Planting seeds of Change-Women-Led Eucalyptus Farming for a Sustainable Future in Thailand

Tapaswini Dash[1]

Abstract

This paper investigates the role of women-led eucalyptus farming in achieving the Sustainable Development Goals (SDGs) in Northeastern Thailand, Amidst the growing pulp and paper industry, which has been a significant economic driver but also a source of environmental pressure, the study explores the socio-economic impacts of the industrial timber plantation sector. It highlights the eucalyptus plantations established by many northeastern villages as a response to these impacts and as a means to generate extra income and improve socio-economic status. The study employed a mixed-methods approach, incorporating both quantitative and qualitative data from a survey of 300 respondents and testimonies from most deforested communities in Khanna Kheti.

The findings revealed three dimensions of development among the farmers planting eucalyptus along their rice field borders, indicating that this practice is an economically rational response to recent changes in rural economic environments. The study underscores that eucalyptus farming not only brings substantial income and empowers women, but also promotes environmentally friendly practices through the use of short rotation plants. This research contributes to the discourse on sustainable development and women's empowerment in the context of industrial plantation activities.

Keywords: Eucalyptus Farming, Sustainability, Women Empowerment, Environment, Short Term Rotation Plant

[1] Naresuan University International College, Yunus Center
239, Huay Kaew Road, Muang District,Chiang Mai, 50200. THAILAND.
E-mail: -

1. Introduction

As the world strives to achieve the Sustainable Development Goals (SDGs) by 2030, the intersection of gender equality and environmental sustainability has become increasingly important. SDG 5 emphasizes the full participation and leadership of women in economic and public life, while SDG 13 highlights the urgency of integrating climate action into policies to build resilience against climate hazards. Achieving these goals is particularly challenging in rural communities, where traditional gender roles often limit women's access to decision-making positions, economic opportunities, and environmental leadership. However, emerging initiatives, such as women-led eucalyptus farming in Northeastern Thailand, present a promising strategy to address these challenges.

Historically, rural women in Thailand have been constrained by cultural expectations, primarily seen as caretakers responsible for household duties. This limited their participation in agriculture beyond basic labor. Yet, in recent years, women's involvement in eucalyptus farming has grown significantly, offering a path towards financial independence, leadership, and environmental stewardship. According to the Global Gender Gap Report (2022), Thailand ranks poorly in political empowerment for women (130th out of 148 countries), underscoring the importance of improving gender equality in economic sectors such as agriculture. Eucalyptus farming, a high-value cash crop, is creating new opportunities for women to gain economic autonomy and influence decision-making within their communities.

Eucalyptus, traditionally cultivated for its industrial value, is now being used by women farmers as a means of income diversification and ecological preservation. Studies have shown that eucalyptus farming can generate up to nine thousand Baht per hectare annually, significantly more than traditional crops like rice or cassava. This economic potential is vital in rural Thailand, where women-led initiatives are transforming farming practices and contributing to local economic growth. The involvement of women in eucalyptus farming represents a critical shift from traditional gender roles to leadership positions in agriculture, fostering social empowerment while addressing economic disparities.

Beyond the economic benefits, women-led eucalyptus farming plays a crucial role in promoting environmental sustainability. Women farmers are more likely to adopt sustainable practices, such as using organic fertilizers, water conservation techniques, and mixed cropping systems. These practices are essential in mitigating the environmental concerns often associated with eucalyptus plantations, such as soil depletion and water usage. By integrating these climate-smart techniques, women farmers in Thailand contribute to SDG 13 (Climate Action), ensuring that eucalyptus farming not only enhances their livelihoods but also supports long-term ecological health.

However, the environmental impact of eucalyptus plantations remains a contentious issue. Critics argue that large-scale eucalyptus farming can lead to water scarcity and biodiversity loss. Nonetheless, initiatives like Double A's Farmed Trees Concept have introduced sustainable eucalyptus farming models that allow farmers—many of them women—to plant eucalyptus trees alongside traditional crops, preserving the ecological balance of their land while increasing income. This model encourages the integration of eucalyptus farming on the peripheries of rice fields, ensuring that the crop does not compromise food production or environmental quality.

Women's participation in eucalyptus farming also contributes to reducing the environmental burdens traditionally placed on rural women. Studies by Kelemu and Tadesse (2010) and Alemayehu and Melka (2022) have shown that women benefit from eucalyptus plantations by reducing the time and energy spent on tasks like collecting firewood, thereby

freeing them to engage in more productive economic activities. However, while eucalyptus farming offers job opportunities and increased income, the gender dynamics within rural households must be carefully considered to ensure that women gain decision-making power and financial autonomy from these initiatives.

