JPSTD
Journal of Placemaking and Streetscape Design
JPSTS 3(1): 1–22
ISSN 3025-5449

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Environmentally-conscious cities: Energy transformation through ecoregional planning and carbon trading for sustainable regional development

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Received Date: June 2, 2025 Revised Date: July 27, 2025 Accepted Date: July 31, 2025

ABSTRACT

Background: The global climate crisis and dependency on fossil fuels pose serious threats to food, water, and energy security in Indonesia, particularly in ecologically and economically strategic regions such as Garut Regency. This research proposes an integrated strategy for sustainable regional development based on ecoregional planning and carbon trading, addressing spatial inequality, environmental degradation, and clean energy transformation. **Methods**: Spatial-territorial analysis and participatory cross-sectoral policy review serve as the primary methodology, supplemented by stakeholder interviews and geospatial assessments. **Findings:** The findings reveal significant renewable energy potential in Garut, including geothermal (PLTP Darajat), solar, micro-hydro, and biomass from agricultural waste. However, 52.57% land-use misalignment, a 42.46% decline in forest area, and water deficits in 19 sub-districts endanger ecosystem stability and local economic resilience. Strategic ecoregional planning, including environmental carrying capacity-based zoning, 45% protected area retention, and renewable energy integration into spatial plans, can reverse these negative trends. Implementation requires multi-sectoral collaboration involving government, private sector, and communities, supported by green technologies and innovative financing (APBD, KPBU, CSR). The environmental benefits encompass biodiversity conservation, enhanced climate resilience, and emission reductions toward the net-zero emissions 2045 target. **Conclusion**: This study concludes that Garut's transformation into an energy-independent, socially equitable, and ecologically resilient region can serve as a national model for achieving the Golden Indonesia 2045 vision. **Novelty/Originality of this article:** The novelty of this article lies in proposing an integrated ecoregional planning and carbon trading framework as a scalable model for aligning spatial planning, renewable energy development, and socio-political risk management in regional sustainability transitions.

KEYWORDS: climate resilience; ecoregional planning; land conservation; renewable energy; sustainable development.

1. Introduction

Climate change and the global energy transition have become central challenges for regional planning in the 21st century. Rising global temperatures, increasing climate-related disasters, and accelerating biodiversity loss highlight the urgency of shifting from fossil fuel dependency toward low-carbon, climate-resilient development pathways (IPCC, 2021; UNEP, 2022). Indonesia ranked among the world's top greenhouse gas (GHG) emitters due to deforestation and heavy coal reliance has committed to reducing emissions

Cite This Article:
Fallah, K. (2025). Environmentally-conscious cities: Energy transformation through ecoregional planning and carbon trading for sustainable regional development. *Journal of Placemaking and Streetscape Design, 3*(1), 1-22. https://doi.org/10.61511/jpstd.v3i1.2025.2168

by 29% unconditionally, and up to 41% with international support, by 2030, and achieving net-zero emissions by 2060 (KLHK, 2021). Achieving these targets requires not only national-level reforms but also transformative actions at the sub-national level.

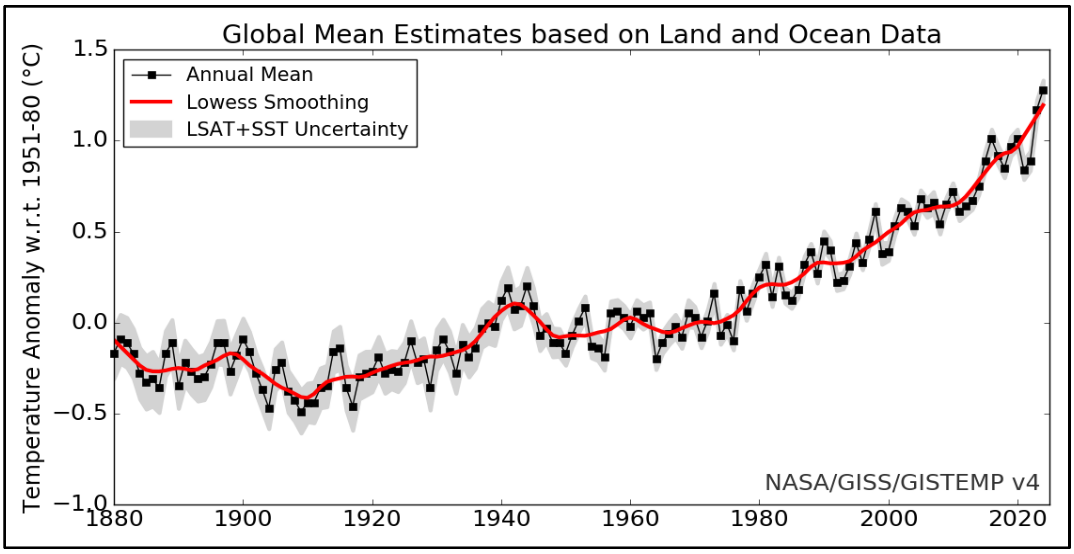

Fig. 1. Average global temperature rise (1850-2022)
(NASA GISS, 2023)

However, the gap between policy frameworks and on-the-ground implementation remains significant. Spatial planning regulations, such as Regional Spatial Plans/*Rencana Tata Ruang Wilayah* (RTRW), often fail to prevent land-use misalignments and environmental degradation (Bappenas, 2020). The mismatch between designated protected areas and actual land use often driven by agricultural expansion, settlement encroachment, and infrastructure projects undermines both climate and development goals. This reflects a broader governance challenge in Indonesia: the limited integration of ecological capacity, renewable energy development, and economic diversification into local planning frameworks.

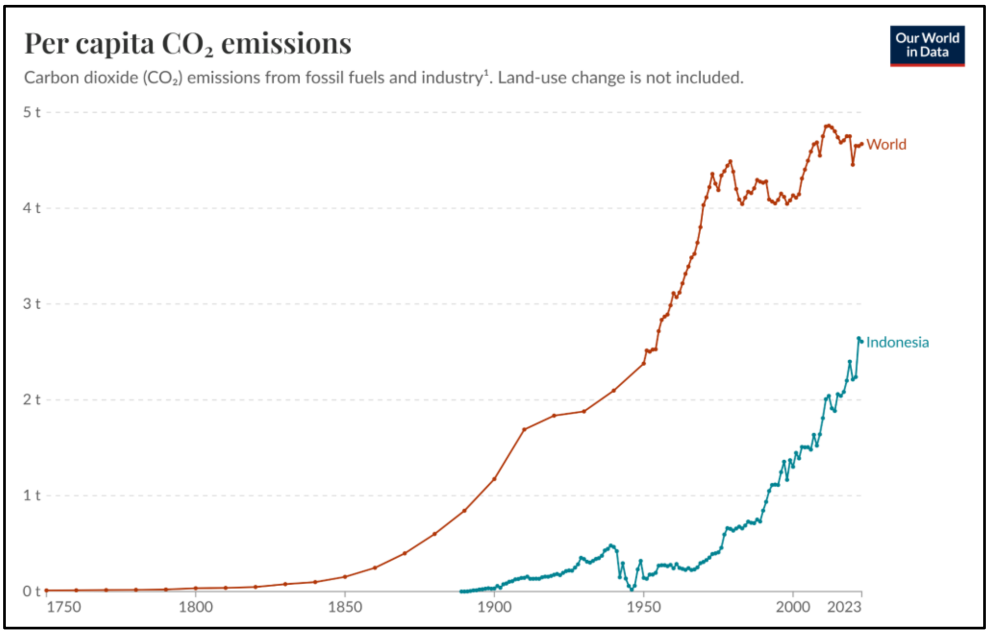

Fig. 2. CO_2 emissions per capita graph in Indonesia (2000-2020)
(Global Carbon Budget, 2024; World Bank, 2024)

Garut Regency, located in West Java, offers a critical test case for addressing these challenges. As a key agricultural supplier, eco-tourism hub, and host to major geothermal facilities (e.g., PLTP (Geothermal Power Plant/*Pembangkit Listrik Tenaga Panas Bumi*) Darajat, 330 MW capacity), Garut holds strategic importance in Indonesia's food and energy security. Yet, it faces a paradox: high ecological value and renewable energy potential coexist with significant environmental degradation, socio-economic disparities, and vulnerability to climate-related hazards. These include a 52.57% mismatch between land use and spatial plans, 42.46% forest cover decline in seven years, and water deficits in 19 sub-districts.

