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Assessing Sustainable Development Initiatives in Central Taiwan Science Park: A Study of Residents' Opinions and the Impact on the Urban Ecosystem

Fu-Hsuan Chen

Department of Political Science, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan; fhchen@mail.ntcu.edu.tw; Tel.:+886-2-3366-3366 or +886-2-2362-7651

Abstract: The present study aims to explore the role of the Central Taiwan Science Park (CTSP) in promoting sustainable development, with a specific focus on the park's recycling technologies. By combining survey research and conducting in-depth interviews with residents living around the CTSP, their observations were analyzed using statistical data released by the government. The purpose of this study is to gain a deeper understanding of how technology parks can promote circular economy and waste reduction, as well as to understand the potential impact of the CTSP on the environment and neighboring communities. The study found that the CTSP is committed to maximizing the use of recycling and has established advanced recycling facilities and green infrastructure to promote waste reduction. Residents' opinions played a crucial role in understanding the current situation and the way forward, helping the CTSP design effective green infrastructure for the urban ecosystem. The results of this study could inform stakeholders about sustainable recycling and zero-waste initiatives in Taiwan's technology industry and support government efforts to cultivate more sustainable urban ecosystems. Furthermore, this study found that environmental education can effectively raise awareness and promote action

Keywords: sustainable development; Central Taiwan Science Park; green infrastructure; residents' opinions; urban ecosystem; environmental education

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1. Introduction: Science Parks and Sustainability

The critique of development in the environmental movements of the 1960s contributed to the emergence of "sustainable development" in the 1980s [1]. The concept of sustainable development has undergone significant evolution since its initial definition by the Brundtland Commission in 1987. These days, there are controversial concepts of sustainability [2]. The ongoing debate about technicalities of definitions and practical applications led to the emergence of alternative approaches to the whole range of issues [3]. Sustainable development is an approach to economic growth that aims to encourage industrial and economic advancement while preserving finite resources, such as air, water, and soil, to ensure future generations have the same opportunities to thrive as previous ones [4,5]. The new guidelines are based on the United Nations' Sustainable Development Goals (SDGs) and address economic development, social growth, and environmental protection from a three-dimensional perspective. In recent years, there has been growing interest in incorporating science parks into research on industrial sustainable development. Science parks are physical locations where research institutions, universities, and businesses co-locate to facilitate innovation, research, and development [6]. They offer a platform for collaboration, knowledge exchange, and commercialization of new technologies. By integrating science parks into research on sustainable development, scholars can better understand the environmental and social impacts of technological innovation and commercialization, as well as the economic benefits that can arise from sustainable practices. By promoting sustainable development in industrial settings, more effective policies and management practices can ultimately be developed [7,8]. The sustainability goals, including social equity, economic efficiency, and environmental performance, should be incorporated into the organizations' operational practices [9].

At the outset, Taiwan's government supported the development of science and technology parks through new policies aimed at promoting industrial development in surrounding areas and establishing them as regional growth centers. Since 2018, the science park has been producing environmental profit and loss reports in order to evaluate the environmental externalities and associated social costs generated by the manufacturing process. The development of Central Taiwan Science Park (CTSP) is based on the principles of "phased development" and "ecological construction". The environmental protection concept of this park emphasizes co-prosperity of humans and the environment. This paper illustrates Taiwan's achievements in sustainable development, which are outstanding on a global scale [10–14]. In the development of science parks, the Taiwanese government combines production, research and development, innovation, and cross-border exchange to promote the interaction between sustainable development and the technology industry [8,12]. The Taiwanese government is committed to developing green infrastructure and promoting circular economy processing in the construction of science parks in order to reduce the negative impact of the industrial development on health and resource consumption [14,15]. Although every country operates in individual circumstances, Taiwan's experience of sustainable development in technological industries is applicable across the world. Strengthening policy integration, establishing environmental protection regulations, promoting green technology, and developing circular economy models are key elements of success [14]. Growth poles, which are regions or cities targeted for investment and development to stimulate economic growth and development in surrounding areas, contribute greatly to promoting sustainable development [16–18]. Recycling is one of the most important aspects of sustainable development, especially in an industrial area where abundant waste is produced, as it helps to reduce waste and conserve natural resources [19,20]. Recycling is a process of converting waste materials into new products and is essential for creating a circular economy [20,21]. Moreover, the development of green spaces, urban agriculture, and sustainable transportation systems is also essential for creating a sustainable urban environment [22]. The urban ecosystem is also an important area of focus for sustainable development because the majority of the world's population now lives in cities. Urban sustainability initiatives involve the management and integration of natural, built, and social systems in urban areas to create a more livable and sustainable environment [23–26]. These initiatives have not only contributed to the creation of a sustainable environment but have also improved the quality of life for residents [27].

