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To cite this article: E F Rini *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **129** 012022

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The ecological impacts of primary education facilities based on a child-friendly neighborhood unit criteria in Surakarta

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Abstract. A city should accommodate the citizen needs, especially for children. The absence of elementary school in a neighborhood unit (NU) will increase the use of transportation by children in the NU, every day at the same time. This activity will produce large quantities of carbon dioxide (CO₂) that can trigger climate change. This article aims at discovering the ecological impacts of CO₂ emitted from the transportation used by children when commuting to their school, based on the conformity of each NU to the criteria of the a child-friendly city. Quantitative and spatial analysis techniques were employed in these four stages: (1) dividing the NU; (2) constructing the NU's typology based on a child-friendly criteria; (3) identifying the characteristic of children movements in each NU when accessing their elementary school; and (4) analyzing the ecological impacts (in CO₂ form). The result shows that 88.14% of CO₂ emissions in Surakarta can be reduced by interventions through the fulfillment of all NU's child-friendly criterias.

1. Introduction

The idea of child friendly city has become a concern in Indonesia since the enactment of the Minister of Women Empowerment and Child Protection Regulation Number 11 and 12 of 2011 on Cities and Children, including the availability of social facilities that accommodate the rights of children. Elementary School is one of the children's social facilities that should be available in a neighborhood unit (NU), considering the distance of children's walking capabilities [1,2,3,4,5,6]. The availability of elementary school in the NU can give the opportunity for children to access primary education services by walking. On the other hand, its unavailability will result in the increasing number of transportation, as the children use them to commute to their school. However, the simultaneous use of transportation (especially motorcycle) in a certain period of time will give ecological impacts on the region; for instance, the air pollution caused by the residual burning of motorcycle energy. Therefore, it is hypothesized that the exhaust gases originating from transportation activities are the major contributors to greenhouse gas emissions, including CO₂. Since the characteristics of CO₂ gas that can directly react in the air and increase the temperature of Earth's surface, there is a need to reduce the source of CO₂ gas emissions.

Surakarta as a child-friendly city is the awardee of Nindya category in 2011 from the Ministry of Women's Empowerment and Child Protection [7]. For the purpose of discovering the concept of a child-friendly city and its relation to the existing ecological impacts, this city became an interesting object to study. Based on the assessment of NU in Surakarta (2016) and the number of population



served, it is known that there is only a 36.27% of the 246 elementary schools that meet the standard capacity of elementary school services [8]. This indicates that the characteristics of the Surakarta NUs still has not fulfilled the requirements of the child's decent NU. Based on this background, this study aims at determining the ecological impacts of daily population movement activities in accessing basic education service facilities (elementary schools) in terms of applying the criteria of child-friendly NUs.

2. Methodology

2.1. Neighborhood Unit Distribution in Surakarta

For the process of identification and intervention, in this study, Surakarta is divided into several NUs. This division process is conducted through the use of ArcGIS mapping software. There are three aspects that serve as the main input: (1) a social scale facility around the elementary school distance (equal to 800 m), (2) the environmental administration boundaries (RT and RW), and (3) the physical boundaries.

2.2. NU Typology Formulation Based on child-friendly criteria

The criteria of NU child-friendly city used to assess the characteristics of NU in Surakarta are:

Table 1. The criteria and indicator used to identify suitability for each NU in Surakarta.

Criteria	Indicator	
	NU zone characteristic	
	Suitable	Not suitable
1 Service capacity to residents	≤1600 residents/elementary school (ratio ≤0.000625)	>1600 residents/elementary school (ratio > 0.000625)
2 Children’s safety and comfort in accessing social infrastructure	All criteria are suitable	There is a criterion which is not suitable
a. Walking distance on foot to reach the school by children	≤800m to reach on foot	> 800m to reach on foot
b. Free from unwanted traffic across the roads	All of the internal roads (which connected to the local or collector roads) meet indicators: <ul style="list-style-type: none"> • 3.5-6 meters wide of road • has a difference of width or pavement between the different road function to reduce the vehicle speed when entering the NU area 	Not meet the two indicators
c. Separator between pedestrian and main street	Has separator between pedestrian and main street on local roads, collectors, and arteries	No separator between pedestrian and main street
d. Children’s safety in crossing the street	- Utilize with zebra cross or pedestrian bridge - Utilize with school zone mark(ZoSS)	Not meet the two indicators
3 Access of elementary school utilization by all children including disabled	Inclusion school	Not accepting children with special needs

From the criteria above, the NUs can be formulated into eight typologies of NUs that are derived from a combination of the results of the conformity of those three criteria.

2.3. The Identification of Child Movement Characteristic in Accessing Elementary School

Movement characteristics in this study are the distance between school and the transportation. In this step, it can be known the distance traveled by each student to their school. From those data, we can analyze the average distance traveled by each respondents, either who choose to go to school inside or outside the NU. For the characteristics of transportation preferences, the respondent data will be classified based on the NU typology. The data are then analyzed to know the tendency of the transportation preferences of the respondents who attend school in and outside the NU.

2.4. Ecology Impact Analysis Based on Movement Characteristics

2.4.1. CO₂ Emission Based on Movement Characteristics. The energy used by the students to go to school produces a combustion gas that impacts on air condition around the student movement areas. To understand the impacts of the combustion gas, it is necessary to identify the sources of air pollutants and the number of emissions released.

Table 2. Vehicle Emission Factors [9].

Category	CO ₂ (g/km)
Motorcycle	0.398
Passenger car	0.663
Urban Buses Standard	2.65

Meanwhile, the following formula can be used to calculate the amount of emissions in a region based on the vehicle types and its distance [10]:

$$TE = \sum_j (N_j \times M_j \times EF_{i,j}) \tag{1}$$

TE = Total emissions of gas in a region (g)

N_j = Number of vehicles type j used in a region

M_j = average distance per vehicle type j (km)

E_{f_{i,j}} = emission factor for pollutant i and vehicle type j (g/ km)

2.4.2. The Average of Existing CO₂ Gas Emissions in Each Typology. Based on the formula above, the process of calculating CO₂ emissions of existing gas begins by calculating the number of CO₂ emissions in each vehicle type in each NU. After knowing the amount of emissions of existing CO₂ gas in each type of vehicle in each NU, the total amount of CO₂ emissions in each typology is calculated to know the total number of CO₂ emissions in the typology.

2.4.3. The Average of CO₂ Gas Emissions After Intervention on Each Typology. Interventions are made if the three criteria of child-friendly NUs are fulfilled in all NU. The intervention is formulated by multiplying the number of students on each NU intervened by constants. The constants are obtained from the average of each student’s emissions on the ideal NU.

3. Result

3.1. The Distribution of NU in Surakarta

Surakarta has totally 263 elementary schools (or those that are equivalent with public elementary schools), private elementary schools, Madrasah Ibtidaiyah (MI) and schools for children with special needs (SLB). Based on the coverage analysis of elementary schools (800 m); overall, the existence of elementary schools in Surakarta has been able to serve almost all areas of Surakarta. The area that is not served by the existence of elementary schools/equivalent is situated in the West Surakarta,

precisely in the westernmost Karangasem Village. However, the area is still served by the existence of other elementary schools that are administratively located outside Surakarta.

