

Exploring the Role and Function of Government in the Development of Green Economy in the Region Based on the Planning of Ecological Industrial Zones — A Case Study of Jurong Island in Singapore and Rio de Janeiro in Brazil

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Abstract: Green Economy has been gradually realized through various methods including the establishment of Ecological Industrial Parks (EIPs). Current research on EIPs mainly focuses on engineering aspect with analysis of facilities layout, balancing industrial production and environmental preservation through energy cycling system. Though EIPs' economic value is mentioned in the articles, few of them delved deeply into the practical development process of EIPs and they just remain in design analysis. Actually, government plays an indispensable role in real life in terms of EIPs' success and upgrading. This article chooses two cases, namely Jurong EIP in Singapore and Rio de Janeiro in Brazil to excavate government's function as 'predominance'. Cases reflect problems occurring in EIP development and offer objective suggestions based on successful examples. Our study claims that the successful EIP is always quipped with valid and scientific macro-control that can be implemented fully. Despite complete engineering cycle is presented, EIP still faces potential hazard without corresponding government oversight. In the other word, 'engineering optimization' and 'economic trade-off' achieving in an EIP rely on predominant macro-control to a very large extent.

Keywords: Green Economy, Eco-industrial Parks, government role, policy implementation, sustainable development.

1. Introduction

The concept 'Green Economy' is one pathway to sustainability that represents a radical transition for more efficient, environmentally friendly and resource-saving technologies to reduce emissions and mitigate the effects of climate change, and alleviates resource scarcity as well as severe exacerbation of environment [1]. More specifically, Industrial Ecology (IE), a practical policy tool, has been one prominent embodiment of this oriented developing approach. 'IE has informed various practical initiatives, particularly through the promotion and development of eco-industrial parks (EIP) [2].' In the process of EIP establishment, engineering success in achieving the objective of recycling and maximum energy utilization is most often discussed. However, in real implementation, government role, summarized as predominance, did profoundly impose on this policy tool.

Government function has often been mentioned in terms of EIP development. Yu et al. discovered that countries at every developing level, has enacted incentive policies such as tax preference and financial subsidies to encourage EIP evolution [3]. Also, government's design based on stricter environmental standards can lead indirectly to enterprises entering in EIP. Jurong Town Corporation (JTC), one of government agency that sponsored a studio program of developing the Jurong EIP in 1988 is highlighted in the informative article [4]. In Rio de Janeiro, law was introduced by the Economic and Social Development Fund (FUNDES), offering extra financial incentives to corporations participating in local EIP project [5]. Though government role always appears in articles demonstrating EIP value above, few papers place high value on it or summarize its function to offer advices for practical EIP evolution and polish.

According to previous studies, as a result of the nuances and intricacies between countries, it is policy that remains as one variable. Under different government's intervention, EIPs like Jurong Island in Singapore and Rio de Janeiro (RJMA) in Brazil develops distinctly in terms of social wealth and sustainable development extending overall utility. In this paper, we took a closer investigation in the two regions' EIP development experience, aims of government intervention and validity, scientificity, possibility of implementation of the policies so as to summarize efficient government function as 'predominance' in green economy. Thus, suggestions for better EIP evolution strategy are offered.

Our research is mainly a case-based design. To be more specific, we focus on particular cases, namely Jurong Island in Singapore and Rio de Janeiro EIP. Organizations there and current situation are studied to collect data and evidence that proves the quality of EIP project. Relevance between data are ensured with direct observation of practical photos. Evidences are analyzed to com up with insights bout reasons behind success or failure. The evaluation includes measurement of social maximum utility for which different elements in social welfare are compared.

Since green economy is a comprehensive subject that covers a range from engineering, biology to economics and politics. Government predominance does offer a feasible solution for balancing stakeholders' interests and figuring out the key for a sustainable EIP development and even economic growth. We hope future studies can investigate more paths towards IE, contraposing different process throughout a pipe. Government roles in different IE projects would definitely inspire us a more typical and effective approach to achieving green economy in terms of public sector function.

2. Evaluation on Efficient Government Role in Achieving EIP Goals

2.1. Principle of Evaluation

First, policy must match its specific aims. Two terms of IE, namely 'engineering optimization' and 'economic trade-off' are introduced as aims for feasible policies and are reflected on the two case studies respectively [6]. Engineering optimization in EIP mostly reflects in well-directed establishment of an efficient recycling system taking advantage of pollution released with particular designs like water corridor. Sharing similar features with natural systems, waste after production and consumption is minimized while fulfilling the demand of 'decomposer'(firms that can reprocess waste materials), contributing to an overall preservation of energy. Under government coordination, above targets can be achieved by co-location of 'decomposers' and industrial clusters with similar waste or by-products [7]. 'Economic trade-off' means a principle pursuing equilibrium between economic prosperity and environmental protection. After government evaluation, this process follows Kaldor-Hicks Efficiency criterion which promotes to a collective prosperity without the sacrifice of industry profit with enactment of government incentive policies for those who are worse off (companies in EIP).

