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Full Length Research Paper

Spatio-temporal Dynamics of Wetlands and their Effects on Biodiversity in Dinsho District, Bale Mountain Eco-Region, Southeastern Ethiopia

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Abstract

Wetlands are ecologically significant ecosystems that provide a wide range of environmental, economic, and social services, including biodiversity conservation, water purification, and livelihood support. Despite their value, wetlands have undergone substantial degradation and reduction in both spatial extent and ecological function, particularly in developing regions. This study analyzes the spatiotemporal dynamics of wetlands and explores the major drivers of change, and the ecological consequences of wetland biodiversity in Dinsho District Bale Zone, Southeastern Ethiopia. ERDAS IMAGINE 2015 was used to explore multi-temporal Landsat satellite imagery from 1990, 2000, 2010, and 2020 to analyze trends in wetland land cover over 30 years. Apart from the remote sensing data, qualitative and quantitative data were gathered from household surveys, key informant interviews, focus group discussions, and direct field observations. Socioeconomic data were processed using SPSS version 20. The results indicated a major decline in wetland cover, from 10,934.25 hectares (16.88%) in 1990 to 6,090.79 hectares (10.19%) in 2020, with a total loss of 4,843.46 hectares (7.48%). Agricultural land expansion, overgrazing, sediment deposition, and climate variability drive these changes. Misconceptions of wetlands as marginal or unproductive land have contributed to their conversion for farming and grazing. This wetland habitat decline has resulted in a significant loss of biodiversity and the disappearance of endemic water bird species and indigenous vegetation. The study highlights the pressing need for integrated wetland management and stakeholder involvement to redress further ecological degradation and promote sustainable resource utilization.

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1. Introduction

Wetlands are vital ecological systems at the interface of terrestrial and aquatic environments, offering a wide array of ecosystem services essential for ecological sustainability and human well-being. According to Max Finlayson *et al.*(2011), wetlands encompass marshes, swamps, peatlands, and water bodies that are permanent or seasonal and are typically no deeper than six meters. These wetland ecosystems are marked by saturated soils and specific hydrologic regimes that support diverse biological communities(Bhowmik, 2021; Mccartney, 2011). Wetlands contribute significantly to water purification, flood regulation, groundwater recharge, climate regulation through carbon sequestration, and biodiversity conservation worldwide(Jian, 2025; Kingsford *et al*., 2021; Kudumba, 2022; Moomaw et al., 2018). Although wetlands occupy only about 6% of the Earth's surface, their ecological and socioeconomic contributions are disproportionately large, particularly in developing countries where they support millions of livelihoods(Max Finlayson *et al.,* 2011; Omolo *et al.,* 2018; Ramsar Convention on Wetlands, 2018). Among the many globally important wetland systems found in Africa are the Sudd, Niger Delta, and Okavango Delta(Mandishona & Knight, 2022). In Ethiopia, diverse wetland types such as riverine, floodplain, lacustrine, and seasonal arise from the country's varied topography and climate(Fenetahun *et al.,* 2021)(Assefa & Eneyew, 2025). These systems provide crucial provisioning, regulatory, and cultural services, sustaining local agriculture, livestock, and fisheries while acting as drought buffers and biodiversity reservoirs(Abebe *et al.,* 2014; He *et al.,* 2025; Seifollahi-Aghmiuni *et al.,* 2019).

Despite their value, Ethiopian wetlands face increasing threats from land use change, weak governance, and limited public awareness(Assefa & Eneyew, 2025; Dixon *et al.,* 2021; Wondie, 2018). In particular, the expansion of agriculture, unregulated grazing, eucalyptus encroachment, and population pressure have accelerated wetland degradation in ecologically sensitive regions (Assefa & Eneyew, 2025; Mandishona & Knight, 2022; Zekarias *et al.,* 2021). The Dinsho District exemplifies these challenges since wetlands are increasingly exploited for immediate economic benefits in the absence of defined conservation frameworks. The perception of wetlands as "wastelands," combined with precarious land ownership and institutional weaknesses intensifies this deterioration (Assefa & Eneyew, 2025; Zekarias *et al.,* 2021).

Moreover, the lack of consistent, high-resolution, and spatially explicit data on wetland extent and dynamics undermines effective policy design and local conservation efforts(Jian, 2025; Kingsford *et al.,* 2021; Kudumba, 2022; Zekarias *et al.,* 2021) Although national strategies acknowledge wetland significance, implementation remains limited, particularly at the local level where ecosystem services are most directly linked to community resilience. To address these gaps, this study assesses the spatiotemporal dynamics of wetlands in Dinsho District over the past three decades. Using remote sensing techniques, it aims to (i) quantify wetland cover changes, (ii) identify key drivers of wetland conversion, and (iii) evaluate the ecological and socioeconomic consequences of these changes. The findings are intended to support evidence-based policymaking and inform sustainable wetland management and community-based conservation strategies in the Bale Eco-Region and beyond.

2. Materials and methods

2.1 Description of the Study Area

This study was conducted in Dinsho District, located in the southern highlands of Ethiopia. Geographically, the district lies between latitudes 6°53′30"N and 7°15′30"N, and longitudes 39°38′0"E and 39°54′30"E. Dinsho, the administrative center of the district, is situated approximately 30 kilometers from Robe—the zonal capital—and about 400 KM southeast of Addis Ababa. The district covers a total area of 64,768.90 hectares (Figure 1). It is characterized by diverse topography, with elevations ranging from 2,532 to 4,047 meters above mean sea level. The area experiences a bimodal rainfall pattern, with annual precipitation ranging from 1,060 mm to 1,150 mm. The average minimum and maximum annual temperatures are approximately 12.5°C and 15.0°C, respectively. The predominant soil types in the district include Luvisols, Eutric Nitisols, Cambisols, and Lithosols (BZPDO, 2015).