This study aims to explore the dual roles of gender empowerment and environmental sustainability through women-led eucalyptus farming in Northeastern Thailand. By investigating how women benefit economically and socially from eucalyptus farming, and how their participation influences sustainable agricultural practices, the research will provide crucial insights into how women's leadership in agriculture can drive sustainable development. Additionally, this study will evaluate the environmental impacts of eucalyptus farming, focusing on key issues such as water use, soil fertility, and biodiversity. In doing so, it aims to offer practical recommendations for promoting gender-inclusive and environmentally sustainable agricultural models that can support Thailand's broader efforts to balance economic growth with climate action.

2. Literature Review

Eucalyptus has been both praised and critiqued for its role in agroforestry. On one hand, it is known for its efficiency in water usage and its economic benefits, but on the other, environmental concerns arise due to its high transpiration rates. Early research, such as Prabhakar (1998), demonstrated that eucalyptus uses significantly less water to produce wood compared to native species like Siris and Shisham, making it a valuable tree in regions where fast growth and high biomass are key priorities. Prabhakar also highlighted that eucalyptus can produce as much as 40 cubic meters of wood per hectare in an eight-year cycle, outpacing slower-growing native trees.

Despite its efficiency, there have been concerns about the impact of eucalyptus on water resources. Shiva (1993) critiqued eucalyptus for contributing to water shortages in arid areas due to its high transpiration rates, a claim that was later echoed by Saxena (1994) and Chaturvedi et al. (2005). They acknowledged that while eucalyptus is efficient in water use, its high overall productivity leads to increased water demand. More recently, Thomas et al. (2021) suggested that eucalyptus plantations could strain local water resources if not properly managed but noted that these effects can be mitigated through sustainable practices such as mixed cropping and effective irrigation systems.

According to Patil and Rao (2023), high transpiration rates can indeed pose problems in water-scarce regions, but they emphasize that sustainable management practices can greatly reduce these risks. Additionally, Kanowski and Saville (2020) highlighted that well-managed eucalyptus plantations can contribute to reforestation and soil rehabilitation efforts, showing the potential for eucalyptus to be part of broader environmental restoration goals.

2.1 Economic and Social Benefit of eucalyptus Plantation

Economically, eucalyptus remains a valuable cash crop for small-scale farmers. Kaakkurivaara (2024) points out that over 64% of Thailand's eucalyptus farms are managed by smallholders, particularly in the northeastern region, where they play a crucial role in job creation and income generation. These findings align with earlier research by Luna (1996), who found that planting eucalyptus alongside agricultural crops can boost profitability for small farmers without harming crop yields. Nath et al. (2022) further supported eucalyptus's

economic viability, noting its ability to thrive on poor soils with minimal pest issues, making it an ideal low-maintenance crop for rural communities.

However, Kaakkurivaara (2024) highlights ongoing issues such as declining yields and market structures that benefit traders more than the farmers themselves. The study suggests that better market access and improved yields through sustainable farming methods are essential to maximizing the benefits of eucalyptus farming. Further supporting this gender-based perspective, Alemayehu and Melka (2022) demonstrated that women in Ethiopia, like their counterparts in Thailand, are more likely to adopt sustainable farming techniques when given control over agricultural resources, including eucalyptus cultivation. Their leadership in this area significantly contributes to rural economic development and environmental sustainability, indicating that empowering women in agriculture leads to more resilient and sustainable farming systems. Additionally, Galié et al. (2023) explored the psychological and social benefits of women's involvement in eucalyptus farming. Women who participate in community-led agricultural projects, including eucalyptus farming, report improved mental health and social cohesion. This highlights the broader social and community benefits of empowering women in agriculture. Finally, Dalpati et al. (2022) conducted a systematic review on women's empowerment through agriculture in South and Southeast Asia, including eucalyptus farming. The review found that including women in these agricultural practices led to higher crop yields, better resource management, and enhanced social resilience, making eucalyptus cultivation a critical strategy for both economic growth and environmental sustainability.

2.2 Ongoing Debate in Thailand

Large scale planting of eucalyptus in Thailand has caused concern to many people as they thought it would have adverse environmental impacts particularly in relation to nutrient depletion and high-water use. A number of studies have been undertaken in various sites on the water use of eucalyptus but none of the findings are conclusive. study on the ecological aspects of eucalypt planting should be area specific, and generalization in this aspect may not hold true.