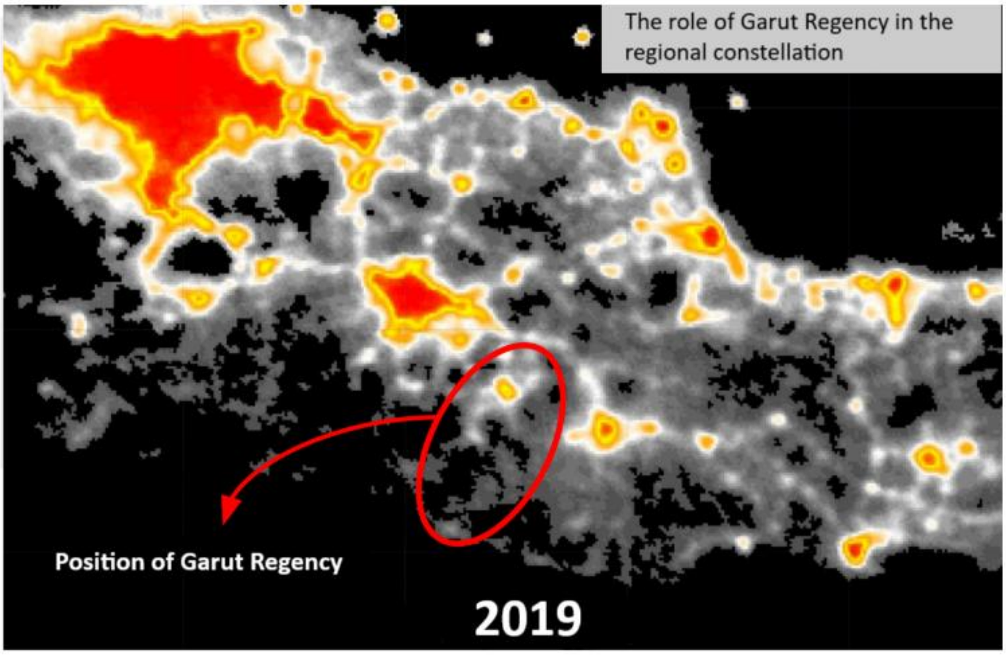

Fig. 3. Night time lights map showing Garut's role as a hinterland

This study proposes an integrated approach combining ecoregional planning which aligns land use with ecological boundaries and carrying capacity with carbon trading as a financing mechanism for conservation and renewable energy projects. This integration aims to address the intertwined challenges of spatial inequality, environmental degradation, and clean energy transformation. While ecoregional planning has been applied in biodiversity conservation and watershed management, and carbon trading has been implemented in industrial emission reduction, their combined application to sub-national spatial and energy policy remains underexplored, particularly in developing country contexts.

The novelty of this research lies in its multi-scalar integration: linking ecological zoning to renewable energy placement, embedding carbon trading revenues into local development financing, and aligning these strategies with both the Sustainable Development Goals (SDGs) and Indonesia's long-term development vision (RPJPN (National Long-Term Development Plan/*Rencana Pembangunan Jangka Panjang Nasional)* 2025–2045). By focusing on Garut, this paper also addresses the placemaking dimension of sustainable regional development showing how energy infrastructure, ecological restoration, and community participation can shape not only the environmental footprint but also the social and spatial character of urban-rural landscapes.

1.1 Ecoregional planning in sustainable development

Ecoregional planning is a spatial management framework that prioritizes ecological boundaries over administrative ones, integrating environmental, social, and economic dimensions (Millennium Ecosystem Assessment, 2005). Its application in biodiversity conservation, watershed management, and climate adaptation has been documented in both developed and developing contexts (Li et al., 2020; UNEP, 2022). In Southeast Asia, ecoregional planning has been promoted as a means to harmonize conservation with livelihood enhancement (FAO, 2021). However, in Indonesia, its adoption remains fragmented often limited to conservation areas without fully influencing regional development strategies (KLHK, 2021). Recent studies emphasize that ecoregional approaches must be embedded in legally binding spatial plans and backed by cross-sectoral governance mechanisms to be effective (Taghvaee et al., 2017; Wheeler, 2004).

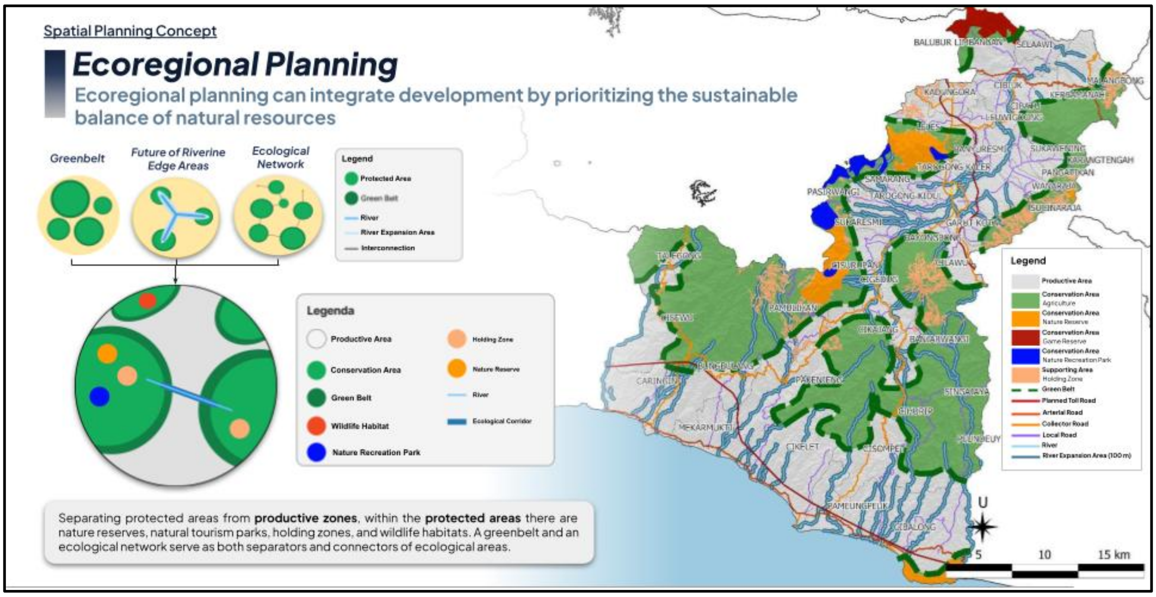

Fig. 4 Application of ecoregional planning concept in spatial planning of Garut Regency

1.2 Renewable energy transition in developing countries

Renewable energy adoption in the Global South faces structural barriers, including high initial investment costs, limited grid infrastructure, weak policy enforcement, and competing land uses (IRENA, 2021; Hasan et al., 2022). In Indonesia, while geothermal, solar, and micro-hydro resources are abundant, deployment has been hindered by regulatory uncertainty, financing constraints, and public resistance due to land acquisition issues (IEA, 2023). Comparative studies show that countries like Vietnam and the Philippines have accelerated renewable deployment through feed-in tariffs, clear permitting processes, and community ownership models (World Bank, 2022). Integrating renewable energy zones into spatial plans has been proposed as a way to reduce conflict, ensure grid readiness, and align infrastructure with ecological carrying capacity (Li et al., 2020).

1.3 Carbon trading mechanisms in the global south

Carbon trading, both in compliance and voluntary markets, has emerged as a market-based mechanism for financing emission reductions (Tietenberg, 2006; Stavins, 2008). In developing countries, voluntary carbon markets (VCM) often dominate due to the absence of comprehensive national emissions trading systems (World Bank, 2022). Indonesia's carbon market framework established under Presidential Regulation No. 98/2021 enables both cap-and-trade and result-based payments for sectors including forestry, energy, and waste (KLHK, 2021). However, challenges remain in establishing transparent measurement, reporting, and verification (MRV) systems, ensuring equitable benefit sharing, and preventing elite capture of carbon revenues (Agrawal & Gibson, 1999). Successful examples, such as community-based REDD+ projects in Kalimantan, illustrate the potential for carbon finance to support local livelihoods while conserving ecosystems (UNEP, 2022).

