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GIS-Driven Evaluation of Agricultural Land Abandonment: Gal Oya's Long-Term Impacts in Addalaichenai DSD, Sri Lanka

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Abstract: This research examines the primary factors that lead to the conversion of agroecological land in Sri Lanka's Addalaichenai Divisional Secretariat Division (DSD) into formed wetlands and abandoned land. At the heart of this change lies the enormous irrigation initiative known as the Gal Oya Development Project. The already inadequate infrastructure is further undermined by social and political tensions among government factors that have led to inconsistent management and maintenance of agricultural infrastructure. The study outlines several socio-economic factors, beyond infrastructure, that jeopardise the sustainability of agricultural production, and performs various analyses using Geographical Information Systems (GIS) to create a geodatabase that stores the main factors generally associated with abandonment. The study aims to evaluate the abandonment of agricultural land and wetlands to increase productivity in the Addalaichenai DSD. A mixed-method approach was used to analyse the drivers and impacts of agricultural land conversion in abandoned lands and wetlands. Data were collected through field visits, stakeholder consultations, and remote sensing datasets, including NDVI, elevation, slope, aspect, hillshade, and hydrological layers, which were integrated with GIS-based modelling in ArcGIS 10.8 to build a geodatabase of environmental and infrastructural variables. For many farmers, unstable agricultural policies, limited livelihood diversification, and rural migration further exacerbate their resilience challenges. Conclusively, land degradation and land conversion require integrated land-use policies, as the challenges extend beyond agriculture-specific solutions in the study area. Effective adaptation measures must be considered to address the ongoing shortages, inadequate infrastructure and governance failures. By mitigating these issues, the adverse impacts on the region can be minimised. Furthermore, ecological values, socio-economic resilience, and the livelihoods of local communities must be prioritised to ensure sustainable development.

Keywords: Addalaichenai DSD, Adaptive practices, Gal Oya project, Land abandonment, Poor water management.

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INTRODUCTION

The global escalation of land use change remains a defining characteristic of the Anthropocene, with significant consequences for biodiversity, ecosystem and human livelihood (Foley *et al.* 2005). While the conversion of natural habitats to agricultural land has received considerable scholarly attention, the reverse process, agricultural land abandonment, is an increasingly prevalent but less understood phenomenon, especially in tropical regions of the globe (Queiroz, 2014). Which can lead to the formation of a hybrid ecosystem, including a secondary wetland (Hobbs *et al.* 2006). The drivers for this change are rarely singular; they are intertwined complexes of environmental, socio-economic and institutional factors that vary significantly across geographical contexts (Meyfroidt *et al.* 2016). Sri Lanka's agricultural sector, particularly the small-holder paddy farming systems that form the backbone of its rural economy, is under severe strain from a confluence of challenges (Dharmasena, 2010).

The eastern province, historically famous as a productive agricultural region, now exhibits widespread abandonment of paddy lands, signalling a deepening agrarian crisis with implications for national food security (Herath & Weerahewa, 2016). Thus, the Addalaichenai DSD in the Ampara district analyses a critical issue related to these dynamics. This has a long-term impact on the study area due to issues associated with the irrigation intervention of Gal Oya. The Gal Oya Watershed has been recognised as one of the notable water bodies in the southeast dry zone of Sri Lanka (Banu, 2025). The Gal Oya development project, initiated in the post-independence era, was one of the most ambitious agricultural modernisation schemes, designed to harness water resources for irrigation and settlement (Moore, 1989).

Even though Gal Oyas's legacy is deeply embedded in decades of research, so far, no solid actions have been taken to address the ongoing issues, such as improper waste management, inadequate drainage systems and deficient infrastructure. These technical and governance failures have created a pervasive precondition for waterlogging and salination,

fundamentally undermining the agricultural viability of command areas like Addalaichenai over the long term (Leach, 1961). The existing literature highlights a significant research gap concerning the issues arising in the Gal Oya project. Furthermore, there is a lack of integrated analysis that connects these historical institutional drivers with current socio-economic pressures, such as rural migration and declining profitability and their combined multidimensional impact on both ecosystems and community vulnerability. Thus, the study focuses on evaluating the abandonment of agricultural land and wetlands to increase productivity in the Addalaichenai DSD.

