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Assessment of environmental sustainability through integrated agricultural performance metrics

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ABSTRACT

The evolution of corporate reporting in today's world is heavily influenced by a growing emphasis on environmental sustainability and the evaluation of its impact on the environment, as well as the assessment of a company's environmental responsibility, ecological attractiveness, and competitiveness. Traditional accounting and corporate reporting methods are proving inadequate to fulfil the information needs of a diverse array of stakeholders who play a pivotal role in making strategic decisions. This concept seeks to divulge information regarding the environmental impact and ecological footprint of a company, showcasing the interplay between the company's operations and their environmental consequences. The focus is on the future outlook, aligned with the company's strategic objectives and business model. The development of tools for environmental analysis in the corporate world is an essential means of putting these theoretical principles into practice. The importance of this study lies in its potential to provide a theoretical foundation for evaluating a company's agricultural performance through integrated reporting metrics, which in turn will establish a set of indicators reflecting the achievement of both short-term and long-term environmental objectives of the company. All of these factors, in our perspective, underscore the significance of this study and the practical implications of the results it yields.

Keyword: Ecological footprint, Environmental sustainability, Agricultural performance, Practical implications.
Article type: Review Article.

INTRODUCTION

The pace of economic and social progress has aggravated global environmental challenges, including a rise in water consumption, increased wastewater discharge, and a diminished environmental carrying capacity (Colella *et al.* 2021). The United Nations Framework Convention on Climate Change (UNFCCC) advocates for bolstering ecosystems' resilience to climate change while ensuring sustainable food production and economic development. Certain nations have bolstered their commitment to the Paris Agreement, curbing emissions and actively transitioning towards eco-friendly, sustainable growth models (Ju *et al.* 2021; Asmah & Salam 2022; Uralovich *et al.* 2023). The fifth United Nations Environment Conference in 2021 emphasized that the key to combating the

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impending climate crisis lies in policy and regulatory reforms, sufficient funding, and the application of technology and innovation. Economic and social development lends support to the sustainable growth of agriculture, with a growing demand for high-quality green agricultural products. The tension between agricultural economic advancement, ecological preservation, and societal needs is growing more conspicuous. Consequently, research into the synergies between regional agricultural economic stability, ecological conservation, and social development has become a noteworthy focus of academic inquiry. Key performance indicators play a crucial role in evaluating the environmental sustainability and success of an organization's strategic objectives. Enhancing comprehension of the ecological scorecard at various management levels necessitates establishing a coherent connection between corporate sustainability metrics. When forging these relationships between environmental indicators, it is advisable to engage numerous environmental experts, ensuring that by the end of this process, the majority of employees possess a comprehensive understanding of the new eco-friendly scorecard. This empowers them to implement it not only at their individual levels but also within specific business unit sublevels. Sustaining equilibrium across the organization demands that all lower-level strategic environmental goals and key performance indicators are aligned with the overarching environmental objectives and indicators (Eliferov & Repin 2019). Hence, the primary objective during the implementation of an eco-conscious scorecard revolves around the development of environmentally focused KPIs, encompassing their computation, assessment, and methodological adjustments (Marr 2014). Let us explore the use of key performance indicators, as exemplified in integrated environmental reporting, to appraise environmental performance within the context of power companies. The realm of agricultural systems research is a vast and dynamic landscape, characterized by a rich tapestry of ideas and perspectives. At its core, the sustainability and vitality of our agricultural systems are deeply intertwined with the policies that underpin the livelihoods of farmers and the relentless march of technological progress (Phetheet *et al.* 2021). Scholars have undertaken comprehensive investigations into the social dimensions of agriculture (Dent *et al.* 1995), actively championing the cause of social-ecological transformation within the realm of agricultural development (Fullana Llinas *et al.* 2021). This shift towards a more ecologically and socially conscious approach to agriculture acknowledges the intricate interplay between human societies and the environment. Furthermore, researchers have ventured into exploring the intricate connections between "energy-water-food" and "water-land-food" within regional agriculture. This approach offers a holistic strategy for the judicious management of agricultural resources, recognizing that these resources are intimately interconnected (Yue *et al.* 2021; Yuxi *et al*. 2021). It is a recognition that one cannot isolate the issues of energy, water, and food production from the broader context of land and resource utilization. Inescapably, climate change has left an indelible mark on the sustainable development of agriculture (Liu *et al.* 2021a; Liu *et al.* 2021b; Liu *et al.* 2021c; Liu *et al.* 2021d; Liu *et al.* 2021e; Liu *et al.* 2021f). Researchers are compelled to propose innovative countermeasures to safeguard the future of agriculture. These include enhancing the efficiency of agricultural water use (Wei *et al.* 2021), applying cutting-edge science and technology to assess the economic value of agricultural waste (Ge *et al.* 2021), and embracing the concept of climate-intelligent agriculture (Xin & Tao 2021). In this rapidly changing world, the future of agriculture is inextricably linked to how we address the complex challenges it faces. Scholars, policymakers, and practitioners alike are collectively striving to craft solutions that ensure both the productivity of agriculture and the preservation of our environment. This dynamic and evolving landscape of agricultural research seeks to strike a delicate balance between the needs of a growing global population and the imperative of environmental sustainability. This study endeavours to accurately assess the interplay between the agricultural economy, the environment, and society through the lens of systemic theory. It aims to present targeted recommendations for the sustainable advancement of regional agriculture. Nonetheless, several key questions persist: How can we establish a more comprehensive environmental evaluation index system? How can we utilize models effectively to conduct objective assessments based on multifaceted data? Will the proposed policy recommendations effectively bolster local government decision-making? These issues present formidable challenges to our research. To address these challenges, we draw upon prior research (Xu *et al.* 2018; Liu *et al.* 2021a,b).