However, research, conducted by Kasetsart University and the Thailand Research Fund indicates growing eucalyptus trees in rice fields has less impact on soil and water quality, unlike growing them as a stand-alone crop (Bangkok post, 2010). These results support other research findings which suggest that growing eucalyptus trees for pulp as a mixed crop is less damaging to the environment than a single, un- rotating crop. However, to our knowledge, research in this arena emphasizing gender role in sustainable Eucalyptus farming in Thailand is limited and not a single research so far has been conducted on socio-economic aspect of eucalyptus planted along the border of the rice field in Thailand. Socio-economic status (SES) refers to the social and economic standing of an individual or group, typically measured by a combination of factors such as income, education, occupation, and wealth. SES is a key indicator used to assess and compare levels of inequality within societies, as it often influences individuals' access to resources, opportunities, and overall quality of life.

The present study is motivated by the growing body of literature that highlights the intersection between eucalyptus farming, women's empowerment, and sustainable development. Research indicates that eucalyptus farming, especially when managed by women, offers significant socio-economic and environmental benefits in rural regions. Studies by Kaakkurivaara (2024) show that women-led eucalyptus farming not only improves household income but also fosters greater financial independence for women. While the

economic potential of eucalyptus has been well-documented (e.g., Luna, 1996; Nath et al., 2022), challenges such as declining yields and unequal market structures persist (Kaakkurivaara, 2024). These barriers hinder the full realization of the benefits that eucalyptus can offer to rural farmers, particularly women. Moreover, the environmental impact of eucalyptus is still debated, with concerns around its water usage and impact on local ecosystems (Patil and Rao, 2023). However, recent studies suggest that these environmental issues can be mitigated through sustainable management practices (Thomas et al., 2021). Research, conducted by Kasetsart University and the Thailand Research Fund says that growing eucalyptus trees in rice fields as a mixed crop is less damaging to the environment than a single, un-rotating crop. Also, it has less impact on soil and water quality, unlike growing them as a stand-alone crop (Bangkok post, 2010).

In the past, rural women in Thailand were often seen primarily as homemakers, with limited involvement in areas outside of household duties. However, that perception is changing. Today, women are playing an increasingly significant role in agricultural production, proving that with the right training and support, they can become powerful agents of change. Of the 12.7 million women currently in Thailand's workforce, 67 percent are actively engaged in agriculture. In fact, women make up almost half (47 percent) of the 20 million farm workers in the country. (Waikakul,1995). These women are deeply involved in every aspect of farming, from planting seeds to harvesting crops, showcasing their vital contribution to Thailand's agricultural sector.

Given the pivotal role of women in agriculture, particularly in adopting sustainable practices, there is a need for more localized studies to explore the socio-economic and environmental impacts of eucalyptus farming when led by women. This study seeks to fill this gap by providing an in-depth analysis of how women's involvement in eucalyptus farming can contribute to both economic growth and environmental conservation in rural Thailand. By integrating gender perspectives into the discourse on eucalyptus farming, the study aims to offer practical insights for policymakers and development agencies, emphasizing the importance of inclusive, sustainable agricultural practices.

2.3 Double A's Profile

Double A 1991 Public Company Limited (formerly Advance Agro Public Company Ltd) is one of the most advanced fully integrated pulp and paper manufacturer and aims to become international brand leader with the brand Double A. It was established on March 9, 1989. Within 3 years from its launch, Double A was sold in over 100 countries worldwide and is today highly regarded as a high quality Double quality paper.

As per their claim, Double A selects, environmentally friendly processes and technologies. Empty and un-used spaces on the existing farmed land are utilized to plant fast growing Double A Paper Trees. State-of-the-art technology is used in everyday operations, including an Elemental Chlorine Free (ECF) bleaching process which does not use chlorine gas and thus does not harm the environment. The agricultural and waste by-products generated during pulp and paper production are used to generate power for the mills. Double A paper is made from fast growing Trees which we call Double A Paper Trees farmed on empty space alongside farmers' existing crops. Over 1.5 million contract farmers in Thailand grow these trees alongside their rice, cassava, sugarcane and corn plots.

