

THE IMPACT OF DIGITAL TRANSFORMATION ON GREEN JOBS IN VIETNAM DURING THE PERIOD 2020-2022

Dr. Hoang Thi Hue

National Economics University

hoanghue@neu.edu.vn

Abstract: In light of the growing trends of globalization and climate change, green jobs have surfaced as a significant strategy for fostering sustainable and eco-friendly development. In Vietnam, this issue is gaining increasing attention, particularly as digital transformation is accelerating across all sectors of the economy. This study analyzes the relationship between digital transformation and green jobs, thereby assessing the role of digital transformation in fostering green job creation aligned with sustainable development goals. Using the classification framework of green jobs provided by the O*NET, the study collects data from the Labor Force Survey (LFS), the Digital Transformation Index (DTI), and provincial statistical yearbooks for the period 2020-2022. The Generalized Least Squares (GLS) method is applied to examine the impact of digital transformation on green jobs. The findings indicate that digital transformation has a statistically significant and positive effect on the expansion of green jobs in Vietnam. In light of these findings, the research suggests multiple policy recommendations aimed at promoting green employment and supporting the wider goals of sustainable development.

Keywords: Digital transformation, green jobs, O*NET, sustainable development.

Code: JHS - 267

Received: 15th March 2025

Revised: 17th April 2025

Accepted: 15th May 2025

1. Introduction

In an era shaped by rapid technological advancements and the digitalization of nearly all aspects of life, the concept of digital transformation has emerged as a compelling imperative for nations seeking to sustain their relevance and competitiveness (Fitzgerald et al., 2014; Owoseni, 2023). Consequently, in recent years, digital transformation has garnered significant attention from both policymakers and scholars due to its profound impacts on the economy and society at large (Huang, 2024). Specifically, digital transformation presents new opportunities for economic actors across all sectors in terms of organizational structure, productivity, and

skills development (Phung, 2019). However, alongside its undeniable benefits, the relationship between digital transformation and jobs remains a contentious issue (Huang, 2024). On one hand, proponents of the substitution effect argue that the adoption of automated and intelligent production models poses a threat to job stability (Goaied & Sassi, 2019; Ballestar et al., 2021), particularly for low-skilled workers who are more susceptible to technological replacement (Akerman et al., 2015). As digital applications become increasingly widespread, a growing number of jobs are at risk of disappearing (Goaied & Sassi, 2019). On the other hand, advocates of the creative effect of digital transformation contend that it enables businesses

to scale up and expand their operational reach, thereby stimulating labor demand (Pantea et al., 2017; Lu et al., 2023). Furthermore, technological advancements have led to the creation of numerous new job positions, contributing positively to overall employment levels (Aubert-Tarby et al., 2018).

Although the relationship between digital transformation and jobs has been extensively studied, the specific connection between digital transformation and green jobs has rarely been addressed in the existing literature (Zheng & Zhang, 2023). This gap is particularly noteworthy given that the impact of digital transformation on green jobs holds significant implications for the labor market and for the development of skills essential to a sustainable future (Thake, 2025). In the context of Vietnam, both digital transformation and green jobs are identified as key priorities in the National Action Plan for Green Growth for the period 2021-2030. Nonetheless, previous domestic studies have tended to focus on green transition and green employment rather than on the nexus between digital transformation and green jobs, as seen in the works of Thuy (2023) and Thach & Thanh (2024). In order to fill this research gap - specifically (1) the persistent discussion regarding the connection between digital transformation and employment, and (2) the insufficient research on the influence of digital transformation on green jobs - this study intends to investigate and elucidate the effects of digital transformation on green jobs throughout all 63 provinces and cities in Vietnam from 2020 to 2022. Furthermore, the study aims to offer policy recommendations to enhance green jobs, thus aiding in the achievement of the National Green Growth Strategy for the period 2021 to 2030, with a long-term vision extending to 2050. This paper is structured as follows: following the Introduction, Section 2 reviews the theoretical framework on the impact of digital transformation on green job creation. Section 3 outlines the research methodology, while Section 4 presents and discusses the empirical findings. Finally, Section 5 concludes the study and offers several recommendations and policy implications.

