Mapping Complexity of Green Jobs and Green Transition: Opportunities and Challenges

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Introduction

The global discussion on Green Transition (GT) presents both theoretical and practical challenges. Identifying sustainable practices and pathways, and how to revert non-sustainable societies are key goals. One of these challenges is regarding the GT and the labour market: how is it possible to define or classify a green industry and a green occupation, or, a polluting industry and a polluting occupation? Also, how such definitions and classifications could guide governments and policymakers to a fair and balanced GT?

Regarding the definitions of green and polluting occupations, there is no uniformity in the literature concerning the specific areas in which these green positions can be created, or transformed from polluting to green. For instance, governmental institutions and international organizations can vary in their definitions regarding which industry/occupation is considered green or polluting. The International Labour Organization (ILO) defines green jobs as work in agricultural, manufacturing, research and development, administrative, and service activities that contribute substantially to preserving or restoring environmental quality (ILO 2012a, 2012b). Regarding industries, the Organisation for Economic Co-operation and Development (OECD) has stated that there is no internationally or nationally recognized definition for "green industries" (OECD 2023). These are some of the definitions that are frequently used in the literature.

While green occupations and industries are expected to promote the use of renewable energy and reduce greenhouse gas emissions (GHG), polluting or brown occupations/industries are those that involve highly polluting activities, such as mining, manufacturing, and agriculture (Dierdorff et al. 2009; Vandeplas et al. 2022). In the literature, there is also not a strict concept for these industries/occupations, which are mainly correlated to GHG emissions and environmental degradation at some level (Dierdorff et al. 2009; Dierdorff et al. 2011; OECD 2023). With the GT and climate policies, these jobs/industries would be most negatively affected, with the possibility to go through a decrease in demand for labor in the future, with some sectors like coal and lignite mining even facing a complete phase-out (OECD 2023). The greening of these sectors will bring significant structural changes, and here is where one of the biggest challenges relies on, once these industries and occupations will require different policies for adapting and being included in the GT (Vandeplas et al. 2022; OECD 2023).

In this context of GT, we also have the European Green Deal (EGD), which is a comprehensive initiative focusing on three main areas: achieving net zero emissions by 2050, promoting economic growth that is not dependent on resource exploration, and ensuring that no person or region is left behind (Vandeplas et al. 2022; OECD 2023). The initiative is particularly important for industries and occupations that have a significant impact (e.g., GHG emissions) on the environment, as it aims to transition these sectors/industries and occupations towards more sustainable practices. To achieve these goals, the EGD relies on two transitions: decarbonizing and digitalizing Europe's economy. Although the EGD reports are clear on their goals, is important to highlight that this transition is not a straightforward change, and several studies have pointed out flaws and challenges when trying to apply effectively the EGD and GT (Consoli et al. 2016; Vandeplas et al. 2022; Rodríguez-Pose and Bartalucci 2023). Therefore, understanding trends and potential challenges of both sustainable and polluting occupations and industries is essential for making fine-tuned investments and policy decisions. It allows policymakers to elaborate informed policy by considering the existing green capacities in the economy of each region, country, and society. The transition to a green economy will bring significant changes in technology, design, production, services, consumption, and investments. For this reason, it is vital to

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consider the local and regional aspects of each country to achieve a sustainable and successful transition to a greener economy.

This work aims to discuss the green and polluting classifications of occupations and industries under a contextualized spatial scale, considering national and regional levels, as well as employment-industry characteristics. The present work uses as the main reference the methodology elaborated by Vona et al. (2017), which is one of the most referenced works on the topic of occupational classification regarding its level of "green" or "polluting" (Dierdorff et al. 2009; Dierdorff et al. 2011; Consoli et al. 2016; Vandeplas et al. 2022; OECD 2023). An adapted approach and analysis for green and polluting occupations and industries is being proposed. The goal is to analyze the temporal evolution, from 2013 to 2022, of the employment distribution in the industry sectors. The study will also consider the greenness intensity of what is considered a green job and the GHG emissions per sector for those years with data available. The analysis will be conducted at the regional and, if possible, at the municipal level. The results will be discussed in a contextualized frame, taking into account the sectors strengths and weaknesses of each region. This means the main industry sectors developed over time will be analyzed. By identifying any trends, this study can modestly improve our understanding of the potential opportunities in GT, industries, and employment.