3. Theoretical Concept Material and Method

This research study is based on the research concept and methodological approach, of Naila Kabeer, and the conceptualization of women's empowerment as the combination of resources, agency, and achievements (Kabeer, 1999). The study focused on the women farmers' opinions on their changing socio-economic status while doing sustainable eucalyptus farming. Mixed research design was applied to meet the purpose of this investigation. The field research was conducted in 16 provinces of Thailand. The provinces were selected based on the availability of women farmers cultivating mixed Eucalyptus species along the borders of their rice fields and around the sides of fish ponds. The provinces were confirmed reviewing the list of farmers maintained at the Double A office, Prachinburi. The villagers and key informants were consulted to further validate the farmers cultivating Eucalyptus. According to the Royal Forest Department Informatics and Space Technology Development Agency (GISDA, 2023) in Thailand, the total Eucalyptus plantation area in 2023 was estimated to be 846,708 ha, from which 48% of these areas are in the northeast, 33% are in the east, and 13% are in the central region, corresponding to 94% of total Eucalyptus plantation area. There were eight hundred (800) women farmers in the sample frame, cultivating mixed Eucalyptus species along the borders of their rice fields and around the sides of fish ponds. From the sample frame, a total of three hundred women farmers were surveyed purposefully considering their willingness to be a part of the study.

Table 3. 1 No. of Respondents for the Study

Province	No. of Farmers	Province	No. of farmers
Prachinburi	20	Chainart	40
Kamphaengphet	7	Ubonratchathani	59
Uthaithani	11	Sukhothai	27
Sakaeo	20	Phichit	1
Buriram	12	Phetchabun	5
Chachoengsao	20	Nakhonsawan	15
Roi-et	12	Amnatcharoen	20
Chaiyaphum	22	Nakhonratchasrema	9
Total	**300**		

Source: Field research, 2010

3.1 Selection of Respondents

For this research, three hundred women respondents were selected based on the following criteria: a. Farmers cultivating mixed Eucalyptus species along the borders of their rice fields. b. Farmers cultivating mixed Eucalyptus species along the borders of their rice fields and around the sides of fish ponds. C. Farmers who had been involved at least 7 to 15 years in farming.

Field surveys were conducted in a period from September to November 2010 to achieve the research objectives, across 16 provinces in Thailand. A total of 300 questionnaires were distributed among the farmers to assess the impact of eucalyptus trees on crop production, soil properties, and moisture retention.

To collect comprehensive socio-economic data, the study employed a mixed-methods approach, including questionnaire surveys, key informant interview with the research team of Double A, direct field observations, and group discussions with the women leader. In-depth Interviews with twenty-five actively engaged farmers, representing from all provinces of the targeted study area were conducted to gather qualitative data. These interviews focused on the historical and contextual background of eucalyptus farming, providing insights into key issues and experimental questions. The respondents' answers were analyzed and expressed as percentages for comparative purposes. Given the farmers' deep familiarity with their environment, their indigenous knowledge about eucalyptus and its environmental interactions was invaluable.

4. Findings

4.1 Farmer's perception on the environmental impact of Eucalyptus Plantation

Regarding the investigation on environmental effect of Eucalyptus most of the farmers 70% (210 out of 300) didn't find any environmental effect of it. However, (20%) opined that it had some effect caused by shade and root system. About 6% were not sure about any effect, while about 2% said there are negative effects without substantiation.

Farmer's perception on the environmental impact of Eucalyptus Plantation

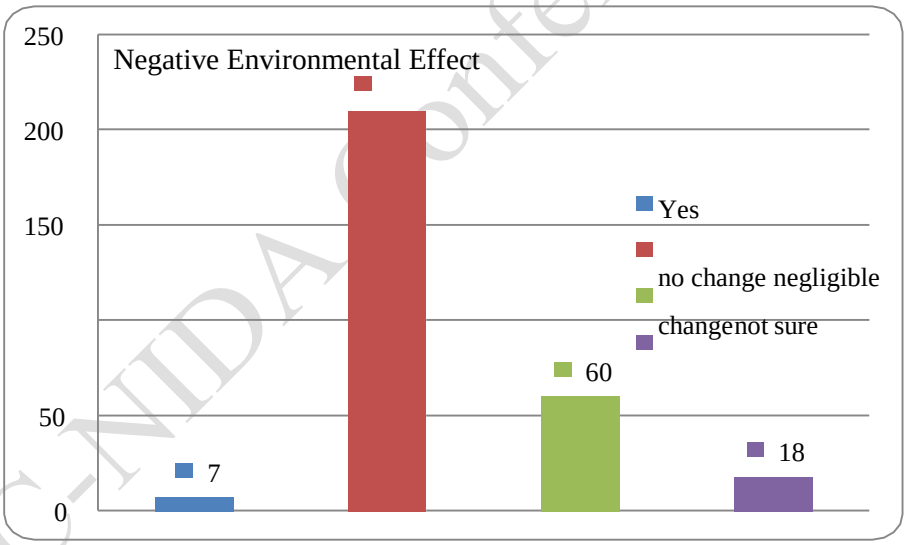

Figure 1: Farmer's perception on the environmental impact of Eucalyptus Plantation