Besides, efficient policy must be equipped with some characteristics like scientificity, validity and possibility of implementation. Policies' scientificity is how the plan corresponds pragmatic situation. Validity is whether government possesses the capacity to enacting these proposals. Extent of implementation are accessed through how efficient political resources are allocated in real life examples. The three evaluation perspectives work as basis for feasible government role in EIP and even green economy. Since practical situation is more complicated than theory assumption, one external factor always positively or negatively influence more than one considerations included, which will be discussed later.

2.2. Effective Government Intervention

'Success' indicates social maximum utility is realized as more as possible with engineering techniques in EIP. Jurong Island did contribute to environment preservation with its unique EIP designs. We focus on Singapore Jurong Island as one example, collect official information about its engineering plan from government website and related informative papers.

Strategies for the aim 'engineering optimization' have been conducted properly in Singapore's Jurong Island. Jurong Island's carbon emission is about 27 million tons or 54% of Singapore total carbon emissions in 2019 while annual manufacturing output amounts to more than S\$80 billion, contributing about a quarter of Singapore's total manufacturing output. Here, significant IE master plans drew up by JTC match 'engineering optimization' in most occasions. According to Yang and Lay, three designs are accessible and stressed by central government. Miniparks as a 'stepping stones' system, water corridor program and long-term evolution together with prospective fuel technology all treat and then utilize waste, also taking an attempt to alternative energy for sustainable development.

As a mentioned before, Jurong is a typical example of engineering success and these three designs are closely dependent on government intervention.

Speaking of miniparks, when designing the landscape of an IE, not only should visual aesthetics be considered, but also the layout and selection of plant species matter which means plants in miniparks are meant to implement the goal of off-gas treatment. The selection process is completely based on government target-oriented zoning plan. The Singapore government treats Jurong Island as central chemical industry zone so corresponding plants possessing special capabilities for treating chemical industry waste gas are spread for this target-oriented approach. To be more specific, government program group mainly gathered refining, petrochemical, and specialty chemicals which bring sulfide, oxynitride and volatile organic compound (VOC) as off-gas in common in Jurong. So plants in miniparks are efficient for absorbing gases mentioned above under government's plan.

Under the same line, water corridors' success in sewage recycling and closing the ecology circulation won't occur without government's co-location proposal and the layout strategies of corridors themselves. The layout could be more complicated than imagine with diverse considerations like building pipe system and pleasant exteriors. Government places higher value on requirements facilitating social utilities than other stakeholders in EIP thus water corridor projects could be built with adequate budget.

Long-range improvement through future fuel technology is the most explicit showcase of government power imposed on EIP upgrading. This method contributes to 'engineering optimization' directly by simplifying reproduction process and creating a more fluent cycling chain. Therefore, JTC began programs supporting optimization of clean energy based on local algae farming, and other land-based resources. In 2007, the Singapore government addressed to the nation that clean energy industry was a key in economic realm and allocated S\$350 million funding to research and development as well as manpower capabilities [8].

Besides from matching aim of EI, only when the proposals are equipped with scientificity, validity and possibility of implementation, the ‘predominance’ function can be fully embodied.

To begin with, the three master plans by Singapore's government responded to the potential of the local nurtured landscape as an integral component of the eco-industrial park in different ways. Concern over practical situation corroborates scientificity of projects. Respectively, the first proposal stayed close to current government's need, namely a chemical industry center, and understanding of industrial ecology, namely plants' selection for high off-gas dealing efficiency. The second proposal involved the restoration of natural ecosystems, particularly swamps and coastal ecosystems, which converts Jurong Island features into an efficient EIP design with natural advantage for water corridors' building. Along the same line, artificial ecosystems were proposed, enabling the buffer zone between industrial facilities and the natural landscapes to work as alleviation area, and helped recycle and utilize the waste through diverse manufacturing processes. The third proposal enacts projects based on land-based resources like local algae farming, illustrating full consideration of Jurong district's natural landscape thus ensuring scientificity.