MATERIAL AND METHOD

Background of Study

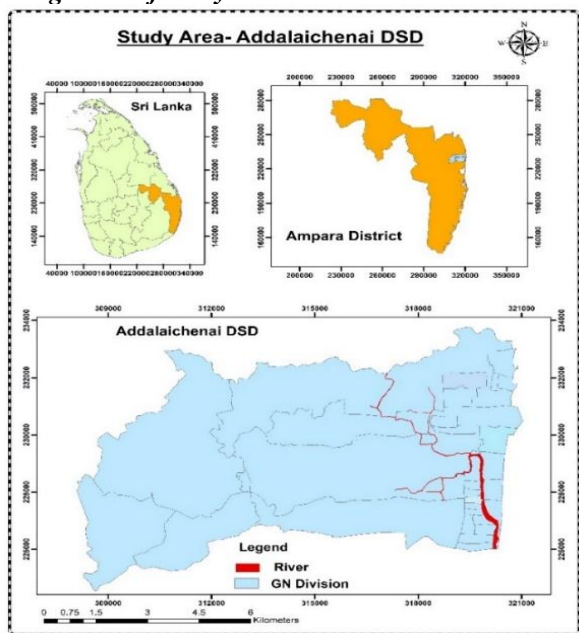


Figure 1: Study area map of Addalaichenai DSD
 Source: Retrieved by the author using ArcGIS 10.8

This study was carried out in the Addalaichenai Divisional Secretariat (DSD), situated in the Ampara District of Sri Lanka's Eastern Province (figure 1). Geographically, the division is situated between approximately 7.15° to 7.25° North latitude and 81.52° to 81.62° East longitude. Addalaichenai DSD is characterized by predominantly flat terrain, forming a part of the country's Dry Zone and is agriculturally important, with a large portion of its land dedicated to paddy cultivation, supported by irrigation schemes from nearby tanks and canals. Bimodal rainfall patterns are the major source of cultivation in the Addalaichenai DSD. The study area is a rural agricultural community in the Ampara district.

METHODOLOGY

A mixed-methods approach was employed in the study to comprehensively analyse the consequences of the issues in the study area. Thus, through field visits

and stakeholder consultations and some of the secondary sources such as government reports, papers from the Agrarian Development Centre in Addalaichenai, and other published and unpublished sources, all the necessary information was gathered. Digital Elevation Models (DEM), slope, aspect, hillshade, roughness layers and NDVI, along with additional hydrological data, were utilised to assess the physical drivers of land conversion. All spatial analyses were conducted using ArcGIS 10.8 software to pinpoint the spatial dynamics of land abandonment.

RESULTS AND DISCUSSION

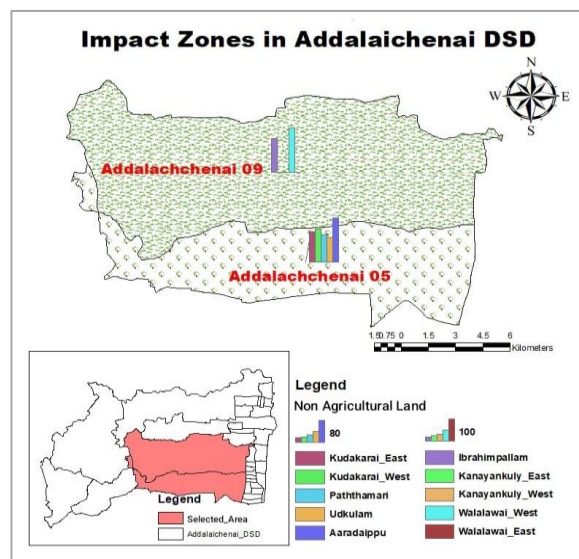


Figure 2: Impact zones and the spatial distribution of abandoned agricultural lands in Addalaichenai DSD.