4.2 Farmer's perception on the Effect of Eucalyptus Plantation on Rice Production and climate change

Monitoring occurred over two agricultural seasons (approximately 24 months), allowing for observations of seasonal variations in climate and agricultural cycles. Data collection was performed quarterly, coinciding with key stages of the agricultural calendar—planting, growing, harvesting, and post-harvest periods. Regarding the investigation on the

effect of Eucalyptus on rice production, 69 percent (210 out of 300) did not find any effect, followed by 14 percent farmers found negligible effect.

Climate Change

In terms of climate-related impacts, farmers were asked about their perceptions of how eucalyptus plantations affected rainfall, temperature, wind velocity, and humidity: Some farmers observed slight changes in rainfall patterns, but the majority did not attribute significant shifts directly to eucalyptus. When a minority expressed concerns about rising temperatures, though no conclusive connection to eucalyptus was established. With regard to Velocity and Storms A few farmers indicated that eucalyptus trees might affect wind patterns or storm strength, potentially providing windbreaks. However, changes in local humidity were not widely reported, though some believed eucalyptus had a minor impact due to its water absorption capacity. These insights suggest that while eucalyptus plantations are perceived to have minimal impact on rice production, there are mixed views regarding their influence on local climate factors. Further research might be needed to quantify and fully understand these effects.

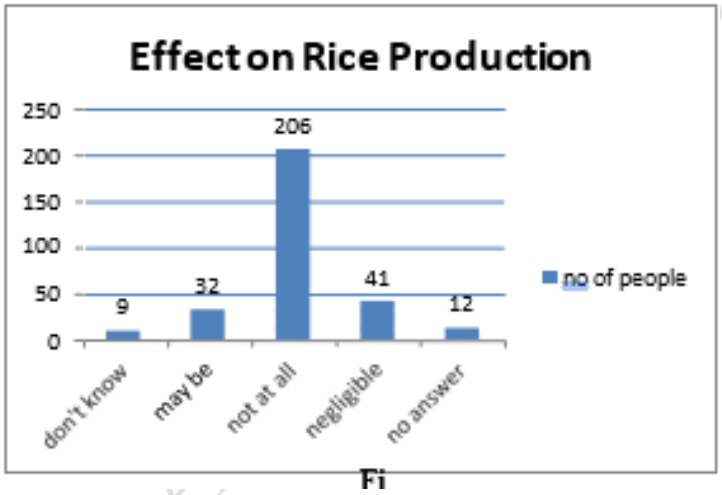

Figure 2: Effect of Eucalyptus Plantation on Rice Production

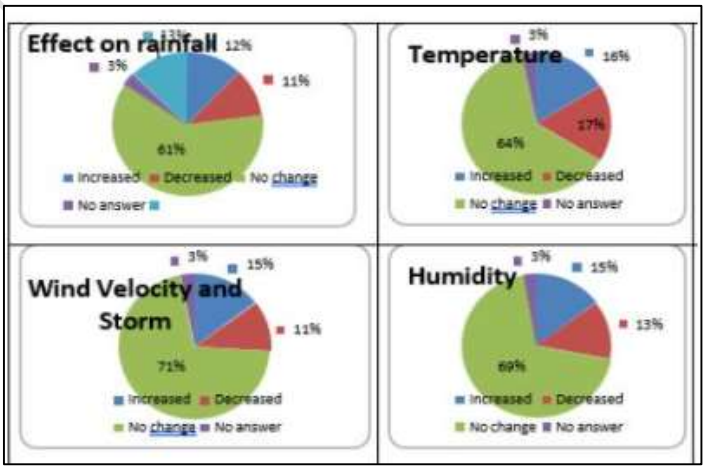

Figure 3: Effect of Eucalyptus Plantation on rainfall, Temperature, Wind velocity storm, Humidity

4.3 Reason of planting eucalyptus

The farmers in the study area favor the planting of eucalyptus for six important reasons (Table 3). The most important reasons they (92%) identified were for extra income, 65% considered the adoptability of the species as it grows wells both in dry and wet sites followed by its fast-growing characteristics. The other reasons were –For excellent fuel wood productivity, ornamental and less shade casting characteristics of the plant. However, there was a variation in between the poor and rich respondents in ranking the reasons. The respondents emphasized on the importance of fuel wood while the affluent farmers choose it for its ornamental characteristics though the entire respondent acknowledged all the above mentioned six reasons. Farmers get an extra income of 650-800 Baht (22-27 US Dollar) / ton by selling the wood log to Double A. However, the income is more, once they decide to sell the log to the furniture company.

