

Analysis of the Role of Society in Utilizing Yards as Carbon Emission Reduction

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Abstract. The increasing population in Bekasi Regency has led to higher demand for housing, vehicles, and industrial areas, resulting in carbon dioxide (CO₂) emissions of approximately 8,148,642 tons per year, which negatively impact human health. Residential yards hold significant potential as green spaces that can be developed to enhance carbon absorption through vegetation. This research aims to analyze the role of society in utilizing residential yards to mitigate carbon emissions. The statistical analysis was conducted using the Chi-square test with a significance level of p-value < 0.05. The results indicate that the success of planting vegetation in residential yards is significantly associated with age, gender, and education level. However, cultural factors do not show a significant relationship with yard utilization in Bekasi Regency. The most effective yard model for carbon absorption includes diverse vegetation types, particularly perennial plants, which can absorb a greater amount of carbon dioxide. A residential yard with a variety of fruit and perennial plants can absorb approximately 228 kg of CO₂ per year for a housing area of 120 m².

Keywords: Society, yard, green open space

Introduction

The global demand for green spaces continues to rise alongside economic growth and technological advancements. Conversely, existing green spaces and primary forests are declining due to population growth and industrial expansion. The decline in carbon absorption capacity in Indonesia's green spaces is attributed to inadequate management of deforestation and insufficient enforcement of legal sanctions. The reduction and conversion of forest land to agricultural areas can lead to various ecological problems, including decreased soil fertility, erosion, biodiversity loss, floods, droughts, and global warming. This incident occurred due to land use that was not in accordance with the potential for use and carrying capacity (Rizqi & Eppy, 2021). One alternative to mitigate the impacts of land conversion is by enhancing the potential of residential yards (Arifin & Wibowo, 2020). Yards can be utilized as carbon emission absorbers because plants can absorb carbon dioxide from the air through the process of photosynthesis. Through photosynthesis, plants absorb carbon dioxide from the atmosphere and convert it into carbohydrates, which serve as an energy source for growth and development (Fauziyah et al., 2020). Oxygen is released as a by-product during this process. According to oxygen is released into the atmosphere as a by-product of photosynthesis.

When yards are filled with various types of plants, the amount of CO₂ that can be absorbed will be greater (Irma et al., 2022). Furthermore, vegetation around homes can lower ambient air temperature through transpiration, a process where plants release water vapor into the atmosphere. (Nuliang & Safrizal, 2019) explained that planting vegetation in residential yards can mitigate the effects of urbanization, such as reducing flooding and environmental pollution. Vegetation absorbs rainwater into the soil, reducing surface runoff and subsequently decreasing the risk of flooding. In addition, plants can also absorb pollutants and chemical waste from the air and soil, thereby helping to reduce environmental pollution. Some plant species exhibit greater carbon absorption capacity compared to others. For instance, broadleaf trees are more effective in absorbing carbon than shrubs or grasses due to their larger leaf surface area and longer lifespan (Hariyadi et al., 2019). Therefore, variations in vegetation can affect the amount of carbon stored in a particular ecosystem. Additionally, changes in land use can significantly impact the amount of carbon stored in the soil and vegetation. Converting land for intensive agriculture or housing significantly decreases vegetation cover, thereby diminishing the environment's capacity to sequester carbon (Hidayat & Sari, 2019).

The role of society in controlling carbon emissions involves efforts to minimize greenhouse gas (GHG) emissions resulting from human activities, such as industry, transportation, and energy. Carbon emissions cause global climate change and have significant impacts on the environment, economy, and human health. Society plays a crucial role in controlling carbon emissions, as it is the largest energy user. Efforts to reduce carbon emissions include individual and collective actions, such as reducing energy consumption, using environmentally friendly transportation, and increasing environmental awareness. Several studies have evaluated the role of society in controlling carbon emissions. A study by the International Energy Agency (IEA) showed that 50% of the carbon emission reductions needed to address global climate change must come from individual and community actions. Additionally, a study by the University of California emphasized that government policies targeting carbon emission reductions are more effective when supported by active community participation, which enhances policy implementation and public adherence. This research aims to analyze the role of society in utilizing residential yards to mitigate carbon emissions.

Methods

The research was conducted in Bekasi Regency located in the eastern part of West Java Province and has an area of approximately 1.220,28 km². Several areas in Bekasi Regency that are famous for their green areas include Mount Halimun Salak National Park, Angke Kapuk Mangrove Nature Tourism Park, and Bekasi City Forest. In 3 sub-districts in Bekasi Regency, West Java. The sub-districts are Setu District, North Cikarang District, and Babelan District. There are several reasons why researchers chose Bekasi Regency as the research location. First, Bekasi Regency is a district that contributes industrial products and integrated factory areas with a fairly high population, namely 3.112.698 people, so the potential for pollutants to be produced is quite high.