In deciding the limit of the NU, administrative boundaries are used with local service scales, such as neighborhood units (NU) and community units (CU). Some limitations in determining NU are necessary because each NU can consist of 30-50 family with four persons in each family. Thus, the provisions in a NU is related to the standard of elementary school services serving (<1600 people) which can be seen from the administrative boundaries of NU and CU. Ideally, the NU has alleys inside and surrounded by road functions higher than alley. But it is not used as the consideration in determining the boundary of NU in Surakarta.

The results of the analysis of those three aspects revealed that there are 108 NUs that are close to elementary schools inside or outside the NU itself, and one NU that does not have any school facility.

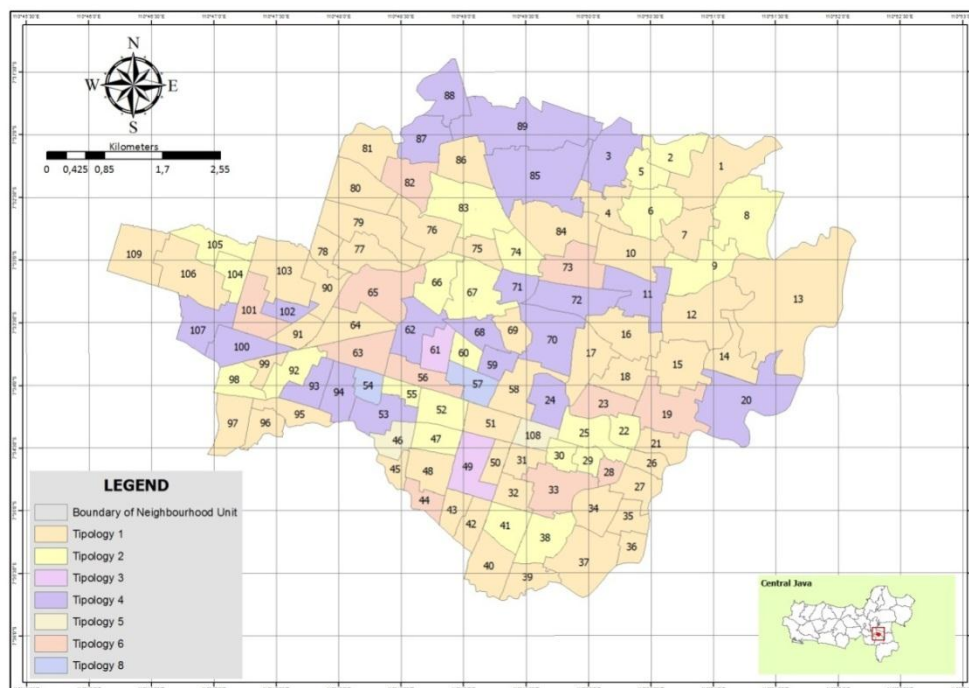


Figure 1. Neighborhood unit distribution in Surakarta.

3.2. Neighborhood Unit Typology in Surakarta based on Child-friendly city criteria

The method of grouping the NU in Surakarta to each typology starts with the identification of each NU based on the three criteria of child-friendly city.

3.2.1. Elementary School Services Capacity Towards the Total Population. The elementary school service capacity criteria are used to identify the existence of elementary schools in a NU as well as its capacity to serve a certain population. A NU can meet the criteria of the capacity of elementary school services to the population if its entire population is able to be served by the elementary schools within the same NU. In calculating the number of residents, it is assumed that every house is inhabited by five family members. Meanwhile, one elementary school unit is supposed to serve 1600 residents. The result indicated that there are 38 NUs that meet the criteria of elementary school service capacity towards the total population. On the other hand, there are totally 71 NUs that do not meet that criteria.

3.2.2. The Children’s Safety and Comfort in Accessing Social Infrastructure. A NU can be said to meet the criteria of children's safety and comfort in accessing social infrastructure if it satisfies the following four sub-criteria:

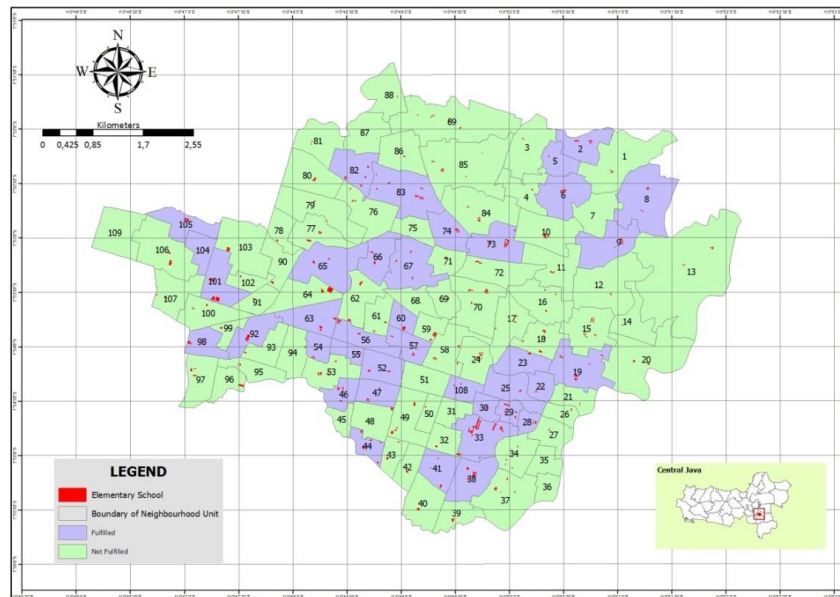


Figure 2. The suitability of NUs in Surakarta with the criteria of elementary school services capacity towards the total population.

3.2.2.1. The distance to reach elementary school. Ideally, the maximum distance for students to walk to their school is 800 m, which is the distance between the school and NU. From the result of analysis, there are totally 108 NUs that meet the criteria whereas one NU do not satisfy the criteria.

3.2.2.2. Free from unwanted traffic across the road. There is one NU that is traversed by the alley and limited by the road function above the neighborhood. The difference of road function as the boundary of the NU must also be accompanied by traffic calming utilities to enter the NU area. Those traffic calming utilities are the difference of width and pavement between the roads and portal at the entrance of the NU. From the result of identification, it is known that there are 30 NUs that meet the criteria of the free traffic jam, while 79 NUs do not satisfy the criteria.

3.2.2.3. The existence of a separator between pedestrian and main street. It can be road markings or the clarity of the boundary between the main road and the pedestrian, either with a barrier or high street difference. The analysis showed that 76 NUs meet the sub-criteria of separation between pedestrian and the main road, while 33 other NUs do not.

3.2.2.4. Children’s safety in crossing the street. The fulfillment of criteria for children’s safety in crossing the street can be identified from the existence of child safety support facilities in the traffic. The facilities can be in the form of zebra cross, pedestrian bridges, and school zone marks (ZOSS). Based on the result of identification, there are 33 NUs that were appropriate whereas 76 other NUs were considered to be inappropriate.

