Quality Function Deployment Environment (QFDE) of Water Stewardship to Achieve Net-Positive Water: Case Study in Company I, A Manufacturing Company in Penang

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ABSTRACT

This study aims to identify the departments involved in water stewardship and examine how water stewardship efforts contribute to achieving net-positive water at Company I in Penang. Water stewardship is an integrative process that translates environmental goals into effectively conserving, reusing, and restoring water resources. A systematic approach to water stewardship provides clear guidance for organizations aiming to achieve net-positive water by returning more clean water to the environment than is consumed in operations. The likelihood of success in sustainable water management created by a structured process ensures that companies follow well-planned methods. Water stewardship has become critical to long-term corporate sustainability, especially in water- intensive industries like semiconductor manufacturing. Currently, the semiconductor sector faces growing scrutiny due to high water consumption, and there is an urgent need for innovative water management practices. This explanatory case study examined the water stewardship in Company I in Penang. The researcher collected primary data from 15 respondents through semi-structured interviews. The researcher triangulated the primary data they had collected with other primary and secondary data sources to guarantee the information's correctness and dependability. The first research objective of the study is to identify the department involved in water stewardship that helps achieve net-positive water. The second research objective was to examine the ways water stewardship helps in achieving net- positive water. This research benefits the researcher by providing insights into how departments coordinate water stewardship efforts and the specific practices that enable Company I to meet its net- positive water goals. It also enables the researcher to develop a case study to guide other organizations in implementing effective water stewardship programs.

Keywords: Water Stewardship, Departments, Ways, Net-Positive Water

INTRODUCTION

According to Masui et al. (2003), QFDE is a quality system approach to translate environmental requirements into company requirements at various stages including planning, product design and process design. QFDE can be used to identify the environmental requirements and to translate these into design requirements. QFDE is the environmental version of QFD which at allows designers to consider both customer and environmental requirements simultaneously.

In this research, the researcher focuses on investigating the QFDE of water stewardship in Company I. Company I's water stewardship aims to achieve net positive water by funding water projects that will replenish local watersheds with more fresh water than is used and preserving 60 billion gallons of water (total from 2020), which aims to translate environmental goals in QFDE systematically. Achieve net positive water by conserving 60 billion gallons of water and funding water restoration projects that restore more fresh water than Company I consumes to local watersheds. Net positive water is defined as water returned through water management practices, plus water restored to local watersheds, equivalent to >100% of our freshwater consumption (Company I, 2023-24 Corporate Responsibility Report).

Company I's Penang site reclaims wastewater from its assembly test manufacturing (ATM) operations through filtration and biocide control. The reclaimed water is then recirculated in cooling towers, reducing overall freshwater consumption. Company I continue to identify opportunities to segregate and recover rinse water and bypass flows from process manufacturing equipment. Adding an advanced treatment step to remove ozone has significantly increased water reuse for factory systems, including cooling towers, scrubbers, and abatement units. The system was installed and is expected to save approximately 200 million gallons of water annually once fully implemented. Additional retrofits o expand this initiative are planned at other Company I factory sites in 2024 (Company I, 2023-24 Corporate Responsibility Report).

This research focuses on the department under water stewardship and the ways water stewardship helps in achieving net-positive water. The researcher will identify the department involved in water stewardship that aims to achieve net-positive water, and the ways water stewardship helps in achieving net-positive water. This research is being conducted with some limitations. First, the researcher selected a company called Company I as the research subject. Through this company, the researcher can understand what departments are involved in water stewardship and the ways water stewardship helps in achieving net-positive water.

Secondly, the respondents' knowledge of water stewardship may be lacking. As a result, they may need help to provide proper and formal answers to theoretical questions during the interview sessions. The critical assumption of this research is that the researcher will ask questions understandably and believe that the respondents will answer all prepared questions honestly and carefully during the interview session. Besides that, throughout this way, the respondent may provide the best possible answers and responses within their best understanding of the department under water stewardship and the ways water stewardship helps in achieving net-positive water involved in the primary data collection. The researcher believes this would help the researcher obtain accurate data, findings, and results.

LITERATURE REVIEW

In the literature review, the literature concepts and introduce the literature review of this research study. At the same time, the outline for the research study talked about the reviews of the Quality Function Deployment for Environment (QFDE) and its reflection in corporate sustainability strategies. The company must identify the reflect of the QFDE that implement sustainability for its commitment to net positive water. Aside from that, once the requirements of QFDE have been identified, the company should apply in corporate sustainability strategies.