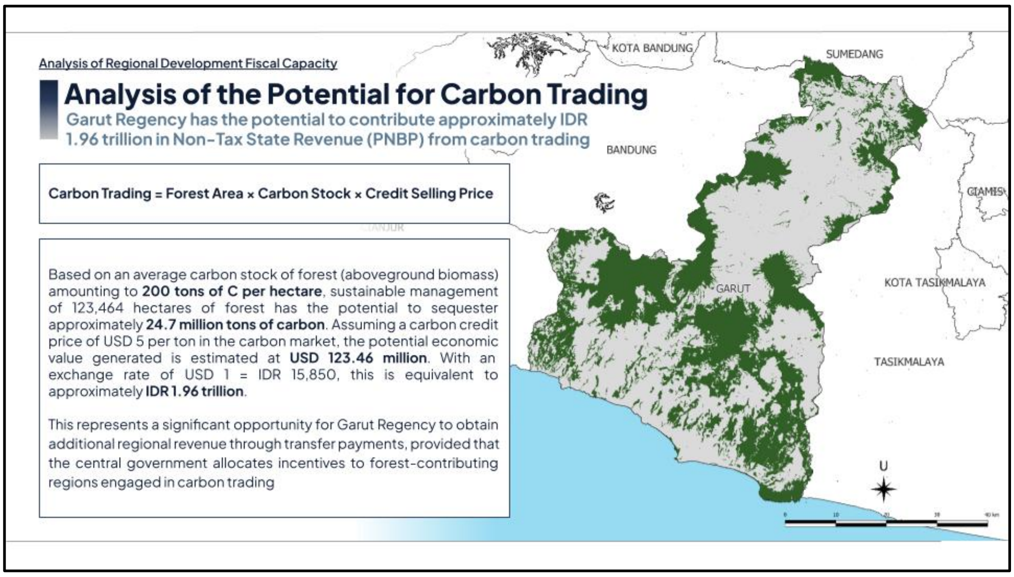

Fig. 5. Garut regency carbon trading potential analysis

1.4 Best practices in integrating ecoregional zoning and carbon trading

Globally, few studies have combined ecoregional planning with carbon trading as an integrated policy tool. In Costa Rica, ecological zoning has been linked to payment for ecosystem services (PES) funded partly through carbon credit sales, leading to both forest recovery and rural income growth (Pagiola, 2008). Bhutan's Gross National Happiness framework integrates watershed protection with hydropower development, using carbon finance to subsidize rural electrification (Wangchuk et al., 2021). These cases highlight the importance of aligning ecological zoning with market incentives, stakeholder participation, and robust institutional arrangements. For Indonesia, applying these principles at the regency level could bridge the persistent gap between conservation goals and development financing.

2. Methods

This research was conducted over a four-month period, from September to December 2024, covering the entire administrative area of Garut Regency, West Java Province. The study applied a mixed-methods approach that integrated spatial-territorial analysis, participatory cross-sectoral policy review, and geospatial assessment to formulate an integrated strategy combining ecoregional planning and carbon trading.

Primary data were collected through semi-structured interviews with stakeholders from nine Garut Regency government agencies, the Department of Public Works and Spatial Planning/*Dinas Pekerjaan Umum dan Penataan Ruang* (DPUPR), Regional Development Planning Agency/*Badan Perencanaan Pembangunan Daerah* (Bappeda), Department of Transportation/*Dinas Perhubungan* (Dishub), Department of Tourism and Culture/*Dinas Pariwisata dan Kebudayaan* (Disparbud), Regional Disaster Management Agency/*Badan Penanggulangan Bencana Daerah* (BPBD), Department of Marine and Fisheries/*Dinas Perikanan dan Peternakan* (Diskanak), Department of Agriculture/*Dinas Pertanian* (Disperta), Department of Housing and Settlement Areas/*Dinas Perumahan Rakyat dan Kawasan Permukiman* (Disperkim), and Environmental Service/*Dinas Lingkungan Hidup* (DLH) as well as the West Java Provincial Energy and Mineral Resources Office/*Kementerian Energi dan Sumber Daya Mineral Jawa Barat* (ESDM Jabar). In addition, informal random-sampling interviews were conducted with local residents in various sub-districts to capture community perspectives. Stakeholders were selected based on decision-making authority, technical expertise, or direct exposure to spatial and energy policies. Secondary data were obtained from INA-Geoportal (*Badan Informasi Geospasial*), *Rupa Bumi Indonesia* topographic datasets, and spatial data provided by DPUPR Garut. Policy documents included the Garut Regency Spatial Plan (RTRW 2011–2031), the National Medium-Term Development Plan (RPJMN (*Rencana Pembangunan Jangka Menengah Nasional*/National Long-Term Development Plan) 2020–2024), renewable energy development roadmaps, socio-economic statistics from Statistics Indonesia (BPS), and environmental quality indices from the Ministry of Environment and Forestry (KLHK).

Spatial analysis was conducted using QGIS 3.34, including overlay analysis to identify mismatches between actual land cover and RTRW zoning, buffer analysis to assess renewable energy siting relative to ecological sensitivity, and weighted overlay analysis to determine priority zones for renewable energy infrastructure considering slope, hydrology, and conservation areas. Validation was carried out using data triangulation, cross-checking GIS results with policy reviews and stakeholder interviews. Discrepancies were resolved through follow-up consultations with relevant agencies. While the study offers robust spatial and qualitative evidence, quantitative scenario modelling for intervention versus non-intervention futures was not undertaken due to time and data constraints.

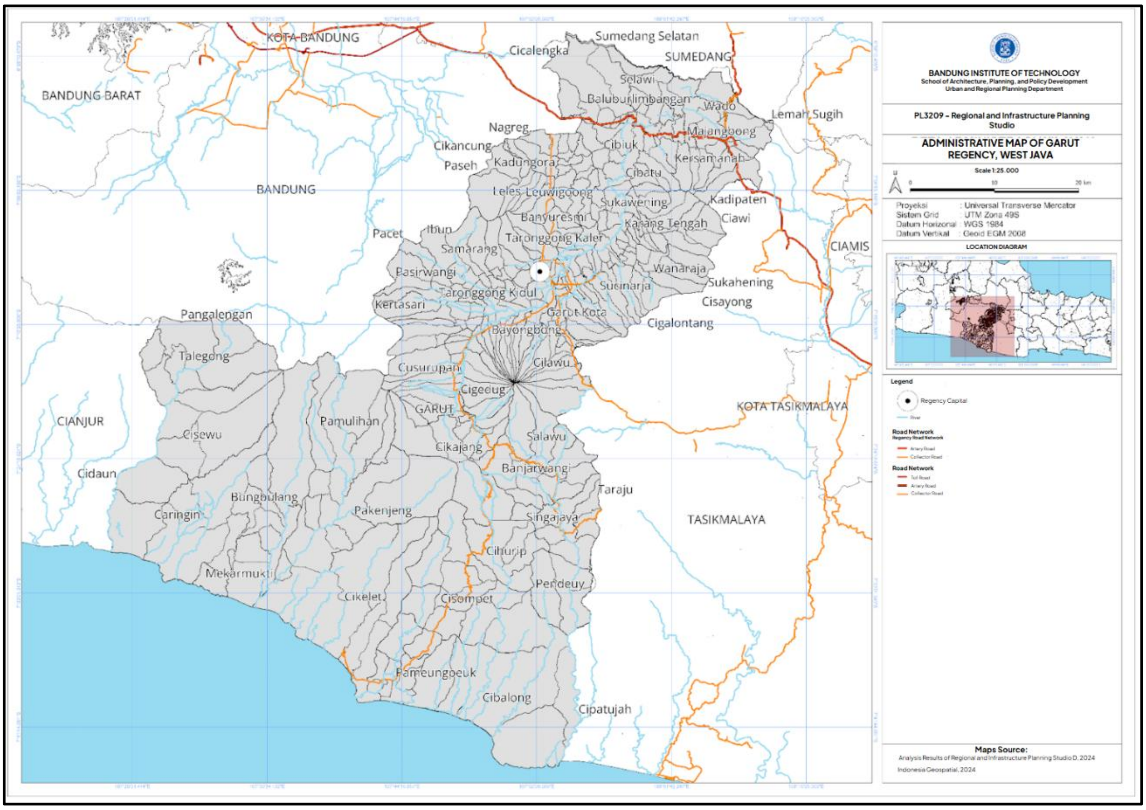

Fig. 6. Administrative map of Garut regency

3. Results and Discussion

3.1 Existing conditions and quantitative findings

The spatial-territorial analysis of Garut Regency reveals a set of pressing environmental and planning challenges that threaten the sustainability of the region's ecological assets and socio-economic systems. A comprehensive overlay of the current land use map against the official Garut Regency Spatial Plan (RTRW 2011–2031) indicates a mismatch of approximately 52.57%, underscoring the significant divergence between intended spatial allocations and actual on-the-ground usage. The most severe deviations are concentrated in the conversion of protected forest zones into agricultural plantations and residential settlements, a phenomenon that has accelerated in tandem with demographic pressures, speculative land markets, and insufficient enforcement of zoning regulations. Between 2017 and 2024, Garut experienced a 42.46% reduction in forest cover, with the most critical losses occurring in the upper watershed areas of the Cimanuk and Cisanggarung basins. These upstream ecosystems serve as the hydrological backbone for much of the regency, and their degradation has cascading effects on water regulation, erosion control, and biodiversity integrity.