Based on the four criteria above, the result of the assessment showed that six neighborhoods meet all those four sub-criteria while the other 103 NUs only meet several sub-criteria. The following is a map of the NUs suitability in Surakarta with the criteria of free traffic.

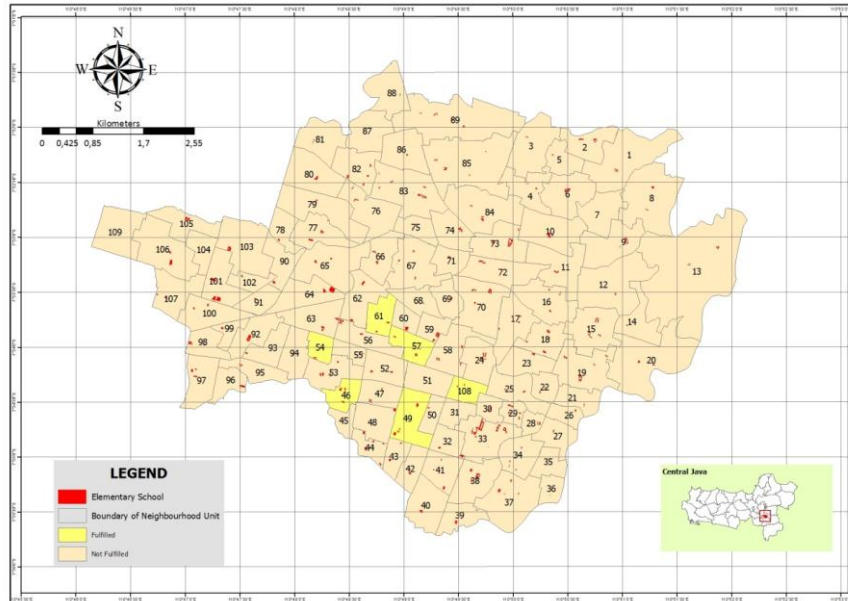


Figure 3. The suitability of NUs in Surakarta with the criteria of children’s safety and comfort in accessing social infrastructure.

3.2.3. *The Access to Elementary School Utilization.* The identification of elementary schools existence that can be accessed by all children, including the disabled, is conducted through listing the existing inclusion schools in Surakarta. The inclusion school is a public elementary school (not elementary schools for disabled) appointed by the government of Surakarta to educate children with special needs.

The result of analysis revealed that there are 26 NUs that meet these criteria, while the other 83 NUs do not. The following is a map of the conformity of the NU in Surakarta with the criteria of the access of elementary schools utilization by all children.

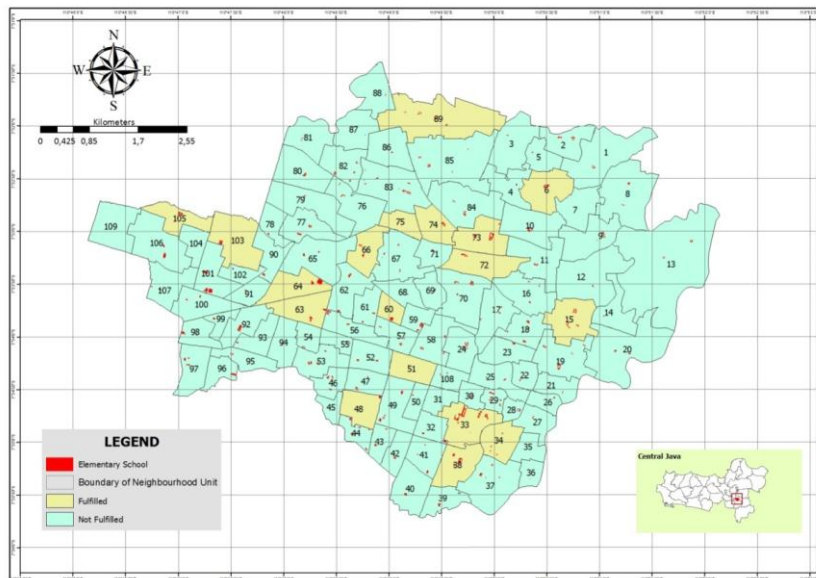


Figure 4. The conformity of NU with the criteria of elementary school utilization by all children including disabled.

After identifying the NU conformity in Surakarta based on three criteria of the child-friendly neighborhood, the NU is then classified into a typology that is in accordance with the results of the criteria assessment. The following are the distribution of NU based on the typology that has been formulated before.

Table 3. Neighborhood unit grouping based on typology.

Typology	Conformity criteria (1-2-3)	Neighbourhood unit	Total	Percentage
1	NS-NS-NS	1-4-7-10-12-13-14-15-16-17-18-21-26-27-31-32-34-35-36-37-39-40-42-43-45-48-50-51-58-64-69-75-76-77-78-79-80-81-84-86-90-91-95-96-97-99-103-106-109	49	44.95%
2	S-NS-NS	2-5-6-8-9-22-25-29-30-38-41-47-52-55-60-66-67-74-83-92-98-104-105	23	21.10%
3	NS-S-NS	49-61	2	1.83%
4	NS-NS-S	3-11-20-24-53-59-62-68-70-71-72-85-87-88-89-93-94-100-102-107	20	18.35%
5	S-S-NS	46-108	2	1.83%
6	S-NS-S	19-23-28-33-44-56-63-65-73-82-101	11	10.09%
7	NS-S-S	-	0	0%
8	S-S-S	54-57	2	1.83%

S = Suitable NS = Not suitable

3.3. *The Identification of Child Movement Characteristic in Accessing Elementary School in Surakarta*

3.3.1. *Distance Characteristics.* Identification of distance characteristics can be analyzed by using the distance data of respondent of elementary school students/equal from their house to school. The distance characteristic is divided into 2 groups, first is a respondent who goes to school inside residence and second is he/she who goes to school outside his/her NU residence.

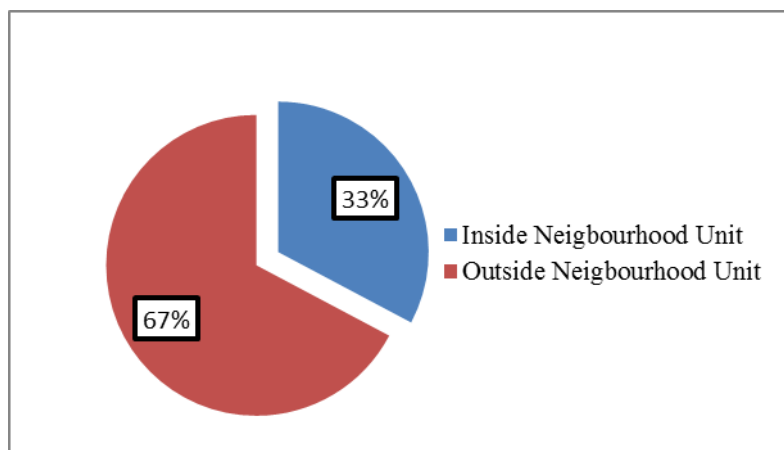


Figure 5. Students' movement diagram.