Preliminary Framework Selecting GHG Reduction Measures

Top-down Loop

For companies that have a top-down loop, the president and board members decide the company's basic policy, then middle management composes the action plan, sets targets, and selects measures needed to bring the action plan to reality, and finally the operating division actually implements the measures. The downward arrows in the figure, i.e. from the basic policy toward the implementation of measures, indicate such a top-down loop (Otani and Yamada, 2011).

The top-down loop in the proposed paradigm utilizes high-level semantic information to guide low-level deraining adaptively. This process enhances deraining by incorporating structured semantic constraints, facilitating improved restoration based on the content of the image (Li et al., 2022).

Bottom-up Loop

Conversely, the upward arrows in the figure illustrate the bottom-up loop. In this loop, the operating division selects measures on the basis of their past experience, including the results of recently implemented or ongoing efforts. Middle management, such as the environment department or corporate planning division, collects information on selected measures from the operating department and creates an action plan, including measures that can be quantitatively evaluated, and sets the targets. Then middle management checks whether the targets are incorporated within the firm's basic policy and request that board members approve the action plan (Otani and Yamada, 2011).

Furthermore, bottom-up approaches should not be advocated uncritically, and there remains a need for empirical evidence on and methodological tools to assess the ways in which participatory approaches might enhance fit (Guerrero et al. 2015).

Basic Principle

Weber and Remer (2011) suggested applying three basic principles to incorporate sustainable practice. The first principle involves integrating environmental concerns and social advancement conduct into core operations. The second involves incorporating sustainability practices in day-to-day activities. The third promotes adopting sustainable development practices regarding the quantifiable business results reported to all the stakeholders.

The basic principle of the environment ethics of sustainable development is an important content of scientific viewpoint of development. It emphasizes that the human being should keep a harmonized relationship with nature and provides an equal opportunity to descendants when they are pursuing the privilege of existence and development (ZHANG, n.d.).

Environmental Policy

Environmental policy is the set of actions the firm takes to reduce its footprint on the environment, as signaled in its annual report or sustainability report. When combined, these two dimensions may reflect a firm's commitment to environmental protection, but they are not necessarily correlated (De Miguel De Blas, 2020).

Domestic structures and patterns of policy-making in the area of environmental protection are characterised by a legacy of centralism combined by weak administrative capacity and a history of considerable implementation gaps both regarding regulatory enactment, enforcement and the formulation and implementation of multi-annual development programs that address the country's developmental imperatives related to land, air and water protection in a comprehensive way (Koutalakis, 2011).

General Target

Targets for sustainability metrics may be set at short, medium, and long-term time scales. Sustainability necessitates long-term thinking by definition, medium-term generational and visionary targets should also be set, and a path laid out on how to navigate from short to medium to long-term. While it is fairly certain these targets will require revision sometime in the future, they provide a reference point from which to work, as opposed to leaving future generations to set a new metric target without any guidance (Rauch and Newman, 2009).

Action Plan

Otani and Yamada (2011) describe the action plan stage as translating general targets into executable programs, with clear responsibilities assigned to relevant divisions. From a perspective of designing interventions that affect choice outcomes, these interventions need to occur within the planning stage in order to affect the outcomes (Ben-Akiva, 2010). An action plan provides the needed roadmap. It is a simple list of all of the tasks that need to be carried out to achieve an objective. To use it, the cities simply carry out each task in the list. In this study, action planning is a collective exercise of city departments, and the output will be short-, medium-, and long-term priority of actions to enhance the city resilience to climate and disaster risks (Fernandez et al., 2011).