As illustrated in Fig. 2, the Addalaichenai DSD comprises 32 Grama Niladhari Divisions (GNDs), and a GIS-based assessment conducted in ArcGIS 10.8 produced a detailed map of the Gal Oya Project impact zones and the spatial distribution of abandoned agricultural land, with support from the Agrarian Service Centre in Addalaichenai. The findings highlight land abandonment across the DSD, especially with high-level impacts on the Addalaichenai 05 and Addalaichenai 09 GNDs. These GNDs underscore the urgent need for effective management and intervention strategies.

Causes of Land Degradation

Land degradation is a major threat in the study area, considering both natural and human activities. Adverse traditional agricultural practices and increasing settlement patterns have accelerated soil erosion and negatively impacted soil fertility. Consequently, sediment accumulation has occurred in and around water bodies. Addalaichenai 05 and 09 are the highly affected areas here due to farmers' lack of awareness & mismanagement of irrigation, which resulted in salination and waterlogging. Traditional and continuous cultivation without adequate soil conservation and unsustainable farming practices have exhausted nutrients

and reduced agricultural productivity, too. Moreover, increasing population growth and unregulated land use cause more stress on the limited resources in the study area. Thus, altogether these causes resulted in various patterns of land abandonment, which led to high risks to biodiversity and sustainability.

Soil Type of the Study Area

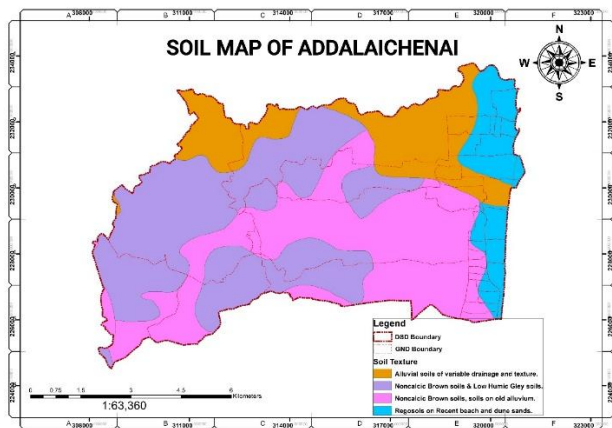


Figure 3: Soil Map of the Addalaichenai DSD

The soil of Addalaichenai DSD is naturally fertile and well-suited for paddy cultivation (Fig.3 Soil Texture of Addalaichenai DSD). Non-calcic brown soil and low humic clay soil have good water retention capacity and high natural potassium content, traditionally requiring lower fertiliser inputs. However, the current degradation and abandonment of these lands as uncultivable areas are primarily a result of an erroneous irrigation system. There are some circumstances which lead to floods, and their impact is fatal during excessive rainfall in residential places and agricultural lands (Banu, 2021). Improper water management practices, as observed in Addalaichenai DSD, have caused severe waterlogging, transforming once productive agricultural lands into uncultivable areas.