Table 4. Students’ average distance on each typology.

Typology	Distance average (Meter)	
	inside <i>NU</i>	outside <i>NU</i>
1	232	1,696
2	264	1,688
3	297	1,307
4	302	1,917
5	301	1,437
6	292	1,672
7	-	-
8	291	1,390

The distance characteristic shows that the respondents likely tend to choose schools that are outside the NU residence. This is the character of most students in Indonesia who prefer to study in favorite schools. The number of movement outside the NU is greater than the movement inside the NU, with the average distance of respondents to the school reached more than 1 km or beyond the reach of elementary school services (800 meters). This distance can also indicate the use of vehicle by respondents. The farther the distance traveled, the greater the chance of using the motor vehicle. Therefore, it increases the number of emissions released by the vehicle.

3.3.2. *Transportation Preference Characteristics.* In this discussion, it will be identified the tendency of transportation preference used by respondents to go to school.

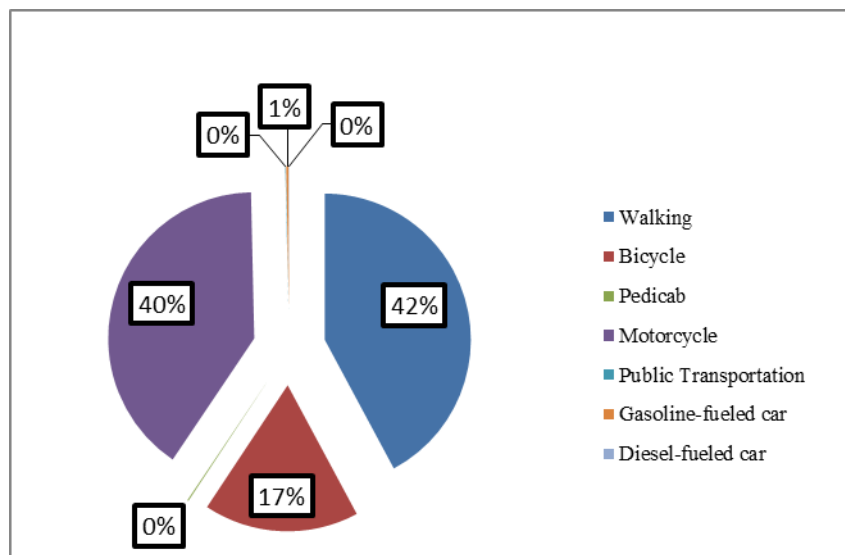


Figure 6. Respondents’ preference of Transportation Mode Diagram inside the NU Zone.

The most preferred modes of transportation by the respondents who attend the same neighborhood school unit are walking (42%), motorcycle (40%), and bicycle (1%). The findings indicated that, although the distance between home and school in a NU is just less than 1000 meters, the number of motor vehicle usage is quite high.

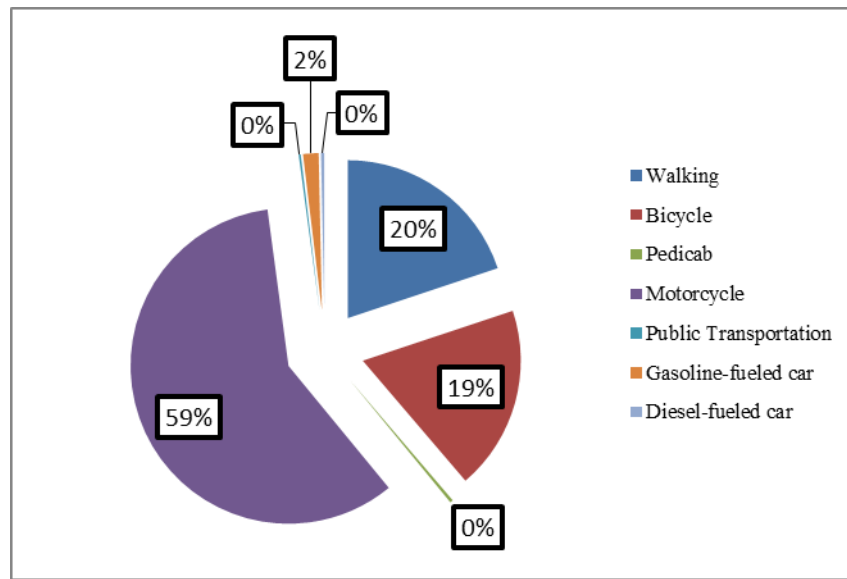


Figure 7. Respondents' transportation preference diagram outside the NU zone.

In the group of respondents who choose to go to school outside the NUs, the use of motorcycles shows a fairly high number, because it has a percentage of more than 50%. Based on the data above, it can be seen that the respondents who go to school outside the NU tend to choose motorized vehicles to go to their school.

Table 5. The preference type of transportation used by students.

Typology	Types of Transportation (%)						
	Walking	Bicycle	Pedicab	Motorcycle	Public transportation	Gasoline-fueled car	Diesel-fueled car
1	26	19	1	49	1	2	2
2	28	17	2	51	-	2	-
3	25	17	-	56	-	2	-
4	28	19	-	51	-	2	-
5	37	20	-	43	-	-	-
6	33	16	1	50	-	-	-
7	-	-	-	-	-	-	-
8	24	13	-	63	-	-	-

From Tabel 5, it can be seen that the use of motor vehicles, in general, is still the main choice of transportation used to go to school. Even in typology 8, where there is a NU that meet all criteria of child-friendly, the use of motor vehicles reaches more than 50%.

3.4. Ecological Impact Analysis based on Movement Characteristics

3.4.1. Existing CO₂ Gas Emissions. Transportation is one of the activities that produce air pollutants in the form of CO₂, contributing to a global warming index [11]. The movement of children to elementary school also has great potential in increasing the amount of air pollutants, especially when the children's companions use motor vehicles. The following is the calculation of the average amount of existing CO₂ gas emissions in each typology based on the use of motor vehicles.

Table 6. Average Existing CO₂ Gas Emissions.

Typology	The average of CO ₂ (g/day)
1	2,959,728.04
2	203,007.63
3	112,615.69
4	274,571.70
5	250,074.146
6	316,205.91
7	-
8	49,578.86
Surakarta City	1,463,211.80

3.4.2. *CO₂ Gas Emissions After Intervention.* Interventions are conducted in a condition where the entire NU in each typology has met all criteria of a child-friendly NU. Then, the number of CO₂ in every NU in each typology is calculated with the following results.

Table 7. The Average of CO₂ Gas Emissions After Intervention

Typology	The average of CO ₂ (g/day)	The average changes of CO ₂ (%)
1	174,730.02	-94.10
2	187,023.61	-7.87
3	111,550.48	-0.95
4	166,934.31	-39.20
5	141,123.32	-43.57
6	192,183.90	-39.22
7	-	-
8	49,578.86	0
Surakarta City	173,582.83	-88.14

From the results of calculation, it can be seen that all typologies have decreased the number of CO₂ after all criteria of child-friendly NUs are met in every NU in each typology.