Individual Target

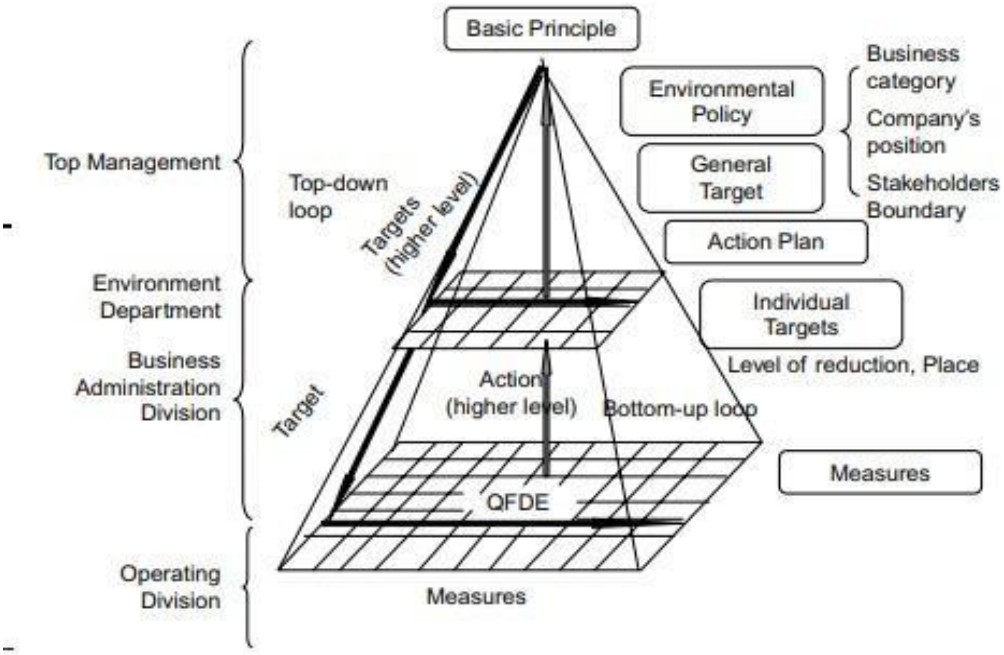
Individual target ensure that environmental goals are quantified, localized, and continuously evaluated to verify their contribution to corporate sustainability outcomes (Otani and Yamada, 2011).

Measures

According to Mitra (2021), once the special causes have been eliminated and only chance or common causes remain, which represent the inherent variation in the process, the output from a process is predictable. So, under these circumstances, measures of process performance through capability indices may be computed. rior research

has studied univariate measures of process performance where only a single-quality characteristic is of importance or a multivariate measure that involves several quality characteristics.

Figure 1: Revised framework for selecting GHG reduction measures Sources: Otani and Yamada (2011)



METHOD

This case study has used a qualitative method to explain the department involved with water stewardship and the ways water stewardship achieves Net-Positive Water in Company I in Penang. A case study is an in-depth inquiry into a topic or phenomenon within its real-life setting (Yin 2018).

According to Saunders et al. (2023), qualitative meanings are not formed from numbers but rather from words. This is because words and images have unclear and multiple meanings. Therefore, researchers need to discuss and clarify this with participants. In this study, the researcher will express water stewardship through words and images in qualitative research.

The traditional data sources under qualitative research were mainly through interviews, observation, focus groups, and recordings (Gill et al., 2008). Therefore, the qualitative research method used for this study is to conduct interviews, this is so that the researcher can easily understand the opinions and views of the respondents. For the researcher to accomplish the purpose of this research, the researcher asks the respondents a variety of questions throughout the interview sessions in order to obtain pertinent information for the research. In order to collect literacy data and textual descriptions for the research, the researcher conducted interviews with 15 respondents.

Primary data are collected specifically for the research question at hand (Saunders et al., 2023). There are several ways to collect primary data, such as surveys, observations, questionnaires, and interviews. For this study, primary data were collected through interviews and questionnaires. 15 participants took part in the research through semi-structured interview methods.

Secondary data refers to data that was previously collected for purposes other than the current research (Hox & Boeije, 2005). In this research, secondary data was used to provide context, support the findings from the primary data or to gather information that was not feasible to collect through primary methods. Among the secondary data sources used in this study are academic databases. Past company reports, newspapers, newsletters, company website, company social media, and articles were collected to get to know the department and the ways water stewardship helps achieve net-positive water.

Furthermore, a pilot test is conducted on a subset of the target population to evaluate their dependability. According to Saunders et al. (2023), a pilot test of the interview question with respondents who are similar to those who will fill it out should be conducted before data collection. The pilot test aims to fine-tune the interview questions so that respondents can quickly answer questions and record the data.