Improper Water Management Practices

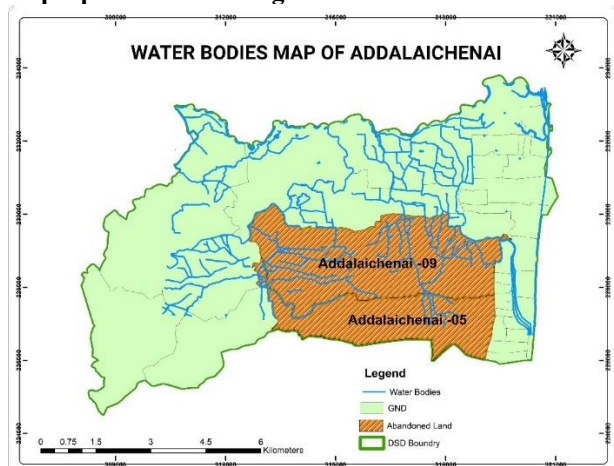


Figure 4: Water bodies of Addalaichenai DSD



Figure 5: Improper Management of Wetlands in Addalaichenai DSD

This natural potential has been undermined by human activities. The primary cause of land degradation and abandonment is the mismanagement of the irrigation system. Improper water management practices are visible in the distribution. Figure 4 clearly illustrates that the water bodies of Addalaichenai have caused severe waterlogging. This has transformed once-productive agricultural lands into unmanageable wetlands and abandoned tracts, rendering them unsuitable for farming despite their inherent fertility. This is proven through figure 5. As further demonstrated in figure 5, most of these water bodies have been abandoned due to improper water management practices within the study area.

Slope Characteristics of the Addalaichenai DSD

The slope characteristics of the study area suggest that an overwhelming proportion of the area is made up of very gentle to gentle slopes ($0 - 2.34^\circ$), while steeper slopes only exist in small, localised areas. The very low gradient landform significantly affects drainage and hydrology, as well as the sustainability of land-use in the area. Specifically, the flat topography slows the interaction between surface water and sediments, resulting in insufficient natural drainage and prolonged periods of flooding and stagnation. These conditions are exacerbated by high-volume inflows from the Gal Oya irrigation system and the limited maintenance of field and water infrastructure.

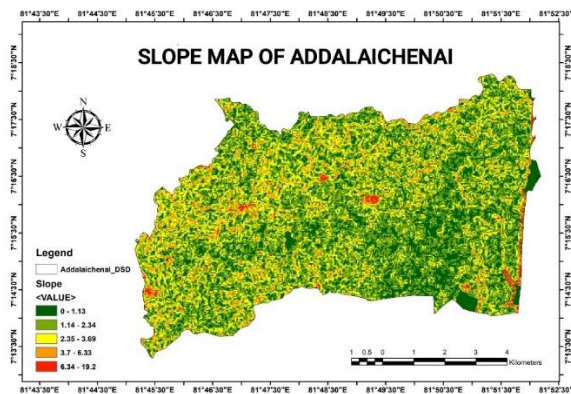
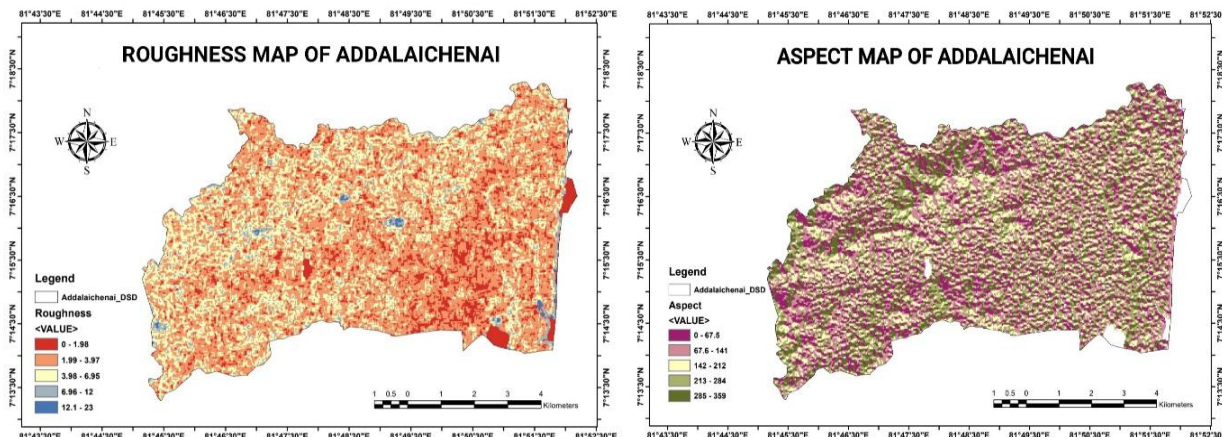