Material and Methods

For this work, the case study of Sweden has been chosen, taking into account its eight regions: Mellersta Norrland, Övre Norrland, Stockholm, Östra Mellansverige, Norra Mellansverige, Västsverige, Småland med öarna, Sydsverige. This territorial level of analysis is compatible with the EUROSTAT database and also allows for the use and matching of EUROSTAT data with the Statistics Sweden database (SCB), which is the Swedish government agency for demographic, social, and economic data, among other areas. The municipality level is also used for the specific analysis of green-task concentrations, and for Sweden, there is a total of 290 municipalities.

Data Collection and Preprocessing

Employment and Industry Data

The employment data were obtained from the official government agency, the SCB, and EUROSTAT database. The data on occupation were obtained considering the municipal level and the Standard för Svensk Yrkesklassificering (SSYK) code, which has its equivalents to the International Standard Classification of Occupations (ISCO). A time series of occupations and SSYK codes is available in the SCB database from 2007 to 2021, with minor variations on SSYK codes, requiring a standardization for time series analysis. For this first phase, it was analyzed the latest available employment data, which is from 2021. The EUROSTAT data on employment was obtained through the table "Employment by sex, age, economic activity, and NUTS 2 regions (NACE Rev. 2)" - table referenced as lfst-r-lfe2en2.

The author utilizes information from the Occupational Information Network (ONET) to determine the greenness of job tasks. ONET provides detailed descriptions of the tasks, skills, and knowledge associated with various occupations.

In order to apply the Vona et al. (2017) method of green classification to employment data, the first processing step involved standardizing green occupational codes from the Occupational Information Network (O*NET) to the Standard Occupational Classification (SOC). The O*NET from the U.S. Department of Labor/Employment provides detailed descriptions of the tasks, skills, and knowledge associated with various occupations. The standardization was done by identifying O*NET green codes and their corresponding SOCs, and adjusting the 8-digit SOC codes to 6-digit. Once the codes were standardized, they were linked to their corresponding SSYK-ISCO codes obtained from the SCB. This correlation was made at a 4-digit level to ensure consistency between the classifications. The resulting list of green codes contained 83 and 87 occupations, respectively. Minor differences between the original green occupational codes table from O*NET and the final green occupational codes table for Sweden occurred mainly due to the correspondence between the codes from O*NET, SOC, and ISCO. Finally, the greenness of each occupation was calculated using the following (Vona et al. 2017):

$$\text{Greenness} = \frac{\text{Green Tasks}}{\text{Total Tasks}}$$

where *Green Tasks* represents the number of tasks classified as green according to O*NET classification (O*NET 2010), and *Total Tasks* denotes the total number of tasks.

With the greenness of each occupation calculated, the greenness concentration was calculated for Swedish municipalities in the year 2021. For greenness concentration, the focus relied primarily on the total employment classified as green occupations only. This calculation emphasizes the concentration of greenness within the subset of green jobs. This method measures the intensity of greenness specifically within sectors identified as green, possibly providing a clearer picture of the green sector's characteristics but not its scale relative to the entire job market. The greenness concentration was calculated as follows:

Step 1: Sum the greenness values for each municipality The total greenness for each municipality is calculated as the sum of greenness across all green occupations within that municipality:

$$\text{Summed Greenness} = \sum \text{Greenness per municipality}$$

Step 2: Count the number of unique occupations (SSYK) per municipality The total number of unique occupations within each municipality is determined by counting the distinct SSYK codes:

$$\text{Occupation per municipality} = \text{Count of SSYK code per municipality}$$