This paper comprises several sections, including an introduction and research objectives, a literature review, a research methodology, results and analysis, and conclusions and recommendations. The introduction and research objectives section introduces the development of science and technology parks in Taiwan, along with related policies. The purpose of this study is to investigate the benefits of recycling programs in science and technology parks and to understand the potential impact of these parks on the environment and surrounding community. In the literature review section, relevant research studies are discussed. The research methodology section explains the use of questionnaire surveys and interviews to collect data, as well as the selection method of research samples. In the results and analysis section, the data obtained from the questionnaire surveys and interviews are analyzed, and the benefits and impact of recycling programs on science and technology parks and the surrounding communities are discussed. Finally, in the conclusions and recommendations section, the suggestions derived from the research results are proposed to promote the sustainable development of Taiwan's technology industry.

2. Urban Ecosystems and Growth Poles

The urban ecosystem is an area characterized by a complex network of built structures such as buildings, roads, sewers, and power lines. Current research on the urban ecosystem mainly focuses on urban sustainability [28]. To design an urban ecosystem, current studies suggest several steps, including investigating and evaluating the ecological environment, analyzing the ecosystem, assessing environmental impact, optimizing design, and establishing monitoring and evaluation systems [29]. Growth poles are the most contributing factor to urban ecosystems' sustainability [30]. Growth poles, which are clusters of economic activities that stimulate the growth of an area, are considered to be the most contributing factor to urban ecosystems' sustainability. They can promote economic development and innovation while also enhancing environmental sustainability through the adoption of green infrastructure and other sustainable practices. The results showed that there is a strong correlation between "green infrastructure", "ecosystem services", "urban planning", and "sustainable development [31]".

The term "growth pole" refers to a regional space that attracts external economic development and economic benefits through the concentration of industries in one place [32–34]. Since not all types of industrial investment and development can lead to the growth of the endogenous economy of the region, states tend to promote their regional economic development by creating growth poles [35]. The planning and establishment of growth poles create a space with regional and locational advantages [16], and promote the development of other industries [24]. The concept of industrial ecology and its relationship to regional development have been largely overlooked in academic literature [36]. However, there is a close alignment between the principles of industrial ecology and the strategies used in regional development, such as clustering, networking, and local economic development [37]. This alignment can be seen in the example of incorporating blue-green infrastructure into urban drainage adaptive approaches, which can mitigate natural capital losses and contribute to other forms of capital crucial for human well-being. Blue-green options can enhance natural capital and ecosystem services, including amenity value, while also contributing to social and human capital [38].

Growth pole-based development is a common industrial decision used in developing or late industrialized countries [39]. The selection of the site is crucial in defining a growth pole, as it is determined by the relationship between space and political economy policies, which dictate the layout of resource allocation policies. To ensure the success of innovation districts in fostering and sustaining knowledge and innovation economy growth in cities, a user-centric approach should be taken into consideration, considering the needs and preferences of both users and decision-makers [40]. Recognizing the connection between industrial ecology and the cluster policy approach can lead to a more strategic and integrated approach to promoting sustainable economic growth. Incorporating the principles of industrial ecology into cluster development strategies can also lead to more environmentally sustainable and economically resilient regional economies in regional development policies. Eco-industrial development refers to the process of creating industrial parks or clusters where firms collaborate to optimize resource utilization, reduce waste, and improve environmental performance. These eco-industrial developments create closed-loop systems, where the waste from one firm becomes a resource for another, leading to greater efficiency, reduced costs, and improved environmental outcomes. Clustering firms with complementary resources and capabilities can also create economies of scale and scope, generating new business opportunities and jobs.

Regional space can form an economic development center through territorial innovation policies and resource investment, which can enhance the overall competitiveness of the country by creating an economic growth center in the region [41,42]. According to Parr's study of growth poles, economic activity through institutions in the urban system can have a spillover effect in the surrounding area [35]. Darwent assumes that economic development usually starts with an urban center as a starting point of regional planning [16]. The planning and testing scale of exploring the diffusion of modern industries through urban industrial growth poles is still used as a policy for regional development by growth poles [43]. The spillover effect of these urban growth poles can lead to the economic development of the regional space. The lack of sustainable strategic approaches has resulted in non-functional, unsafe, inaccessible, and fragmented urban green infrastructure within cities [44]. To summarize, this paper highlights the importance of recognizing the potential synergy between industrial ecology and regional development policies. By combining the principles of both, it is possible to achieve a more sustainable and prosperous future for regions and the wider economy. Therefore, designing an urban ecosystem in the context of growth poles can be an effective approach to promoting sustainable urban development and economic growth [45].