The research method used is quantitative research using observational analytical methods with cross sectional. The independent variable is community participation in the utilization of yards as a solution to meet the lack of green open space. The sample used in this study was all people who have yards in Bekasi Regency totaling 54 people. The questionnaire research instrument which is the primary and secondary data. The data collection method is carried out in 3 ways, namely in-depth interviews, observations, and document reviews using primary data by distributing questionnaires containing observation guidelines and interview guides to all yard owners. Univariate data analysis describes or describes each variable, namely community participation and utilization of yards and

bivariate to analyze two variables, namely one independent variable and one dependent variable that are suspected of having a relationship or correlation. This analysis was carried out after the calculation of univariate analysis. This study conducted an analysis to determine the relationship between each variable such as community participation in the addition of green open space. The statistical test used is the significant value of the Chi-square test p-value: 0.05. Formula for test connection between two variables in table contingency is:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Information:

O = The observed frequency in every cell table .

E = Calculated expected frequency with formula:

$$E = \frac{\text{Total rows} \times \text{Total column}}{\text{Total everything}}$$

Σ = Addition all over mark $\frac{(O-E)^2}{E}$ For all cells.

Calculation Steps

1. Count E value for every cell.
2. Subtract O from E, then square it the result.
3. Profit sharing square the with E.
4. Add up results all over cell For get χ^2 value.

The result of the value of χ^2 compared to with mark critical from Chi-square table based on degrees freedom ($df = (n_{\text{rows}} - 1)(n_{\text{columns}} - 1)$) and the level of significance (α). If χ^2 calculate more big from mark critical, The relationship between variables is considered statistically significant if the value is greater than the critical value in table based on the specified degrees of freedom and level of significance (Wahyudi, 2023).

Results and Discussion

Role of Society

In general overall form demographics Bekasi Regency consists of from various ethnicity and tribe. Characteristics land solid flat suitable for various type industry and housing grow. The role of society in control carbon emissions are important known because the community has house with enough pages for planted tree absorber carbon in the middle difficulty government build land open green for absorb emissions produced from all activity resident cities, vehicles and industry.

Table 1. Characteristics Respondent based on Age, Gender, Education, Occupation and income.

Characteristics	Frequency	Respondent (%)
Gender		
Man	42	77.7
Woman	12	22.2

Age		
20 – 30 years	11	20.3
31 – 40 years	22	40.7
41 – 50 years	15	27.7
50 – 60 years	6	11.1
Education		
Elementary school	3	5.5
Junior high school	9	16.6
Senior high school	15	27.7
Diploma	6	11.1
Bachelor	19	35.1
Master	2	3.7
Work		
Employee Private	14	25.9
Laborer	16	29.6
civil servant	7	12.9
Trader	4	7.4
Farmer	9	16.6
Freelancer	4	7.4
Income per month		
1 - 5 Million	22	40.8
5 – 10 Million	20	37.0
10 – 15 Million	2	3.8

Based on Table 1 is known that from 54 respondents there were 42 respondents (77.7%) of this type male gender and 12 respondents (22.2%) were female sex women . There are Respondent with age 31–40 years dominant 22 respondents (40.7%) and respondents with aged 50–60 years 6 respondents with percentage lowest (11.1%). Respondents' education level the majority were filled by bachelors 19 respondents (35.1%) and the lowest is masters education Level 2 (3.7%). Average work respondent is laborer as many as 16 respondents (29.6%) and freelance workers as many as 4 respondents (7.4%). Based on income per month average income of 22 respondents is Rp. 1.000.000 to Rp. 5.000.000 with percentage dominant (40.8%) and only There are 2 respondents who have income of Rp. 10.000.000 to Rp. 15.000.000 with percentage (3.8%).

Table 2. Community Participation in Plant Trees in the Yard.

Role of Society	Frequency	Respondent (%)
Man	42	77.78
Woman	12	22.22
Planting in the Yard		
Once	52	96.30
Never	2	3.70

According to Table 2, it is observed that 96.30% of the 54 respondents have planted vegetation in their yards, while 3.70% have never engaged in yard planting. The majority of yard owners have a history of planting trees in their residential yards. Planting trees in residential yards significantly enhances urban green spaces, providing ecological benefits such as carbon dioxide absorption and microclimate regulation (Jones & Baker, 2019).