Typology 1 shows the decreasing number of CO₂ emissions after the intervention. The characteristics of NUs in typology 1 do not meet all criteria of child-friendly. However, the data shows that the intervention process in this typology plays a role in decreasing the amount of CO₂ emissions.

Other typologies also show that the number of CO₂ emissions are decreased after the intervention. On the other hand, the NU group on typology 8 is not intervened because it has already fulfilled all criteria of child-friendly NU.

The data also reveals that the number of CO₂ emissions released by motor vehicles from the school children's shuttle activity in Surakarta is decreased. That can be done by fulfilling all three criteria of child-friendly in each NU.

4. Conclusion

The findings showed that Surakarta residences do not consider the child-friendly NU criteria in choosing an elementary school. This can be seen from the majority of student who prefer to study in the schools outside their NU. It certainly leads to greater emissions due to the movement of students when commuting to and from their schools every day. Simulated interventions in each typology showed that fulfillment of all three child-friendly NU criteria can reduce overall CO₂ emissions in Surakarta by 88.14%.

Acknowledgments

Authors would like to thank all the elementary school students who fulfilled the questionnaire as a part of the data in this research.

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Submission date: 31-Dec-2018 08:50AM (UTC+0700)

Submission ID: 1060936472

File name: 3_Rini_2018_IOP_Conf._Ser._3A_Earth_Environ._Sci._129_012022.pdf (1.07M)

Word count: 4194

Character count: 21931

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To cite this article: E F Rini *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **129** 012022

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2. Methodology

2.1. Neighborhood Unit Distribution in Surakarta

For the process of identification and intervention, in this study, Surakarta is divided into several NUs. This division process is conducted through the use of ArcGIS mapping software. There are three aspects that serve as the main input: (1) a social scale facility around the elementary school distance (equal to 800 m), (2) the environmental administration boundaries (RT and RW), and (3) the physical boundaries.

2.2. NU Typology Formulation Based on child-friendly criteria

The criteria of NU child-friendly city used to assess the characteristics of NU in Surakarta are:

Table 1. The criteria and indicator used to identify suitability for each NU in Surakarta.

Criteria	Indicator	
	NU zone characteristic	
	Suitable	Not suitable
1 Service capacity to residents	≤1600 residents/elementary school (ratio ≤0.000625)	>1600 residents/elementary school (ratio > 0.000625)
2 Children's safety and comfort in accessing social infrastructure	All criteria are suitable	There is a criterion which is not suitable
a. Walking distance on foot to reach the school by children	≤800m to reach on foot	> 800m to reach on foot
b. Free from unwanted traffic across the roads	All of the internal roads (which connected to the local or collector roads) meet indicators: • 3.5-6 meters wide of road • has a difference of width or pavement between the different road function to reduce the vehicle speed when entering the NU area	Not meet the two indicators
c. Separator between pedestrian and main street	Has separator between pedestrian and main street on local roads, collectors, and arteries	No separator between pedestrian and main street
d. Children's safety in crossing the street	- Utilize with zebra cross or pedestrian bridge - Utilize with school zone mark(ZoSS)	Not meet the two indicators
3 Access of elementary school utilization by all children including disabled	Inclusion school	Not accepting children with special needs

From the criteria above, the NUs can be formulated into eight typologies of NUs that are derived from a combination of the results of the conformity of those three criteria.

2.3. *The Identification of Child Movement Characteristic in Accessing Elementary School*

Movement characteristics in this study are the distance between school and the transportation. In this step, it can be known the distance traveled by each student to their school. From those data, we can analyze the average distance traveled by each respondents, either who choose to go to school inside or outside the NU. For the characteristics of transportation preferences, the respondent data will be classified based on the NU typology. The data are then analyzed to know the tendency of the transportation preferences of the respondents who attend school in and outside the NU.

2.4. *Ecology Impact Analysis Based on Movement Characteristics*

2.4.1. *CO₂ Emission Based on Movement Characteristics.* The energy used by the students to go to school produces a combustion gas that impacts on air condition around the student movement areas. To understand the impacts of the combustion gas, it is necessary to identify the sources of air pollutants and the number of emissions released.

Table 2. Vehicle Emission Factors [9].

Category	CO ₂ (g/km)
Motorcycle	0.398
Passenger car	0.663
Urban Buses Standard	2.65

Meanwhile, the following formula can be used to calculate the amount of emissions in a region based on the vehicle types and its distance [10]:

$$TE = \sum_j (N_j \times M_j \times EF_{i,j}) \tag{1}$$

- TE = Total emissions of gas in a region (g)
- N_j = Number of vehicles type j used in a region
- M_j = average distance per vehicle type j (km)
- EF_{i, j} = emission factor for pollutant i and vehicle type j (g/ km)

2.4.2. *The Average of Existing CO₂ Gas Emissions in Each Typology.* Based on the formula above, the process of calculating CO₂ emissions of existing gas begins by calculating the number of CO₂ emissions in each vehicle type in each NU. After knowing the amount of emissions of existing CO₂ gas in each type of vehicle in each NU, the total amount of CO₂ emissions in each typology is calculated to know the total number of CO₂ emissions in the typology.

2.4.3. *The Average of CO₂ Gas Emissions After Intervention on Each Typology.* Interventions are made if the three criteria of child-friendly NUs are fulfilled in all NU. The intervention is formulated by multiplying the number of students on each NU intervened by constants. The constants are obtained from the average of each student’s emissions on the ideal NU.

3. Result

3.1. *The Distribution of NU in Surakarta*

Surakarta has totally 263 elementary schools (or those that are equivalent with public elementary schools), private elementary schools, Madrasah Ibtidaiyah (MI) and schools for children with special needs (SLB). Based on the coverage analysis of elementary schools (800 m); overall, the existence of elementary schools in Surakarta has been able to serve almost all areas of Surakarta. The area that is not served by the existence of elementary schools/equivalent is situated in the West Surakarta,

precisely in the westernmost Karangasem Village. However, the area is still served by the existence of other elementary schools that are administratively located outside Surakarta.

In deciding the limit of the NU, administrative boundaries are used with local service scales, such as neighborhood units (NU) and community units (CU). Some limitations in determining NU are necessary because each NU can consist of 30-50 family with four persons in each family. Thus, the provisions in a NU is related to the standard of elementary school services serving (<1600 people) which can be seen from the administrative boundaries of NU and CU. Ideally, the NU has alleys inside and surrounded by road functions higher than alley. But it is not used as the consideration in determining the boundary of NU in Surakarta.

The results of the analysis of those three aspects revealed that there are 108 NUs that are close to elementary schools inside or outside the NU itself, and one NU that does not have any school facility.