The analytical proposition of this article is that a careful site selection enables the growth poles to play a significant part in developing spatial economy and sustainable regional development through corporate social responsibility and shared value strategies [46] in a regional space; such strategies are created through policies regulating the external economy, agglomeration economy, and spillover effects [17]. The issue of sustainability in the growth pole is given support by a regional innovation system (RIS), i.e., science parks that favor trans-local, cross-cluster, and multi-scalar resource and knowledge fertilization through networks of relevant stakeholders [9,47,48]. Ultimately, ensuring the sustainability of urban ecosystems is vital to enhancing the quality of life in urban areas and minimizing any adverse environmental effects [49]. Growth poles, or regional economic development centers, play a significant role in promoting sustainable regional development through policies involving the external economy, agglomeration economy, and spillover effects. These growth poles can also be supported by a regional innovation system that favors knowledge sharing and collaboration. Achieving urban ecosystem sustainability requires the collaboration of various stakeholders and the implementation of various strategies, such as sustainable urban planning, green infrastructure development, and community engagement [50]. The benefits of sustainable urban ecosystems are numerous and include improved public health, increased resilience to climate change and natural disasters, and increased biodiversity [51].

3. Materials and Methods

Established in 2003, CTSP is the latest science park established in Taiwan. CTSP is home to six industries: (1) Optoelectronics, (2) Integrated Circuits, (3) Precision Machinery, (4) Computer Peripherals, (5) Biotechnology, and (6) Green Energy. CTSP is an important hub for innovation and technological development in the region, and it is crucial to have a comprehensive understanding of its operation and impact. According to the latest official government data, the Central Science Park has attracted the entry of domestic and foreign high-tech industries. As of the end of 2021, there were 233 approved companies, with 14 research institutions and incubation centers introduced, and the number of employees reached 52,888, an increase of 2.05% compared to 2020. The semiconductor industry accounted for 43.33% of the total employment in the park, followed by the optoelectronic industry at 32.44%. The proportion of employees with a college degree or higher was as high as 79.88%, and the gender ratio was 65.99% male and 34.01% female. The business revenue of the park reached 1035.232 billion NT dollars. The land currently managed by the Central Taiwan Science Park Administration includes three completed science parks and two under construction. The completed parks are Taichung Science Park, which covers 466 hectares, Huwei Science Park, covering 97 hectares, and Houli Science Park, spanning 255 hectares. In total, the completed parks cover 818 hectares. The two parks under construction are Erlin Science Park, covering 631 hectares, and Chung Hsing Science Park, covering 37 hectares. The total planned area is expected to reach 667 hectares. Overall, the total planned area of the Central Taiwan Science Park is approximately 1485 hectares. The locations of each park are as follows (Figure 1):

(1) Taichung Science Park: located in Xitun and Daya districts in Taichung City;
(2) Huwei Science Park: located in Huwei Township, Yunlin County;
(3) Houli Science Park: located in Houli District in Taichung City;
(4) Erlin Science Park: located in Erlin Township, Changhua County;
(5) Chung Hsing Science Park: located in Zhongxing Village, Nantou County.