Step 3: Calculate the average greenness per occupation within each municipality The average greenness per occupation within each municipality is then calculated as follows:

$$\text{Average Greenness} = \frac{\text{Summed Greenness}}{\text{Occupation Count}}$$

Where:

- **Greenness per municipality**: Represents the greenness score assigned to specific tasks or roles within the municipality.
- **SSYK**: A unique code assigned to each occupation, used here to identify distinct occupations within a municipality.
- **Summed Greenness**: The total greenness score accumulated from all occupations within a municipality.
- **Occupation Count**: The number of unique occupations identified within a municipality, based on SSYK code.
- **Average Greenness**: The average greenness score per occupation, calculated across each municipality.

Spatial and Emissions Data

The spatial data on Sweden's regional and municipal delineations were obtained through the official source Lantmäteriet, which is the authority belonging to the Ministry of Rural Affairs and Infrastructure in Sweden and is responsible for the real estate division, providing society - public sector, business, and private individuals - with information on geography and real estate. The emissions data were obtained through EUROSTAT for emissions per sector and at the municipal level, the data was obtained through the Swedish Meteorological and Hydrological Institute (SMHI), available in the database Nationella Emissionsdatabasen. Both datasets at this first attempt were obtained regarding CO_2 equivalent emissions.

Results

Here are presented part of the preliminary results. The total employees and total emissions data for Sweden were plotted for the last decade (Fig. 1, and Fig. 2, respectively). The temporal data on employment and emissions were also plotted simultaneously for comparison (Fig. 3).

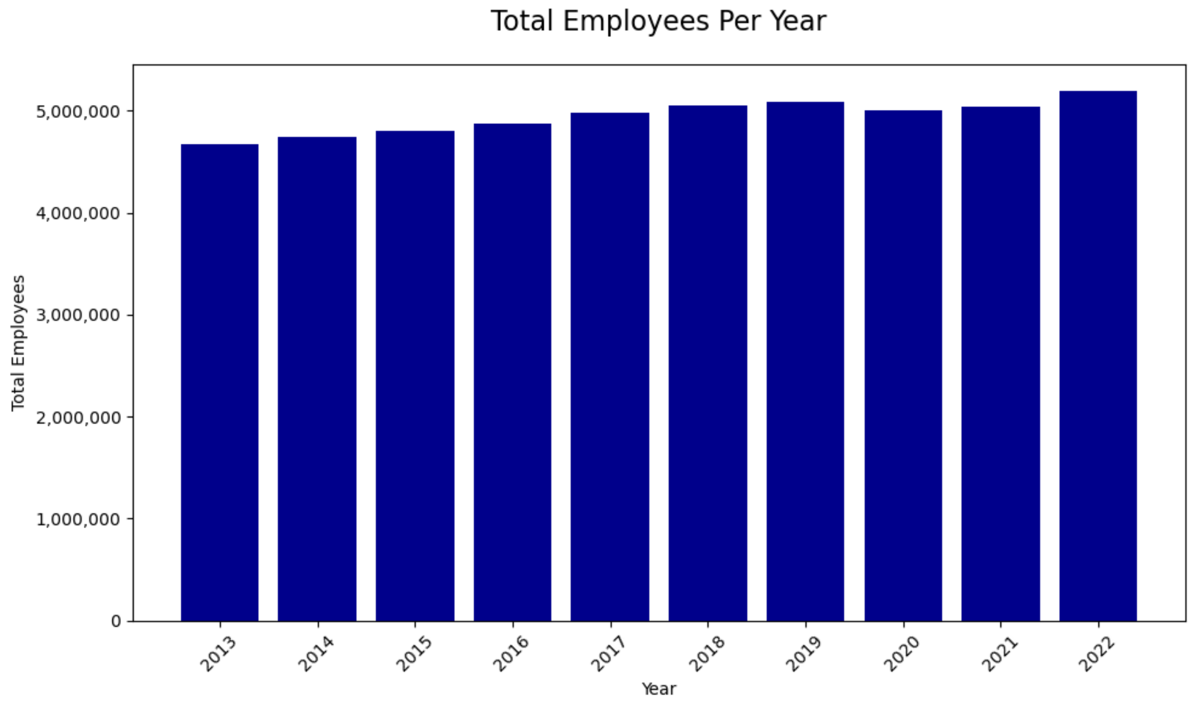

Figure 1: *Total Employment per year, from 2013 to 2021. Data from EUROSTAT database (table lfst-r-lfe2en2).*