2. Theoretical framework

2.1. Theoretical foundation

According to the Resource-Based Theory proposed by Barney (1995), an organization's sustainable competitive advantage is not solely determined by market conditions but primarily relies on the ownership and effective utilization of resources that satisfy four key criteria: value, rarity, inimitability, and organizational alignment. In this framework, a firm's resources encompass both tangible and intangible assets (Barney & Arikan, 2005). In the context of digital transformation and advancements in information technology, intangible assets include digital software, data systems, digital infrastructure, and, notably, a highly skilled technological workforce which is regarded as critical strategic resources. Tangible assets refer to machinery and equipment that form part of the digital infrastructure and operational systems of production lines (Dung et al., 2024). In order to maximize the benefits of these technological resources, organizations need to establish suitable organizational structures and hire individuals who are skilled in operating, managing, and perpetually innovating technological systems. As a result, this theory provides an indirect explanation for the rise and growth of new job categories in areas such as technology, data, and innovation. Thus, from the perspective of Barney's Resource-Based Theory (1995), job creation is not merely a byproduct of technological progress but a strategic outcome of resource optimization aimed at achieving sustainable competitive advantage in the process of digital transformation. Accordingly, this study adopts the Resource-Based Theory as the foundational theoretical framework to construct an empirical model assessing the impact of digital transformation on green jobs.

2.2. The definition of green jobs

In tandem with the transition toward a green economy, green jobs have garnered growing attention as a strategy to address environmental challenges, with efforts underway to scale up and expand its development (Al-Ammarat & Mashaqaba, 2022). Most studies define green jobs from two fundamental perspectives: job output and job tasks (Hoa et al., 2024).

From the output-based perspective, green jobs are understood as those aligned with environmental objectives and policies (Bowen & Hancké, 2019), or in other words, jobs concentrated in industries that benefit the environment (Bowen et al., 2018; Granata & Posada, 2022). More specifically, Moreno-Mondejar et al. (2021) assert that green jobs are directly linked to technologies, information, or materials that contribute to restoring and maintaining environmental quality.

From the task-based perspective, the World Bank (WB, 2023) defines green job based on environmentally friendly tasks - referred to as “green tasks” - within an occupation. Additionally, drawing from the U.S O*NET occupational classification system, green jobs are categorized into three types: (1) Green Increased Demand (Green ID), (2) Green Enhanced Skills (Green ES), and (3) Green New and Emerging (Green NE) (Bowen et al., 2018). Based on the greenness of job tasks, green job includes all tasks associated with economic activities that do not harm the environment, such as reducing fossil fuel use, minimizing pollution and greenhouse gas emissions, and developing and utilizing renewable energy sources (Martin & Monahan, 2022).

Furthermore, the International Labor Organization (ILO, 2016) defines green jobs as decent jobs that contribute to preserving or restoring the environment, whether in traditional sectors such as manufacturing and construction or in emerging sectors such as renewable energy and energy efficiency.

In the context of Vietnam, the output-based and ILO-based approaches present certain limitations. The output-based approach may misclassify green jobs by including all occupations with green outputs, regardless of whether the job tasks themselves are green. Meanwhile, the ILO (2016) definition is often only applicable to selected sectors and may not fully capture the range of green jobs that meet the decent work criteria outlined by the ILO.

To address these limitations, this study adopts the O*NET task-based approach, which defines green jobs as those comprising tasks related to economic activities aimed at reducing fossil fuel

consumption, lowering CO₂ emissions, improving energy efficiency, and promoting the development and use of renewable energy (Martin & Monahan, 2022). This approach not only allows for the quantification of green jobs but also offers a broad definition that captures the full range of jobs affected by the green transformation of the economy (Anna et al., 2021). This approach has also been employed in recent research on green jobs in Vietnam by Hue et al. (2024).

2.3. The impact of digital transformation on green jobs

Digital transformation offers new prospects for economic development across all dimensions (Guyot Phung, 2019). In Vietnam, digital transformation is defined as a comprehensive and fundamental shift in how individuals and organizations live, work, and produce, driven by digital technologies (Ministry of Information and Communications, 2023). Within this context, green jobs have emerged as a particularly compelling topic, given that it is embedded in sectors anticipated to grow significantly under the momentum of digital transformation in the coming decades (Phung, 2019). However, there remains a noticeable gap in the literature, both domestically and internationally, regarding the specific impact of digital transformation on green jobs. Existing studies have primarily focused on the broader relationship between digital transformation and jobs. For example, Binswanger (2019) suggests that digital transformation may result in job displacement in certain countries, whereas Huang (2024) argues that it contributes to the creation of new jobs and enhances job stability. In parallel, when examining green jobs, scholars often explore the correlation between the green transition and green jobs. Notably, Esposito et al. (2017) found that the green transition generates a significant number of new green jobs with better income levels, although it may simultaneously increase job losses in environmentally harmful industries. These findings are consistent with the results of Taran-Baciu Georgescu et al. (2024), who studied the relationship between the green transition and green jobs in Romania. Recognizing the need to