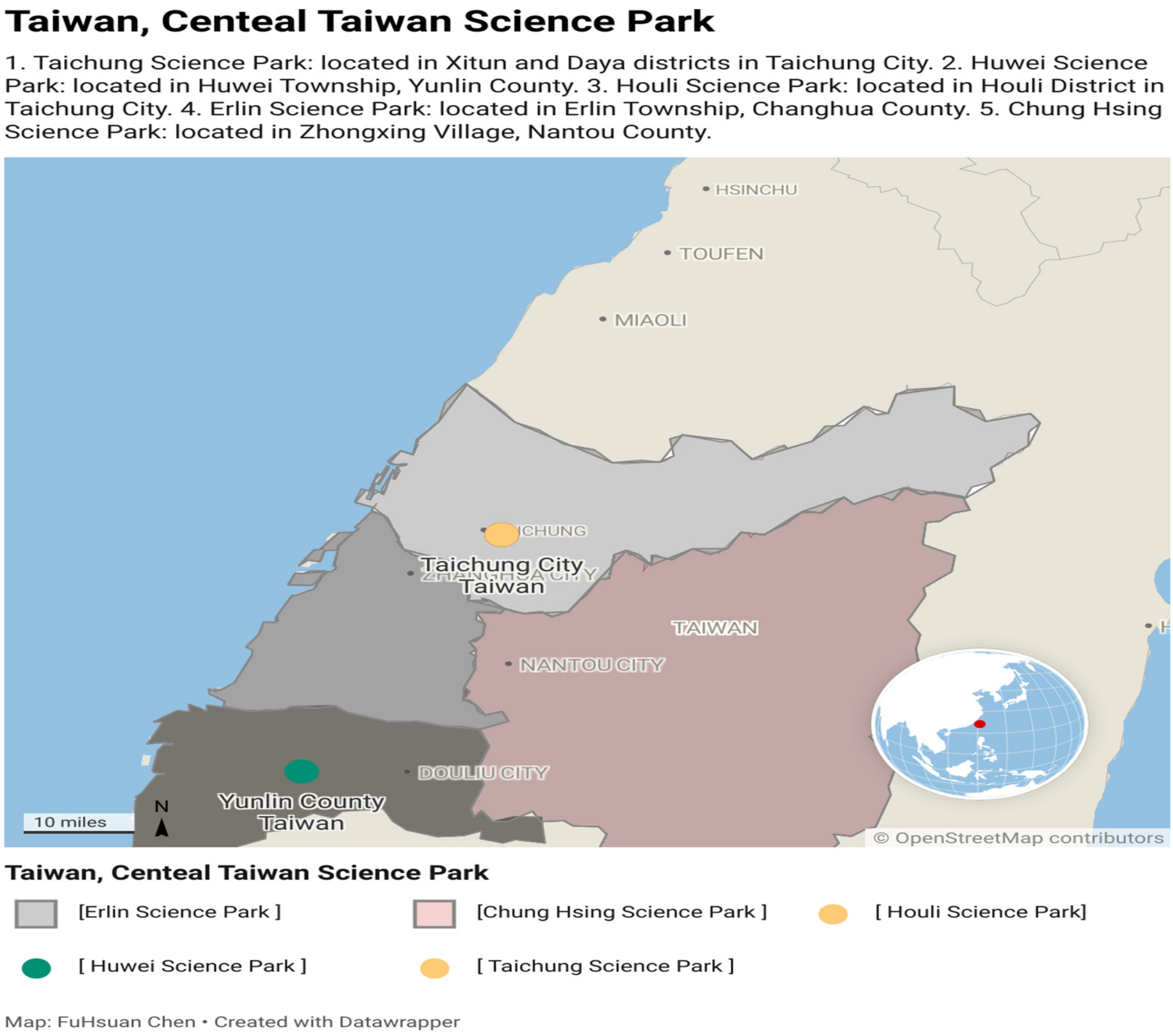

Figure 1. Geographical distribution of Central Science Park in 2023. Source: Author.

In January 2023, there were 153 manufacturers registered in the zone, with the opto-electronics, integrated circuits, computers, peripherals, and precision machinery industries accounting for approximately 66% of the overall CTSP industry. These industries contribute to economic growth by creating jobs and generating income but also pose challenges, such as depletion of natural resources and environmental impact.

To analyze the role of CTSP in the urban ecosystem and to promote sustainability, the researcher utilized a combination of survey methods. The data collection process involved in-depth interviews with surrounding residents, observation, and analysis of statistical reports released by the government. The study recognizes the critical role of residents' perspectives in promoting sustainability and improving the health of urban ecosystems. A theoretical approach alone may not capture the diverse perspectives of local communities, which can significantly influence the success or failure of sustainability initiatives. Therefore, involving residents in decision-making processes related to urban planning, design, and management can lead to more equitable and inclusive outcomes that reflect the needs and aspirations of the community. Engaging residents can foster a sense of ownership and responsibility towards the urban environment, promoting active participation in sustainability efforts.

Incorporating the local knowledge and experiences of residents into sustainability planning and implementation can provide valuable insights into the functioning of urban ecosystems and potential solutions for addressing environmental challenges. This approach aligns with the principles of participatory governance, emphasizing the importance of involving local communities in decision-making processes that impact their lives and the environment.

4. Data Collection

The data are collected through the survey research method. Specifically, the survey includes in-depth interviews with residents living within the CTSP boundaries, as well as making direct observations. The survey data obtained firsthand information regarding the current state and potential impact of the CTSP on the environment and the surrounding community. The interviewees were selected from residents residing in the Core Park-Taichung Park, Satellite Park-Houli Park, Huwei Park, Zhongxing Park, and Erlin Park areas within the CTSP (see Figure 1).