In the scientific canon, internal validity, external validity, construct validity, and reliability are significant factors contributing to the research's overall quality and credibility. These are crucial concepts for modern studies since they help to improve the accuracy of the assessment and evaluation of studies (Tavakol & Dennick, 2011). Saunders et al. (2023) emphasize that reliability and validity are essential for evaluating the quality of research in the natural sciences and quantitative social sciences. Validity and reliability enhance transparency and reduce the chances of researcher bias in qualitative research (Singh, 2014).

Thematic analysis was employed to uncover themes that are critical to understanding Company I's water stewardship efforts. As highlighted by Nowell et al. (2017) in Emerald Insight, thematic analysis ensures rigor through a structured process of familiarization, coding, theme development, and review, which enhances the trustworthiness of findings.

RESULTS AND DISCUSSION

Department Involved in Water Stewardship

Top-down Loop

The president and board members decide the company's basic policy, then middle management composes the action plan, sets targets, and selects measures needed to bring the action plan to reality, and finally the operating division actually implements the measures (Otani and Yamada, 2011).

The intervention strategy the organizations are likely to choose depends on the nature of environmental factors and the organizational change/learning strategies they adopt to respond to their institutional environments (Sisaye, 2003).

Respondent 7 has declared that Company I's net-positive water commitment is translated by the Environmental Health and Safety Department (EHS) by data indicators and reporting systems. "This is not just about collecting data, but it is a compliance verification against external regulatory standards and our own environmental policy," said Respondent 7. They also communicate goals to other departments to provide technical guidance and data systems, ensuring each department aligns with the policy, as stated by Respondent 8.

After receiving data from the EHS Department, the Facilities and Operations Department will proceed with the technical and engineering actions. Respondent 3 has been described as playing a role in supporting water stewardship efforts by ensuring that the water discharged from the Company I treatment system is within regulations and also reclaiming water for reuse in the cooling tower. This process enhances deraining by incorporating structured semantic constraints, facilitating improved restoration based on the content of the image (Li et al., 2022).

"Water stewardship not only deals with environmental sustainability but also deals with employee health, safety, and well-being", points out Respondent 1. Respondent 13 indicates that Occupational Health ensures health related to water usage, which aligns with Company I's environmental policy of net-positive water.

Bottom-up Loop

Conversely, the upward arrows in the figure illustrate the bottom-up loop. In this loop, the operating division selects measures on the basis of their past experience, including the results of recently implemented or ongoing efforts. Middle management, such as the environment department or corporate planning division, collects information on selected measures from the operating department and creates an action plan, including measures that can be quantitatively evaluated, and sets the targets (Otani and Yamada, 2011).

The bottom-up loop places a strong emphasis on improvement and feedback via data and experience acquired from operational activities. Respondent 4 indicates that the Facilities and Operations Department is involved in activities such as water treatment and reuse, as well as rainwater harvesting, in the context of water stewardship. The performance data of the activities will be recorded daily and presented at the Environment Performance Monitoring Committee (EPMC) meeting every quarter, showing how much water is reclaimed and used.

At the same time, the Environmental Health and Safety (EHS) Department serves as the one who link between operations and company strategy will compile the information to evaluate the success of implemented measures. Respondent 1 explains that the progress on water stewardship is communicated to top management through the company bulletin. Updating performance data of water stewardship through internal bulletins has become a bridge of communication with the top management to ensure performance data is updated in real-time.

According to Respondent 15, the health and safety observations from workers engaged in activities water stewardship will be reported occasionally to the EHS Department to evaluate the exposure level and safety risks. The system integrates corrective actions that will be processed by the upper department when the occupational risk is identified.

Ways Water Stewardship Achieves Net-Positive Water

Basic Principle

Weber and Remer (2011) suggested applying three basic principles to incorporate sustainable practice. The first principle involves integrating environmental concerns and social advancement conduct into core operations. The second involves incorporating sustainability practices in day-to-day activities. The third promotes adopting sustainable development practices regarding the quantifiable business results reported to all the stakeholders.

Company I's sustainability goals included a commitment to achieve net-zero Scope 1 and 2 greenhouse gas (GHG) emissions by 2040 and net-zero upstream Scope 3 GHG emissions by 2050.

Respondent 1 explains that the majority of Company I's goods are made in-house at the water fabrication facility. Because of this, Company I has a greater direct environmental impact than "fab- less" rivals which having manufacturing footprints.