address the research gap concerning the impact of digital transformation on green jobs, this study aims to investigate how digital transformation affects green jobs in Vietnam. The ultimate objective is to propose evidence-based recommendations and policy implications to promote green jobs and support the broader agenda of sustainable growth.

3. Research methodology

3.1. Identifying green jobs

As previously discussed in Section 2, this study adopts the definition of green jobs proposed by O*NET. Accordingly, any job affected by the greening of the economy is considered a green job and categorized into three groups based on differences in tasks, skills, and required knowledge throughout the green transition. These categories include Green New and Emerging (Green NE), Green Enhanced Skills (Green ES), and Green Increased Demand (Green ID). Since the O*NET green occupational classification system was issued in 2010 and is based on labor market characteristics specific to the United States, applying it to labor data from other countries requires constructing a crosswalk between the occupational classification systems of the two countries. It is also necessary to acknowledge the assumption that occupations considered green in the U.S. context are also green in the country under study. In the context of Vietnam, this study constructs an indirect mapping process to match the O*NET green occupations to the Vietnamese Standard Classification of Occupations (VSCO), due to the absence of a direct conversion between O*NET SOC 2010 and VSCO. The detailed steps are as follows:

(1) Conversion of Occupational Classifications from O*NET to VSCO

- Step 1: Convert between O*NET releases (from ONET SOC 2010 to O*NET SOC 2019)

- Step 2: Convert from O*NET SOC 2019 to US SOC 2018

- Step 3: Convert from US SOC 2018 to ISCO-08

- Step 4: Convert from ISCO-08 to VSCO 2020

- Step 5: Convert between VSCO versions (from VSCO 2020 to VSCO 2008)

(2) Identifying Green Job Codes in Vietnam

After compiling the complete crosswalk from O*NET to VSCO, the study identifies green job codes in Vietnam based on the O*NET's green job list. The result is a comprehensive mapping between O*NET SOC 2010, VSCO 2020, and VSCO 2008.

In this classification, the terms "Green NE" and "Green ES" are regarded as direct green jobs due to their involvement in explicitly green tasks as outlined by O*NET. Conversely, jobs categorized as "Green ID" are deemed indirect green jobs, as the heightened demand stems from green economic activities and technologies, yet does not necessarily entail a substantial alteration in job responsibilities. In the process of identifying green job codes in Vietnam, this study employs the maximum greenness approach, wherein a single VSCO code corresponds to multiple O*NET green job codes. This methodology has been utilized by Bowen & Hancké (2019) to assess green job shares across EU nations, by de la Vega et al. (2024) in Argentina, and by Hue et al. (2024) in Vietnam.

3.2. Data processing method

To analyze the impact of digital transformation on the share of green jobs in Vietnam, this study employs regression analysis methods on a balanced panel dataset consisting of 189 observations across 63 provinces and cities in Vietnam over the period from 2020 to 2022.

Regarding data collection, based on the green job codes identified in Section 3.1, the study evaluates the impact of economic growth on the potential for generating green jobs in Vietnam using three main data sources: (1) The Labor Force Survey (LFS), (2) The Digital Transformation Index (DTI) compiled by the Ministry of Information and Communications, (3) The Statistical Yearbooks of 63 provinces and cities, published by the General Statistics Office (GSO) for the years 2020-2022. Detailed measurements of variables are presented in Table 1.