In the first part, the survey data is collected from experts in the field. Twenty interviewees who participated in this study were placed in five groups according to their specialized activity area, namely Group A (Residents living around Taichung Park), Group B (Residents living around Houli Park), Group C (Residents living around Huwei Park), Group D (Residents living around the Chung Hsing Park), and Group E (Residents living around the Erlin Park). Among them, 12 were male respondents, accounting for 60% of participants, and their average age was M = 55.25, and there were 8 female participants with an average age of F = 46.625 (see Table 1). The selection of respondents was based on a combination of purposive and snowball sampling techniques. Purposive sampling was used to select residents and experts in the field of sustainability and urban ecosystems who were likely to provide valuable insights and perspectives on the research questions. Snowball sampling was used to identify additional participants through referrals from initial respondents.

Table 1. List of Survey Respondents.

Interviewee	Group	Sex	Age	Nearest SP	Coding	Occupation	Education
Group A							
Female	A-1	F	51	Taichung Park	A-1	Engineer	Master
Female	A-2	F	70	Taichung Park	A-2	NA	Primary School
Male	A-3	M	78	Taichung Park	A-3	NA	NA
Male	A-4	M	37	Taichung Park	A-4	Manager	Master
Group B							
Female	B-1	F	19	Houli Park	B-1	Student	College Students
Female	B-2	F	69	Houli Park	B-2	NA	Bachelor
Male	B-3	M	53	Houli Park	B-3	Engineer	Master
Male	B-4	M	75	Houli Park	B-4	NA	NA
Group C							
Male	C-1	M	45	Huwei Park	C-1	Engineer	Master
Male	C-2	M	68	Huwei Park	C-2	NA	Bachelor
Female	C-3	F	54	Huwei Park	C-3	Engineer	Master
Male	C-4	M	20	Huwei Park	C-4	Student	College Students
Group D							
Female	D-1	F	65	Chung Hsing Park	D-1	NA	Master
Male	D-2	M	29	Chung Hsing Park	D-2	Engineer	Master
Male	D-3	M	38	Chung Hsing Park	D-3	Engineer	Master
Male	D-4	M	56	Chung Hsing Park	D-4	Manager	Master

Table 1. *Cont.*

Interviewee	Group	Sex	Age	Nearest SP	Coding	Occupation	Education
Group E							
Female	E-1	F	45	Erlin Park	E-1	Manager	Bachelor
Male	E-2	M	79	Erlin Park	E-2	NA	NA
Male	E-3	M	33	Erlin Park	E-3	Engineer	Bachelor
Male	E-4	M	52	Erlin Park	E-4	Manager	Master

Source: The author.

Regarding the identity of the respondents, both residents and experts were included in the study. Residents were selected based on their proximity to the CTSP and their potential interest in the sustainability issues related to the park. Experts were selected based on their professional experience and expertise in the fields of sustainability and urban ecosystems.

More information about the respondents' field of work or schooling was collected during the data collection process and will be included in the analysis and discussion sections of the research report. This will allow for a comparison of their answers and typologies with their respective backgrounds and provide further insights into the factors that influence their perceptions and attitudes towards sustainability in the context of the CTSP and its surrounding urban ecosystem.

The questions are open-ended and cover a range of topics, such as:

1. What is your awareness of the CTSP and its role in the local economy?

2. Have you heard of the CTSP's recycling and green infrastructure initiatives?

3. How effective do you believe these initiatives are in promoting sustainable development?

4. What suggestions do you have for improving the CTSP's recycling and green infrastructure initiatives?

5. How concerned are you about the potential impact of the CTSP on the environment and surrounding community?

6. What specific environmental concerns do you have regarding the CTSP?

7. Do you believe the CTSP is taking adequate measures to address these concerns?

8. How important do you think it is for the CTSP to prioritize sustainable development initiatives?

9. What actions do you believe the CTSP should take to promote sustainable development?

A decision tree can be constructed based on participants' knowledge and opinions about CTSP, following these steps:

1.The first question: "Have you heard of CTSP?"

(1) If the answer is "No," then classify them as the fourth type of participant;
(2) If the answer is "Yes," then proceed to the next question.

2. The second question: "How much do you know about CTSP's recycling and green infrastructure initiatives?"

(1) If the answer is "Little knowledge," then classify them as the third type of participant;
(2) If the answer is "Some knowledge" or "High knowledge," then proceed to the next question.

3. The third question: "Do you believe CTSP's recycling and green infrastructure initiatives are effective?"

(1) If the answer is "Effective in promoting sustainable development," then classify them as the first type of participant;
(2) If the answer is "Room for improvement," then classify them as the second type of participant.