Additionally, Jurong Island local government and JPC was full equipped with cutting-edge development group and financial resources. Adequate resources from the government lay a solid foundation for a valid project. In Jurong, the Energy Market Authority (EMA) and JTC have illustrated three facility construction proposals under the \$6 million budget to test-bed new clean energy innovation. Government provides enough financial incentive to encourage the development of sustainable development. Also, it has the equipment of institutions like EMA, JTC to fully support government policy. In 2021, EMA and JTC Corporation launched the Jurong Island Renewable Energy Request for Proposal which accelerates clean energy innovations for implementation on the island. JTC, together with the support of other government agencies, brought 51 key industry players together to forge potential collaborations in the Jurong Island Circular Economy (JICE) study, allowing companies to optimize resources and data at the systems level. With the government's leadership, there is a great improvement in the efficiency. Singapore government has enough funds and professional departments to carry out its plan and ensure the effectiveness of the process, from which validity is guaranteed.

In the aspect of implementation, Jurong has more than paid back its investment. Since it opened, it has attracted over S\$50 billion worth of investments consistently over the years, with more than 100 companies employing some 26,000 people. It is a symbol of Singapore government's insistence and long-term supervision on the project [9]. With the development of hydrogen-ready power plant, It also achieve an annual reduction of 220,000 tons of carbon emissions. Long-term research and development can be another evidence for implementation of policies throughout.

2.3. EIP Failure due to Improper Management

Failure occurs even when advanced technique occurs. The actual achievements shown by the data explain that with objective showcase of environmental hazard and economic junction. We excavate a few EIP projects in Rio de Janeiro and all of them have no satisfying results. So data analysis and is enacted to come up with insights into failure reasons. Also, suggestions for enhancement are offered. A pragmatic example requiring more consideration of ‘economic trade-off’, namely maximum social utility achieved, is Rio de Janeiro Metropolitan Area (RJMA) in Brazil. As a result of absence of public sector to coordinate, ‘only 20% of RJMA's trans- formation industries (1908 out of 9544) are located inside the 56 industrial zones. This heavy industrial concentration outside the industrial zones (80%) is compromising the region's environment and the community wealth’ [10]. Actually, the obvious detriment of social welfare has attracted local government's attention, and government arrangement represented as financial incentive was once enacted. Nevertheless, due to shortage of program continuity and immoderate performance of private sectors, policies are gradually rejected.

Therefore, the failure in RJMA EIP acts as one disproof of government predominance, especially significance of proper financial incentive. Then, this article compares the validity supposed and the fact in pursuit of a more informed explanation.

The financial incentive used to prove validity of RJMA's EIP development. Initially, for compensation, a municipal law (Law 552/2002) was enacted by the Paracambi municipality local government, aiming at offering industries engaging in the EIP program independent provision as a price of possible descent in productivity due to environmentally-friendly regulations there. Also, tax redistribution related laws introduced, promoting the municipality of Morretes from the 203rd in the ranking of tax redistribution to the 107th after the law, while the municipality of Antonina moved from the 191st to the 84th position, lowering cost of production. On the contrast, the central government, has withdrawn the program due to political instability five years after the enactment. Variation of leadership is often accompanied with change in far-reaching designs, blocking the continuity of industry transformation process in EIP. Thus, the cost-benefit analysis held by only enterprises, even those who care about environmental issues, won't decide extra weight assigned to social welfare projects.

Meanwhile, the heavy industrial concentration outside the industrial zones (80%) is compromising the region's environment and the community wealth. The total amount of industrial waste generated in Rio de Janeiro state has reached 293,953 metric tons a year. Only 5 out of 39 industrial zones in Brazil have successfully transformed into EIPs. It is quite apparent that without government support and interventions, the extent of sustainable development is still very low in Brazil.

'Economic efficiency' then isn't achieved because both financial shortage and environmental degradation occurred. If the decree remains, EIP transformation project would typically be given the go-ahead when the benefits exceed the costs. However, as mentioned above only 20% of RJMA's transformation industries are located inside the 56 industrial zones.

Besides from imprecise evaluation of aim of EIP, policy from RJMA government didn't work as 'predominance' as well with a lack of scientificity, validity and possibility of implementation.

To begin with, in Brazil RJMA region, political leadership changes frequently, good programs and ideas do not always last due to the subjectivity of new regime. It becomes really difficult for private sectors to make decisions because of lack of familiarity and knowledge of the concept and potential benefits resulting from the implementation of EIPs. Even though these concepts are spread worldwide, industries and communities don't have experience about this terminology, hampering the development of both the Santa Cruz and Paracambi EIPs, which leads to so complicated situation that few proper plans based on practical knowledge can be made, thus the failure of policy in terms of scientificity occurs.