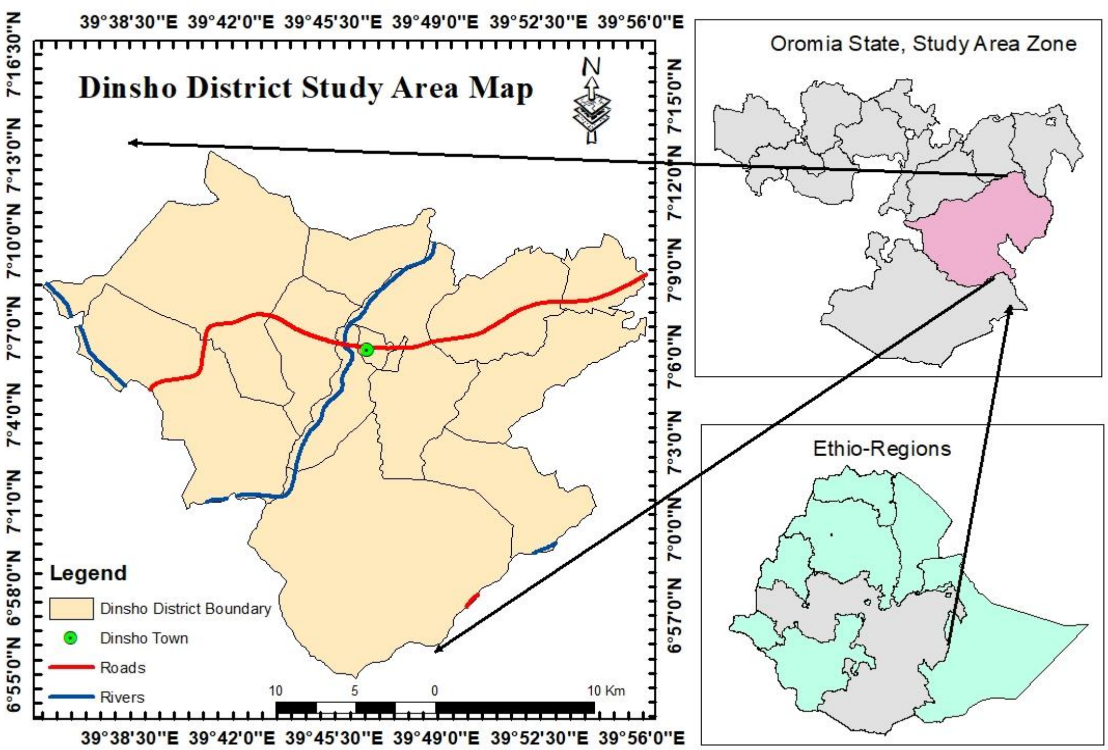

Figure: 1. Location Map of the study area (Ethio-GIS, 2015)

2.2 Methods

2.2.1. Satellite Data Acquisition and Preprocessing

Landsat imagery from 1990 (TM), 2000 (TM), 2010 (ETM+), and 2020 (OLI) was sourced from the United States Geological Survey (USGS) website to detect the past dynamics of land use/land cover (LULC) and wetland change for three decades (1990, 2000, 2010 and 2020). A summary of the satellite data used is presented in Table 1. Complement the remote sensing data, and supplementary socio-economic data-both primary and secondary were gathered from relevant institutions.

Table: 1. Satellite Data Used for LULC Mapping

Image	Sensor	Path	Row	Resolution	Acquisition Date	Source	Application
Landsat 4	TM	167	55	30m	14/01/1990	USGS	LULC
Landsat 5	TM	167	55	30m	14/01/2000	USGS	LULC
Landsat 7	ETM+	167	55	30m	29/01/2010	USGS	LULC
Landsat 8	OLI	167	55	30m	07/01/2020	USGS	LULC

Source: Compiled by the authors from USGS data.

2.2.2. Image Processing and Classification

Image classification was conducted using ERDAS Imagine 15 software, with the aid of 158 ground control points. The nearest neighbor resampling technique was applied to assign new pixel values during geometric correction. A false-color composite was generated by stacking relevant bands. Supervised classification was employed to categorize land cover types, using the Maximum Likelihood Classification (MLC) algorithm, which accounts for class statistics including mean, variance, and covariance (Asokan *et al.,* 2020; Shao *et al.,* 2021). Training samples were selected based on field knowledge and remote sensing interpretation, and their signatures were compiled using the signature editor tool. Classification outputs consisted of six LULC classes: wetland, forest, shrubland, built-up area, farmland, and grassland (Table 2). High-resolution SPOT imagery (via Google Earth), aerial photographs, and topographic maps were used for verification.

Table: 2. LULC Classification Categories

LULC Type	Description
Wetland	Vegetated areas with permanent or seasonal water presence near or above the land surface
Built-up Area	Regions characterized by concentrated human settlements, infrastructure, and construction
Farmland	Cultivated land, including fallow areas and rural homesteads
Forest	Densely wooded areas with 70–100% canopy closure
Shrubland	Areas dominated by scattered shrubs, thorny bushes, and low vegetation
Grassland	Grass-dominated zones, typically used for grazing on slopes, ridges, or plains

2.2.3. LULC Change Detection

Temporal changes in LULC were analyzed using a post-classification comparison approach. Each year's classified map was independently prepared and analyzed using ERDAS IMAGINE 15. The absolute and relative changes for each LULC class were computed between time intervals (1990–2000, 2000–2010, 2010–2020, and overall 1990–2020). The LULC change matrix was generated to quantify class transitions. Image differencing methods (Lillesand *et al.,* 2015) were used to assess spatial and temporal changes. Negative values indicated land cover decline, while positive values signified expansion.

2.2.4. Accuracy Assessment

The accuracy of LULC classification was

assessed using ground-truth points collected via GPS (Table 3). An error matrix was constructed to compute the user's and producer's accuracy metrics, which are key to evaluating classification performance (Asokan *et al.,* 2020; Shao *et al.,* 2021). Change detection was further refined through per-band subtraction of historical images from the 2020 image (Shao *et al.,* 2021), helping to isolate stable zones. Training samples from these unchanged zones were then reused to improve classification consistency.