Table 4.1 Reasons of planting Eucalyptus as stated by the respondent in the study area

Reason	Percentage of respondents
For extra income	92
Fast growing	87
Excellent fuel	86
Less shade	69
Suited both in dry and wet areas	65
Ornamental	43

Source: Field Survey, 2010

4.4 Benefit of Growing Eucalyptus

It was also observed that most of the farmers are practicing border planting in their paddy field. They also reported that they cultivate bean during winter in association with Eucalyptus. Within a short time after planting (about two or three years) the farmers also get twigs and branches as intermediate products. Since it is difficult to find employment round the year they rely on their land, no matter how small and unproductive it might be. They found work as agricultural labors only during peak agricultural crop seasons and remain without work for remaining several months of the year. But practicing Argo- forestry-incorporating Eucalyptus can save them from poverty in such a way that it will provide them some supporting returns as well as handsome return after harvesting the trees. So, as food production is the basic need of the respondents, it is most profitable for them to raise the species (Eucalyptus) along the border of rice fields. there is virtually no requirement of fertilizers during the farming, although some might use fertilizer during the preparation of the soil which only occurs once when the saplings are planted. The environmental burden associated with this growth stage is therefore relatively very small and negligible.

Farmers grow the eucalyptus trees with the help of their family members. Each and every farmer grows K7 seedling. Some even use fertilizer in the earliest stage such as urea and organic formula while others use natural product (made of chicken) instead of any fertilizer. They water the plant in the earliest stage and only in the dry season. Generally, roots spread up to 2 meters, which need to be cleaned periodically and demands extra work for the farmers, although don't go deep. The plantation doesn't affect the capacity of land in terms of rice production. They are getting same amount of rice as before the mixed plantation.

However, some of the farmers complained that color of the eucalyptus leaf changes often. “I feel disappointed while seeing the color of eucalyptus leaf changes. I have no idea. Why it’s changing” (Titipat, a farmer from Chaiyaphum)

“I am from southern part of Thailand. Two years back I migrated with my family and started working here as a driver for Double A. The salary is not enough to raise three children; I am working as a labor and so can manage my family. After getting this s job I have repaid my loan. My three children are studying in the school” (Bunnao, Uthaithani

It was also observed that the farmers who have been involved in this scheme are quite interested to make the other farmers learn to practice this kind of activity to get some extra income. Farmers of other region of Thailand are visiting to these farms to learn the new way and technique of plantation that could be provide them supplementary income in the long run. Farmers can earn about 10,000 baht/ rai (2063 US Dollar per hectare as per exchange rate at study period in 2010) without any substantial investment.

4.5 Water Availability and Access Concerns

There was a growing perception that plantation may dries up the water table. However, majority of the respondents opined that no visible change in water table in the farming area is marked due to Eucalyptus plantations around the rice farm.

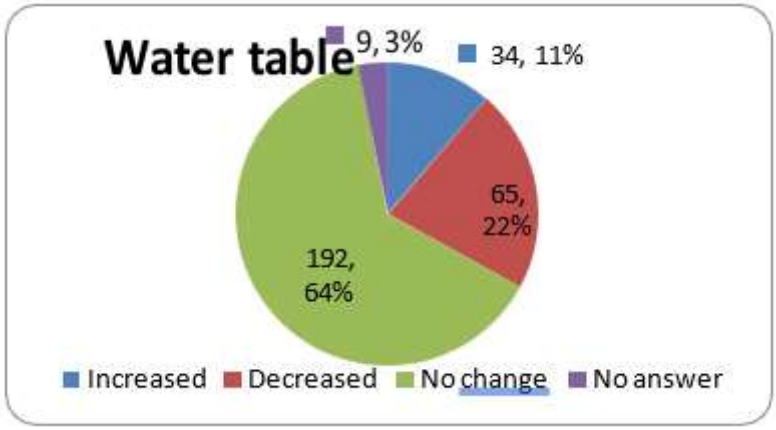

Figure 4: Water Availability and Access Concerns

‘I was afraid if the water table gone down, I may have to walk a long distance for water. But as we found it was not like that since this eucalyptus grows within three years and won’t suck the water’. Anuwan, Chacherngcho