For validity, the promulgation of State Decree 31,339/2002, initially was a strength, but it eventually became a weakness. The limited funding, subsidies and investment capital might prevent EIP dissemination, particularly regarding SMS industry participation, as these industries usually need greater financial support. This further diminished the validity of the local government and brings about an asymmetric information. Even worse, inertia and lack of capacity and bureaucracies of the public institutions, particularly in Paracambi exposed government's lack of complete political structure from coordination aspect. In RJMA, private sectors are short of knowledge of the opportunities existing in interfirm collaboration since the confusing government lacks ability to coordinate and command different institutions. For most industries, they just look to see what they can do by themselves, without realizing opportunities resulting from cooperation. Even if the government does enact advocacy, it does not coordinate and lead, does not create and maintain favorable conditions with incentive policies, also down not conduct direct macroeconomic regulation like environmental taxation system. As a result, EIP project is deviated from the original direction by individual enterprises' actions based on their own interests with little validity of policy.

Implementation of RJMA EIP establishment is almost impossible. Changes in political administration and public agency leadership interrupted public sector support. Deficiencies of long-term planning was a huge obstacle for Brazil government. EIP development is a long-term planning process for which collaboration, perseverance and mutual trust among all actors in RJMA in order are essential to contribute to the success, and private sectors normally don't consider that. Brazil government failed to make a proper estimation about itself, ignoring its instability. The EIP program is not the first program to be launched in Rio de Janeiro as a tool to promote political careers, nor will it be the last one. Anyway, every generation of government all can't be able to take measures to maintain the construction of EIPS if Brazil's current unstable situation can't be solved.

3. Discussion

Problems in RJMA EIP distinct could be boiled down as a sequence of error from central politicians to economic administrators then overwhelmed private sector account. Political instability, mainly reflects on frequent variations in national leaders and administrative parties, directly results in policy disadvantage in terms of possibility of implementation. The most basic need, namely safe environment for economic development is presented as absence, thus the policy is destined to be a failure. Even though EIP project boosts for a while in the evolution history, RJMA project eventually becomes a pity of time due to the fundamental flaw in safety. Safety issue occurring from time to time blocks the continuity of EIP project, so the destination of fiasco can be explained in long-term.

Lack of government budget is another key problem and significantly affects policy validity. Budget itself is just one type of government resource and shortage in it obviously embodies weakness of the subsidy system. Thus, incentive policy and subsidies appear as 'invalid' approaches which require more money than governments spending. Though the amount of subsidy can be large enough initially to attract more cooperation to the EIP, problem of continuity is exposed again, indicating low possibility of policy implementation.

Private sector's inability to behave well in EIP by themselves also takes account since absence of government guidance. Firms mainly focus on their own profits. They can't figure out the potential benefit before they decide to join the EIP so government is responsible for informing them with current green economy situation. What contradictory is that companies can't see a promised future at all with severe domestic violence between parties. None of the government can design an EIP program fitting the complicated practical requirements perfectly thus scientificity of policy is lost. Even when companies have moved into EIP zones, they just stop to follow instructions that reduce waste in EIP since reduction in profit due to inadequate subsidies. As a result, validity problem causes profound influence at the same time.

As a conclusion, difficult evaluation of current situation, improper policy requiring too much investment and improper behavior of private sectors are the most serious problems in RJMA EIP development. To solve them, firstly, political parties are meant to be united at least in terms of peace maintaining. Only when the war is away could Brazil concentrated on economics. Also, incentives should be eliminated to a proper amount every year to ensure the continuous advantage for industries in EIPs over others since total budget is quite limited. Guidance from government to ensure companies aware of sustainable benefits from green economy approach is meant to be presented as well.

4. Conclusion

Also the process of construction is supposed to be under the conditions, scientificity, validity and implementation, in order to obtain a beneficial result. From this article, we would like to help governments know how to manage EIPs' construction efficiently.

All in all, government role and function, whatever the form it appears, could boil down to the concept mentioned for several times, namely 'predominance'. Through two case studies, the degree of importance of government's predominance in EIPs' construction has been analysed from both positive and negative aspects. It can be seen that government that targets as 'Engineering optimization' and 'Economic trade-off' does play an significant role in the construction of EIPs.