Table: 3. Accuracy Statistics of LULC Classification (1990–2020)

Class name	1990		2000		2010		2020	
	Producers	Users	Producers	Users	Producers	Users	Producers	Users
Built-up area	85.71	85.71	86.67	92.86	100	92.86	100	100
Farmland	93.33	100	93.33	100	92.86	92.86	92.86	92.86
Forest	86.6	92.86	93.33	100	93.33	100	100	100
Grassland	100	92.86	100	92.86	100	92.86	100	92.86
Shrub land	84.62	78.57	91.67	78.57	86.67	92.86	100	92.86
Wetland	85.71	85.71	85.71	85.71	85.71	85.71	87.50	100

Source: Authors work compiled from LULC classification outputs.

2.2.5. Assessing the Effects of Wetland Changes

To explore the underlying drivers and effects of wetland changes, targeted socio-economic data were collected from three purposively selected kebeles adjacent to wetland areas. The study focused on communities directly affected by wetland dynamics. Data collection included household surveys, focus group discussions (FGDs), key informant interviews (KIIs), and field observations (Table 4). FGDs consisted of diverse participants (one group of 9 per kebele), while KIIs involved local elders, development agents, and kebele administrators. Transect walks were conducted during both dry and wet seasons to assess seasonal wetland dynamics. Secondary information was collected from the Dinsho District offices and the Ethiopian Space Science and Geospatial Institute. Survey data were analyzed using SPSS v20, while qualitative insights from FGDs, KIIs, and observations were thematically presented.

Table: 4. Socio-economic Data Collection Summary

No	**Tool**	**Description**	**Sample Size**
1	Questionnaire	Survey of households with direct wetland interaction	319
2	FGD	Discussions with community elders (both genders)	3 groups × 9 members
3	KII	Interviews with elders, development agents, and local leaders	3 kebeles × 9 members
4	Observation	Field-based transect walks and visual inspections	3 kebeles

Source: Authors work from field data.

3. Results and Discussion

3.1. Results

3.1.1. Accuracy Assessment

The classification accuracy of Landsat imagery for the years 1990, 2000, 2010, and 2020 was 89.29%, 91.67%, 92.86%, and 96.43%, respectively. These results demonstrate a high level of concordance between the classified land use/land cover (LULC) categories and reference (ground truth) data, aligning with the standards set. The overall Kappa coefficient was 0.95, further confirming the robustness of the classification outputs. The Kappa statistic, ranging from 0 (no agreement) to 1 (perfect agreement), is widely used to assess classification reliability, and when expressed as a percentage, provides a clear indicator of mapping accuracy. These results validate the use of the classified maps for subsequent change detection and spatial analysis (Asokan *et al.,* 2020; Shao *et al.,* 2021).

3.1.2. LULC Changes and Wetland Dynamics in Dinsho District

In 1990, the land cover of Dinsho District was predominantly composed of grassland (30.12%) and forest (23.62%). Shrubland (16.91%), wetlands (16.88%), and farmland (12.22%) also constituted significant portions of the landscape (Table 5, Figure 2). These values served as a baseline for evaluating land cover changes over the subsequent three decades. By 2000, grassland (29.26%) remained the dominant cover type, followed closely by a marked increase in farmland (23.24%). Over the next decade, farmland experienced a significant expansion, reaching 35.62% by 2010. During the same period, forest, shrubland, grassland, and wetland areas continued to decline. By 2020, forest cover had reduced to 13.93%, a sharp decline from 23.62% in 1990. Wetland areas also declined dramatically, from 16.88% to 9.40%. In contrast, farmland expanded to 42.16%, while built-up areas increased from 0.25% to 1.58%, reflecting growing human settlement and agricultural pressure.

Between 1990 and 2000, approximately 10,934.25 hectares of wetlands were altered, with significant conversions to farmland (25%), forest (19%), grassland (3%), and built-up areas (1%) (Table 6). The 2000–2010 period witnessed continued degradation of wetlands, with further transitions to farmland (28%), forest (15%), and grassland (8%). The 2010–2020 change matrix further confirmed the conversion of wetlands and forests to farmland and urban areas, intensifying the loss of ecologically sensitive landscapes. Overall, wetland extent declined from 10,934.25 ha in 1990 to 6,090.79 ha in 2020, amounting to a net loss of 4,843.46 ha. This degradation was most pronounced in areas adjacent to farmland and settlements, suggesting anthropogenic drivers such as agricultural expansion and urban encroachment.

Table: 5. Absolute area (ha) and coverage (%) of LULC from 1990 to 2020

Class name	1990		2000		2010		2020	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up Area	159.50	0.25	490.16	0.76	736.95	1.13	1027.02	1.58
Farm Land	7910.81	12.22	15042.72	23.24	23050.32	35.62	27310.76	42.16
Forest	15303.44	23.62	13120.04	20.25	10500.00	16.21	9027.39	13.93
Grass Land	19506.61	30.12	18955.78	29.26	15381.95	23.74	15037.26	23.21
Shrub Land	10954.29	16.91	8057.51	12.44	6864.14	10.59	6275.44	9.72
Wetland	10934.25	16.88	9102.17	14.05	8235.55	12.71	6090.79	9.40
Total	64768.90	100	64768.90	100	64,768.90	100	64768.90	100

Source: Authors work from LULCC outputs

3.1.3. LULC Transitions between 1990 and 2020

Between 1990 and 2020, Dinsho District experienced dynamic LULC transitions. Wetlands, forests, shrublands, and grasslands consistently declined, while farmland and built-up areas expanded at an accelerating pace. Wetland cover decreased from 10,934.25 ha (16.88%) to 6,090.79 ha (9.40%), highlighting severe ecological change. Forest areas declined from 15,303.44 ha (23.62%) to 9,027.39 ha (13.93%), while shrubland shrank from 10,954.29 ha (16.91%) to 6,275.44 ha (9.72%). Grassland also diminished from 19,506.61 ha (30.12%) in 1990 to 15,037.26 ha (23.21%) in 2020. Conversely, farmland expanded substantially, increasing from 7,910.81 ha (12.22%) to 27,310.76 ha (42.16%). Built-up areas, though smaller in magnitude, grew from 159.50 ha (0.25%) to 1,027.02 ha (1.58%), marking a notable rise in human settlement.