Table 1. Summary of variable's measurements

No.	Variable		Measurement	Source
1	Digital transformation		Provincial-level Digital Transformation Index (DTI)	Ministry of Information and Communications
2	Green job		(Number of green jobs / Total jobs in the province)* 100	Calculated from the LFS using the green job code mapping for Vietnam
3	Trade openness		FDI inflows/GRDP at constant 2010 prices	Provincial Statistical Yearbooks
4	Urbanization rate		Share of average population living in urban areas by province	Provincial Statistical Yearbooks
5	Training Rate		Share of employed labor force aged 15+ with formal training	Provincial Statistical Yearbooks
6	Gender Ratio	Male	Number of male workers/Total workers in the province	Calculated from LFS
7		Female	Number of female workers/Total workers in the province	Calculated from LFS
8	Age Group	Age Group 15–24	Workers aged 15-24/Total workers in the province	Calculated from LFS
9		Age Group 25-34	Workers aged 25-34/Total workers in the province	Calculated from LFS
10		Age Group 35-44	Workers aged 35-44/Total workers in the province	Calculated from LFS
11		Age Group 45-54	Workers aged 45-54/Total workers in the province	Calculated from LFS
12		Age Group 55-64	Workers aged 55-64/Total workers in the province	Calculated from LFS
13		Age Group 65+	Workers aged 65+/Total workers in the province	Calculated from LFS

Source: Author's compilation.

The author builds a linear regression model (1) as follows:

$$GJS_{jt} = \beta_0 + \beta_1 * DTI_{jt} + \beta_2 X_{jt} + u_{jt} \quad (1)$$

Where:

GJS_{jt} : Share of green jobs in province j at year t

DTI_{jt} : Digital Transformation Index in province j at year t

X_{jt} : Vector of control variables including: trade openness, urbanization rate, training rate, gender ratio, and age group composition

u_{jt} : Unobserved variables

According to Gujarati (2012), the Pooled Ordinary Least Squares (Pooled OLS) model with constant coefficients does not account for the dual nature of panel data, as it assumes that coefficients remain unchanged over time and across cross-sectional units. As a result, OLS is often subject to

issues such as multicollinearity, autocorrelation, and heteroskedasticity, which can reduce the accuracy of statistical inferences within the model (Gujarati, 2011). To overcome these limitations, many researchers adopt alternative models such as the Fixed Effects Model (FEM) and the Random Effects Model (REM) (Gujarati, 2012).

In this study, the F-test, as proposed by Gujarati (1999), is employed to assess the appropriateness of the Pooled OLS versus FEM. Simultaneously, the Hausman test (Hausman, 1978) is used to determine the optimal choice between FEM and REM. The results in Table 2 indicate that the F-test yields a p-value of 0.0000 (<0.05), confirming that the Fixed Effects Model is more suitable than the Pooled OLS. Meanwhile, the Hausman test produces a Chi-squared statistic of 17.43 with a p-value of 0.06539 (>0.05),

suggesting that there is no statistically significant correlation between the unobserved effect and the explanatory variables. Hence, the Random Effects Model (REM) is deemed more appropriate.

Following the Hausman test, the study continues by testing for the presence of autocorrelation and heteroskedasticity using the Wooldridge test and the LM - Breusch and Pagan Lagrangian Multiplier test, as suggested by Wooldridge (1991) and Breusch &

Pagan (1980), respectively.

The Wooldridge test results ($\text{Prob} > F = 0.0000 < 0.05$) indicate the presence of first-order autocorrelation, while the LM - Breusch and Pagan test ($\text{Prob} > \text{chibar}2 = 0.0000 < 0.05$) confirms the existence of heteroskedasticity. To address these issues and enhance the model's efficiency, the study applies the Generalized Least Squares (GLS) estimation method. Detailed results are presented in Table 4.

Table 2. Model specification test results

F Test			
F (61,111)		= 4.83	
Pro>F		= 0.0000	
Hausman Test			
Chi2 (10)		= (b-B)'[(V_b-V_B)^(-1)](b-B)	
	= 17.43		
Prob>chi2		= 0.0653	
Wooldridge Test and LM – Breusch and pagan Lagrangian Multiplier Test			
Wooldridge Test		LM - Breusch and pagan Lagrangian Multiplier Test	
F(1.59) = 21.285	Prob>F= 0.0000	chibar2(01) = 52.17	Prob>chibar2 = 0.0000

Source: Author's Calculations.

4. Result and discussion

4.1. The Status of green jobs in Vietnam during 2020-2022

In summary, the data presented in Table 3 indicates that from 2020 to 2022, the average proportion of green jobs in Vietnam is relatively low,

comprising merely 17.60% of the total employment. Nevertheless, it is noteworthy that throughout the research period, there was a consistent increase in the proportion of green jobs. In particular, between 2020 and 2022, the rate of green jobs rose by 3.66 percentage points, reflecting a growth rate of 23.77%.