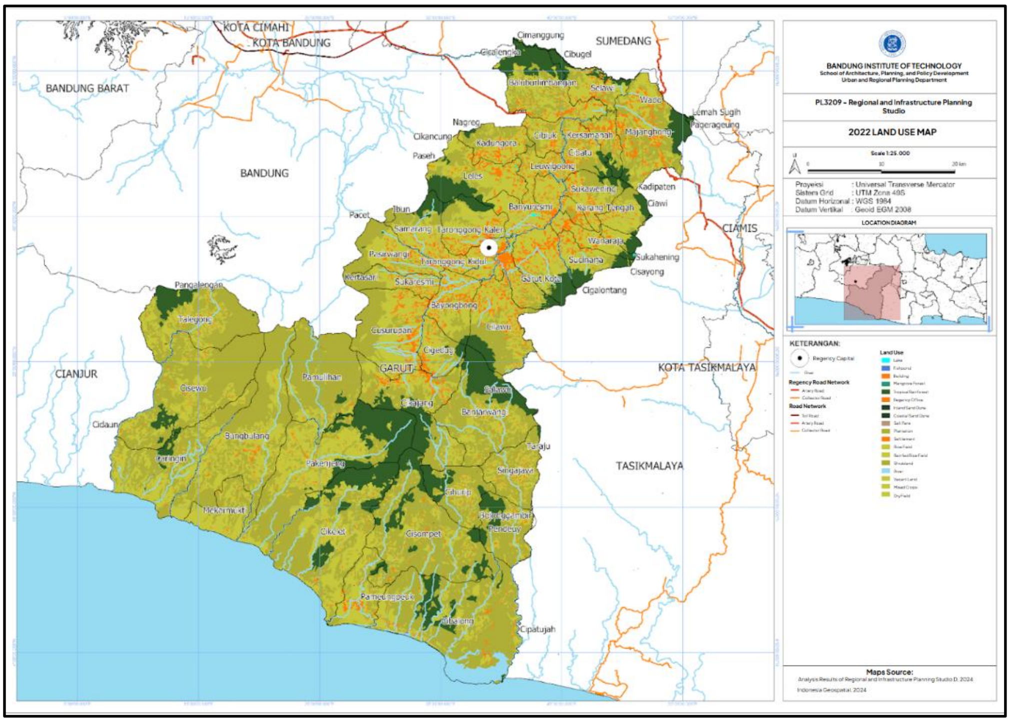

Fig. 7. Garut regency land use map 2022

Hydrological analysis based on water balance data shows that 19 sub-districts face chronic deficits, particularly during the dry season, which compromises both agricultural productivity and domestic water supply reliability. This deficit is not solely a result of climatic variability; it is exacerbated by the expansion of impervious surfaces, the degradation of riparian buffers, and unregulated groundwater extraction. Such trends raise concerns about the resilience of Garut's agro-ecological systems in the face of projected climate change scenarios, which predict increased rainfall variability and heightened incidence of extreme weather events. The interplay between land degradation, water scarcity, and agricultural vulnerability highlights the systemic nature of the challenges, where ecological stressors intersect with socio-economic fragility.

Despite these mounting pressures, Garut holds substantial renewable energy potential that remains underutilized. The Darajat Geothermal Power Plant/*Pembangkit Listrik Tenaga Panas Bumi* (PLTP) alone contributes 330 MW to the grid, making it one of the largest geothermal facilities in Indonesia and a critical component of the national renewable energy mix. Beyond geothermal, the regency benefits from solar radiation levels exceeding 4.8 kWh/m^2/day in several southern districts, offering viable conditions for photovoltaic installations. Additionally, the topographical features of upland river systems provide significant micro-hydro potential, while agricultural residues such as rice husks, corn stalks, and sugarcane bagasse present opportunities for biomass-based energy generation. However, the deployment of these renewable resources has been hampered by infrastructural limitations, fragmented policy frameworks, and a lack of integration between energy planning and spatial development strategies.

The current institutional framework in Garut is further challenged by the absence of a coherent roadmap that synchronizes energy transition objectives with ecological conservation mandates. Renewable energy projects often proceed without a spatially explicit assessment of their environmental trade-offs, leading to suboptimal siting and, in some cases, conflicts with existing land uses. This gap in strategic planning is compounded by the insufficient capacity of local agencies to conduct comprehensive environmental impact assessments that incorporate ecosystem services valuation. As a result, opportunities for maximizing the co-benefits of renewable energy such as carbon sequestration, biodiversity enhancement, and community empowerment are frequently overlooked.

Furthermore, Garut's economic profile remains heavily dependent on agriculture, tourism, and small-scale industries, with limited diversification into high-value green sectors. This economic structure, while reflective of local comparative advantages, is vulnerable to shocks from environmental degradation and global market fluctuations. The regency's fiscal dependency on central government transfers, with a regional financial independence rate of only 15.05%, constrains its ability to invest in large-scale sustainable infrastructure. The underutilization of renewable energy resources thus represents not only an environmental challenge but also a missed economic development opportunity that could contribute to both fiscal autonomy and climate resilience.

In this context, the existing conditions present a paradox on the one hand, the degradation of ecological capital threatens the very foundations of Garut's development, on the other, the untapped potential of renewable energy and ecosystem-based economic models offers a pathway toward a more resilient and sustainable future. The quantitative findings from this analysis establish the empirical foundation for the subsequent exploration of governance challenges, socio-political risks, and strategic interventions required to reconcile these competing dynamics.

3.2 Socio-political risks and governance challenges

The governance landscape in Garut Regency presents a complex interplay of institutional, socio-political, and cultural dynamics that can significantly influence the feasibility and effectiveness of implementing ecoregional planning and carbon trading mechanisms. While the existence of regulatory frameworks at national, provincial, and local levels ostensibly provides a legal basis for these initiatives, the translation of policy into practice is frequently hampered by fragmented authority, weak enforcement, and competing development priorities. These governance deficiencies not only undermine environmental stewardship but also perpetuate socio-political tensions that can derail even well-designed interventions.

One of the most persistent challenges is the issue of land tenure conflicts, which are particularly pronounced in areas where customary land rights (*hak ulayat*) overlap with state-designated forest areas. In Garut, such disputes are prevalent in the southern and upland districts, where indigenous and rural communities have long practiced traditional land management systems that do not always align with formal cadastral boundaries. Renewable energy projects especially geothermal and micro-hydro installations often target these resource-rich zones, inadvertently triggering conflicts over ownership, access, and benefit-sharing. Without transparent and participatory mechanisms for land acquisition, there is a high risk of exacerbating local grievances, which can manifest in protests, legal challenges, or even sabotage of infrastructure.

Closely linked to tenure disputes is the problem of institutional fragmentation. The authority to regulate forests, issue spatial permits, and license energy projects is dispersed among multiple agencies such as the Ministry of Environment and Forestry/*Kementerian Lingkungan Hidup dan Kehutanan* (KLHK), the Ministry of Energy and Mineral Resources (ESDM), the West Java Provincial Government, and Garut's own local agencies (Bappeda, DLH, DPUPR). This overlapping jurisdiction creates bureaucratic bottlenecks, delays in project approval, and inconsistent enforcement of environmental standards. In practice, agencies often operate in silos, with limited inter-agency data sharing and coordination. This not only slows down the policy cycle but also leads to contradictory decisions such as a provincial energy license being granted for a site that the local spatial plan designates as protected.

A third governance barrier is public resistance to infrastructure development, which has been observed in multiple cases across Indonesia, including Garut. Communities often perceive renewable energy projects as externally imposed, particularly when they are spearheaded by private developers with limited local engagement. Concerns typically revolve around potential environmental degradation, loss of agricultural land, and inequitable distribution of benefits. Historical precedents such as the displacement of farmers for dam projects or the limited local hiring in geothermal operations have created a trust deficit that complicates future project rollouts. In Garut, the social acceptability of energy transition policies will depend heavily on early-stage consultation, transparent communication of risks and benefits, and mechanisms for direct community participation in decision-making.

Another critical risk factor is elite capture, where the financial benefits of carbon trading and renewable energy investments accrue disproportionately to political or economic elites rather than being equitably distributed. Without robust safeguards, there is a danger that carbon credit revenues will be absorbed into opaque budgetary channels or captured by well-connected actors through preferential contracting. This risk is not hypothetical case studies from other Indonesian regions have documented how conservation funding and climate finance can be diverted away from intended beneficiaries due to weak oversight and political patronage systems. In the context of Garut, elite capture could erode public trust, discourage community participation, and ultimately undermine the legitimacy of both ecoregional planning and carbon trading mechanisms.

These socio-political risks are compounded by broader national governance patterns. While Indonesia has enacted progressive environmental laws and is a signatory to major international climate agreements, the operationalization of these commitments often suffers from limited human resource capacity, insufficient monitoring systems, and a lack of cross-sectoral alignment. In Garut, the absence of a unified monitoring and reporting system that integrates spatial, ecological, and socio-economic data makes it difficult to evaluate the outcomes of development interventions in real time. This creates a reactive rather than proactive governance environment, where problems are addressed after they escalate rather than being anticipated and mitigated.