According to the 1990–2020 LULC transition matrix (Table 6), wetlands were predominantly converted to farmland (5,352.82 ha), forest (3,490.54 ha), built-up area (232.11 ha), grassland (217.50 ha), and shrubland (34.53 ha). Farmland absorbed the largest proportion of these transitions, underscoring its role as the primary driver of land conversion. Although built-up areas expanded over a relatively small area, they exhibited the highest relative increase. These findings illustrate a significant and ongoing transformation of natural land cover, particularly wetlands, into human-dominated land uses. The rapid and unidirectional loss of wetlands signals urgent conservation and land use planning needs in the area.

Table: 6. Land use land cover change matrix between 1990 and 2020

1990/2000	Built up Area	Farm Land	Forest	Grass Land	Shrub Land	Wet Land	Grand Total	Class Change
Built up Area	8.74	12.08	4.76	6.67	5.66	0.6	159.5	150.76
Farm Land	189.24	4671.65	896.02	247.98	498.89	407.09	7910.81	3239.16
Forest	71.07	3217.65	6801.78	1073.53	1124.88	14.79	15303.44	8501.66
Grass Land	24.28	895.78	1707.42	15413.55	611.82	953.34	19506.61	4093.06
Shrub Land	89.87	3314.82	539.37	1940.69	3737.64	131.76	10954.29	7216.65
Wetland	106.99	2630.09	2151.05	273.18	78.71	3694.14	10934.25	7240.11
Grand Total	490.16	15042.72	13120.04	18955.78	8057.51	9102.17	**64768.90**	30441.4
Class Change	481.42	10371.07	6318.26	3542.23	4319.87	5408.03	30440.88	
2000/2010								
Built up Area	63.37	332.66	3.95	18.20	2.54	2.52	490.16	426.79
Farm Land	407.41	10033.79	612.93	674.93	261.31	2052.36	15042.72	5008.93
Forest	84.23	3635.09	5583.23	1168.41	877.01	772.12	13120.04	7536.81
Grass Land	11.50	3462.36	845.55	12137.48	1239.23	1259.58	18955.78	6818.30
Shrub Land	92.51	2275.37	707.04	756.21	4225.05	0.85	8057.51	3832.46
Wet Land	77.93	3011.06	1727.30	926.73	64.00	3095.43	9102.69	6007.26
Grand Total	736.95	23050.32	10500.00	15381.95	6864.14	8235.55	**64768.90**	29630.55
Class Change	673.58	13016.53	4916.77	3244.90	2639.09	5140.12	29630.99	
2010/2020								
Built up area	138.71	49.86	7.09	24.88	77.6	3.91	736.95	598.35

Farm Land	568.21	14924.77	562.93	3100.26	1707.07	187.57	23050.32	8125.55
Forest	126.75	2930	1857.27	1116.63	1873.83	95.86	10500.35	8642.73
Grass Land	73.54	3671.07	903.17	8947.1	852.84	1233.37	15381.95	6434.85
Shrub Land	13.34	1565.19	2308.97	1223.75	702.45	50.5	6864.14	6161.69
Wetland	106.49	3831.37	1315.62	624.56	61.9	1495.3	8235.54	6739.95
Grand Total	1027.02	27310.86	9027.39	15037.40	6275.44	6090.79	**64768.90**	36703.12
Class Change	888.31	12386.09	7170.12	6090.3	5572.99	4595.49	36703.30	
1990/2020								
Built up Area	26.42	90.45	6.92	9.25	12.57	3.89	159.5	133.08
Farm Land	372.07	5267.7	905.46	434.06	604.94	326.58	7910.81	2643.11
Forest	215.2	4842.37	2698.96	1542.03	2270.87	333.94	15303.44	12604.48
Grass Land	89.93	4236.47	966.59	11126.37	2521.62	665.15	19506.61	8380.24
Shrub Land	91.79	7182.23	949.32	1708.22	630.88	32	10954.29	10323.41
Wetland	232.11	5352.82	3490.54	217.5	34.53	1506.89	10934.25	9427.36
Grand Total	1027.02	27310.86	9027.39	15037.40	6275.44	6090.79	**64768.90**	43511.4
Class Change	1000.6	22043.16	6328.41	3911.03	5644.56	4583.90	43511.66	