Figure 6: Slope map of Addalaichenai DSD

Surface lateral spreading of water increases when conditions conducive to wetland development are present in the study area. Flat and low-slope areas will experience seasonal or prolonged waterlogging, which will affect and hinder the essentials of farming. Which

ultimately results in the abandonment of agricultural land. Slope maps for this study were produced based on SRTM GL1 30 m data - added calculations using ArcGIS 10.8 and the OpenTopography visual raster tools (Fig. 6).



Figures 7 & 8: Roughness and Aspect Map of Addalaichenai DSD

Low Relief Feature of the Study Area

The geomorphological analysis of the Addalaichenai DSD, which integrated roughness, aspect, and hillshade into a single assessment (Figures 7, 8 & 9), reveals that the DSD is characterised by very low relief and minimal landscape variation. These landscape features have a distinct impact on both hydrology and land-use change. Most roughness values fall within the lowest category (0 - 1.98), indicating that the terrain is relatively smooth, with few micro-depressions or obstructions to distribute surface runoff. Water in the study area does not follow a distinct slope direction; instead, it spreads laterally across flat terrain, allowing it to remain in the fields and distribute more evenly. The aspect analysis revealed a patchy distribution of slope orientation, with no dominant pattern evident.

The nearly flat terrain of the DSD resulted in the slope direction having few to no effects on surface flow, affecting only small drainage pockets. The hill shade (fig. 9) visualises this precipitation and drainage uniformity with soft, even shadowing, indicating the

flattest landscape without significant ridges or breaks. Together, the geomorphological assessment indicates that the flat, low-roughness terrain of the DSD indicates prolonged onsite water retention. Combined with land management practices in the Gal Oya irrigation system, this hydrological setting suggests that the DSD is highly susceptible to waterlogged conditions. Banu (2025) stated that effective watershed management and sustainable development require an understanding of land use changes; thus, a watershed develops diverse ecosystems, cultivation and various settlements. The combination of unique soil hydrology and previous management issues has facilitated the abandonment of agricultural land use and accelerated the transition of these areas into wetland environments. This shift is reinforced by the increased frequency and stability of waterlogged conditions within the prevailing hydrological setting. All layers were created using the SRTM GL1 ft., which is a 30 m DEM in ArcGIS 10.8 (Fig. 10).