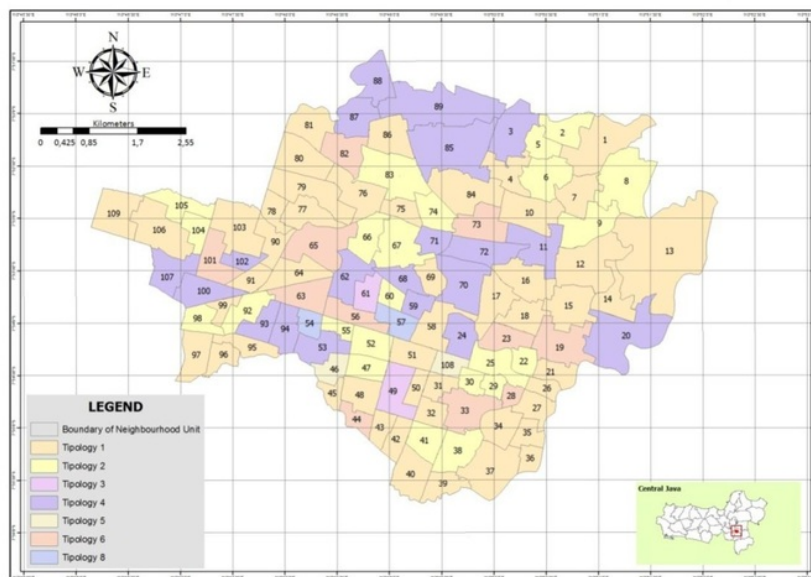


Figure 1. Neighborhood unit distribution in Surakarta.

3.2. Neighborhood Unit Typology in Surakarta based on Child-friendly city criteria

The method of grouping the NU in Surakarta to each typology starts with the identification of each NU based on the three criteria of child-friendly city.

3.2.1. Elementary School Services Capacity Towards the Total Population. The elementary school service capacity criteria are used to identify the existence of elementary schools in a NU as well as its capacity to serve a certain population. A NU can meet the criteria of the capacity of elementary school services to the population if its entire population is able to be served by the elementary schools within the same NU. In calculating the number of residents, it is assumed that every house is inhabited by five family members. Meanwhile, one elementary school unit is supposed to serve 1600 residents. The result indicated that there are 38 NUs that meet the criteria of elementary school service capacity towards the total population. On the other hand, there are totally 71 NUs that do not meet that criteria.

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3.2.2. The Children's Safety and Comfort in Accessing Social Infrastructure. A NU can be said to meet the criteria of children's safety and comfort in accessing social infrastructure if it satisfies the following four sub-criteria:

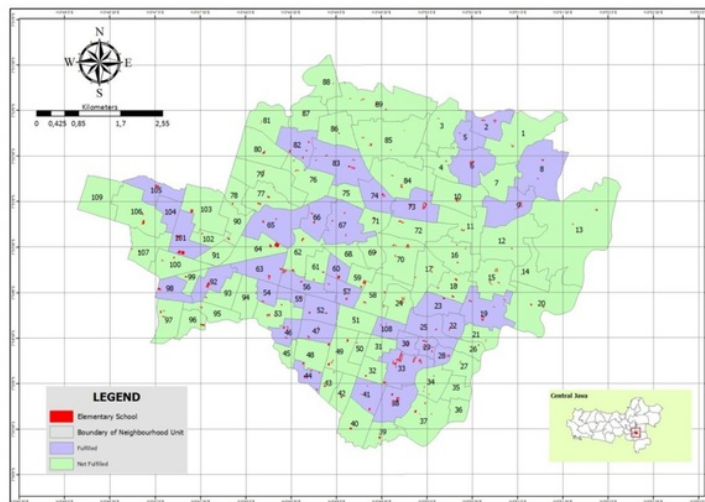


Figure 2. The suitability of NUs in Surakarta with the criteria of elementary school services capacity towards the total population.

3.2.2.1. *The distance to reach elementary school.* Ideally, the maximum distance for students to walk to their school is 800 m, which is the distance between the school and NU. From the result of analysis, there are totally 108 NUs that meet the criteria whereas one NU do not satisfy the criteria.

3.2.2.2. *Free from unwanted traffic across the road.* There is one NU that is traversed by the alley and limited by the road function above the neighborhood. The difference of road function as the boundary of the NU must also be accompanied by traffic calming utilities to enter the NU area. Those traffic calming utilities are the difference of width and pavement between the roads and portal at the entrance of the NU. From the result of identification, it is known that there are 30 NUs that meet the criteria of the free traffic jam, while 79 NUs do not satisfy the criteria.

3.2.2.3. *The existence of a separator between pedestrian and main street.* It can be road markings or the clarity of the boundary between the main road and the pedestrian, either with a barrier or high street difference. The analysis showed that 76 NUs meet the sub-criteria of separation between pedestrian and the main road, while 33 other NUs do not.

3.2.2.4. *Children's safety in crossing the street.* The fulfillment of criteria for children's safety in crossing the street can be identified from the existence of child safety support facilities in the traffic. The facilities can be in the form of zebra cross, pedestrian bridges, and school zone marks (ZOSS). Based on the result of identification, there are 33 NUs that were appropriate whereas 76 other NUs were considered to be inappropriate.

Based on the four criteria above, the result of the assessment showed that six neighborhoods meet all those four sub-criteria while the other 103 NUs only meet several sub-criteria. The following is a map of the NUs suitability in Surakarta with the criteria of free traffic.

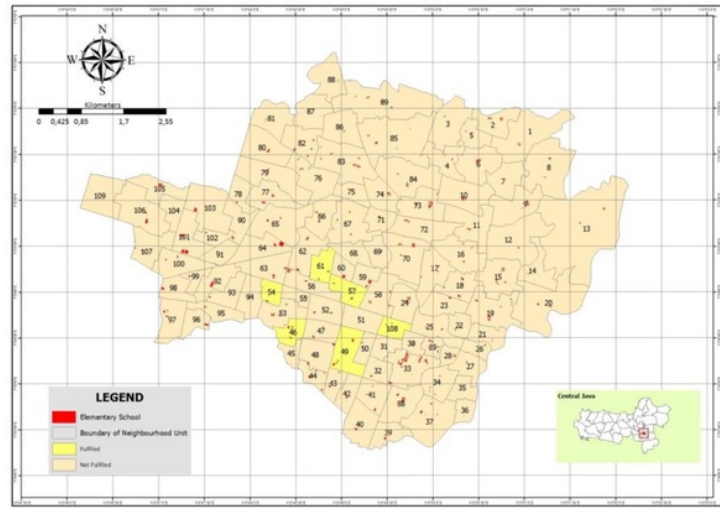


Figure 3. The suitability of NUs in Surakarta with the criteria of children’s safety and comfort in accessing social infrastructure.

3.2.3. *The Access to Elementary School Utilization.* The identification of elementary schools existence that can be accessed by all children, including the disabled, is conducted through listing the existing inclusion schools in Surakarta. The inclusion school is a public elementary school (not elementary schools for disabled) appointed by the government of Surakarta to educate children with special needs.

The result of analysis revealed that there are 26 NUs that meet these criteria, while the other 83 NUs do not. The following is a map of the conformity of the NU in Surakarta with the criteria of the access of elementary schools utilization by all children.