Table 3. Average green job rate by year and over the period 2020-2022 (%)

	2020	2021	2022	Average (2020-2022)	Growth rate
Nationwide	15.4	18.35	19.06	17.60	23.77
Central Highlands	7.46	7.97	7.98	7.80	6.97
Northern Midlands and Mountainous areas	10.85	16.25	15.8	14.30	45.62
Mekong River Delta	15.42	17.11	18.56	17.03	20.36
North Central and Central Coastal region	15.8	19.27	19.81	18.29	25.38
Southeast region	18.3	21.08	22.3	20.56	21.86
Red river Delta	20.67	24.67	25.26	23.53	22.21

Source: Author's calculations based on the LFS during the period 2020-2022

By economic region in Vietnam, during the period 2020-2022, the average green job rate across regions

increased each year, and the ranking (from lowest to highest) remained consistent as follows: Central

Highlands; Northern Midlands and Mountainous Areas; Mekong River Delta; North Central and Central Coastal Region; Southeast; and Red River Delta. Accordingly, the Central Highlands recorded the lowest average green job rate (7.8%), while the Red River Delta reported the highest (23.53%). Although the Red River Delta consistently had the highest green job rate in the country throughout the three years, it only ranked third in terms of growth rate, with an increase of 22.21%. In contrast, the Northern Midlands and Mountainous Areas experienced the fastest growth in green jobs, reaching 45.62% over the same period. On the other hand, the Central Highlands not only had the lowest average green job rate, but also recorded the lowest growth rate nationwide, at only 6.97%.

4.2. The impact of digital transformation on green jobs in Vietnam

Table 4 shows a positive relationship between digital transformation and the green job rate. Specifically, a 1% increase in digital transformation leads to a 10.61% increase in green jobs. This can be explained as follows:

Firstly, the process of digital transformation generates new employment opportunities, including green jobs. According to the primary directives outlined in the environmental agenda

programs pertaining to the labor market, it is clear that the economic landscape resulting from digital transformation in the future will modify the employment framework, set fundamental guidelines for environmental governance, and guarantee both economic and environmental security (Danskaya, 2023). According to a World Bank's report (2021), the number of new jobs created in Vietnam due to digital transformation is projected to be seven times higher than the number of jobs displaced. By 2045, approximately 10 million new jobs are expected to be created, mostly in modern service sectors and to a lesser extent in eco-friendly manufacturing industries.

Secondly, digital transformation contributes to greening the production process, thereby generating additional green jobs. In production, digitalizing the entire lifecycle of input factors related to products, production data, and processes aids in bolstering firms' product development and operations operational activities. This enables enterprises to track resources in real time, optimize resource allocation, implement lean manufacturing practices, conserve energy, reduce emissions, minimize resource waste, enhance production efficiency, identify surplus resources, and secure the availability of essential inputs for green technological innovation (Xue et al., 2022).

Table 4. Estimated impact of digital transformation on green jobs

Variable		Symbol	Green Job
Digital transformation		DTI	10.61***
Trade Openess		LnOPEN	11.96***
Urbanization Rate		URBAN	0.0393*
Training Rate		HUMAN	0.257***
Gender (<i>The proportion of female workers is used as the reference group</i>)		SEX	0.732***
Age group (<i>The proportion of age group 15-24 is used as the reference group</i>)	Proportion of workers aged 25-34	AGE2	-0,0417
	Proportion of workers aged 35-44	AGE3	0.446***
	Proportion of workers aged 45-54	AGE4	0.391***
	Proportion of workers aged 55-64	AGE5	0.338**
	Proportion of workers aged 65+	AGE6	0.282***
-cons			-60.21***
Pro>chi2			0.0000
Observations			189
Statistical significance level: * p < 0.1, ** p < 0.05, *** p < 0.01			

Source: Author's calculations

In addition, to further analyze the green job rate in Vietnam, the study examines the variation in green jobs based on different characteristics of each province and city, including trade openness, urbanization rate, training rate, gender ratio, and age group distribution.