4.6 Gender Issues

It was also revealed that selling of wood logs back to the paper industry or for furniture was mostly (54%) done by husband. But both husband and wife consult with each other before selling the wood log to the industry. Women are allowed to collect the barks of eucalyptus as to use for firewood and for this they don’t require the permission of their husband. It was also noted that even though gender relation has not changed completely, women have transformed from invisible to visible as they expressed that their voices are heard in family. Women,

however, generally spend less time on productive activities and community politics in comparison to men due to their heavy daily workload. While men are able to focus principally on their productive tasks and carry out their other activities sequentially, women are often obliged to carry out a large number of tasks, especially reproductive tasks, simultaneously and dispersed over the day. Thus, women's productive time and flexibility are much more constrained compared to men, often leading to trade-offs between their non-productive and productive roles (Moser, 1993). A clear division of labor found according to sex and age exists in these farming communities in terms of tasks performed and their participation in different farming activities. Women are more involved in farming activities such as planting, weeding, watering, and harvesting, whereas men are more involved in the initial clearing of the land, the tilling of the soils and the marketing. In most of the cases both sale the wood log, however, about 25 % families, husband took the responsibility. So the responsibility of sale is quite balanced and families take it on mutual agreement. Income generated from the crop is well accepted as an extra income. While majority of them have told to have saved the income for children, some have used for repair/ construction of house or buying new properties. People with first cycle of the crop have very high hope on the income and consider it as a bonus like product. They have plans to spend them for special purposes, such as debt repayment or savings for children's education etc. A hooping 40% of farmers wish to repay their debt through paper tree benefit and about 20% wish to spend on their children. Some 18% of the people do wish to save the money for a new house or setting up of a business.

4.7 Environmental impact (Estimation of Number of trees and its impact on carbon Sequestration) Double A Report

Estimate 1

The study used a simple calculation to estimate number of eucalyptus trees planted around the border of rice field and fish pond to estimate its potential impact on carbon Sequestration. According to Double A information, about 100 trees/ rai (625 trees per ha.) are planted in paper tree project. Considering 486.4 million tree a whopping 486.7/100= 4.86 million ≈ra5imillion rai rice field would be needed. Thailand has about 9.2 million hectare of rice cultivation=57.5 million rai (1 hectare= 6.25 rai). This brings Double A paper tree to be standing on about 7% of Thailand's total rice field.

Estimate 2

The study takes reference of the Biomass survey done by Kassetsart University (KU) which studied a sampled area of 58,804,440 rai (9,408,710 ha.) considering Double A factory centrally, but considering both paper tree in paddy ridge and plots. The KU study gathered secondary data including administration boundary zone by province and district, land use information from satellite image interpretation, production of Eucalyptus which was grown in plots and along the paddy field embankment from previous researches. Also, gathered primary data regarding the sampled plots with Eucalyptus plantation. The study collected information of Eucalyptus planted area of each sub-district by interviewed government officer who take responsibility in agriculture and environment at Sub-district Administrative Organization (SAO) and/or municipality and did questionnaire analysis, analysis of satellite image interpretation output coupled with rectification test of the obtained information from interviewing the personnel of SAO and/or municipality. As per the finding of KU, Eucalyptus is grown in 1,377,503 rai (220,400 ha.) in a sampled size of 58,804,440 rai (9,408,710 ha.) of land. Given 100 trees/ rai (625 trees per ha.) ratio, the numbers of tree are 137,750,300. Considering each tree as 60 kg weight; total bioma≈s8s ,265,018 tons≈8.2 million tons of green

mass. The quantity of CO2 offset to kg of green mass is 1:1 as found by Prasert et al . . 2009. Therefore, the total CO2 uptake by the Paper tree is 8.2 million tons of CO2yr, which is substantial. This can be compared with the Carbon Footprint of Double A which provide a carbon negative status if compared together. This indicates potential ecological changes due to Eucalyptus farming along the borders of rice fields. Further, the Eucalyptus plantations are sparingly available and not covering the vital landmass in the farming area. Eucalyptus only covers 2.3% of the area in a total sampled area of 58,804,440 rai (9,408,710 ha.) considering Double A factory centrally. (Source: Dr PasuthaEt All- Biomass Survey, 2011)

5. Discussion and Conclusion

This is the first empirical study to examine women's empowerment and environmental sustainability through industrial eucalyptus plantations in Thailand. As stated by Gebreegziabher (2020), Eucalyptus trees can provide both ecological and economic benefits to the households. This study has established that the lives and standards of living of local communities have been improved by the paper tree program of Double A. Tree planting opportunities have been widely embraced as a viable livelihood option, providing additional income to the women. This practice has positively impacted the social, cultural, and economic lives of farming communities without causing significant harm to the traditional farming methods.