Table 3. Sex Relations with the Role of Society in the Yard

Gender	Role of Society		Chi square value
	Once	No	
Man	0.06	1.56	7.61
Woman	0.21	5.78	

Based on statistical test analysis known that of the 54 people interviewed related with the role of society for yard there is Chi-square value of 7.61 with degrees freedom (df=1). Because the Chi-square value is calculated more big when compared with mark critical of 3.841 at the level significance $\alpha=0.05$. Then the result this can withdrawn conclusion that There is significant relationship between variable type sex and planting trees in the yard. The results give base that factor type sex related with gender preference in general individual to planting trees in the yard. The role of society is divided based on type sex man Once plant plants in the yard compared to women. Man own role important in election plant based on mark economical or culture, especially in context garden family traditional based on knowledge local. Garden the often managed together between member family, but role man dominant in make decision about use land For plant food or commodity economy certain (Setiani et al., 2022).

Table 4. Relationship Levels Age with Choice Plants in the Yard

Age	Plant Type Selection		Chi-square Value
	One Type of Plant	Various Types of Plants	
20-30 years	0.08	0.01	3.00
31-40 years	0.92	0.16	
41-50 years	0.67	0.12	
51-60 years	0.89	0.15	

Based on Table 4, the calculated Chi-square value is 3.00. Compared to the critical value of 7.815 (at 3 degrees of freedom and a significance level of 0.05), the calculated Chi-square value is smaller. Therefore, these results are not significant enough to reject the null hypothesis, indicating that there is no strong evidence of a significant connection between age and preferences for the number of plant types (single type or various types of plants). Studies have indicated that residential yard planting practices are closely linked to both aesthetic and functional preferences, where ornamental and fruit plants are favored by younger individuals, while older groups tend to integrate medicinal and fruit-bearing plants (Lee & Park, 2020). However, there was a significant relationship between the age of respondents and the types of plants selected for planting in the yard. Respondents aged 20 to 30 years tend to choose ornamental and fruit plants. Out of 11 people in this age group, 4 selected a combination of ornamental, fruit, and medicinal plants. The 31-40 years age group predominantly chose ornamental and fruit plants, as well as a combination of ornamental, fruit, and medicinal plants. Out of 22 people in this group, 6 planted this combination. This indicates that this age group tends to choose plants that not only beautify the yard but also provide benefits from fruit and medicinal plants. In urban gardening, preferences for ornamental, fruit, and medicinal plants are often age-dependent, with individuals in their 30s and 40s showing a strong inclination toward plants that combine aesthetic and practical benefits (Chen et al., 2019).

The 40-50 years age group mainly planted ornamental and fruit plants, as well as a combination of ornamental, fruit, and medicinal plants. A third of the 15 people in this group chose this combination. Preferences in this age group suggest a tendency towards utility plants that serve as both a food source and for other functions. The last group predominantly chose a combination of ornamental and fruit plants, with all 6 respondents in this group planting these types of plants. The analysis results show that younger age groups tend to choose a combination of plants with aesthetic and fruit benefits, while older age groups show a stronger preference for combinations of plants that provide additional benefits such as medicinal or food value. The selection of ornamental and fruit plants in urban gardens reflects a growing trend of combining aesthetic with practical benefits. In particular, older age groups are more inclined towards plants that offer both visual appeal and functional uses such as medicinal or food resources (Rahman & Ali, 2019). This confirmed that age plays a significant role in determining plant type preferences and patterns, which can be used as a reference in mitigating climate change in urban areas with varying age demographics. The utilization of residential yards for planting vegetation is a common practice in urban and peri-urban areas, contributing to environmental sustainability and carbon sequestration efforts (Smith et al., 2020)

Table 5. Relationship Levels Age with Choice Plants in the Yard

Profession	Connection Culture in Yard		Chi-square Value
	There is	There isn't any	
Employee Private	0.04	0.01	1.85
Laborer	0.33	0.11	
Civil servant	0.06	0.02	
Trader	0.96	0.31	
Farmer	0.01	0	
Freelancer	0	0	

Based on test results shown on Table 5, the calculated value is 1.85, while the critical Chi-square value ($df = 5$, $\alpha = 0.05$) is 11.07. Since the calculated Chi-square value was smaller than the critical value, it can be interpreted that there was no significant relationship between cultural factors and planting vegetation in the yard. This result indicates that respondents' preferences for planting vegetation in their yards are not significantly related to cultural factors or profession. Although culture can influence plant preferences in the yard, profession is not a dominant factor in determining whether someone chooses plants based on cultural significance. Research shows that profession is not related to decisions about planting vegetation in the yard (Sumarna, 2019).