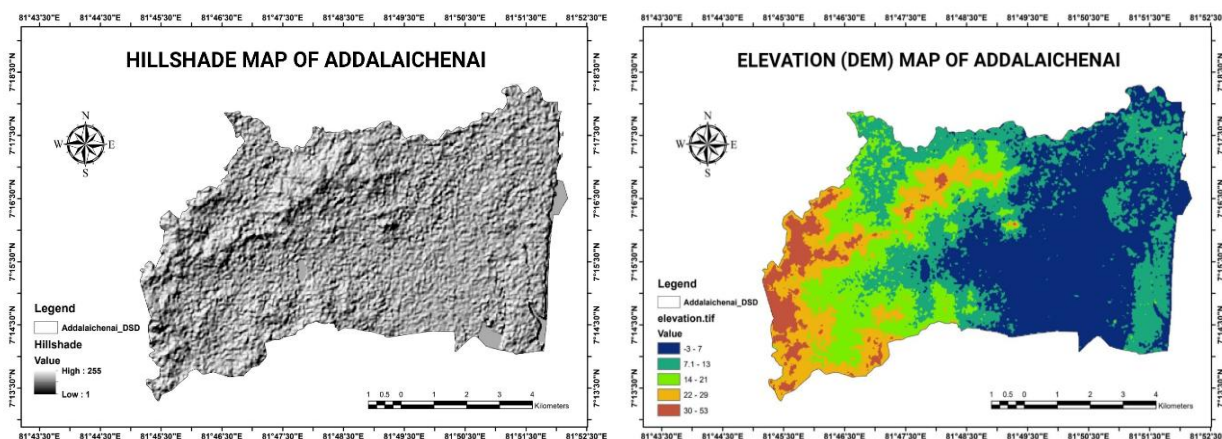


Figure 9 & 10: Hillshade and Elevation Map of Addalaichenai DSD

The elevation features within the Addalaichenai DSD exhibit a dominant west-to-east trend, which influences water flows, flooding, and agricultural land use across the division. The Digital Elevation Model (DEM) (fig. 10) was evaluated using GIS in terms of relative elevation and classified into five zones based on elevation: Very Low (-8–7 m), Low (7.1–13 m), Moderate (14–21 m), High (22–29 m), and Very High (30–53 m). Within the DSD, the classification reveals that the highest elevation zones are located along the western boundary, while the lowest elevations are distributed across the eastern coastal plain. Additionally, the overall elevation gradient directs runoff from the higher central and western regions towards the lower eastern zones, which function as water sinks.

Due to limited drainage, high water table, and tidal influence, both Very Low and Low elevation zones are extremely vulnerable to flooding. This vulnerability arises from external environmental factors, as well as the inefficient management of the Gal Oya irrigation system. If waterlogging persists for extended periods and wet field drainage is not managed properly, agricultural production becomes extremely difficult. This leads to the abandonment of fields and the gradual formation of wetlands, particularly when compounded by external flooding factors. This transition from agriculture to wetland increases the susceptibility of low zones, including saline areas, to long-term land use changes as significant waterlogging events become increasingly frequent and annual in occurrence.

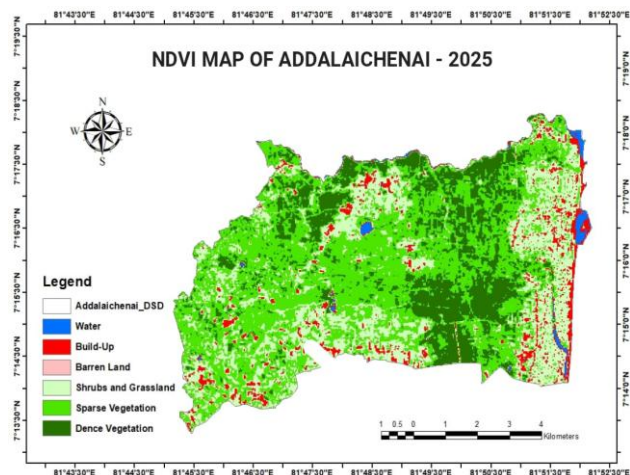


Figure 11: NDVI Map of Addalaichenai DSD-2025

Figure 11 indicates the NDVI (Normalised Difference Vegetation Index) assessment for 2025, conducted at the Addalaichenai Divisional Secretariat Division (DSD). The analysis identifies spatial trends in vegetative vigour, the abandonment of agricultural land, and the emergence of wetlands.

In accordance with the classified land cover categories of Water, Build-Up, Barren Land, Shrub and

Grass land, Sparse Vegetation, and Dense Vegetation, the central and western areas of the landscape are dominated by dense and sparse vegetation land cover classifications. The barren land is characterized by patches of previously cultivated fields that have since been abandoned, most likely due to recurrent flooding and the poor operational management of the Gal Oya irrigation system. Due to the flooding in the paddy lands, cultivators are reluctant to invest mostly in the Maha season rather than the Yale season (Banu, 2021). Thus, water bodies located in lower-lying areas are indicative of wetland areas that have recently emerged. The varied nature of the landscape raises critical questions about the role that failures of infrastructure and physiography may have played in the decline of agriculture, which leads to abandonment of more productive farmland to "wetlands" that are ecologically important, but socioeconomically detrimental.