Regarding trade openness, at the 1% statistical significance level, there is a positive relationship between trade openness and the green job rate. Specifically, a 1% increase in trade openness leads to a 0.1196% increase in the proportion of workers engaged in green jobs. This may be attributed to the positive correlation between trade openness and economic growth (Hien & Suong, 2022), and the fact that economic development tends to generate more job opportunities, including green jobs (Kaspos, 2005).

As for the urbanization rate, at the 10% significance level, a 1% increase in urbanization results in a 0.0393% increase in the green job rate. The rise in urbanization can affect green jobs in two major ways. Firstly, as urban areas expand due to internal migration, the potential labor force increases significantly. This is due to the fact that urban regions typically possess more vibrant economies, thereby providing greater opportunities for green employment compared to rural regions. Furthermore, when urbanization coincides with industrialization and modernization where rural areas progressively evolve and advance, the demand for green jobs increases as well. This phenomenon arises from the needs of sustainable economic growth, which require industries to adjust and become more eco-friendly. Regarding the training rate, Table 4 indicates that a 1% rise in the percentage of trained laborers results in a 0.257% increase in the green job rate. Green jobs necessitate a greater level and intensity of human capital in comparison to non-green jobs (Consoli et al., 2016). Therefore, improving the quality of human resources and raising the training rate among individuals aged 15 and older yields dual advantages. Firstly, workers gain vital skills and enhance their technical and professional qualifications. Secondly, this paves the way for them to access the growing green job market, thus aiding in the expansion of green job

opportunities.

In terms of characteristics individual, including gender and age, the study reveals that there is a statistically significant positive influence on the expansion of green jobs in Vietnam. Specifically, at the 1% significance level, gender demonstrates a positive effect, where a 1% rise in the male labor force leads to a 0.732% increase in the rate of green jobs. Among the various age groups, those aged 35-44 contribute the most to the growth of green jobs, whereas the 65+ age group shows the least effect.

5. Conclusion and policy implications

This study utilizes the concept of green jobs from the U.S. O*NET and converts green job codes from O*NET to VSCO system of Vietnam, thereby enabling a concrete estimation of the number of green jobs in Vietnam. In addition, the research reveals that digital transformation contributes to promoting green job creation. Moreover, the green job rate is also influenced by factors such as trade openness, urbanization rate, training rate, gender, and age groups. These findings provide both theoretical and practical implications.

From a theoretical perspective, the study develops and analyzes a model to examine the impact of digital transformation on green jobs. Thus, it is expected to serve as a foundation for future studies to further develop the concept and measurement methods of green jobs, as well as the influence of digital transformation on green jobs. The ultimate aim is to design sustainable development strategies that focus not only on economic growth but also on environmental protection and social sustainability.

From a practical perspective, Vietnam is currently implementing its National green growth strategy, associated with a sustainable development model. Green jobs are a strategic direction within this objective. Therefore, research on the concept and measurement of green job in Vietnam is both urgent and essential. The government should standardize the definition and establish a set of green job indicators appropriate for the country's socio-economic context. This can be achieved by issuing an official conceptual framework for green job that reflects Vietnam's reality, drawing from international experiences, and integrating a green

job indicator system into the national statistical framework. At the same time, it is necessary to raise public awareness about green jobs in order to widely promote it, for example, by enhancing media campaigns about the benefits and roles of green jobs or incorporating green job-related content into vocational training curricula.

Furthermore, green job indicators should be included in the annual monitoring frameworks of each industry, region, and at the national level to assess progress and align green jobs with the economic growth strategy. Since the study has demonstrated that digital transformation promotes green job creation, the government should develop a detailed National Digital Transformation Plan aligned with the socio-economic development strategy for each phase. Each province should also formulate its own action plan tailored to its development conditions. In the context of ongoing

provincial mergers, each locality should design a digital transformation and green job development plan that suits the new characteristics and potential of the merged administrative unit. Additionally, the process of restructuring provincial-level administrative units presents an opportunity to reorganize the labor force, prioritize retraining and occupational transition toward greener jobs, and review and identify industries with green growth potential. Besides, to guarantee that the digital transformation process advances seamlessly, it is essential to enhance public understanding of digital technologies and their everyday applications. In order for digital transformation to yield effective results, ministries, sectors, and localities ought to establish specific metrics to oversee the digital transformation process and carry out regular, annual statistics by year and by implementation phase to facilitate timely and effective modifications.

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