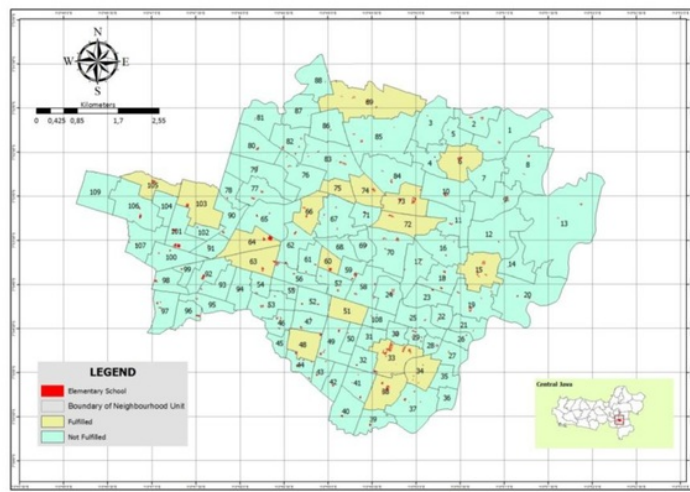


Figure 4. The conformity of NU with the criteria of elementary school utilization by all children including disabled.

After identifying the NU conformity in Surakarta based on three criteria of the child-friendly neighborhood, the NU is then classified into a typology that is in accordance with the results of the criteria assessment. The following are the distribution of NU based on the typology that has been formulated before.

Table 3. Neighborhood unit grouping based on typology.

Typology	Conformity criteria (1-2-3)	Neighbourhood unit	Total	Percentage
1	NS-NS-NS	1-4-7-10-12-13-14-15-16-17-18-21-26-27-31-32-34-35-36-37-39-40-42-43-45-48-50-51-58-64-69-75-76-77-78-79-80-81-84-86-90-91-95-96-97-99-103-106-109	49	44.95%
2	S-NS-NS	2-5-6-8-9-22-25-29-30-38-41-47-52-55-60-66-67-74-83-92-98-104-105	23	21.10%
3	NS-S-NS	49-61	2	1.83%
4	NS-NS-S	3-11-20-24-53-59-62-68-70-71-72-85-87-88-89-93-94-100-102-107	20	18.35%
5	S-S-NS	46-108	2	1.83%
6	S-NS-S	19-23-28-33-44-56-63-65-73-82-101	11	10.09%
7	NS-S-S	-	0	0%
8	S-S-S	54-57	2	1.83%

S = Suitable NS = Not suitable

3.3. The Identification of Child Movement Characteristic in Accessing Elementary School in Surakarta

3.3.1. *Distance Characteristics.* Identification of distance characteristics can be analyzed by using the distance data of respondent of elementary school students/equal from their house to school. The distance characteristic is divided into 2 groups, first is a respondent who goes to school inside residence and second is he/she who goes to school outside his/her NU residence.

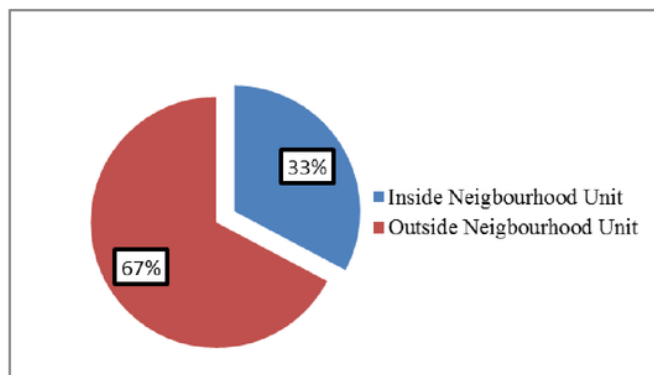


Figure 5. Students' movement diagram.

Table 4. Students' average distance on each typology.

Typology	Distance average (Meter)	
	inside NU	outside NU
1	232	1,696
2	264	1,688
3	297	1,307
4	302	1,917
5	301	1,437
6	292	1,672
7	-	-
8	291	1,390

The distance characteristic shows that the respondents likely tend to choose schools that are outside the NU residence. This is the character of most students in Indonesia who prefer to study in favorite schools. The number of movement outside the NU is greater than the movement inside the NU, with the average distance of respondents to the school reached more than 1 km or beyond the reach of elementary school services (800 meters). This distance can also indicate the use of vehicle by respondents. The farther the distance traveled, the greater the chance of using the motor vehicle. Therefore, it increases the number of emissions released by the vehicle.

3.3.2. *Transportation Preference Characteristics.* In this discussion, it will be identified the tendency of transportation preference used by respondents to go to school.

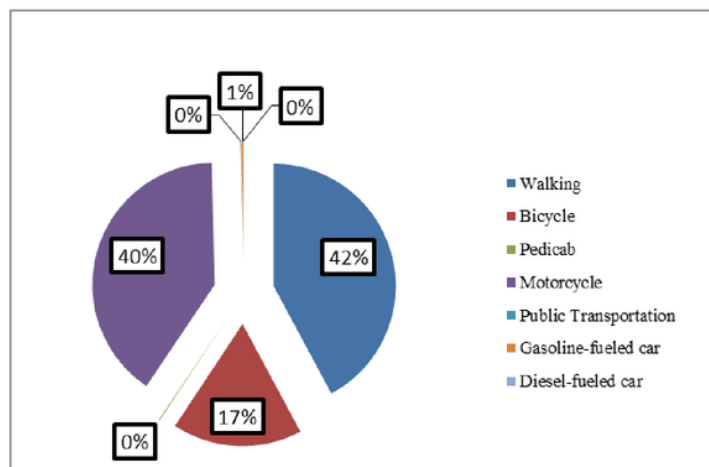


Figure 6. Respondents' preference of Transportation Mode Diagram inside the NU Zone.

The most preferred modes of transportation by the respondents who attend the same neighborhood school unit are walking (42%), motorcycle (40%), and bicycle (1%). The findings indicated that, although the distance between home and school in a NU is just less than 1000 meters, the number of motor vehicle usage is quite high.

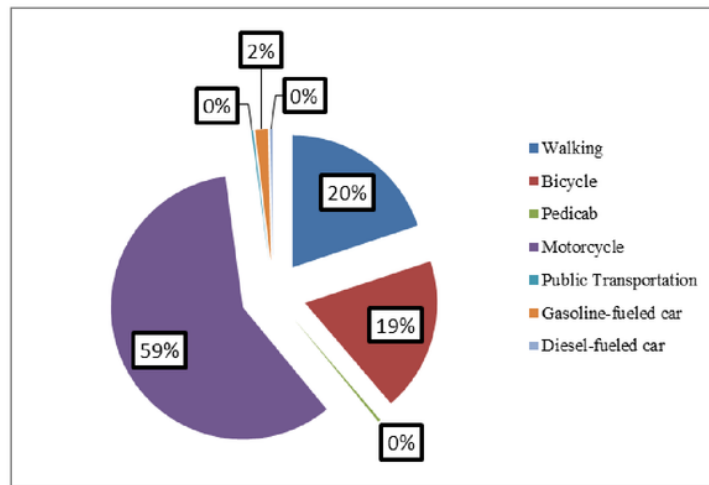


Figure 7. Respondents' transportation preference diagram outside the NU zone.