MATERIALS AND METHODS

An ecological perspective on agriculture encompasses the scale, structure, and efficiency of regional agricultural development (Feng *et al.* 2021). In comparison with previous research parameters, this study introduces additional metrics, such as crop sowing area (Zhu *et al.* 2021), the proportion of agro-fisheries (Guo *et al.* 2021), the ratio

of professional and support agricultural activities (Shi *et al.* 2020a,b), grain yield per hectare of cultivated land (Chai *et al.* 2020), and others, into the pertinent factors of agricultural development scale. This comprehensive approach sheds light on the composition of the five subsectors within agriculture and offers a more intuitive representation of regional agricultural production efficiency. The assessment criteria for an ecological agricultural subsystem encompass three key facets: the ecological impact of regional agricultural development, ecological resources, and ecological assets (Shaver *et al.* 2015; Yang *et al.* 2019). In this context, we incorporate factors like affected crop area (Wang & Sun 2022), cultivated land area (Zhu *et al*. 2021), and indicators related to agricultural energy consumption, including the total agricultural energy consumption, agricultural power usage, agricultural water usage, and other related metrics (Ren & Yu 2021). These additions provide a comprehensive view of the ecological pressures stemming from agricultural ecological assets and energy consumption. This study established its theoretical and methodological underpinnings by drawing from a rich tapestry of sources within the realm of environmental studies. It placed particular emphasis on the following key sources:

Scientific publications. The foundation of this research was built upon the insights and findings of environmental scientists and economists, both from local and international perspectives. These experts contributed to the study with their extensive work in the domains of management accounting, control mechanisms, and comprehensive management strategies aimed at addressing environmental challenges and promoting sustainability.

Reports from power grid corporations. Vital insights were also gleaned from comprehensive reports provided by major power grid corporations, notably Inter RAO PJSC and Kubanenergo PJSC. These reports provided in-depth information about the environmental initiatives and sustainability efforts undertaken by these corporations, shedding light on their commitment to environmental responsibility.

To achieve the research's objectives and effectively navigate the obstacles encountered during the research process, a diverse array of research methodologies and techniques were harnessed. These included:

Monographic analysis. In-depth examination and analysis of specific aspects of environmental management within the chosen power grid corporations, providing detailed insights into their practices.

Economic-statistical techniques. The application of statistical methods to evaluate the economic implications and outcomes of the environmental strategies adopted by the companies.

Abstract-logical reasoning. Employing abstract and logical reasoning to synthesize data, identify patterns, and make informed conclusions about the environmental practices of these corporations.

This multifaceted approach enabled the research to provide a comprehensive overview of the key features observed in the environmental practices of these power companies. The findings are presented in Table 1, offering a succinct yet informative snapshot of the environmental strategies and initiatives employed by these corporations in their pursuit of sustainability and responsible environmental management.