4. The fourth question: "What are your specific environmental concerns about CTSP?"

(1) If the answer is "Concerns about specific environmental issues," then proceed to the next question;

(2) If the answer is "No specific concerns," then classify them as one of the first, second, or third types of participants.

After the fourth question, a sixth question can be added: "What specific environmental issues do you have regarding CTSP?" If the participant answers that they have specific environmental concerns, then proceed to the seventh question. If the participant answers that they have no specific concerns, then proceed to the fifth question. The seventh question can be directly following the sixth question, allowing the participant to express their thoughts on CTSP's efforts to address environmental issues. The eighth question can be added after the third question, allowing the participant to express their thoughts on the importance of CTSP prioritizing sustainable development plans. The ninth question can be the final question, allowing the participant to provide specific recommendations on how CTSP can promote sustainable development.

Through the above questions and decision-making process, participants can be divided into four categories: the third type of participant who knows little about CTSP, the second type of participant who has some knowledge but believes there is room for improvement, the first type of participant who has a high knowledge of CTSP and believes that the initiatives are effective in promoting sustainable development, and the fourth type of participant who is unfamiliar with CTSP's initiatives and may not have considered its potential impact on the environment and community.

This decision tree (Figure 2) helps to organize the interviewee's responses into categories, depending on their level of awareness and opinions about CTSP's sustainable development initiatives. To sum up, interviewees' recognition of the ecosystem is an important aspect of assessing the success of urban ecosystems. By using various methods to collect and analyze data, we can obtain a comprehensive understanding of the urban ecosystem and its impact on residents' well-being.

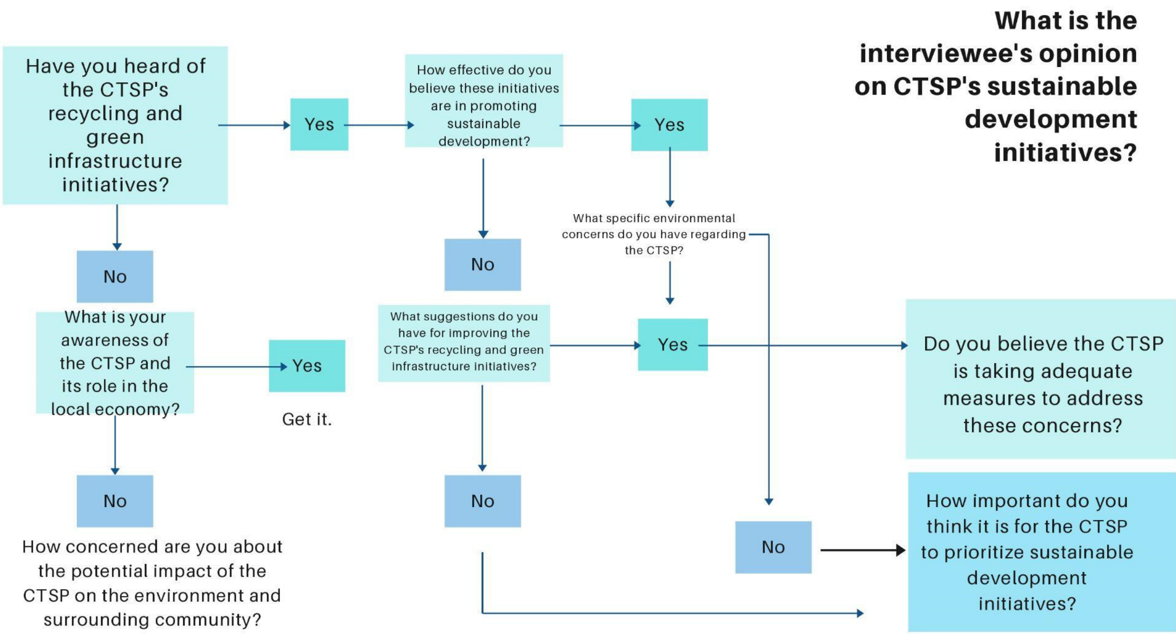

Figure 2. Decision Tree Based on the Questions Provided. Source: The Author.