In the group of respondents who choose to go to school outside the NUs, the use of motorcycles shows a fairly high number, because it has a percentage of more than 50%. Based on the data above, it can be seen that the respondents who go to school outside the NU tend to choose motorized vehicles to go to their school.

Table 5. The preference type of transportation used by students.

Typology	Types of Transportation (%)						
	Walking	Bicycle	Pedicab	Motorcycle	Public transportation	Gasoline-fueled car	Diesel-fueled car
1	26	19	1	49	1	2	2
2	28	17	2	51	-	2	-
3	25	17	-	56	-	2	-
4	28	19	-	51	-	2	-
5	37	20	-	43	-	-	-
6	33	16	1	50	-	-	-
7	-	-	-	-	-	-	-
8	24	13	-	63	-	-	-

From Tabel 5, it can be seen that the use of motor vehicles, in general, is still the main choice of transportation used to go to school. Even in typology 8, where there is a NU that meet all criteria of child-friendly, the use of motor vehicles reaches more than 50%.

3.4. Ecological Impact Analysis based on Movement Characteristics

3.4.1. *Existing CO₂ Gas Emissions.* Transportation is one of the activities that produce air pollutants in the form of CO₂, contributing to a global warming index [11]. The movement of children to elementary school also has great potential in increasing the amount of air pollutants, especially when the children's companions use motor vehicles. The following is the calculation of the average amount of existing CO₂ gas emissions in each typology based on the use of motor vehicles.

Table 6. Average Existing CO₂ Gas Emissions.

Typology	The average of CO ₂ (g/day)
1	2,959,728.04
2	203,007.63
3	112,615.69
4	274,571.70
5	250,074.146
6	316,205.91
7	-
8	49,578.86
Surakarta City	1,463,211.80

3.4.2. *CO₂ Gas Emissions After Intervention.* Interventions are conducted in a condition where the entire NU in each typology has met all criteria of a child-friendly NU. Then, the number of CO₂ in every NU in each typology is calculated with the following results.

Table 7. The Average of CO₂ Gas Emissions After Intervention

Typology	The average of CO ₂ (g/day)	The average changes of CO ₂ (%)
1	174,730.02	-94.10
2	187,023.61	-7.87
3	111,550.48	-0.95
4	166,934.31	-39.20
5	141,123.32	-43.57
6	192,183.90	-39.22
7	-	-
8	49,578.86	0
Surakarta City	173,582.83	-88.14

From the results of calculation, it can be seen that all typologies have decreased the number of CO₂ after all criteria of child-friendly NUs are met in every NU in each typology.

Typology 1 shows the decreasing number of CO₂ emissions after the intervention. The characteristics of NUs in typology 1 do not meet all criteria of child-friendly. However, the data shows that the intervention process in this typology plays a role in decreasing the amount of CO₂ emissions.

Other typologies also show that the number of CO₂ emissions are decreased after the intervention. On the other hand, the NU group on typology 8 is not intervened because it has already fulfilled all criteria of child-friendly NU.

The data also reveals that the number of CO₂ emissions released by motor vehicles from the school children's shuttle activity in Surakarta is decreased. That can be done by fulfilling all three criteria of child-friendly in each NU.

4. Conclusion

The findings showed that Surakarta residences do not consider the child-friendly NU criteria in choosing an elementary school. This can be seen from the majority of student who prefer to study in the schools outside their NU. It certainly leads to greater emissions due to the movement of students when commuting to and from their schools every day. Simulated interventions in each typology showed that fulfillment of all three child-friendly NU criteria can reduce overall CO₂ emissions in Surakarta by 88.14%.

Acknowledgments

Authors would like to thank all the elementary school students who fulfilled the questionnaire as a part of the data in this research.

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Status Pengusul : ~~Penulis pertama~~ / penulis ke 3/ ~~penulis korespondensi~~**

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c. Tahun Terbit, Tempat Pelaksanaan : **Surakarta, 24-26 Oktober 2017**

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Judul Karya Ilmiah (paper) : The Ecological Impact of Primary Education Facilities Based on a Child-Friendly Neighborhood Unit Criteria in Surakarta

Jumlah Penulis : 4 Orang (EF Rini, RA Putri, **Mulyanto**, N Handayani)

Status Pengusul : ~~Penulis pertama~~ / penulis ke 3/ ~~penulis korespondensi**~~

Identitas Prosiding :

a. Nama Prosiding : **International Conference on Climate Change: Challenges and Opportunity on Environment Degradation Researches**

b. ISBN/ISSN : -

c. Tahun Terbit, Tempat Pelaksanaan : **Surakarta, 24-26 Oktober 2017**

d. Penerbit/organiser : **IOP Publishing**

e. Alamat repository PT/web : <http://iopscience.iop.org/article/10.1088/1755-1315/129/1/012022>

f. Terindeks di (jika ada) :

Kategori Publikasi Makalah : Prosiding Forum Ilmiah Internasional
(beri ~ pada kategori yang tepat) Prosiding Forum Ilmiah Nasional

Hasil Penilaian Peer Review :

Komponen Yang Dinilai	Nilai Maksimal Prosiding 15		Nilai Akhir Yang Diperoleh
	Internasional <input type="checkbox"/>	Nasional <input type="checkbox"/>	
a. Kelengkapan unsur isi paper (10%)	1.5		1.5
b. Ruang lingkup dan kedalaman pembahasan (30%)	4.5		4.5
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Total = (100%)	15		12
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Catatan Penilaian artikel oleh Reviewer :

- a. Kelengkapan dan kesesuaian unsur isi artikel : Artikel ini sesuai dengan aturan seminar internasional International Conference on Climate Change: Challenges and Opportunity on Environment Degradation Researches di Surakarta (abstract, introduction, literature review, methodology, result, references) (skor=1.5)
- b. Ruang lingkup dan kedalaman pembahasan : Ruang lingkup studi ini adalah Dampak lingkungan terhadap fasilitas pendidikan dasar di Kota Surakarta, dikaji cukup mendalam dengan analisis kuantitatif dan spasial. (skor=4.5)
- c. Kecukupan dan pemutakhiran data/informasi dan metodologi : Secara umum paper ini menggunakan data dan informasi yang cukup mendalam serta metodologi yang cukup lengkap yakni kuantitatif dan spsial skor =3.5)
- d. Kelengkapan unsur dan kualitas terbitan : Paper ini dipresentasikan di sebuah konferensi internasional yakni International Conference on Climate Change: Challenges and Opportunity on Environment Degradation Researches di Surakarta yang cukup bergengsi (skor=2.5)
- e. Indikasi plagiat: Tidak ada indikasi plagiarism
- f. Kesesuaian bidang ilmu: Sangat sesuai bidang ekonomi terutama dalam bidang ekonomi regional

Surakarta, 04 MAY 2020

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Jabatan : Lektor Kepala

Pangkat, Gol Ruang : Pembina/IVa

Unit Kerja : FEB UNS

Bidang Ilmu : Ekonomi Pembangunan

*Dinilai oleh dua Reviewer secara terpisah

**Coret yang tidak perlu