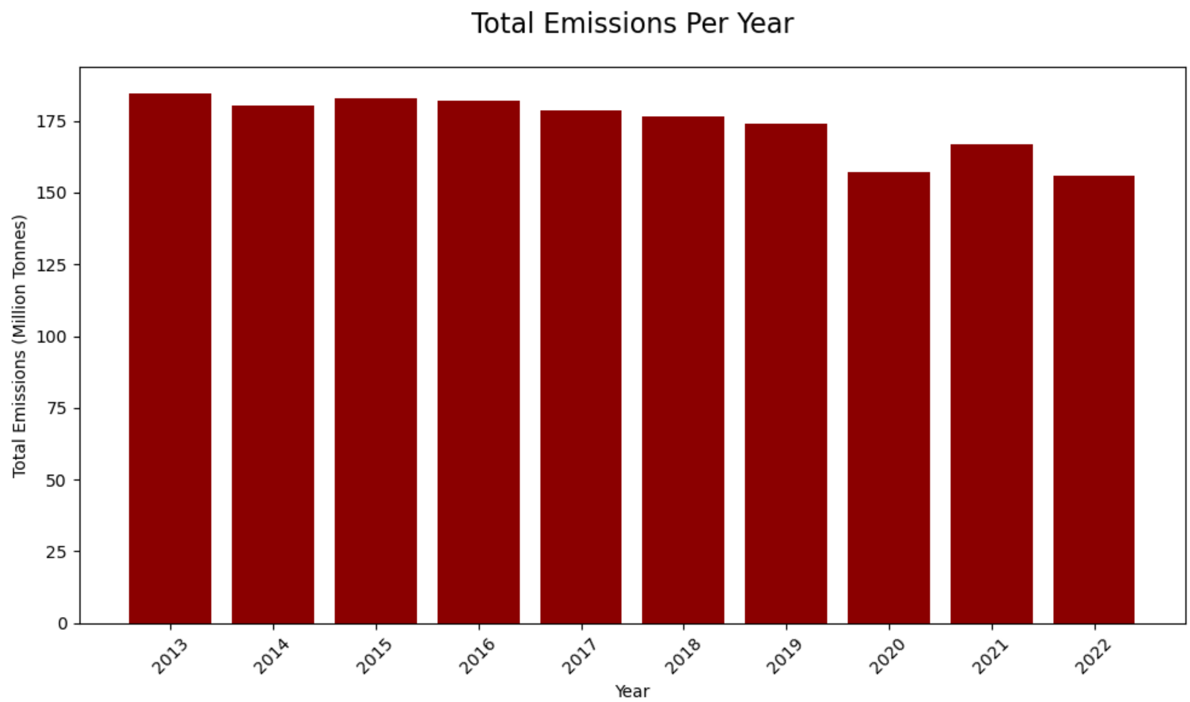

Figure 2: *Total emissions of CO2eq per year, from 2013 to 2021. Data from EUROSTAT database (table env-ac-ainah-r2)*

It can be observed from the data presented in Figure 1 that employment has shown an overall increasing trend. Although there was a slight dip in 2020, which may have been caused by the COVID-19 pandemic, there was a recovery in 2021. On the other hand, based on the data shown in Figure 2, it is possible to note that there has been a gradual decrease in total emissions over time, with a significant drop of approximately 9.69 percent in 2020 compared to the previous year. However, it is important to investigate whether this decline can be attributed to external events like the COVID-19 pandemic. Emissions slightly increased in 2021, suggesting a possible return to previous emissions patterns, but then declined again in 2022. The overall reduction in emissions could be indicative of several factors, which are one of the motives to analyze it together with employment and industry data.

