and very steep class, respectively. Both the classes accounts for 0.68% of the total catchment area

Soil

Soil is a structurally complex habitat of enormously diverse microbial community and million of complex biochemical transformations, which is important for primary production.Besides biological properties, its physical and chemical characteristics also affect ecosystems. Soils of the catchment have been developed largely on shale and to some extent on sandstones. The high rainfall coupled with high temperatures are responsible for deep weathering of rocks. The soils have formed *in situ* except at the foothills and near water courses. Due to varied terrain, the soil depth is variable and is susceptible to erosion due to steep slopes and high runoff in the catchment. The total catchment area of Loktak downstream HE project is 54859.44 ha. Five Soil types were delineated in the catchment area from the soil map of Manipur.

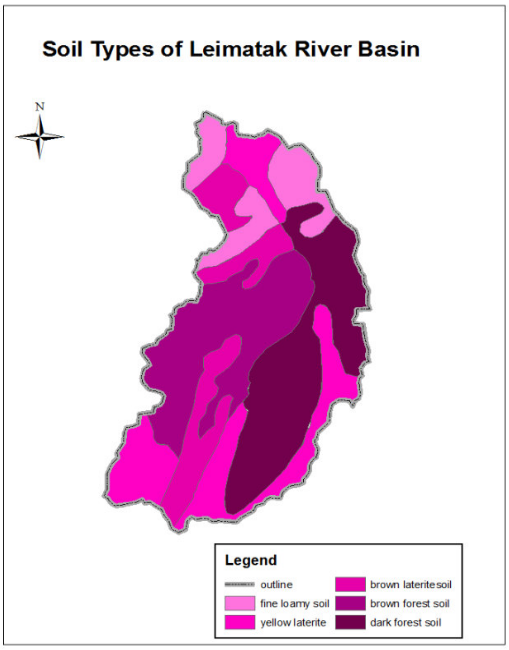

Fig 4 :

Table 3: Various soil associations in the catchment area of Leimatak River Basin

Soil types	**Area in hectares**	**Percentage**
Fine loamy soil	6735.6	12.2
Yellow laterite	11803.95	21.5
Brown laterite	8027.88	14.6
Brown forest soil	13331.43	24.3
Dark forest soil	14935.7	27.2
Total	54859.44	

Decision Tree Approach

A decision tree can be used as a model for a sequential decision problems under uncertainty. A decision tree describes graphically the decisions to be made, the events that may occur, and the outcomes associated with combinations of decisions and events. Probabilities are assigned to the events, and values are determined for each outcome. A major goal of the analysis is to determine the best decisions (Padraic G. Neville,1999). Decision Tree (DT) is a search space made up of a sequence of nodes and branches. The nodes represent question points, which are embodied in rules of the following form: if something is true, then draw a conclusion or take action. Which branch to follow depends on the answer to the particular question. The leaf nodes are the solutions, which are different ecosystem services in this case.

Table 1: Decision tree rule for the effect of slope, cover and soil types classes on the value of three ecosystem function

Ecosystem services	Physical factors	Effect on ecosystem function value
Protection	slope	< 15= no effect;15-25 = -1; 25-35= -2
	cover	High(dense and open forest)= +1; Low (degraded and scrub forest) =no effect; None (settlement, cultivation and river = -1
	soil	Dark and brown forest soil= +1; brown and yellow laterite and fine loamy soil= no effect
Biodiversity	slope	< 15= no effect;15-35 = no effect
	cover	High(dense and open forest)= +1; Low (degraded and scrub forest) =no effect, None (settlement, cultivation and river = -1
	soil	Dark and brown forest soil= +1; brown and yellow laterite and fine loamy soil= no effect
Production	slope	< 15= no effect;15-25 = no effect ; 25-35= -1
	cover	High(dense and open forest)= +1; Low (degraded and scrub forest) =no effect, None (settlement, cultivation and river = -1
	soil	Dark and brown forest soil= +1; brown and yellow laterite and fine loamy soil= no effect

The DT was built by estimating how slope angle, soil type, and cover percentage would affect ecosystem function performance. We adopted a three-point interval scale: negative effect, 1; no effect, 0; and positive effect, +1. For instance, evergreen broad-leaved forest may, in itself, perform very well in terms of its protection function, but when the cover is lower than usual, or when the forest is situated on a very steep slope, the ecosystem's protection function performance may be reduced (?1). Three slope gradient classes were adopted by grouping the six classes of slope angles, namely, moderate slope (<15?), steep slope (15? to 25?), and very steep slope (>25?). Soil erosion during rainfall is strongly affected by surface runoff and slope steepness. Sediment concentration in the runoff and infiltration rates normally increases with slope gradient , so that steeper slopes mean less protection. Usually, the forest productivity of a site increases as one moves downhill because trees may utilize more water and the nutrients carried with it . On average, primary productivity increases asymptotically with the original biodiversity of a community , and the average aboveground biomass decreases with loss of species . However, landform features besides slope may determine factors such as solar radiation and soil wetness, which also contribute to productivity . So slope angle effects on biodiversity are vague, and therefore assumed that they were zero.