According to Table 1, Addalaichenai-05, Addalaichenai-09, and Addalaichenai-17 are the major divisions within the study area, consisting largely of abandoned land or wetlands. The table further shows that in Addalaichenai-05, 580 acres of land were abandoned out of a total of 901 acres of agricultural land, while in Addalaichenai-09, 355 acres were abandoned out of 2,399 acres. Moreover, Soil salination was also affected by water salination in the study area. The consistent evaporation of non-flowing water can lead to the accumulation of salt on the soil surface. This process of water salinisation further inhibits growth and reduces soil fertility, and contributes to the abandonment of agricultural lands or wetlands. In addition, the long-term and imbalanced use of chemical fertilisers can acidify soil, thereby diminishing crop yields. Inefficient irrigation practices, largely stemming from inadequate farmer training in modern water management, further exacerbate these challenges in the study area.

Table 1: Agriculture and Abandoned Lands of Addalaichenai DSD

GN division	Abandoned land or wetland (acr)	Agricultural land (acr)
Addalaichenai-05	580	901
Addaichenai-09	355	2399
Addalaichenai-17	-	1072

Source: Agrarian Service Centre - Addalaichenai

CONCLUSION

In conclusion, the conversion of agricultural land into abandoned lands and unmanaged wetlands in the Addalaichenai DSD is primarily driven by catastrophic failure of hydrological management associated with the Gal Oya irrigation scheme. It has resulted in extensive waterlogging and salinisation. The unexpected emergence of wetlands presents a complex duality. Negatively, they signify economic loss and can become a hotspot of Dengue Mosquitos. In positive terms, they offer potential ecosystem services such as

habitat for biodiversity, water purification and filtration and carbon sequestration, if they are purposefully managed rather than left degraded. Protecting the remaining agricultural lands requires investments in sustainable water management, while the strategic management of emerging wetlands calls for purposeful restoration planning.

RECOMMENDATIONS

- Promotion of eco-tourism and environmental education.
- Establish a partnership with a local university or research institution to monitor species, water quality, paddy growth and quality.
- Paradigm shift from agricultural rehabilitation to wetland conservation.
- The most degraded agricultural lands and hydrologically altered divisions or areas should be officially designated as protected wetland zones or conservation areas.
- Create a soil health and salinity monitoring system.
- Long-term monitoring program using UAVs (Drones) to protect agricultural lands.
- Design an Eco Tourism accessibility and site suitability.
- Conduct an awareness program for farmers in Addalaichenai DSD.