Source: Authors work from LULCC outputs

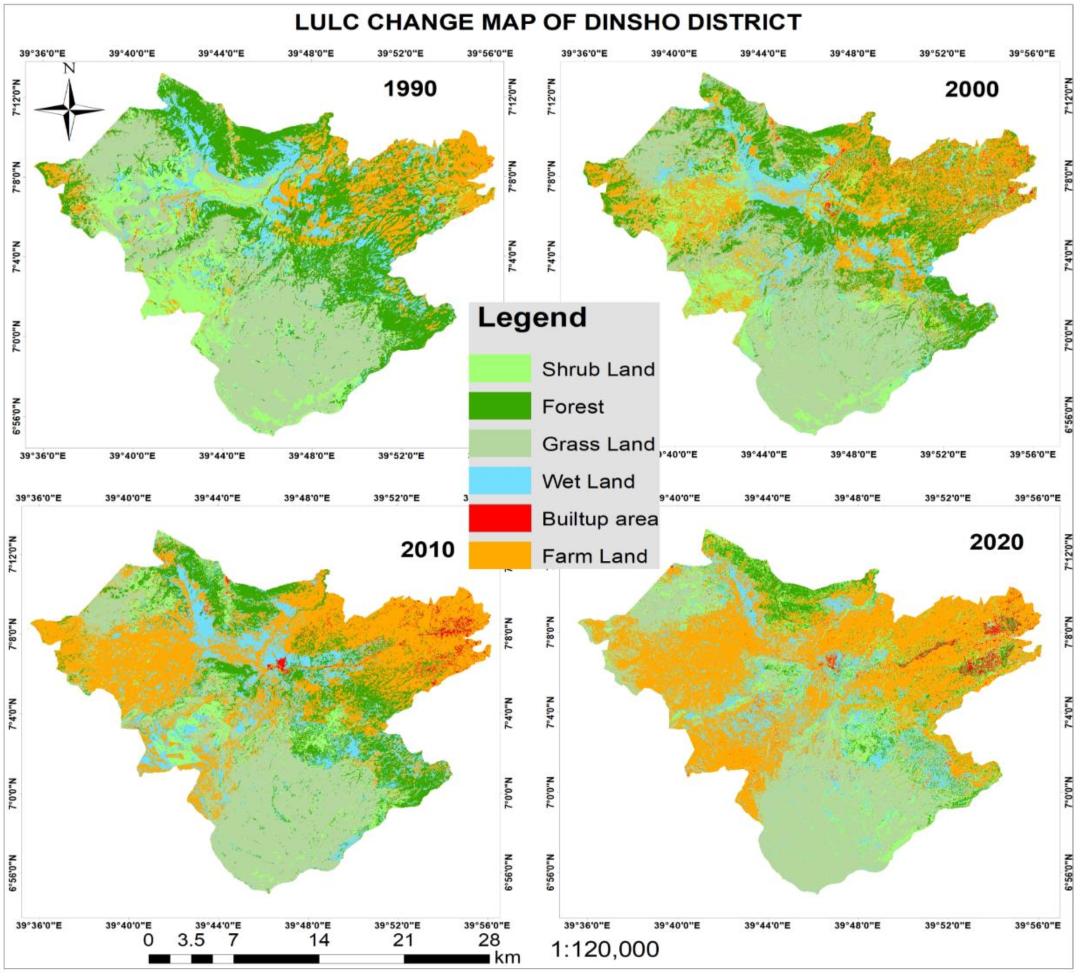

Figure: 2. Land use land cover map of the study area between 1990 and 2020

Table: 7. Land use land cover and their extent between 1990 and 2020

Class Name	1990		2000		2010		2020		Change rate in 30 years
	Area	%	Area	%	Area	%	Area	%	
Built-up Area	159.50	0.25	490.16	0.76	736.95	1.13	1027.02	1.58	867.52
Farm Land	7910.81	12.22	15042.72	23.24	23050.32	35.62	27310.76	42.16	19399.95
Forest	15303.44	23.62	13120.04	20.25	10500.00	16.21	9027.39	13.9	-6276.05
Grass Land	19506.61	30.12	18955.78	29.26	15381.95	23.74	15037.26	23.21	-4469.35
Shrub Land	10954.29	16.83	8057.51	12.44	6864.14	10.59	6275.44	9.72	-4678.85
Wetland	10934.25	16.88	9102.17	14.05	8235.55	12.71	6090.79	9.40	-4843.46
Total	64768.90	100	64768.90	100	64768.90	100.00	64768.90	100	

Source: Authors work from LULCC outputs

3.2. Spatio-Temporal Wetland Changes

Over the past three decades, Dinsho District has experienced a significant reduction in wetland cover. In 1990, wetlands accounted for 10,934.25 hectares, representing 16.88% of the total land area. By 2020, this figure had declined markedly to 6,090.79 hectares, constituting only 9.40% of the landscape (Table 8). This downward trend reflects the growing pressures on wetland ecosystems due to anthropogenic land use changes. The rate of wetland loss accelerated over the study period, with the most substantial decline occurring between 2010 and 2020. This period was marked by intensified land conversion, largely driven by illegal settlement, unregulated in-migration, and limited public awareness of the ecological value of wetlands. Analysis of the land use/land cover (LULC) change matrices confirms that a substantial proportion of wetlands were consistently transformed into other land use classes primarily into farmland.

During the first decade (1990–2000), approximately 2,630.09 ha of wetlands were converted into farmland, followed by 2,151.05 ha into forest, 273.18 ha into grassland, 106.99 ha into built-up areas, and 78.71 ha into shrubland. This resulted in a net wetland loss of 1,832.08 ha, reducing the overall wetland share from 16.88% to 14.05%. The transformation trend continued in the second decade (2000–2010), with 3,011.06 ha of wetlands converted to farmland, 1,727.30 ha to forest, 926.73 ha to grassland, 77.93 ha to built-up areas, and 64.00 ha to shrubland—corresponding to an additional loss of 866.62 ha and a reduction of wetland cover to 12.71%. Between 2010 and 2020, wetland degradation intensified further. A total of 3,831.37 ha of wetlands were converted to farmland, 1,315.62 ha to forest, 624.56 ha to grassland, 106.49 ha to built-up areas, and 61.90 ha to shrubland. This phase accounted for the most significant reduction, amounting to 2,144.76 ha (3.31% of the district's land area), lowering wetland coverage to just 9.40% by 2020.

Throughout the 30 years, farmland expansion emerged as the dominant force driving wetland conversion. The consistent encroachment of agricultural land into wetland areas was largely fueled by population growth, resettlement, and the pursuit of arable land to meet rising food demands. Although built-up areas occupied a relatively small portion of land, their rate of increase was the highest in relative terms, indicating growing urban pressure. Spatial analysis confirms that wetland loss was not only temporal but also spatially extensive across the landscape. Table 8 shows the cumulative wetland reduction over each decade and across the full study period: a net loss of 1,832.08 ha between 1990–2000, 866.62 ha from 2000–2010, and 2,144.76 ha from 2010–2020, totaling 4,843.46 ha over the three decades. This represents a 6.92% decline in wetland area has a significant environmental transformation with implications for biodiversity, water regulation, and local livelihoods.