Environmental Policy

Environmental policy is the set of actions the firm takes to reduce its footprint on the environment, as signaled in its annual report or sustainability report. When combined, these two dimensions may reflect a firm's commitment to environmental protection, but they are not necessarily correlated (De Miguel De Blas, 2020).

The Company I's environmental management is guided by the Company I Code of Conduct, Global Climate Change Policy, Global Water Policy, Energy Policy, and Global Environmental Health and Safety Policy, which set goals and evaluate effectiveness through ISO 14001 and ISO 45001 standards.

Water strategy in Company I has three focus areas: (1) Reuse water in operations by investing in cutting-edge water treatment facilities, (2) lowering operational water usage through creative water conservation projects, and (3) restoring water to Company I's watersheds in collaboration with nonprofit environmental organizations, as added by Respondent 5.

General Target

Targets for sustainability metrics may be set at short, medium, and long-term time scales (Rauch and Newman, 2009).Company I have set a global general target to achieve net-positive water across all operations by 2030. Company I's goal is to achieve net-positive water globally by 2030 by reducing the water used in our operations and restoring more fresh water to the environment that is consumed. In 2024, Company I achieved a 106% net-positive water ratio and restored 2.9 billion gallons to local watersheds and returning 8.8 billion gallons through treatment and reuse.

When conducting interviews with Respondent 2, the respondent mentioned that water restoration projects like water treatment and reuse, and rainwater harvesting are ongoing to achieve net- positive water.

Action Plan

Otani and Yamada (2011) describe the action plan stage as translating general targets into executable programs, with clear responsibilities assigned to relevant divisions. An action plan provides the needed roadmap (Fernandez et al., 2011).

The water stewardship of Company I operates under three actions, which are reduce, reuse, and restore, that are implemented through cross-departmental collaboration.

Respondent 2 has proposed that water reuse is to maximize internal recycling and recovery. It has been used multiple times before reducing dependency on freshwater supply. Company I has successfully operated sustainably in reuse initiatives to close the loop in Company I's water cycle.

Individual Target

Individual target ensure that environmental goals are quantified, localized, and continuously evaluated to verify their contribution to corporate sustainability outcomes (Otani and Yamada, 2011).

Through the interview with Respondent 7, Respondent 12, and Respondent 14 when discussing the target of each department, Respondent 7 has explained that the individual targets in the Facilities and Operations Department are to reduce water consumption and increase reclaimed water usage for the cooling tower. The EHS department is to ensure that data is accurate and contributes to net-positive water, said Respondent 12. Respondent 14 also added Occupational Health Department is to protect workers' well-being while maintaining the water stewardship program.

Measures

According to Mitra (2021), once the special causes have been eliminated and only chance or common causes remain, which represent the inherent variation in the process, the output from a process is predictable. So, under these circumstances, measures of process performance through capability indices may be computed.

Company I gas continues to implement water conservation projects, water reclamation systems, and watershed restoration partnerships to reduce our water footprint and return more water that the company has consumed.

Respondent 6 has explained the onsite water treatment and reclamation facilities. These facilities allow water to be reused multiple times in cooling towers to reduce dependency on freshwater sources. The EHS Department will also monitor real-time performance of tracking water use to ensure environmental compliance.

CONCLUSION

Department Involved in Water Stewardship

Company I's water stewardship operates under a system of top-down and bottom-up loops. The top- down loop ensures that the net-positive water set by top management can be effectively translated into operational practices; the bottom-up loop can enable data-driven improvement by getting continuous feedback from operational departments. The Environment Health and Safety (EHS) Department has played a pivotal role in translating corporate sustainability commitments into measurable indicators to ensure compliance with regulatory standards. Therefore, the Facilities and Operations Department has executed the engineering measures like water treatment and reuse, and rainwater harvesting to demonstrate the tangible realization of Company I's sustainability objectives. Lastly, the Occupational Health Department complements net-positive water by maintaining employees' safety throughout water stewardship. This has reflected the company's holistic approach to sustainability.

Ways Water Stewardship Achieves Net-Positive Water

In this study, Company I's successes in achieving a 106% net-positive water ratio as rooted in its structured action plan. Company I has been focusing on the reduce, reuse, and restore principle to support robust performance monitoring systems. Each department's individual targets are aligned with the company's general target to achieve net-positive water globally by 2030. The target of the company is to ensure accountability and continuous improvement towards net-positive water. This can effectively guide environmental management practices with measurable sustainability outcomes.

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