Addressing these challenges will require a multi-pronged approach that strengthens institutional capacities, clarifies inter-agency roles, and embeds community engagement as a central pillar of policy design. Mechanisms such as inter-governmental coordination committees, participatory land-use mapping, and independent multi-stakeholder monitoring boards could help reduce fragmentation and build trust. Furthermore, the integration of local customary institutions (*lembaga adat*) into formal governance structures can provide a culturally resonant bridge between statutory regulations and traditional norms, enhancing compliance and social legitimacy. By systematically addressing these governance deficits, Garut can lay the institutional foundation necessary for the successful implementation of its ecoregional planning and carbon trading ambitions.

3.3 Trade-offs in renewable energy development in protected areas

The pursuit of renewable energy development in Garut Regency inevitably raises complex trade-offs, particularly in cases where potential energy sites overlap with protected areas, biodiversity hotspots, or critical ecosystem services. While the imperative of transitioning toward low-carbon energy systems is urgent, the ecological, social, and spatial costs of renewable infrastructure cannot be overlooked. This tension reflects a broader paradox in environmental governance: the very projects designed to mitigate climate change can, if poorly planned, generate localized ecological degradation and socio-cultural disruption. In Garut, where 81.39% of the regency's land is formally designated as protected areas under the RTRW, the siting of geothermal, solar, micro-hydro, and wind energy projects requires careful negotiation between environmental protection and energy security.

Geothermal energy provides a salient example of this dilemma. The Darajat and Kamojang Geothermal Power Plants (PLTP) demonstrate the immense potential of geothermal resources in Garut, which together supply hundreds of megawatts to the national grid. Yet, geothermal exploration and drilling are often located within conservation forests and volcanic landscapes, which serve as crucial carbon sinks, water catchment areas, and biodiversity reserves. Although geothermal energy has a significantly lower carbon footprint compared to fossil fuels, its infrastructure such as drilling platforms, pipelines, and access roads can fragment habitats, alter hydrological cycles, and increase erosion risks. Furthermore, geothermal operations may emit non-CO_2 pollutants, such as hydrogen sulfide (H_2S), which pose health and environmental concerns if not properly managed. Thus, while geothermal projects advance Indonesia's renewable energy targets, they simultaneously generate ecological externalities that must be carefully mitigated through stringent environmental safeguards and continuous monitoring.

Solar and wind energy present similarly intricate trade-offs. Southern Garut, with average solar radiation exceeding 4.8 kWh/m^2/day, is well-suited for solar photovoltaic (PV) deployment. However, the large-scale siting of solar farms may necessitate the conversion of agricultural land or encroach upon forest margins, potentially undermining food security and biodiversity conservation. While rooftop and floating solar systems offer alternatives that minimize land-use conflicts, these technologies remain underutilized due to higher upfront costs and regulatory barriers. Wind energy, meanwhile, is concentrated along upland ridges and coastal zones areas that often overlap with high-biodiversity ecosystems and critical erosion buffers. Turbine installation in these zones risks disrupting avian migration routes, fragmenting wildlife corridors, and destabilizing fragile slopes. Without rigorous ecological zoning, renewable energy development could paradoxically exacerbate the very environmental vulnerabilities it seeks to address.

Another dimension of trade-offs concerns the social implications of energy projects in protected or agriculturally valuable areas. Land acquisition for renewable infrastructure often involves the displacement or restriction of local communities, particularly smallholder farmers who rely on customary land for subsistence and income. Even when formal compensation is provided, the loss of access to traditional resources such as grazing lands, forest products, or irrigation water can erode livelihoods and exacerbate poverty. In Garut, these risks are particularly acute in the southern districts, where socio-economic vulnerability is already high and alternative employment opportunities are limited. Renewable energy projects that fail to adequately address social safeguards risk generating local resistance, fueling land conflicts, and undermining the legitimacy of the green transition.

The trade-offs extend into the domain of placemaking and landscape transformation, a critical dimension for a journal focused on placemaking and streetscape design. Renewable energy infrastructure, particularly large-scale facilities such as geothermal plants or wind farms, reshapes local landscapes and reconfigures the spatial patterns of settlement and mobility. For example, access roads built for geothermal operations may open previously isolated areas to new settlement expansion, potentially increasing pressures on protected forests. Wind turbines alter the visual character of ridges and coastal zones, creating tensions between the symbolic value of landscapes (e.g., cultural heritage, tourism aesthetics) and their functional role in energy production. At the same time, renewable infrastructure can catalyze new forms of placemaking if integrated into broader spatial strategies such as community-based solar microgrids that power local markets or agroforestry zones that double as carbon sinks and recreational spaces. The question is not whether renewable energy will transform Garut's landscapes, but whether this transformation can be harnessed to create inclusive, resilient, and ecologically balanced places.

Mitigating these trade-offs requires the adoption of ecological zoning and adaptive management frameworks that prioritize degraded lands for renewable energy siting while avoiding ecologically sensitive zones. This aligns with best practices from other regions: for instance, in Sragen Regency, micro-hydro projects were successfully integrated into degraded irrigation channels, minimizing ecological disruption while enhancing agricultural productivity. In Banyuwangi, solar-powered tourism facilities were developed on underutilized coastal lands, aligning energy development with local economic goals. Beyond Indonesia, ASEAN neighbors such as Vietnam have demonstrated how floating solar projects on hydropower reservoirs can generate clean energy while reducing land-use conflicts. These comparative cases underscore the possibility of designing renewable projects that balance energy generation with ecological and social imperatives, provided that careful spatial planning and participatory processes are in place.

In Garut, the implementation of such strategies would entail revising the RTRW to explicitly integrate renewable energy zones, supported by environmental impact assessments that account for cumulative ecosystem effects rather than project-level impacts alone. Monitoring systems should be embedded into project lifecycles, employing geospatial technologies and community-based reporting mechanisms to track changes in land cover, biodiversity, and water resources. Equally important is the incorporation of Payment for Ecosystem Services (PES) schemes, which can compensate local communities for conserving forest buffers around renewable installations. By linking ecological stewardship with tangible economic benefits, PES can transform potential conflicts into collaborative conservation.

Ultimately, the trade-offs inherent in renewable energy development within protected areas highlight the importance of adopting a systems-thinking approach that transcends narrow cost-benefit calculations. Renewable energy is not a panacea; its success in advancing sustainable development depends on the extent to which it is embedded within broader ecological, social, and spatial systems. For Garut, the challenge is to ensure that the pursuit of energy security and carbon neutrality does not come at the expense of its ecological integrity and cultural landscapes. Instead, renewable energy development must be reframed not merely as infrastructure provision but as a form of ecological placemaking where energy facilities are designed, located, and governed in ways that enhance, rather than diminish, the quality of landscapes, ecosystems, and local livelihoods.

3.4 Regional development plan of Garut regency

The formulation of policy recommendations for Garut Regency must move beyond abstract commitments to sustainability and instead articulate clear, measurable, and time-bound targets that can be monitored and evaluated over time. Such recommendations must also account for the region's ecological vulnerabilities, fiscal constraints, and governance challenges while aligning with Indonesia's national commitments to net-zero emissions by 2060 and the SDG 2045 agenda. Importantly, the recommendations must be designed to anticipate socio-political risks including land tenure conflicts, elite capture of carbon revenues, and local resistance to renewable energy projects while embedding mechanisms of accountability that ensure equitable outcomes. Policy recommendations are therefore structured along four interlinked axes: spatial planning, carbon trading governance, community-based renewable energy, and institutional transparency.

The first axis, spatial planning revision and ecological zoning, requires the integration of renewable energy zones directly into the next revision of the Garut RTRW. This would ensure that land allocation for energy infrastructure is not an afterthought but a central component of spatial planning. A measurable target is to designate at least 10% of cultivation areas as renewable energy priority zones by 2030, with ecological impact assessments conducted at watershed and landscape scales rather than only at project sites. This target should be coupled with the creation of "no-go zones" for energy infrastructure in areas classified as high-biodiversity corridors or critical water recharge zones. Monitoring outcomes would include annual remote sensing audits of land cover change, biodiversity indices in buffer zones, and compliance reports on ecological zoning enforcement. By embedding these mechanisms, Garut can avoid the pitfalls of spatial mismatch that have undermined previous RTRW implementation, where more than 52% of land use was non-compliant with designated plans.

The second axis, carbon trading governance, focuses on the establishment of a semi-autonomous regional carbon trading agency. This institution would regulate Measurement, Reporting, and Verification (MRV) systems, facilitate partnerships with private investors, and ensure that carbon credit revenues are distributed equitably. The measurable target is to operationalize the agency by 2027 with an initial portfolio of at least 500,000 tCO_2-e verified credits, expanding to 2 million credits by 2035. Monitoring outcomes would be tracked through third-party verification reports, financial audits, and transparent disclosure of revenue allocation. To mitigate the risk of elite capture a recurrent problem in natural resource governance in Indonesia, the agency should adopt multi-stakeholder oversight boards, including civil society organizations and community cooperatives, with the legal authority to audit and contest financial decisions. Comparative lessons from the implementation of REDD+ projects in Kalimantan demonstrate that without such safeguards, carbon finance tends to concentrate among political elites, undermining both ecological and social outcomes. Garut must therefore design a governance framework that prevents such distortions from the outset.