The study reveals that farmers are often without work for several months of the year outside of peak agricultural seasons. However, practicing agroforestry by incorporating eucalyptus can alleviate poverty by providing supplemental income throughout the year and substantial returns upon harvesting the trees. Since food production is a basic need for the respondents, raising eucalyptus along the borders of rice fields is highly profitable. Eucalyptus cultivation requires minimal fertilizer use, with some application only during soil preparation when the saplings are planted. This indicates the considerable condition of soil fertility. Consequently, the environmental burden associated with this growth stage is relatively small and negligible. Access to income is a fundamental aspect of increasing women's bargaining power, as employment creation and income-generating opportunities socio-economically empower women. The study provides significant insights into how women's participation in eucalyptus farming impacts their decision-making power and alters household dynamics. The rationale is that higher economic power leads to greater bargaining power, enabling women to influence household resource allocations (Antman, 2014). Consequently, when women engage in economic activities, they gain income that empowers them to make individual decisions previously unavailable to them and contribute meaningfully to the household's allocation of resources.

As per Double A report a study was conducted to analyze the environmental impact of eucalyptus plantation in the targeted province. (Double A report, 2012). The study collected information of Eucalyptus planted area of each sub-district by interviewed government officer who take responsibility in agriculture and environment at Sub-district Administrative Organization (SAO) and/or municipality and did questionnaire analysis, analysis of satellite image interpretation output coupled with rectification test of the obtained information from interviewing the personnel of SAO and/or municipality. As per the finding of their research, Eucalyptus is grown in 1,377,503 rai in a sampled size of 58,804,440 rai of land. Given 100 tree/ rai ratio, the numbers of tree are 137,750,300. Considering each tree as 60 kg weight; total bioma≈s8s,265,018 tons≈8.2 million tons of green mass. The quantity of CO2 offset to kg of green mass is 1:1 as found by Prasert et al 2009. Therefore, the total CO2 uptake by the Paper

tree is 8.2 million tons of CO2yr, which they claim is substantial and it provides a carbon negative status to the environment.

However, the study has limitations in measuring the carbon footprint, which may harm the ecological environment. Assessing the environmental impacts of eucalyptus plantations is complex and requires scientific research to identify and analyze every aspect. Despite this, many farmers hold positive perceptions of eucalyptus plantations, believing them to be beneficial to neighboring crops, soil moisture, and the water table in the general vicinity of the plantations. From a sustainability perspective, while eucalyptus plantations can provide economic benefits and support soil conservation, it is crucial to balance these advantages with potential environmental risks.

Furthermore, the research found that women's empowerment was achieved through participation in eucalyptus farming, enhancing their decision-making power and socioeconomic status. Therefore, sustainable management practices and further scientific research are essential to ensure that eucalyptus farming can be integrated into agricultural systems without compromising ecological integrity while continuing to empower women.

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Pursuing Low Carbon Emissions: Does Local Action at the Secondary City Scale Make Sense: The Case of Samut Sakhon Thailand

Chuthatip Maneepong[1,2]

Abstract

Samut Sakhon Province, part of the Bangkok Metropolitan Region, is an important contributor to Thailand's economy, ranking eighth in terms of Gross Provincial Product (GPP). Samut Sakhon is known for its labor-intensive industrial economy, particularly in agri-business. In 2020, total electrical consumption of this Province was 8,259,267,572 kWh/annum which released greenhouse gas of 8.68365E+14 KgCO2e/annum.

The paper‡ focuses on the feasibility and effectiveness of local action, by implying limited capacity and resources, to reduce greenhouse gas emissions (decarbonization) and related, consistent with national carbon neutrality policies, local action contributions to mitigation of local environmental issues including abatement of air pollution. The relevant activities of ten local government agencies were assessed, plus enterprises with which these agencies were involved. Lessons learned, and recommendations for decarbonization at the secondary city scale, based on the Samut Sakhon case, are drawn. The lessons learned are derived from the actions of local government agencies and large and medium scale firms in addressing carbon emissions, comparing the net benefits of local actions to large-scale national interventions, e.g. implementation of industry standards.

Keywords: Low Carbon City, Local Actions on Decarbonization, Effectiveness of Greenhouse Gas Emission Initiatives at the Local Level

[1] Board Member, Thai Urban Planners' Society
194/17 Condo Ban Saraan, Soi Sukhumvit 31, Wattana, Bangkok 10110. THAILAND.
E-mail: cmaneepong@gmail.com

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