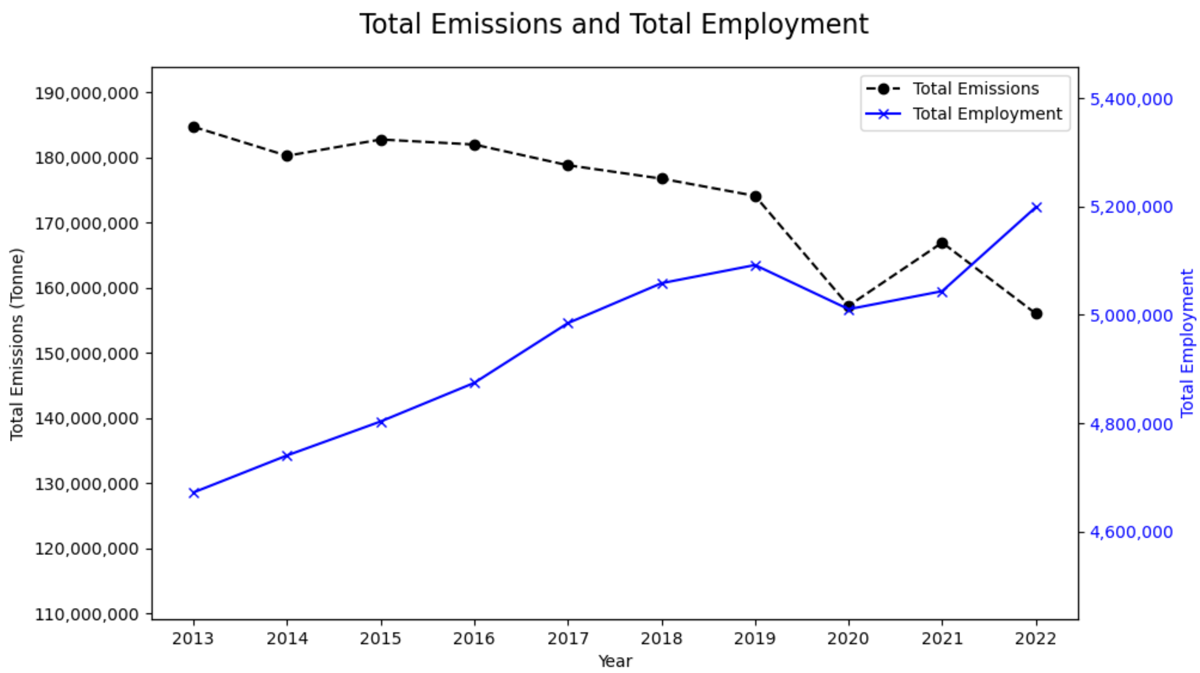

Figure 3: *Total emissions and total employment, from 2013 to 2021. Both data on emissions and employment are from the EUROSTAT database (tables env-ac-ainah-r2, lfst-r-lfe2en2).*

The following result shows the employment by industry classification (NACE) at the regional level, the spatial green task concentration at the municipal level, and the CO2 equivalent emissions also at the municipal level, all referring to 2021 (Figure 4). Further analysis will be developed regarding these results, and one of the major goals of this work is to elaborate a temporal analysis for these three maps.

The data reveals diverse regional economies, with regions like Stockholm focusing on public and professional services, suggesting a diversified, service-oriented economy. On sectoral trends, is possible to observe the presence and absence of sectors across regions, indicating different economic strategies and the level of diversification. The absence in certain areas is possibly due to policy, environmental, or strategic preferences. To summarize, the distribution of employment across different sectors and regions indicates the diverse economic structures, varying from service-based to industrial economies of the regions. These structures can be influenced by strategic choices, local policies, and environmental factors. This approach can be useful when discussing GT and how the actual methods and concepts can help to comprehend the regional and local strengths and weaknesses.