RESULT AND DISCUSSION

The industry-specific aspects of energy companies must be taken into account when formulating a comprehensive approach to environmental management. Key performance indicators (KPIs) in the environmental context are financial or operational metrics that characterize various aspects of a company's environmental efforts. These indicators serve as benchmarks for assessing the achievement of tactical and strategic environmental objectives set at different levels of management (Kroshilin & Telitsyna 2018). Environmental KPIs are evaluative criteria used to measure the effectiveness of environmental activities and can be quantified for analysis. Integrated reporting in the energy sector encompasses several crucial environmental performance indicators, such as:

- Reduction in specific operational expenses and costs.
- Increase in the utilization of renewable energy sources and energy-efficient technologies.
- Level of energy losses in the generation and distribution process.
- Reduction in specific investment costs for eco-friendly initiatives.
- Enhancement of workforce productivity and engagement.
- Reduction in greenhouse gas emissions per unit of energy generated.

Table 1. Key environmental attributes of energy companies

Features	Interpretation
Environmental impact of electricity consumption	Electricity cannot be conserved or stockpiled; the amount of electricity used at each time unit is consistently equivalent to the generated amount. The necessity to oversee and document a multitude of activities, both regulated and unregulated, is driven by the technological aspects of electrical equipment operation and its maintenance processes. Electricity holds substantial social importance and lacks viable alternatives. Uninterrupted power supply is a critical requirement for the functioning of the national economy. Challenges in power transmission stem from substantial energy losses.
Challenges in maintaining and repairing electrical equipment with environmental considerations	Ensuring uninterrupted power supply to consumers necessitates the development and strict adherence to a schedule for disconnecting equipment associated with overhead power lines (OHL) and substations (SS). This schedule should be devised in consideration of fluctuating load patterns, the operation of generating capacities, and the structure of power supply organization that incorporates redundancy. The demand for electricity varies unevenly throughout the day, adding complexity to the task. Furthermore, it is essential to recognize the environmental impact and sustainability concerns associated with the energy sector. The sector faces significant challenges, such as a decline in production potential and equipment wear exceeding 50%. These factors raise the risks of physical damage to generating equipment and power lines, potentially harming the natural environment. It is imperative to address these issues to ensure a more environmentally responsible approach to power supply and infrastructure maintenance.
Environmental category	Resource-Intensive
Staff characteristics in an environmental context	Professionally trained team members
Environmental impact analysis	A significant portion of the environmental footprint stems from depreciation and labor costs, often categorized as fixed expenses, meaning they remain unchanged irrespective of the amount of energy transferred within the network.
Sustainable energy practices	The importance of managing costs is closely intertwined with the imperative of sustainable energy planning. It is crucial to strategize energy consumption and production on a daily and hourly basis throughout the year to minimize the environmental impact. The cost of energy production is significantly influenced by the cost of the fuels consumed, emphasizing the need for environmentally friendly and renewable energy sources.
Environmental considerations	Eco-systemic allocation is essential, which involves apportioning authority between ecological management and operational centers on specific sites. The intricate organizational framework demands meticulous attention to pinpointing spheres of ecological responsibility and delineating their respective domains. There is also a vital requirement to sustain the excellence and effectiveness of ecological communication and information systems.
Environmental context	Eco-friendly frameworks: Eco-zones are established to align with the environment.
Environmental context	The prevailing environmental situation includes substantial debts among wholesale resellers. Energy professionals often lack the genuine incentive to minimize expenses, and consumers may not be sufficiently motivated to conserve electricity.

The determination of these key environmental indicators falls outside the realm of state regulatory control, allowing for a variety of approaches in their formulation. Inter RAO PJSC's integrated report includes indicators such as revenue, net profit, net assets, intangible assets, earnings before interest, taxes, and amortization, as well as social and environmental metrics like employee benefits, injury frequency rate, and specific greenhouse gas emissions per unit of electricity generated.

Further analysis of these indicators can be categorized into:

Operational outcomes (installed capacity, energy generation, fuel consumption, electricity sales, utilization rate of installed capacity).

Financial metrics (revenue, operating expenses, earnings before interest, taxes, and amortization, along with relevant ratios). To enhance environmental management practices, there is a necessity to expand the array of environmental KPIs utilized by energy companies. Within a systematic framework, these indicators aid in planning and managing environmental initiatives effectively. In the pursuit of strategic environmental goals, energy companies frequently adapt the balanced scorecard to align with their internal business models. This adaptation involves restructuring processes to achieve four primary strategic objectives:

- Cost reduction.
- Enhanced public visibility and reputation.
- Improvement in customer service.
- Augmentation of environmental reliability and performance.