Table:8. Spatio-temporal change of wetlands between 1990 and 2020

	Spatiotemporal change magnitude of LULC change in (hectare) and Percent (%)

LU/LC Type	1990 – 2000		2000-2010		2010 -2020		1990-2020	
	Area(ha)	Area %	Area(ha)	Area %	Area (ha)	Area %	Area (ha)	Area %
Built-up area	330.66	0.51	246.79	0.37	290.07	0.45	867.52	1.33
Farm Land	7131.91	11.02	8007.60	12.38	4260.44	6.54	19369.95	29.75
Forest	-2183.4	-3.34	-2620.04	-4.04	1472.61	-2.31	-6276.05	-9.65
Grass Land	-550.83	-0.86	-3573.83	-5.52	-344.69	-0.53	-4469.35	-7.19
Shrub Land	-2896.78	-4.39	-1193.37	-1.85	-588.7	-0.87	-4678.85	-7.49
Wetland	-1832.08	-2.83	-866.62	-1.34	-2144.76	-3.31	-4843.46	-6.92

Source: Authors work from LULCC outputs

This analysis underscores the critical need for sustainable land use planning and integrated wetland management strategies to halt further degradation. Without intervention, the continued loss of wetlands may have severe ecological and socio-economic consequences for the Dinsho District and the broader Bale Mountain Eco-Region.

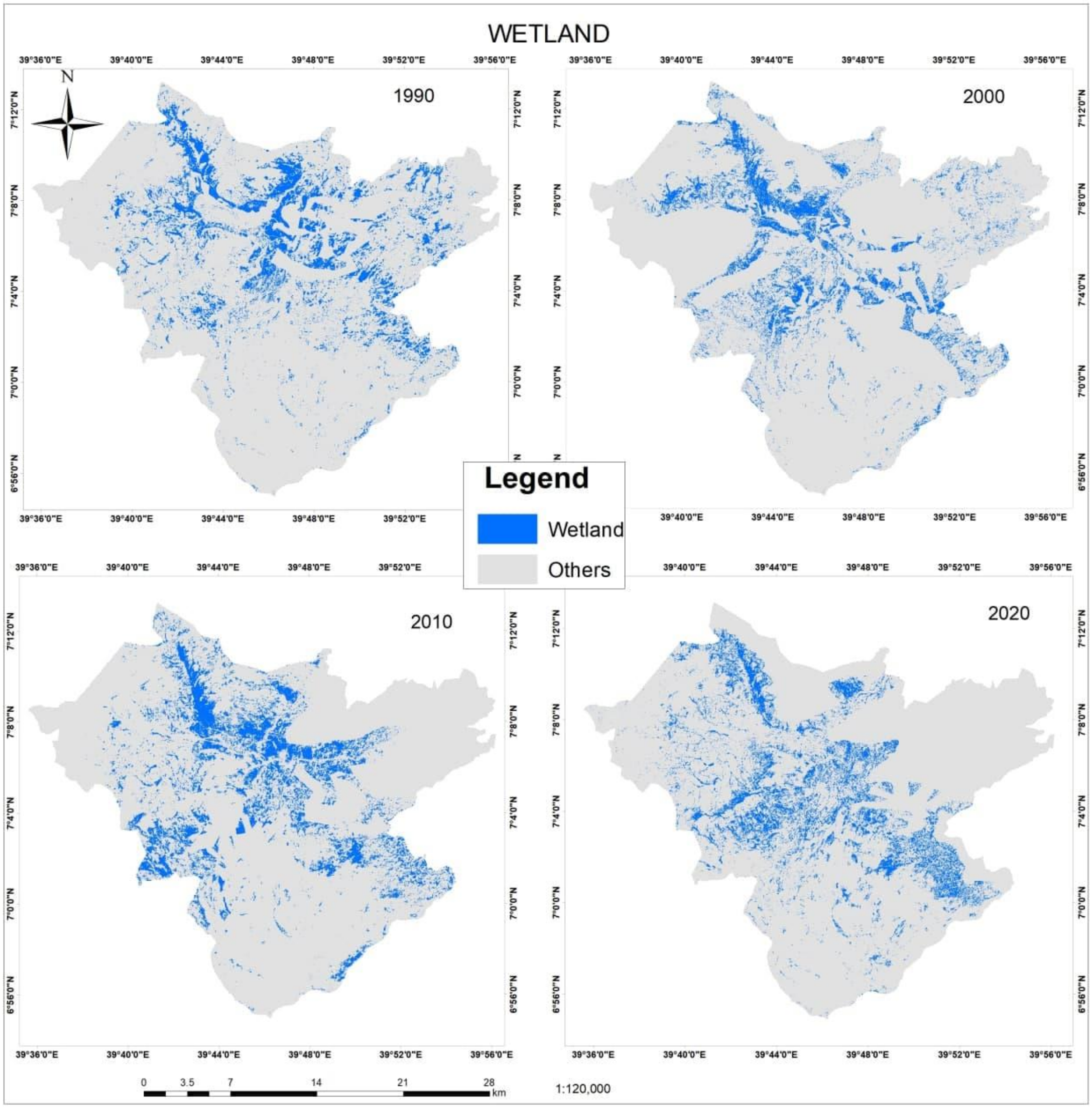

Figure: 3. Spatio-temporal wetland change map between 1990 and 2020

3.4. Drivers of Wetland Change and Its Effects on Biodiversity

3.4.1. Drivers of Wetland Change

The findings from household surveys, focus group discussions (FGDs), and key informant interviews (KIIs) consistently highlight that the local community has occasionally encroached upon wetlands in the study area. According to survey responses, the primary reasons for this encroachment were farmland scarcity (56%), lack of grazing land (26%), absence of clear land demarcation (11%), and a general lack of awareness regarding wetland preservation (7%) (Table 9). The data suggests that wetlands are often viewed as wastelands or areas with no ownership, which contributes to their conversion.