5. Results and Discussion

The interviewees' opinions provide valuable insights into the public's preferences and attitudes towards these initiatives (see Table 2). The residents found the concept of recycling more appealing since they learned about the park's non-linear model of production, which emphasizes leasing, reusing, repairing, and refurbishing used resources to minimize waste. CTSP's recycling rate of industrial waste is the highest among Taiwan's science parks, reaching 94.15%, making it an ideal candidate for further analysis as a case study. This study conducted in-depth interviews to categorize participants' responses into four groups based on their understanding and opinions of the CTSP Sustainable Development Plan. The first category included participants who had a high level of understanding of the CTSP's recycling and green infrastructure measures and believed that these initiatives effectively promoted sustainable development. The second category consisted of participants who had some knowledge of the CTSP's measures but believed that their effectiveness could be improved. The third category comprised participants who had limited knowledge of the CTSP's measures and believed that more education and promotion activities were necessary to encourage participation in the recycling program. The fourth category comprised participants who were unfamiliar with the CTSP's measures and may not have been aware of their potential impact on the environment and community.

Table 2. Table of CTSP Interviewee Classification.

Residential Area	Education	Occupation	Gender	Age	Group Classification
Taichung Park	Master	Engineer, Manager	Female	51, 37	Group A—Type 1
Taichung Park	Primary School, NA	NA	Female, Male	70, 78	Group A—Type 4
Houli Park	College Students, Bachelor	Student, Engineer	Female, Male	19, 53	Group B—Type 2
Houli Park	NA	NA	Female, Male	69, 75	Group B—Type 4
Huwei Park	Master, Engineer, Bachelor	Engineer	Female, Male	45, 54, 68	Group C—Type 2
Huwei Park	College Students	Student	Male	20	Group C—Type 3
Chung Hsing Park	Master, Engineer	Manager	Female, Male	65, 29, 38, 56	Group D—Type 1
Erlin Park	Master, Bachelor	Manager, Engineer	Female, Male	45, 52	Group E—Type 1, Type 2, Type 4

Note: Type 1: High understanding and belief in the effectiveness of CTSP measures in promoting sustainable development. Type 2: Moderate understanding of CTSP measures, combined with a belief that there is room for improvement in their effectiveness. Type 3: Little knowledge of CTSP measures in combination with a belief that more education and promotion is needed. Type 4: Unfamiliar with CTSP measures and potential impacts on the environment and community. Source: The author.

A-1, D-3, and E-4 interviewees stated that manufacturers in CTSP Taichung Park acknowledge the importance of establishing a network of manufacturing systems. As the upstream and downstream manufacturing supplies are sourced from within central Taiwan, these manufacturers are concerned about the "relative lack of R&D technology". This mindset motivates effective R&D as well as the implementation of innovations in order to develop the overall regional industry; in the same way, it leads CTSP to become a regional growth pole that promotes sustainable development, recycling, and green infrastructure. As a result, an industrial cluster can be formed naturally without external factors.

CTSP manufacturers have made significant efforts towards sustainable development, including a water recycling rate of over 85%, equivalent to saving 7.87 Shihgang Dam reservoirs of water per year. In addition, CTSP promotes green transportation, encourages and promotes the installation of renewable energy and solar photovoltaics, and has reduced carbon emissions by more than 33,700 metric tons of CO2e, leading to outstanding energy-saving and carbon reduction results. The "overall satisfaction" score for manufacturers is 87.36, the highest among the three science parks (according to B Group interviewees). These efforts towards sustainable development, recycling, and green infrastructure are commendable and contribute positively to the local economy and environment.

While CTSP has increased the employment rate in the region, it has also been associated with pollution and increased traffic, leading to opposition from some locals. Despite debates on its environmental impact, many still see CTSP as an effective factor for growth and sustainable development, especially with its initiatives towards sustainable development, recycling, and green infrastructure. The interviewee C-1 pointed out that

CTSP's ecosystem development policies have both advantages and disadvantages for local development, and all CTSP entrants should abide by the construction restrictions daily.

CTSP's development has altered the original terrain. During the promotion of the project, I actively went to every village to hold meetings with local residents every night, explaining the benefits of CTSP to the locals and the land. Interviewee C-2. Interviewee D-4.

CTSP can enhance its environmental performance and competitiveness by implementing functional environmental and energy management systems, conducting regular audits, and establishing green production processes that encourage suppliers to comply with environmental guidelines. Incentives should be provided to promote sustainable practices, such as using sustainable materials and implementing environmentally friendly technologies. Recycling standards should also be defined to promote the reuse of materials and products, which can help to reduce waste. Interviewee E-4.

