ENERGY TRANSITION AND LAND USE CHANGE: THE EMERGENCE OF PHOTOVOLTAIC INFRASTRUCTURE IN THE AGRICULTURAL SECTOR OF THE O'HIGGINS REGION, CHILE

Summary

This study examines the rapid expansion of solar photovoltaic (PV) infrastructure in Chile's O'Higgins Region and its implications for agricultural land use. Cartographic and geospatial analysis reveals that over 90% of PV projects are installed on previously cultivated land—a trend driven by national energy policies, growing water scarcity, and the economic appeal of long-term land lease agreements. A review of 100 environmental impact assessments indicates that solar energy infrastructure is increasingly occupying highly productive farmland, raising concerns about soil health, food security, and rural livelihoods. Although mitigation measures are proposed through Voluntary Environmental Commitments (CAVs), their scope and effectiveness remain limited and uncertain. These findings underscore the urgent need for integrated energy and land-use planning that aligns renewable energy development with environmental protection and social equity, offering a critical perspective on the socio-environmental dimensions of Chile's energy transition.

Keywords: renewable energy development, territorial planning, soil degradation, agrivoltaics.

1. Introduction

The transition to renewable energy is advancing rapidly and is expected to intensify global land use competition. The expansion of solar photovoltaic (PV) energy is projected to directly displace productive land (e.g., agriculture) and indirectly affect non-productive areas like forests (Van de Ven et al., 2021). As part of its Nationally Determined Contribution (NDC), Chile has committed to generating 80% of its electricity from renewable sources. This has spurred the development of non-conventional renewables, particularly solar energy. Consequently, PV capacity grew from 7 MW in 2014 to 10,507 MW by December 2024, covering roughly 22,000 hectares. Although PV plants are mostly concentrated in the northern macro-zone due to high solar radiation, central regions have shown notable growth. Between January and July 2024, 82% of new power plants were PV, with 56% located between Valparaíso and Maule (Ministry of Energy, 2024). In the past seven years, 4,317 hectares of former farmland have been converted to PV use (Del Pozo et al., 2024), driven by the need to reduce transmission costs, increasing water scarcity, and the offer of long-term (≈30 years), lucrative land leases. Supreme Decree No. 88/2019, which stabilizes prices for Small Distributed Generation Units (PMGD), has also played a key role in incentivizing these installations. The O'Higgins Region—located in agricultural valleys—has experienced sustained PV growth since 2017 and now hosts 93 plants totaling 457.55 MW, equivalent to about 1,140 hectares (CNE, 2024). A key issue is the impact of this infrastructure on soil health, sustainable land use, and food security. This raises important questions: How does PV infrastructure affect rural soil quality? What are the consequences for agriculture and rural communities? Key aspects include changes in crop types, water use, labor displacement, and transformations in local traditions.

2. Materials and Methods

This study focuses on the O'Higgins Region in central Chile and employs a mixed-methods approach combining cartographic, geospatial, and document analysis. Land use and land cover data were obtained from the MapBiomas Chile platform and analyzed using QGIS software to determine the spatial distribution of photovoltaic (PV) plants in the region. Official data on PV projects—including their status, capacity, and location—were sourced from the Ministry of Energy. Additionally, secondary information from the Environmental Impact Assessment System (SEA) was reviewed for approximately 100 PV projects. This analysis focused on the extent of affected land, the land capability classes (I, II and III) replaced by solar infrastructure, and the types of crops displaced. Information on Voluntary Environmental Commitments (CAVs) was also examined to assess proposed compensation measures and improvement plans.

3. Preliminary Results

The current development status of photovoltaic plants in the O'Higgins Region, categorized by project phase, is presented in Table 1. Each category includes three aspects: the number of projects, installed capacity (in megawatts, MW), and the approximate area occupied, calculated based on 2.5 hectares per megawatt (in hectares, ha). The O'Higgins Region currently hosts 113 PV projects, totaling nearly 1 gigawatt (GW) of installed capacity, of which more than 44% (431.8 MW) is already operational. Although fewer in number, the approved projects contribute an installed capacity almost equivalent to that of the operational ones, which translates into approximately one thousand additional hectares. This situation highlights the significant territorial impact of solar energy expansion in the region.