REFERENCES

1. Adams, W. M., Aveling, R., Brockington, D., Dickson, B., Elliott, J., Hutton, J., Roe, D., Vira, B., & Wolmer, W. (2004). Biodiversity conservation and the eradication of poverty. *Science*, 306(5699), 1146–1149. <https://doi.org/10.1126/science.1097920>
2. Aheeyar, M. M. M. (2012). *Farmer participation in irrigation system management: Achievements and drawbacks*. Hector Kobbekaduwa Agrarian Research & Training Institute.
3. Baldock, D., Dwyer, J., Lowe, P., Petry, J., & Ward, N. (1996). *Farming at the crossroads: Land use changes and policy reforms in Europe*. Institute for European Environmental Policy.
4. Baldwin, A., Thiruchelvam, S., & Pathmarajah, S. (2018). An economic analysis of the challenges in paddy cultivation in the dry zone of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 46(2), 233–244.
5. Bastiaanssen, W. G. M., Molden, D. J., & Makin, I. W. (2007). Hydrological processes of irrigation systems: An overview of waterlogging, drainage, and sustainability issues. *Agricultural Water Management*, 90(1–2), 1–12.
6. Banu, M. N. N. (2021). Causes and impacts of flood inundation: A case study based on Mavadippalli, Sri Lanka. *World Scientific News*, 160, 263–283.
7. Banu, M. N. N. (2025). The comprehensive analysis of land-use and land-cover changes in the Gal Oya watershed. *Journal of Sustainable Agriculture and Environmental Innovations*, 1(2), 1–10.
8. Banu, M. N. N. (2021). Impacts of flood disaster on agricultural lands of the Mavadippalli area, Ampara. *Indiana Journal of Agriculture and Life Sciences*, 1(1), 29–38.
9. Congalton, R. G., & Green, K. (2019). *Assessing the accuracy of remotely sensed data: Principles and practices* (3rd ed.). CRC Press.
10. Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). Sage Publications.
11. Dharmasena, P. B. (2010). Strategies for overcoming agricultural land degradation in the dry zone of Sri Lanka. *Journal of the Soil Science Society of Sri Lanka*, 22, 1–10.
12. Dharmasena, P. B. (2010). Sustainable agricultural development under changing climate and market conditions in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 38(2), 75–80.
13. Endis, S., & Wickramasinghe, W. M. A. D. B. (2019). Economic and social factors influencing the abandonment of paddy lands: A case study in Anuradhapura District. *Sri Lankan Journal of Agricultural Economics*, 12(1), 39–54.
14. Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., Helkowski, J. H., Holloway, T., Howard, E. A., Kucharik, C. J., Monfreda, C., Patz, J. A., Prentice, I. C., Ramankutty, N., & Snyder, P. K. (2005). Global consequences of land use. *Science*, 309(5734), 570–574.
15. Herath, P. H. M. U., & Weerahewa, J. (2016). Agricultural land use change in the dry zone of Sri Lanka: A case study of the Mahaweli River Basin. *Sri Lankan Journal of Agricultural Economics*, 18(1), 55–70.
16. Herath, P. H. M. U., & Weerakoon, S. B. (2017). Spatio-temporal changes of abandoned paddy fields in the Mahaweli River Basin, Sri Lanka: A remote sensing approach. *Tropical Agricultural Research*, 28(4), 386–398.
17. Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., Epstein, P. R., Ewel, J. J., Klink, C. A., Lugo, A. E., Norton, D., Ojima, D., Richardson, D. M., Sanderson, E. W., Valladares, F., Vila, M., Zamora, R., & Zobel, M. (2006). Novel ecosystems: Theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography*, 15(1), 1–7.
18. Kotagama, S. W., & Bambaradeniya, C. N. B. (2006). *An overview of the wetlands of Sri Lanka and their conservation significance*. IUCN Sri Lanka.
19. Leach, E. R. (1961). *Pul Eliya, a village in Ceylon: A study of land tenure and kinship*. Cambridge University Press.

20. Meyfroidt, P., Lambin, E. F., Erb, K. H., & Hertel, T. W. (2016). Drivers of land use change. In R. Potschin, R. Haines-Young, R. Fish, & R. K. Turner (Eds.), *Routledge handbook of ecosystem services* (pp. 105–116). Routledge.
21. Moore, M. P. (1989). The ideological history of the Sri Lankan peasantry. *Modern Asian Studies*, 23(1), 179–207.
22. Nianthi, K. W. G. R., & Shaw, R. (2013). Climate change and its impact on agricultural water resources in Sri Lanka. In R. Shaw, H. Mallick, & A. Islam (Eds.), *Climate change adaptation actions in Bangladesh* (pp. 219–237). Springer Japan.
23. Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
24. Queiroz, C., Beilin, R., Folke, C., & Lindborg, R. (2014). Farmland abandonment: Threat or opportunity for biodiversity conservation? A global review. *Frontiers in Ecology and the Environment*, 12(5), 288–296.
25. Uphoff, N. T. (1992). *Learning from Gal Oya: Possibilities for participatory development*. Cornell University Press.
26. Zedler, J. B., & Kercher, S. (2005). Wetland resources: Status, trends, ecosystem services, and restorability. *Annual Review of Environment and Resources*, 30(1), 39–74.