The third axis, community-based renewable energy and conservation programs, emphasizes the integration of Payment for Ecosystem Services (PES) schemes and community cooperatives into energy transition strategies. Instead of treating local communities as passive recipients of compensation, policy frameworks should position them as active stakeholders and beneficiaries. The measurable target is to establish at least 50 PES contracts between renewable energy operators and local cooperatives by 2030, covering watershed protection, agroforestry buffers, and biodiversity corridors. Monitoring outcomes would include annual assessments of forest cover stability in PES zones, household income data in participating communities, and periodic satisfaction surveys measuring perceived fairness of benefit-sharing. Socio-political risks such as local resistance to land acquisition can be reduced if communities perceive tangible benefits such as improved electrification, infrastructure investment, or livelihood diversification from renewable projects. Case studies from East Nusa Tenggara's community-based eco-tourism and Sragen's micro-hydro cooperatives show that when local actors are co-owners of projects, resistance decreases, and projects achieve long-term viability. Garut could adopt similar models, embedding PES and co-operative frameworks into the licensing requirements of renewable projects.

The fourth axis, institutional transparency and revenue allocation, addresses the critical issue of trust and legitimacy in the implementation of green policies. Transparent revenue management is particularly urgent in carbon trading schemes, where large sums of money are at stake. A measurable target is to publish annual audited reports on the use of carbon revenues starting in 2026, with at least 30% of revenues earmarked for social infrastructure (e.g., schools, health facilities, and clean water systems) in vulnerable districts. Monitoring outcomes would involve independent financial audits, public access to expenditure data, and citizen monitoring platforms (such as digital dashboards) where communities can track project progress. International experience from Bhutan's hydropower revenue allocation where earmarked funds are channeled into social services demonstrates that transparent reinvestment of natural resource rents can bolster legitimacy and reduce social conflict. For Garut, embedding such transparency mechanisms into carbon trading revenues would not only strengthen governance but also establish the regency as a model of sub-national accountability in Indonesia's green economy.

Nevertheless, these policy recommendations must also acknowledge the inherent trade-offs and risks associated with renewable energy deployment in protected or socially contested areas. Infrastructure development in conservation forests or high-biodiversity ridges may trigger ecological degradation, while land acquisition processes could spark social unrest. Monitoring frameworks must therefore not only measure environmental indicators but also track social impacts. Indicators such as the number of land-related disputes, the percentage of projects with free, prior, and informed consent (FPIC) agreements, and the extent of community benefit-sharing must be institutionalized within policy evaluation systems. This dual monitoring ecological and social ensures that the pursuit of carbon neutrality does not exacerbate inequality or ecological vulnerability.

Table 1. Regional development strategy of garut regency

Existing Conditions	Desired Conditions	Strategies
Policy 1: Development of a local resource-based and low-carbon economy		
Garut Regency has significant potential in agriculture, plantations, and fisheries but faces utilization constraints.	Optimization of sustainable local resource utilization.	- Modernization of agricultural and plantation systems. - Development of cultural-based ecotourism and creative industries.
Minimal utilization of renewable energy and low-carbon industries.	Enhancement of a green energy-based and low-emission economy.	- Development of green industries and incentives for low-carbon initiatives. - Optimization of renewable energy sources (solar, biomass).
Policy 2: Increasing regional revenue through carbon trading schemes and green incentives		
Garut Regency has a carbon trading potential of 1.96 T yet to be optimally utilized.	Utilization of carbon trading to increase Local Revenue (PAD).	- Carbon potential inventory and private sector partnerships. - Enhancing government capacity in natural resource governance..
Garut Regency's APBD has increased but still faces budget absorption issues.	Expansion of regional budget absorption.	- Accelerating budget absorption processes and improving inter-agency coordination.
Policy 3: Control of protected area utilization		
Forest cover achievement is only 52.57% of the Spatial Plan target.	Maintenance of protected areas covering 45% of the total land area.	- Strengthening spatial planning regulations and forest conservation.
Forest area has decreased by 42.46% over the last 7 years..	Restoration and rehabilitation of forest areas.	- Enhanced forest ecosystem conservation and rehabilitation.
Policy 4: Optimization of land use based on environmental carrying capacity		
Agricultural land area has decreased by 9.16%.	Control of agricultural land conversion.	- Optimization of land use through sustainable agricultural systems.
Industrial location incompatibility with the Spatial Plan.	Industrial development aligned with spatial planning.	- Establishment of environmentally based industrial zones.
Policy 5: Integration of spatial planning with renewable energy development		
Minimal utilization of renewable energy.	Increased utilization of renewable energy.	- Revision of spatial plans to support green energy development.
Lack of integration between spatial planning and climate change mitigation.	Climate mitigation and adaptation-based spatial planning.	- Spatial zoning based on carbon sequestration and renewable energy.

Garut's policy trajectory can be further strengthened by positioning itself as a national model for integrated ecoregional planning and carbon trading. Comparative insights from Banyuwangi's green tourism corridors, Sragen's micro-hydro cooperatives, and Vietnam's floating solar projects provide replicable best practices that Garut can adapt. By demonstrating how renewable energy infrastructure can be harmonized with ecological zoning, participatory governance, and transparent revenue allocation, Garut could emerge as a leading sub-national case of sustainable energy transition in Indonesia. This positioning would not only attract domestic and international investment but also provide a template for other regencies struggling with similar tensions between energy security, ecological protection, and social equity.

Finally, the recommendations must be tied to a broader narrative of placemaking and landscape transformation. Renewable energy infrastructure is not merely a technical installation but a spatial intervention that reshapes landscapes, alters public spaces, and reconfigures settlement patterns. Geothermal roads can become new economic corridors; solar-powered microgrids can transform village centers into vibrant hubs of economic activity; and wind farms, if carefully designed, can become symbols of sustainable identity rather than sources of visual disruption. By framing renewable energy projects as tools of ecological placemaking, policies can shift public perception from viewing such projects as external impositions to shared investments in a resilient and sustainable future. In this way, Garut's energy transition becomes not only a technical achievement but also a cultural and spatial reimagination of how landscapes, communities, and infrastructures co-evolve.

Subsequently, the ecoregional planning concept is employed in the formulation of the spatial structure plan. The Spatial Structure Plan forms a critical component of the Regional Spatial Plan (RTRW), representing the allocation of land for various designated functions, encompassing both protected and cultivation areas. Its objective is to establish a sustainable spatial arrangement that supports regional development aligned with the local potential and community needs. This plan is formulated by taking into account regional development concepts and emerging strategic issues. The development concept refers to the approach used to construct and manage a region in accordance with its potential and local requirements, in alignment with sustainable development goals. The need for such planning is underpinned by the significant inconsistency between current land use patterns and the designated spatial structure, which has led to a reduction in protected areas and an expansion of cultivation areas, thus threatening the long-term viability of conservation functions. Additionally, the land's carrying capacity is mostly moderate, and its load capacity is already in deficit, which poses constraints to further urban expansion.