Five soil types were identified: Dark and brown forest soil, brown and yellow laterite and fine loamy soil. These five soil types are different in soil organic carbon (SOC) content, which is a key parameter for measuring soil quality. There is a close relationship between the SOC content and many soil properties and functions, such as soil porosity, water-holding capacity, nutrient availability, soil biodiversity, and soil structural stability . Protection, biodiversity, and production are all higher on richer soil types(Chongyun Wang, Peter van der Meer, Mingchun Peng, Wim Douven, Rudi Hessel and Chenlin Dang, 2009). Three maps were used as inputs in the DT: i) a vegetation and land use map, based on remote sensing imagery ii) a slope map; and iii) a soil map (three classes). The values of the three ecosystem functions were calculated base on the scores obtained in the three parameters and analyzed on Arc GIS 9.2.

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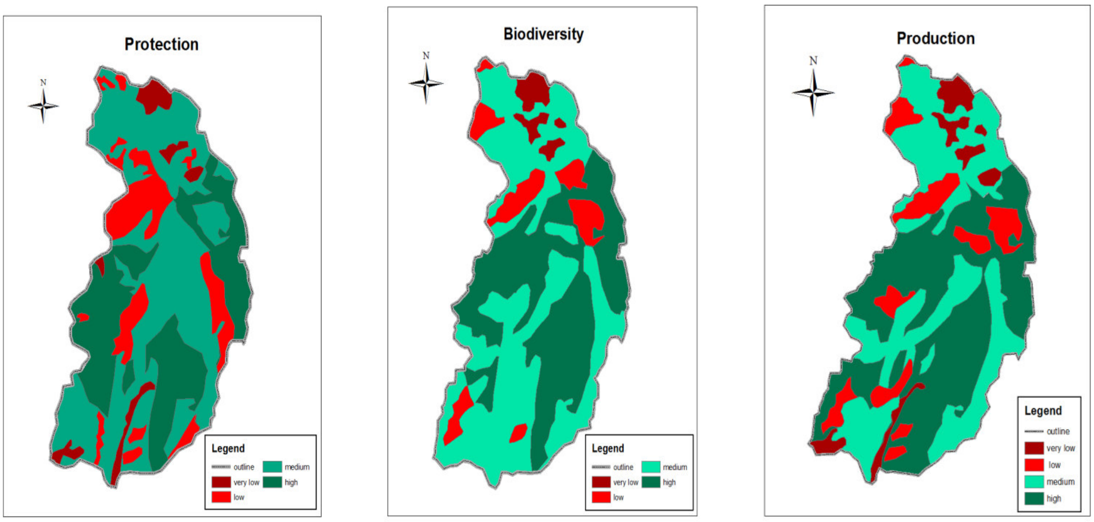

Fig 5: Ecosystem services of the Leimatak River Basin

Ecosystem Services Analysis

From the above three ecosystem services, protection, biodiversity and production, it is clearly indicated that natural ecosystem service has been disturbed by the human intrusion and it is also proof that there is great impacts of hydropower project on the ecosystem. Three of the services are found to be lower in northern and southern parts of the study area. The lowest ecosystem services which scattered in the northern part are found to be coincided with the Loktak downstream power project area. Although the lowest zone are poor in soil quality but it was the highest ecosystem service area prior to 1988 because these areas served as a buffer zone among the villages and remain as an undisturbed area. But after the agreement signed between the government of Manipur and NHPC in 1988 for the construction of Loktak downstream project, many people are migrated in this area mainly the laborers and surrounding villagers with the prospect of project related developmental facilities. Unfortunately government play a delaying strategies to reduce the compensation claimed by the local people and went about two decade without proper constructional work, this force the absorbing population to depend on the surrounding environment for their survival which have much impact on the forest ecosystem.

Southern part of the study area also found to lower in three case of ecosystem services, because the region has witness an unnatural growth of population around 1980s due the construction of Loktak Hydro Power Project but government could not provide facilities to each and every individual, hence the absorbing project related population depend their life on the natural environment which have much impacts on the functioning of ecosystem beyond the replaceable rate. But it is found to be highest ecosystem services in protection, biodiversity, and production in central and central periphery of the study area where there is high fertile soil of black and brown forest soil, moderate gentle sloping, thick canopy and far away from the road connectivity.

From the above discussion, it came to understand that, the function of the ecosystem is deeply disturbed by the human activities which is proof in certain area where there is fertile soil, good slope condition but low in the ecosystem services because of the haphazard land use system. It is clearly indicated from the three ecosystem services map, two Hydro Project, Loktak and Loktak Downstream Projects are considered to be the threshold of the ecological imbalance and degradation. If the present trend is allow the local people to infest the natural environment, the study area will face ecological disaster in the form of landslide, flash flood, extinction of valuable fauna and flora, reducing of ground water level which will ultimately threatening the life system. Hence in order to prevent from the future disaster, the project authority should take up proper watershed management programme after identifying the stage of ecosystem services in the area. It is also urgent need to take up public awareness programme about environment and ecosystem and formulate a systematic land use system and developmental programmes which are base on local color through public active participation. Now the government has formulated difference scientific environment management plan such as biodiversity monitoring plan, catchment area treatment plan, disaster management plan etc., these scientific management techniques are new to the local people. Most of the governmental planning programme are failed due to non-participation of local people. Hence the present aim of this paper is to identify the threshold of environment degradation, demarcating the difference zone base on ecosystem services and planning process should be formulated pedestal on environment and ecosystem through active affected people participation

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