Scientificity, validity and possibility of implementation further emphasize that the government has the function of administrative, and it must play a good role as boss in the implementation process of the plan in the long run, by which everyone gets benefits with optimized engineering design. In the near future with more sustainable requirements, some people will be sacrificed, at this time the government should stand up and coordinate with various parties, evaluate the recent beneficiaries to provide some compensation for the recent losses, or take part of the work funds from the office funds to compensate, valuing 'economic trade off' as well.

In this regard, here are some suggestions that is beneficial for the government to further enhance its effective leadership: firstly, starting from the current situation, familiarize and fully understand the local basic information, strengthening of overall guidance is proposed to effectively implement the planning of green economy construction. Secondly, give full play to the administrative functions of the government, do a good job of coordinating the interests of various parties, and be good at using management, consultation and other means to make good use of government policies. Thirdly, the implementation of the implementation in place to grasp the scale. Grasp the progress of promoting the implementation of construction, evaluate the implementation results in stages, and summarize the gain and loss, the function of government thus matters as the predominance.

Finally, we conclude that the scientific, effective and enforceable leadership of the government can promote the development of green economy by reaching targets of economic balance and industrial optimization.

In the future, studies in other ways to achieving green economies besides from EIP establishment like environmentally-friendly industry transformation and upgrade are suggested to be done. In these methods, government role is meant to be highlighted and compared to that in EIP so as to offer a more precise definition of its role in terms of green economy. Though aims of approaches are quite similar, conditions under that policies can be efficient will also be concluded to more detailed elements. All further investigation provides more clear and pragmatic suggestions that government can follow more logically.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

- [1] Jänicke M 2012 'Green growth': from a growing eco-industry to economic sustainability *Energy Policy* 48 13–21.
- [2] Gibbs, David, and Pauline Deutz. 'Reflections on Implementing Industrial Ecology through Eco-Industrial Park Development.' *Journal of Cleaner Production*, vol. 15, no. 17, Nov. 2007, pp.1683–1695, <https://doi.org/10.1016/j.jclepro.2007.02.003>. Accessed 4 Oct. 2019.
- [3] Yu, Fei, et al. 'Evolution of Industrial Symbiosis in an Eco-Industrial Park in China.' *Journal of Cleaner Production*, vol. 87, Jan. 2015, pp.339–347, <https://doi.org/10.1016/j.jclepro.2014.10.058>. <https://doi.org/10.1016/j.jclepro.2008.11.009>.
- [4] Yang, Perry Pei-Ju, and Ong Boon Lay. 'Applying Ecosystem Concepts to the Planning of Industrial Areas: A Case Study of Singapore's Jurong Island.' *Journal of Cleaner Production*, vol. 12, no. 8-10, Oct. 2004, pp. 1011–1023, <https://doi.org/10.1016/j.jclepro.2004.02.028>. Accessed 8 July 2020
- [5] Elabras Veiga, Lilian Bechara, and Alessandra Magrini. 'Eco-Industrial Park Development in Rio de Janeiro, Brazil: A Tool for Sustainable Development.' *Journal of Cleaner Production*, vol. 17, no. 7, May 2009, pp. 653–661,

- [6] Kuznetsova, E., et al. 'A Methodological Framework for Eco-Industrial Park Design and Optimization.' *Journal of Cleaner Production*, vol. 126, July 2016, pp. 308–324, <https://doi.org/10.1016/j.jclepro.2016.03.025>. Accessed 11 Aug. 2020.
- [7] Roberts, Brian H. 'The Application of Industrial Ecology Principles and Planning Guidelines for the Development of Eco-Industrial Parks: An Australian Case Study.' *Journal of Cleaner Production*, vol. 12, no. 8-10, Oct. 2004, pp. 997–1010, <https://doi.org/10.1016/j.jclepro.2004.02.037>.
- [8] Goh Chee Kiong. "GROOMING CLEAN ENERGY as a KEY GROWTH AREA for SINGAPORE." *WORLD SCIENTIFIC EBooks*, 24 Apr. 2013, pp. 11–18, https://doi.org/10.1142/9789814425582_0002. Accessed 17 Mar. 2024.
- [9] 'Jurong Island: The Chemical Island.' *Www.sg101.Gov.sg*, www.sg101.gov.sg/economy/digging-deeper-case-studies/jurong2/#:~:text=Jurong%20Island%20co%20the%20government.
- [10] Magrini A, MontezEMP. Subsídios para a melhoria da Qualidade Ambiental da Região Metropolitana do Rio de Janeiro através da Proposição de Novas Configurações Industriais. *IX Congresso Brasileiro de Energia, Soluções para Energia no Brasil, Anais*; 2002.