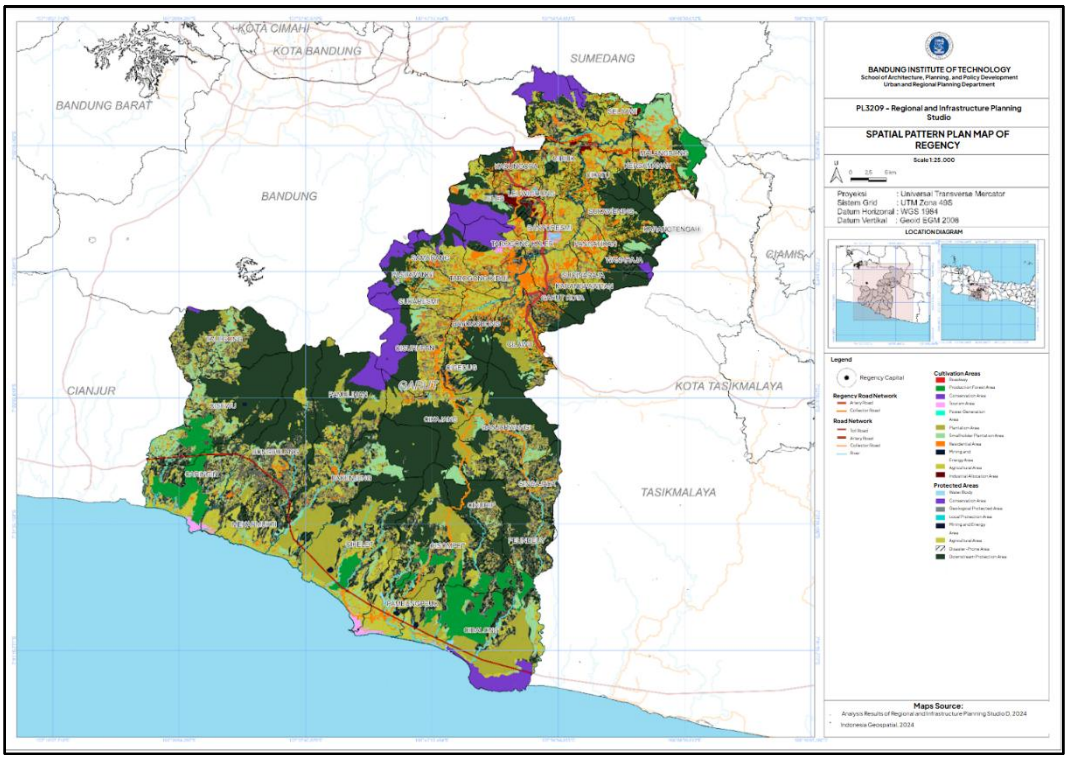

Fig. 8. Garut regency spatial planning map

The Ecoregional Planning Concept, which underpins the formulation of the spatial structure plan, emphasizes a harmonized relationship between ecosystems, the economy, and society, and bases the planning process on natural boundaries of the region or ecoregions, rather than administrative borders. By adopting an ecoregional approach, Garut can better manage cross-boundary ecological networks and watersheds that are often overlooked in conventional planning. For example, the management of the upper Cimanuk watershed, which spans multiple administrative units, requires coordinated planning to address issues of upstream deforestation and downstream flooding. Ecoregional planning ensures that such interdependencies are factored into land use decisions. Moreover, this approach strengthens community involvement in planning processes. Local knowledge, particularly from indigenous and rural communities, plays a vital role in resource conservation. Integrating participatory mapping, local zoning practices (such as *hutan adat* or customary forests), and social forestry programs can enrich the planning process, foster local stewardship, and enhance social acceptance of spatial policies.

3.5 Positioning Garut as a national model: Comparative insights

Positioning Garut Regency as a national model for the integration of ecoregional planning and carbon trading requires situating its experiences within a broader comparative framework, both across Indonesia and in the Southeast Asian region. The novelty of Garut's approach lies not simply in the combination of ecological planning and renewable energy policy, but in its attempt to embed carbon trading mechanisms into local governance and spatial development strategies. While other regencies have experimented with elements of renewable energy transition or conservation-based planning, few have sought to unify these dimensions under a coherent framework that explicitly links spatial zoning, ecological restoration, community participation, and climate finance. In this sense, Garut's policy trajectory has the potential to establish a benchmark for how Indonesian local governments can operationalize sustainability in ways that are measurable, transparent, and replicable.

Comparative insights from other Indonesian regencies reinforce the uniqueness of Garut's model while also highlighting critical lessons. In Banyuwangi, for example, the integration of eco-tourism with renewable energy has created a synergistic development pathway that combines conservation and economic diversification. Solar-powered tourism facilities and green certification programs for resorts have generated local employment while reinforcing the district's image as an environmentally progressive destination. However, Banyuwangi's case also reveals the risks of over-reliance on a single sector: fluctuations in tourism demand, such as those induced by the COVID-19 pandemic, exposed the fragility of a growth model too heavily tied to external visitors. By contrast, Garut's strategy, with its emphasis on carbon trading and diversified renewable energy deployment (geothermal, solar, micro-hydro, biomass), presents a more balanced approach that buffers against sector-specific shocks while embedding resilience into multiple layers of the economy.

Sragen provides another relevant comparator, particularly in the domain of community-based renewable energy. Through the establishment of micro-hydro cooperatives, Sragen has demonstrated how local ownership and cooperative governance can enhance both social legitimacy and project sustainability. Farmers and villagers, as stakeholders in the cooperatives, not only benefit from reliable electricity but also reinvest profits into local development initiatives, creating a virtuous cycle of empowerment and resilience. Garut could adapt this model by requiring renewable energy developers particularly in micro-hydro and solar projects to integrate cooperative structures and Payment for Ecosystem Services (PES) contracts into their business models. Such an approach would directly address socio-political risks in Garut, such as local resistance to land acquisition and elite capture of revenues, by embedding benefit-sharing mechanisms into the institutional DNA of energy projects.

Beyond Indonesia, comparative experiences from ASEAN countries illustrate both opportunities and cautions. Vietnam, for instance, has pioneered the deployment of floating solar on hydropower reservoirs, thereby generating renewable energy while reducing land-use conflicts. The dual-use model has gained international attention as a creative response to spatial trade-offs, and Garut could replicate this approach by installing floating solar panels on its existing water reservoirs and irrigation dams. The Philippines, particularly in Ilocos Norte, has become a regional leader in wind energy, but its projects have also faced criticism for disrupting coastal ecosystems and tourism landscapes. This case underscores the importance of ecological zoning and stakeholder consultation in renewable energy siting lessons that Garut must internalize to avoid repeating similar mistakes. Thailand's experience with community forests linked to carbon markets further illustrates how institutionalizing local participation can enhance trust, ensure equitable benefit-sharing, and build legitimacy for carbon finance mechanisms.

Positioning Garut as a national model also demands that the regency demonstrate its capacity for measurable outcomes and scalable innovation. Unlike projects that remain isolated pilot initiatives, Garut's integrated framework should be designed for replication in other regions with similar ecological and socio-economic profiles. For instance, the measurable target of generating 500,000 tCO_2-e verified carbon credits by 2027 not only provides a clear benchmark but also establishes a precedent for other regencies on how local governments can leverage carbon markets to finance sustainable development. Similarly, Garut's proposal to designate 10% of cultivation areas as renewable energy zones by 2030 offers a replicable spatial policy that can be adapted in regions such as Tasikmalaya or Sukabumi, which face similar pressures of agricultural expansion, forest degradation, and energy insecurity.

At the same time, Garut must confront the socio-political risks that have undermined the credibility of many national "model" projects in Indonesia. Previous attempts to scale up best practices such as community-based forest management or bioenergy programs have often faltered due to elite capture, lack of institutional support, or inadequate monitoring frameworks. Garut can differentiate itself by embedding transparency, participatory governance, and robust monitoring systems into the very architecture of its initiatives. Publicly accessible carbon credit registries, annual environmental audits, and multi-stakeholder oversight boards would not only strengthen local accountability but also demonstrate to national policymakers that sub-national governments can responsibly manage complex sustainability programs.

The positioning of Garut as a national model must also be understood in terms of its symbolic value within Indonesia's broader political economy of development. By showcasing how a regency that has historically struggled with spatial mismatches, ecological degradation, and fiscal dependency can transform these challenges into opportunities for innovation, Garut can inspire other local governments to reimagine their own developmental trajectories. The regency's integrated approach links local realities with global agendas, such as the Paris Agreement and the SDGs, thus positioning Garut not only as a local or national model but also as a contributor to global sustainability discourses.

Ultimately, Garut's claim to be a national model will rest not only on its technical successes in renewable energy and carbon trading but also on its ability to demonstrate resilience, inclusivity, and scalability. By learning from Banyuwangi's eco-tourism integration, Sragen's cooperative-based energy governance, Vietnam's floating solar, and the Philippines' wind power challenges, Garut can craft a distinctive model that is both contextually grounded and globally relevant. The challenge lies in ensuring that this model does not remain a rhetorical claim but becomes a lived reality, evidenced by measurable improvements in ecological integrity, social equity, and economic resilience. If achieved, Garut's integrated strategy could serve as a critical reference point for Indonesia's broader green transition, offering a pathway for other regencies to balance energy security, ecological protection, and socio-political stability in the pursuit of sustainable development.

3.6 Placemaking implications of renewable energy infrastructure

The integration of renewable energy infrastructure into Garut Regency's development strategy is not only a matter of ecological necessity and economic opportunity but also a profound reshaping of landscapes, settlement patterns, and collective identities. Placemaking, understood as the process through which spaces are imbued with meaning, function, and social value, offers a useful lens to analyze the transformative impact of energy transitions on Garut's spatial and cultural fabric. While conventional development approaches often treat energy facilities as isolated technical installations, the paradigm of ecoregional planning calls for renewable energy projects to be embedded within broader territorial logics that acknowledge ecological sensitivities, community participation, and cultural landscapes. This integration has the potential to redefine how people relate to their environment, their livelihoods, and even their sense of belonging to the regency.