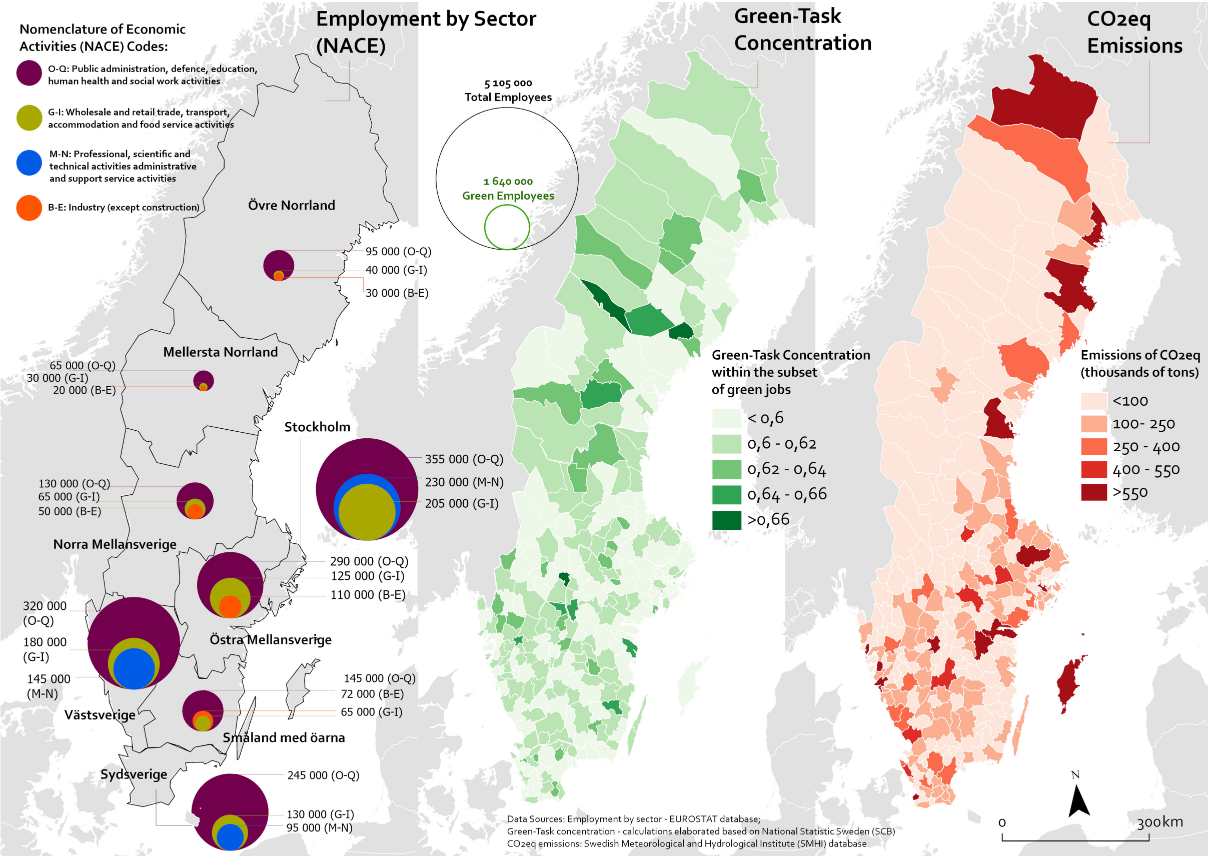

Figure 4: *Employment maps by sector (NACE codes) at regional level for top 3 sectors by employee count, Green-task concentration at the municipal level, and emissions of CO2 equivalent at the municipal level for Sweden in 2021. In the Green-task concentration map, the range of values goes from less than 0,50 (less green-task concentration to more than 0,66 (increasing green-task concentration).*

This is a preliminary paper (extended abstract version), and all sections will be under modifications, improvements, and validation processes. The analysis of green-task concentration and CO2 equivalent emissions is also under development.

Discussion

To be developed.

Conclusions

To be developed.

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