Table 1. Photovoltaic power plants in the O'Higgins Region (Source: Own elaboration based on Ministry of Energy, 2024).

Status	Number of Projects	Installed Capacity	Approximate Area (ha)
Operating	84	431.8	1,079.5
Approved	10	427.4	1,068.5
Under Construction	17	110.7	276.75
Testing	2	14.9	37.25
Total	113	984.8	2,462

On the other hand, the agricultural area of the O'Higgins Region includes more than 32,000 hectares of cereals, 12,000 hectares of forage crops, and nearly 10,000 hectares of vegetables—all of which are fundamental for food security and sovereignty (INE, 2024). However, because these crops are less economically profitable than fruit orchards or vineyards (which together cover more than 120,000 hectares in the region), they are more vulnerable to being replaced by photovoltaic infrastructure. Cartographic analysis using QGIS and data from MapBiomas Chile (https://chile.mapbiomas.org/), together with geospatial information from the Ministry of Energy, has revealed that 93.5% of photovoltaic projects in the O'Higgins region are located on agricultural land. The MapBiomas Chile land classification, including the category "Mosaic of Agriculture and Pasture," has been key to understanding this shift (Figure 1). This finding highlights a high concentration of projects in areas previously dedicated to agriculture and underscores the conversion of highly productive land to photovoltaic infrastructure.

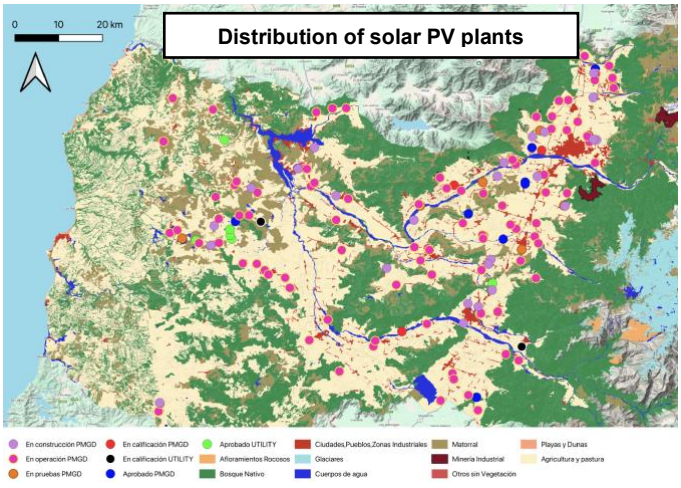

Figure 1: Distribution of photovoltaic plants according to Land Cover and Land Use in the O'Higgins region (Source: Own elaboration based on MapBiomass and Ministry of Energy, 2024).

The preliminary review indicates that the most frequently replaced crops by photovoltaic installations in the O'Higgins Region are maize (Zea mays) and forage grasslands, particularly alfalfa (Medicago sativa). These crops, commonly associated with food production and livestock systems, represent a significant portion of the agricultural land being converted. Their displacement reflects a shift from traditional and multifunctional land uses toward energy generation, with potential implications for local food systems and rural economies.

4. Discussion

The results of this study reveal a marked trend in the O'Higgins Region toward the conversion of productive agricultural land into photovoltaic infrastructure. Over 90% of PV projects are located on land previously used for farming, highlighting a growing competition between food production and energy generation. The findings raise important questions about the sustainability of current energy planning and its long-term implications for food security, rural livelihoods, and land governance. In particular, the displacement of lower-profit crops such as cereals and grassland, in favor of energy projects, could exacerbate social and environmental vulnerabilities. Although some mitigation is proposed through Voluntary Environmental Commitments, the extent and effectiveness of these measures remain limited and largely unmonitored. This study underscores the need for integrated planning approaches that consider not only technical and economic efficiency, but also social equity and ecological integrity in the rollout of renewable energy.

3. References

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