In Garut, geothermal facilities such as PLTP Darajat and Kamojang are already emblematic landmarks that signify both technological modernity and ecological contestation. Traditionally, energy infrastructures in Indonesia have been perceived as extractive or intrusive, often associated with displacement or environmental damage. However, by incorporating placemaking principles, these facilities can instead become sites of community engagement, education, and ecological stewardship. For example, geothermal plants can be designed with interpretive centers that showcase the science of renewable energy, integrating them into eco-tourism routes that highlight Garut's volcanic landscapes, hot springs, and conservation areas. Such integration not only demystifies energy production but also transforms otherwise restricted industrial zones into semi-public spaces that foster environmental awareness and pride in local innovation.

Placemaking implications are equally evident in the potential deployment of solar and micro-hydro systems in rural communities. Distributed solar projects, for instance, can be co-located with community spaces such as schools, markets, and health centers, ensuring that renewable infrastructure serves as both an energy source and a symbolic marker of local development. This creates a dual impact: improving material conditions through affordable and clean energy while reshaping the public realm into visible expressions of sustainability. Similarly, micro-hydro cooperatives can function as nodes of collective identity, where villagers not only manage their own electricity but also use revenues to reinvest in shared facilities such as village halls, irrigation channels, and cultural sites. In this way, renewable energy projects become deeply intertwined with the spatial and social rhythms of everyday life, rather than standing apart as external impositions.

The placemaking dimension also reveals the trade-offs and tensions inherent in energy transitions. As discussed in earlier sections, renewable energy projects may encroach upon protected areas or traditional land-use zones, potentially disrupting ecological and cultural landscapes. For example, wind farms situated in upland ridges could interfere with wildlife corridors or alter scenic vistas that are integral to local identities and tourism economies. Floating solar projects on reservoirs may displace traditional fishing practices or change the visual aesthetics of rural landscapes. Placemaking requires that these trade-offs be explicitly acknowledged and negotiated, ensuring that renewable infrastructure not only minimizes ecological harm but also respects cultural attachments to place. This underscores the need for participatory design processes where communities are consulted not just on compensation or technical siting but also on the symbolic meanings and social functions of landscapes.

Importantly, renewable energy infrastructure can also act as a catalyst for new spatial patterns and economic geographies within Garut. For instance, the designation of renewable energy zones in the updated RTRW has the potential to generate clustering effects, creating green industrial districts that simultaneously produce energy, host eco-enterprises, and support urban amenities. Such clusters can reshape urban-rural linkages by attracting skilled labor, stimulating supporting services, and catalyzing transport and digital infrastructure improvements. Over time, these shifts may alter settlement patterns, with new centers of growth emerging around renewable energy hubs, thereby diversifying the regency's spatial structure beyond the traditional north-south divide. If managed through inclusive and ecological planning, this transformation could mitigate regional disparities and reinforce Garut's identity as a conservation regency that embodies innovation in sustainable placemaking.

The symbolic and cultural dimensions of placemaking further highlight how energy transitions can contribute to local narratives of modernity and resilience. In many regions, renewable energy infrastructure has become a source of local pride and a marker of progressive identity. For example, in Germany's Energiewende villages, solar rooftops and wind turbines are celebrated as symbols of community autonomy and environmental leadership. Similarly, in Bali, micro-hydro projects have been integrated into local cultural narratives of water stewardship, aligning technological innovation with traditional ecological wisdom. Garut could leverage these lessons by embedding renewable projects into local festivals, educational curricula, and cultural expressions, thereby weaving the energy transition into the regency's collective identity. In doing so, renewable energy infrastructure becomes not merely a technical necessity but also a cultural resource that redefines what it means to be part of Garut in the era of climate change.

Finally, the placemaking perspective reveals how Garut's renewable energy transition can influence broader narratives of Indonesian urbanism and regional development. By transforming energy infrastructure into socially meaningful spaces, Garut contributes to the redefinition of regional planning as not only a matter of efficiency and regulation but also of identity and belonging. If successful, Garut's integration of ecoregional planning, carbon trading, and renewable infrastructure could serve as a prototype for how sub-national governments across Indonesia can pursue climate goals while simultaneously enriching the social fabric and spatial quality of their regions. In this way, Garut positions itself not merely as a technical model of sustainability but as a cultural and spatial exemplar of how energy transitions can reshape places, communities, and futures.

4. Conclusions

The findings of this research reveal that Garut Regency stands at a decisive crossroads in shaping its development trajectory, where the pressures of environmental degradation and socio-economic vulnerability converge with opportunities for innovation in renewable energy and ecological governance. The empirical evidence of a 52.57% mismatch between land use and the official spatial plan, combined with the 42.46% decline in forest cover and water deficits across nineteen sub-districts, highlights the systemic nature of environmental stress. These conditions undermine not only ecological resilience but also the viability of agriculture, tourism, and other sectors that form the foundation of Garut's economy. Yet, this same context underscores the urgency and necessity of transitioning toward a regional development model that harmonizes ecological integrity with economic dynamism, and that leverages the principles of ecoregional planning supported by carbon trading mechanisms.

The conclusion that emerges from this analysis is that ecoregional planning and carbon trading are not parallel instruments but mutually reinforcing strategies capable of addressing Garut's multidimensional challenges. Ecoregional planning offers a spatial and ecological framework to guide the allocation of land and resources in a manner consistent with environmental carrying capacity and community needs, while carbon trading provides the financial incentives and regulatory mechanisms necessary to fund conservation and renewable energy projects. The integration of these strategies, however, requires more than technical adjustments; it calls for institutional reform, capacity building, and the creation of a governance architecture capable of mediating land tenure conflicts, coordinating overlapping authorities, and ensuring that the benefits of carbon revenues and renewable energy development are distributed equitably across society.

A critical recommendation is the revision of the Garut Spatial Plan (RTRW) to explicitly integrate renewable energy zones, ecological buffers, and community-based conservation areas. This revision should not be seen merely as a bureaucratic exercise but as a transformative opportunity to align spatial planning with climate resilience and disaster risk reduction. Similarly, the establishment of a semi-autonomous regional carbon trading agency emerges as a necessary institutional innovation. Such an agency would be responsible for managing carbon credit inventories, ensuring transparent monitoring, reporting, and verification (MRV) systems, and facilitating equitable revenue-sharing mechanisms that prioritize community development. Without such institutional arrangements, the risks of elite capture, policy fragmentation, and public distrust could derail the transformative potential of these initiatives.

The research further concludes that Garut's renewable energy transition must be approached as a placemaking process. Renewable energy infrastructure, whether geothermal plants, solar farms, or micro-hydro systems, is not only a technical installation but also a spatial intervention that reshapes landscapes, alters settlement patterns, and redefines the cultural identity of the region. If embedded in participatory governance processes and sensitive to local socio-ecological contexts, such infrastructure can catalyze new forms of public space, enhance community cohesion, and reinforce Garut's emerging identity as a conservation regency. Conversely, if imposed without adequate consultation and ecological safeguards, renewable energy projects risk generating community resistance, exacerbating social inequality, and undermining long-term sustainability. Thus, the recommendation is to treat renewable energy development not as isolated projects but as integral components of a broader vision for sustainable placemaking.

From a national perspective, Garut's pathway holds the potential to serve as a model for sub-national climate governance in Indonesia. Comparative lessons from Banyuwangi, Sragen, and ASEAN counterparts such as Vietnam and the Philippines illustrate that integrated approaches combining ecological zoning, renewable energy deployment, and market-based carbon instruments can succeed when they are anchored in measurable targets and transparent monitoring mechanisms. Garut's case demonstrates the need to set quantifiable benchmarks such as the designation of renewable energy zones by 2030, the operationalization of a carbon trading agency by 2027, and the signing of at least fifty community-based PES contracts by 2030 while also establishing multi-stakeholder oversight boards to ensure accountability in implementation. These targets not only align with Indonesia's commitment to net-zero emissions by 2060 but also provide tangible indicators for evaluating progress at the local level.

Ultimately, the recommendation is that Garut Regency adopt a dual orientation: simultaneously addressing immediate vulnerabilities while positioning itself as a long-term pioneer of low-carbon regional development. This requires integrating local wisdom into policy design, strengthening institutional collaboration across administrative levels, and ensuring that renewable energy and carbon trading revenues are transparently reinvested in social infrastructure, education, and ecological restoration. The conclusion is clear: Garut's challenges are immense, but so too are its opportunities. If managed through a holistic, inclusive, and evidence-based strategy, the regency can not only safeguard its ecological heritage and strengthen its socio-economic resilience but also provide a replicable model for other regions in Indonesia and beyond. In this sense, Garut's transformation is not merely a local imperative but a contribution to the global agenda of sustainable development and climate action.

Acknowledgement
The author gratefully acknowledges the support and encouragement received throughout the completion of this study.

Author Contribution
The author independently conducted the research, including the design, data collection, analysis, and manuscript preparation.

Funding
This research received no external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The author declare no conflict of interest.

Open Access

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