Table 6. Relationship between Education Level and Decrease Temperature Yard and The Role of Community Culture

Founder	Benefits of Yards in Subtraction impact Improvement Carbon Emissions		Chi-square Value
	Lower Temperature Environment	Culture / Education	
Elementary school	1.39	1.61	10.71

Junior high school	4.17	4.83
Senior high school	6.94	8.06
Diploma	2.78	3.22
Bachelor	8.80	10.20
Master	0.93	1.07

Based on the results in Table 6, the calculated Chi-square value (10.71) is smaller than the critical value (11.07). Therefore, the results are not significant enough to reject the null hypothesis. This indicates that there is no significant relationship between the level of education and the perceived benefits of the yard in terms of reducing the impact of carbon emissions and social culture in the community. The analysis concludes that the level of education of respondents is not significantly related to their perception of the benefits of the yard, whether in lowering environmental temperatures or as a means of cultural and educational value. Individuals with higher education levels tend to have greater awareness about climate change and are more involved in activities such as tree planting, which are crucial for mitigating the impacts of climate change and enhancing environmental resilience. This research also emphasized the need to integrate environmental education into the curriculum to ensure that climate change becomes a primary focus, especially in Indonesia, where local culture and daily practices significantly influence interactions with the environment research by (Yuliani, 2021).

Table 7. Influence Culture in interest plant Yard

Subdistrict	Influence Culture with Interest in Planting Yard		Chi-square Value
	Influenced Culture of the Family of Origin Tribe	Interest Not Affected	
Babelan	0.17	0.08	0.5
Setu	0	0	
North Cikarang	0.17	0.08	

Based on the Chi-square test analysis, there is no significant relationship between cultural influence and interest in planting in the yards of the studied sub-districts (Babelan, Setu, and North Cikarang). This is shown by the calculated Chi-square value of 0.5, which is smaller than the critical value of 5.991 at a significance level of 0.05 with 2 degrees of freedom. Statistically, this result indicated that the cultural influence of ethnic group origin on interest in planting in the yard does not show a significant difference between sub-districts. Although culture can be a motivating factor for planting in the yard, in this context, the local cultural differences among the people in Bekasi Regency do not play a significant role in determining this interest. This result differs from the findings of (Suryana et al., 2020). Which state that traditional Indonesian ecological knowledge, rich in moral teachings related to nature, plays an important role in the habit of planting trees in society.

The practice of planting trees by community customs in various regions of Indonesia is motivated not only by economic or food needs and interests but also by deep cultural values. Respect for trees as an integral part of spiritual and social life strengthens public involvement in maintaining environmental sustainability through tree planting. The reduced

interest in planting trees by the community in Bekasi Regency, which is not influenced by culture, is due to the rate of urbanization and economic growth, which prioritizes economic needs and infrastructure development over urban greening. As stated by (Chandra, 2021), urbanization reduces public interest in planting trees because economic and infrastructure development needs are more urgent. Planting trees in urban areas is increasingly constrained by limited space and modernization, leading to a decline in traditional habits, although the cultural roots of the community still value nature.

Yard Model



Figure 1. Yard Design Model with Diversity Tall Plants

Based on the survey results, although Bekasi Regency is predominantly developed land, there are still several vacant plots and potential housing areas with yards that can be optimized for carbon emission reduction efforts. Yard areas are an important factor for homeowners to plant a diverse range of vegetation. In the yard design illustrated in Image 1, there are banana plants, ferns, mangoes, water apples, rambutans, Javanese tamarind, Ketapang, golden Ketapang, guava, and ornamental flowers. Research conducted by (Kumar et al., 2018) stated that the average water apple (*Syzygium aqueum*) absorbs 10-20 kg of CO₂ per year. According to (Singh et al., 2017), mango trees absorb around 22-30 kg of CO₂ per year per tree, (Ahmad & Shukla, 2019) found that banana trees absorb between 10-15 kg of CO₂ per year per tree, and (Choudhary & Pandey, 2020) reported that jackfruit trees absorb between 15-25 kg of CO₂ per year per tree.