Power companies typically initiate the development of a balanced scorecard at the corporate executive level. This strategic approach helps define the company's environmental trajectory, enabling all organizational members to

comprehend the vital factors driving the successful implementation of the company's environmental strategy (Table 2).

Table 2. Proposed framework for environmental balanced scorecard in three dimensions.

Aspect	Strategic problems	KPI measurement	Initiatives and programs
Environmental Sustainability (Popova & Butov 2019)	Eco-efficiency and resource optimization leveraging sustainable assets sustainable operational practices	Environmental impact assessment promoting green growth natural resource conservation eco-friendly operational expenditures	Sustainable resource management initiatives
Market development (Bannykh & Dubrovskii 2019)	Industry-leading customer loyalty	Customer satisfaction score	Customer loyalty program
Staff development (Golovanova & Kukina 2019)	Confidence in the commercial skills of staff	Number of hours of key skill training	Profile competence
	Determining the satisfaction level of key employees	Staff satisfaction rating	Compensation for performance and productivity
	Advanced performance management	Leadership performance rating	Leadership training programs

Table 3. Recommended environmental key performance indicators (KPIs) for the "Finance," "Personnel," and "Customers/Market" strategic perspectives

Strategic perspective	Recommended KPI	Major indicators
Finances	Accounts receivable turnover ratio Accounts payable payment period Financial rate of return Economic rate of return (Glavatskikh & Glushkova 2018) OIBDA rate of return Cash flow rate of return Financial leverage ratio Equity capital flexibility ratio Cash flow efficiency ratio Current solvency ratio	Economic rate of return Financial leverage ratio Current solvency ratio
Staff	Biodiversity conservation rate Ecosystem stability rate Number of sustainability initiatives per 100 acres Proportion of ecological restoration costs in the total budget Per capita spending on environmental education per year Percentage of individuals who have completed advanced ecological training Green job competitiveness ratio Community involvement rate Proportion of residents with environmental science degrees (Karimova 2018) The Sustainable Development Index	Ecosystem stability rate Green job competitiveness ratio Community involvement rate
Customers/market	Sustainability satisfaction index Percentage of eco-conscious customers Ecosystem preservation rate Incidents of environmental concerns per 1000 customers Environmental impact claims against the organization Ecological footprint in products Relative market presence Renewable energy adoption rate Ecosystem retention rate Contribution of top clients to sustainability efforts	Ecological footprint in products renewable energy adoption rate Ecosystem retention rate

Every ecological parameter has its essential values that require periodic adjustments. The ecological scorecard comprises four fundamental components (ecological perspectives): ecosystem health, biodiversity, resource management, and climate change (Ecological scorecard: Shifting from awareness to action). Table 3 presents the

key ecological performance indicators within the scope of the "Ecosystem Health," "Resource Management," and "Biodiversity" from ecological perspectives.

CONCLUSION

Key performance indicators for the "Business Processes" strategic perspective are given in Rybiantseva & Isupov (2020):

– the number of long-term power outages for a certain period of time (including those related to emergency situations);
– Average duration of power interruption in the system;
– Total line losses;
– Standard power supply restoration time;
– Annual duration of peak loads;
– Average delay of regular reports;
– Annual growth of costs for improving the quality of networks;
– Number of detections of illegal consumption;
– Utilization factor of installed electric power;
– equipment downtime.

The most crucial indicators in an environmental context are total line losses, annual growth of costs for improving the quality of networks, and the standard power supply restoration time (Prodanova *et al.* 2019). The formulation of a balanced scorecard should initiate with the development of regulatory documents that govern the calculation and evaluation of key performance indicators within the framework of the material incentive system for employees (Isupov 2019).

KPI calculation requirements:

– Structuring indicators based on various criteria, including the level of environmental impact;
– Determining the time frames for indicators (month, quarter, year);
– Evaluating the possibility of breaking down indicators for their translation to lower levels;
– Analysing indicators while considering the priorities of individual environmental goals within a given calendar period, including in areas such as energy production, resource conservation, and sustainability (Tolmacheva & Isupov 2019).

The developed KPI system will enable the assessment of the environmental efficiency of power companies. The list of indicators used may change due to the evolving dynamics of integrated reporting in the environmental sector.

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