The CTSP's initiatives towards sustainable development, recycling, and green infrastructure play a key role in mitigating potential negative impacts on the environment and community. Implementation of functional environmental and energy management systems, promotion of sustainable practices, and establishment of recycling standards enable the CTSP to reduce waste, promote the reuse of materials and products, and enhance its environmental performance and competitiveness. Based on the information provided, the CTSP appears to have implemented various measures to prioritize environmental protection. In addition to monitoring factory emissions to ensure regulatory compliance, the management bureau also requires companies to manage their own operations, install pollution prevention equipment, improve operational procedures, and implement environmental protection measures. These measures have set a benchmark for various industrial fields and demonstrate the CTSP's commitment to sustainable development, recycling, and green infrastructure. "It is encouraging to see that the CTSP has a rigorous pollution control system and permit review process in place to ensure regulatory compliance and protect the environment. The park's ability to track and trace permit compliance and resolve most identified issues is a positive indication of its commitment to sustainable development. The requirement for companies to pre-treat their wastewater and undergo expert reviews, especially for larger companies, also demonstrates a strong emphasis on environmental protection. These measures align with the CTSP's initiatives towards sustainable development, recycling, and green infrastructure". (According to E Group interviewees).

In-depth interviews were conducted, and the results show that the permit review process is considered a crucial management measure implemented by the CTSP to ensure that companies operating within the park comply with environmental regulations and promote sustainable development. The requirement for companies to submit a pollution estimate, as well as the park's tracking and tracing of permit compliance through conducting 216 permit reviews in 2021, were perceived positively by residents. The high percentage of identified issues (91%) that were resolved is also seen as a positive measure. The CTSP's requirement for companies to pre-treat their wastewater before discharging it into the park's sewage system, with larger companies undergoing expert review to ensure compliance with management standards, was also viewed positively. The fact that 152 companies in Taichung Park comply with regulations indicates that the park has taken significant steps towards sustainable development and environmental protection. However, some residents expressed the need for more initiatives towards sustainable development, recycling, and green infrastructure. Overall, the findings suggest that the CTSP's efforts towards sustainable development and environmental protection are appreciated by residents, but there is still room for improvement, and it is important to continue monitoring and addressing any environmental concerns that may arise.

The CTSP has implemented commendable waste management practices that prioritize minimizing the impact of waste on the environment, including requiring businesses to obtain permission for waste disposal plans and regularly report waste output and storage data online. The park also conducts inspections to prevent arbitrary dumping of waste and employs differentiated waste disposal methods based on whether the waste is hazardous or non-hazardous, with non-hazardous waste treated at private facilities, recycled, and reused in compliance with the Waste Disposal Law, resulting in energy savings and reduced carbon emissions. Hazardous waste undergoes further classification, and overseas processing is an option, with strict adherence to the Basel Convention. These practices align with the CTSP's initiatives towards sustainable development, recycling, and green infrastructure. However, continuous monitoring and improvement of waste management practices are necessary to minimize the impact of waste on the environment, as residents have expressed concerns about the impact of industrial activities on the environment, particularly regarding waste management. The establishment of a "Zero Waste Center" in 2023, jointly built by government departments and six companies, including TSMC, is a positive step towards addressing these concerns. The "Zero Waste Center" aims to promote waste reduction and the circular economy by recycling secondary isopropanol, silicon-containing waste, industrial-grade fluorine-containing sludge, and silicon-containing sludge. By recycling in the center, the demand for outsourced waste treatment is reduced, the overall amount of raw materials purchased in the park decreases, and finished products are regenerated for park manufacturers. This initiative aligns with the CTSP's commitment to promoting green infrastructure and a more sustainable industrial environment.

6. Conclusions

The study reveals that the CTSP has made significant progress in promoting sustainable development through its waste management initiatives. However, there is a need to improve public education and to increase the participation of residents in these programs. This study categorizes the interviewees' responses and provides valuable insights into their understanding and their attitudes toward the CTSP's sustainable development plan. In the future, it will be critical for the CTSP to continue to prioritize environmental education and promotion activities to enhance public awareness and its participation in these initiatives and to achieve a more sustainable industrial environment. The study suggests that recycling programs, such as those implemented at the CTSP, can effectively promote sustainable development in technology parks. However, it is necessary to involve the community and engage in education and promotion activities in order to increase participation of all parties in recycling programs and promote sustainable development. This will help raise awareness and understanding of the potential impact of the CTSP on the environment and community and encourage residents to participate in sustainable development initiatives.

Through in-depth interviews, the study found that CTSP residents had varying levels of awareness and opinions of the CTSP Sustainable Development Plan. The CTSP has significant impacts on the urban ecosystem and the well-being of residents, and although it is a major driver of economic growth, it also presents challenges related to resource depletion and environmental impact. The study highlights the importance of taking into account the potential impact of these parks on the environment and community, and the necessity of promoting sustainable development plans to alleviate any adverse effects. The study also stresses the importance of community involvement in sustainable development initiatives and promoting educational and promotional activities to increase participation in recycling programs.

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