Table: 9. Perceived rank of Encroachment into wetlands

No	Reasons for Encroachment	%	Rank
1	Farmland scarcity	56	1
2	Lack of grazing land	26	2
3	Lack of demarcation	11	3
4	Lack of awareness	7	4

Source: Authors work from field survey

Both natural and anthropogenic factors were identified as key drivers of wetland degradation in the area. Farmland expansion, overgrazing, sedimentation, and climate variability were among the primary drivers contributing to wetland loss (Table 10). Survey respondents emphasized the significance of farmland expansion, with 57% identifying it as the primary driver, followed by overgrazing (23%), sedimentation (11%), and climate variability (9%).

Table: 10 Perceived rank of natural and anthropogenic factors that affects wetland

No	Factors	%	Rank
1	Farmland	57	1
2	Overgrazing	23	2
3	Sedimentation	11	3
4	Climate Variability	9	4

Source: Authors work from field survey

The study's land use/land cover (LULC) analysis further corroborates these findings, with a consistent trend of wetland conversion to farmland throughout the 30-year study period. Between 1990 and 2000, approximately 2,630.09 ha of wetlands were converted into farmland, followed by conversions of 2,151.05 ha to forest, 273.18 ha to grassland, 106.99 ha to built-up areas, and 78.71 ha to shrubland. Similarly, between 2000 and 2010, wetland conversion continued, with 3,011.06 ha transformed into farmland and other land uses, and a further 3,831.37 ha converted in the period from 2010 to 2020. The consistent pattern of wetland conversion to farmland underscores the role of population pressure and agricultural expansion as primary drivers of wetland degradation. Household interviews and community discussions also highlighted that increasing household sizes, coupled with the need for more land for agriculture, grazing, and settlement, have exacerbated wetland loss. Common practices such as water diversion for irrigation and eucalyptus plantation further contribute to wetland shrinkage. Overgrazing, particularly during the dry season, is recognized as a significant pressure on wetland ecosystems, with 23% of respondents acknowledging its adverse impact.

3.4.2. Effects of Wetland Change on Biodiversity

The loss of wetlands has both direct and indirect consequences on the ecosystem services provided by these habitats, as well as on the local community's reliance on wetland resources. Wetland degradation has led to a decline in biodiversity, particularly the extinction of various bird species, grasses, and trees that depend on wetland ecosystems. According to the respondents, 39% observed a reduction in economically important grass species, which are critical for livestock feed. Wetland grasses, especially in swampy areas, are vital resources for local farmers, but their loss has severely impacted livestock nutrition.

Wetland drainage for agriculture and other land uses has disrupted local bird populations, with 37% of respondents attributing the loss of bird species to wetland degradation. The disappearance of wetland-associated bird species, such as ducks, cattle egrets, and great white egrets, was noted by key informants. Furthermore, species that are now endangered, including the Wattled Ibis, Rogett's Rail, and Blue-Winged Goose, have seen declines in their populations due to habitat loss. This highlights the need for immediate wetland conservation efforts to preserve avian diversity and other species reliant on these ecosystems.

The decline in tree species, with 24% of respondents noting the loss, has been another significant consequence of wetland shrinkage. As wetland areas have receded, tree growth has been hindered, and existing vegetation is under increasing pressure due to human activities, including logging and land conversion. Furthermore, water extraction for irrigation has exacerbated the negative impacts on wetland biodiversity, creating a scenario where the ecological and economic costs of wetland conversion to farmland may outweigh the short-term benefits.

Table:11 Effects of wetlands changes on Biodiversity

S No	Variables	%	Rank
1	Loss of grass species	39	1
2	Loss of bird species	37	2
3	Loss of tree species	24	3

Source: Authors work from field survey

The degradation of wetlands in the study area has had profound effects on local biodiversity, with cascading consequences for both the environment and the livelihoods of the people who depend on these ecosystems. Efforts to mitigate further wetland loss must focus on sustainable land use practices, enhanced awareness, and policies that promote wetland conservation to safeguard biodiversity and ecosystem services for future generation

4. Discussion

Over the past three decades, the land use/land cover (LULC) of the study area has undergone profound changes, primarily due to the widespread conversion of wetlands into agricultural, settlement, and grazing lands. Wetlands are essential for maintaining ecological balance and supporting the livelihoods of surrounding communities, particularly in rural and drought-prone areas. They provide critical ecosystem services such as water purification, flood regulation, carbon sequestration, and biodiversity conservation (Jian, 2025; Kingsford *et al.,* 2021). Despite their importance, wetlands in Ethiopia—and in the study area in particular have been subject to extensive degradation, largely driven by anthropogenic pressures.