Based on the data obtained, the total carbon absorption for mango, guava, water apple, and rambutan trees is 4 trees x 22 kg = 88 kg CO₂. For Ketapang Kencana, it is 1 tree x 30 kg = 30 kg CO₂. For tamarind, it is 2 trees x 25 kg = 50 kg CO₂. For banana trees, it is 4 trees x 15 kg = 60 kg CO₂. The total estimated carbon absorption for a yard with a variety of fruit and annual plants is approximately 228 kg of CO₂ per year for an estimated housing land area of 120 m². Plants such as mango, guava, rambutan, golden Ketapang, and Javanese tamarind significantly contribute to CO₂ emission absorption, along with woody trees like Ketapang Kencana. These results show that increasing plant diversity in the yard not only benefits the environmental quality for the homeowner, fulfilling aesthetic, culinary, and medicinal needs, but also mitigates the negative impact of carbon emissions. Having various types of plants (tall trees, bushes, ground cover plants) can create a vegetation structure similar to a forest. This structure increases the efficiency of carbon absorption, as different plant species absorb CO₂ at varying rates. Fruit trees, such as mango and guava, alongside woody trees like Ketapang Kencana, provide both environmental and practical benefits, including substantial carbon dioxide absorption. These plants help mitigate the negative effects of carbon emissions while offering aesthetic and functional values (Kumar & Patel, 2021).

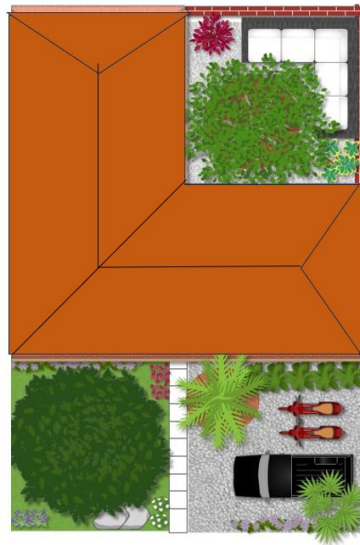


Figure 2. Yard Design Model with Plant Limited

Carbon absorption can vary depending on the age of the plants, environmental conditions, and care. Mango (*Mangifera indica*) is known to be quite effective in absorbing carbon at maturity. Golden ketapang, with its dense foliage, significantly aids in carbon absorption. Palm trees, although they absorb less carbon per plant, can be beneficial in large numbers. The results of the yard model presented in Table 16 shown a total carbon absorption of 72 kg CO₂ per year, which is significantly lower—only 31.58%—compared to the first yard model that can absorb 228 kg of CO₂ per year. With the right selection of plant types and optimal layout, a 120 square meter area planted with mango, golden ketapang, and palm trees can contribute significantly to carbon emission absorption. Optimizing carbon absorption in yard areas can be achieved by adding plant variety and employing care methods that support optimal growth. Larger trees are more effective in absorbing carbon dioxide, filtering air pollution, and providing shade. However, limited space restricts the planting of large trees, so smaller plants with high carbon and pollution absorption capacity are preferable. Reveals that green spatial planning in increasingly dense urban cities is largely determined by various greening strategies, such as the use of green roofs, green walls, and mini parks in narrow areas (Haaland & Van, 2019). The research concludes that with proper planning, even congested cities can provide functional green spaces, despite limited land, for environmental and public health benefits. This statement supports the optimization of narrow yard spaces to be planted with carbon-absorbing trees. Narrow yard models can be maximized with green walls, green roofs, and mini gardens on the sides of houses.

Houses with limited yard space often face greater challenges in striving for greening efforts around Bekasi Regency. According to current law, 30% of the total area must be allocated as green open space (RTH). However, current data from the government indicated that the green open space area has only reached 11.86%, falling short of the required 18.14% (Mohammad et al., 2022). Therefore, it is crucial to optimize the use of even the smallest land areas in Bekasi Regency to meet the legally required percentage of green space. This necessity is further supported by research (Aronson & Lepczyk, 2021). Which identified the main challenges in maintaining biodiversity in urban green spaces, particularly in environments with limited land. The study finds that optimal urban ecosystem management, including the use of private yards and small spaces, can enhance biological diversity sustainability and help mitigate habitat fragmentation in urban settings.

Since plant diversity is directly related to the absorption of pollution and carbon dioxide emissions, optimizing greening models in small personal yards is also essential.

Conclusion

The results of Chi-square test indicated that the community's role in the success of planting in residential yards is significantly related to age, gender, and education level. However, cultural factors do not show a significant relationship in the Bekasi Regency area. The most effective yard model for carbon absorption was one that integrated government programs with proposed models, emphasizing the planting of diverse types of perennial plants with wider canopies. The total carbon absorption of a yard with a variety of fruit and perennial plants can reach up to 228 kg of CO₂ per year for a residential land area of 120 m².

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