The expansion of agricultural land is a major driver of wetland loss. Between 1990 and 2020, significant areas of wetlands in the study region were converted into farmlands, shrublands, and built-up zones. This trend is largely attributable to increasing population pressure and food insecurity, which have prompted communities to encroach on wetlands to expand cultivation(Meresa *et al.,* 2019; Miheretu & Yimer, 2018; Zekarias *et al.,* 2021). In many cases, wetlands are perceived as unproductive or idle lands, making them vulnerable to unregulated transformation (Abera *et al.,* 2022; Moges *etal.,* 2018). Agricultural intensification, aided by irrigation technologies such as motorized water pumps, has also accelerated wetland conversion (Binswanger-Mkhize & Savastano, 2017; Dixon *et al.,* 2021). As farmers seek to mitigate climate variability and increase yields, wetland ecosystems have increasingly been drained to make way for cropland, often with minimal regard for long-term ecological impacts (Dixon *etal.,* 2021; Ewunetu *etal.,* 2021; Mekonnen & Aticho, 2014). Overgrazing is another significant factor, particularly during dry seasons when wetlands serve as fallback grazing grounds. This contributes to soil compaction, hydrological disruption, and vegetation loss (Abera *et al.,* 2022; Assefa & Eneyew, 2025; Fenetahun *et al.,* 2021; Mandishona & Knight, 2022).The absence of clear wetland policies and poor awareness among stakeholders further exacerbate degradation. Many wetlands are exploited in the absence of formal legal protection, with limited institutional capacity to enforce conservation or implement land-use planning (Dixon *et al.,* 2021; Giweta, 2018) Compounded by limited livelihood alternatives, rural communities often depend heavily on wetland resources, leading to a cycle of dependency and depletion (Abera *et al.,* 2022; Dixon *et al.,* 2021; Moges *etal.,* 2018; Zekarias *etal.,* 2021). Built up area expansion and the proliferation of eucalyptus plantations also contribute to wetland degradation. Urban sprawl, particularly in peri-urban areas, has led to the encroachment of settlements into wetland zones, disrupting ecosystem functions (Dixon *etal.,* 2021; Girma *etal.,* 2024; Kudumba, 2022). Additionally, the expansion of fast-growing eucalyptus plantations in wetland catchments reduces groundwater recharge and alters hydrological regimes, further threatening wetland health (Belachew & Minale, 2025)

The ecological consequences of wetland degradation are significant. The loss of wetland habitats has led to a decline in native biodiversity, particularly among wetland-dependent species such as amphibians, migratory birds, and aquatic plants (Dixon et al., 2021; Fentaw *etal.,* 2022; Hussien *etal.,* 2018) This biodiversity loss has cascading effects on ecosystem resilience and the provision of services that sustain local communities. Moreover, the socio-economic impacts are profound while agricultural expansion may offer short-term benefits, the long-term depletion of wetland resources undermines food and water security, exacerbates land use conflicts, and reduces adaptive capacity to climate change(Assefa & Eneyew, 2025; Fentaw *et al.,* 2022; Mkonda, 2022).

Globally, the loss of wetlands is a recognized environmental crisis, with similar patterns observed across sub-Saharan Africa, the Middle East, and parts of Asia (Calhoun *et al.,* 2017; Chignell *etal.,* 2019; Omolo *etal.,* 2018). In Ethiopia, the accelerating rate of wetland degradation highlights the urgent need for integrated wetland management strategies that balance conservation with sustainable use. Without immediate intervention, continued degradation will not only result in irreversible ecological damage but also undermine national commitments to biodiversity protection and climate resilience

5. Conclusions and Recommendations

5.1. Conclusions

The study reveals that wetlands in the Dinsho District have been significantly reduced over the past 30 years due to both anthropogenic and natural factors, with human-induced activities being the primary driver. The loss of wetlands has led to a decline in their ecological and socio-economic services, which has had direct consequences for local communities. Wetland resources, which once supported local livelihoods and biodiversity, have been increasingly encroached upon for farmland and grazing, leading to ecological degradation and resource depletion. Geospatial technology and socio-economic surveys indicate that the land cover of wetlands has decreased dramatically from 10934.25 ha (16.88%) to 6090.79 ha (9.40%) between 1990 and 2020, with an alarming rate of wetland loss attributed to agricultural expansion, built-up area, and overgrazing. The study also highlights the significant impact of population growth, lack of wetland management policies, and limited awareness of the loss of wetlands and their associated ecosystem services.

5.2. Recommendations

Wetlands decreased while farmland and built-up areas increased from time to time due to, dominantly, population pressure which affects the wetland in a multidimensional way. This causes farmland expansion, overgrazing, built-up area expansion, and eucalyptus tree farming. Based on the key finding to addressing wetland issues, the following recommendations were given: To effectively address the degradation of wetlands and ensure their sustainable use, it is essential to implement policies that regulate the expansion of agriculture into wetland areas. Promoting sustainable agricultural practices, such as agroecological or precision farming,

can increase land productivity without further encroaching on wetlands, thereby balancing food security and environmental conservation. Additionally, it is crucial to enforce stricter penalties for unauthorized wetland encroachment. Designating wetlands as legally protected areas, coupled with rigorous monitoring and sanctions, will ensure that environmental regulations are followed. In parallel, developing and implementing integrated wetland management plans that combine conservation with sustainable use strategies is essential. These plans should be tailored to local conditions and involve all stakeholders, including communities, government agencies, and NGOs, to ensure their long-term success. Public awareness campaigns are also vital to educate communities about the immense ecological and socio-economic benefits that wetlands provide, such as flood regulation, water purification, and biodiversity conservation. These campaigns can be effectively conducted through local media and community outreach programs.
Furthermore, promoting alternative livelihoods that reduce the dependency of local populations on wetland resources is critical. Encouraging diversification into sustainable agriculture, eco-tourism, and non-exploitative resource use will offer long-term economic benefits while preserving wetland ecosystems. Wetland conservation must also be integrated into broader land-use and water management strategies. Identifying critical wetland zones and incorporating them into regional and local planning frameworks will prevent future encroachment and ensure the sustainable management of these vital ecosystems. Finally, addressing population pressure through family planning initiatives is necessary to reduce the strain on natural resources, including wetlands. By managing population growth, communities can ease the burden on wetland ecosystems and improve overall resilience. Implementing these recommendations will not only halt further wetland degradation but will also restore their ecological services, ensuring their sustainability for future generations.

Availability of data and materials

The data and materials are available based on request from the corresponding author

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Kefa Feye and Mersha Alemu contributed in conception, design of the project, acquisition of data, analysis and interpretation of the result and write up the draft report. Mersha Alemu, Mulugeta Dadi and Taye Teshome contributes in revising the manuscript critically for important intellectual content. The authors read and approved the final manuscript.

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