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Article

Implementation of carbon tax policies to encourage the use of public transportation in cities

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Abstract: The use of public transport is one of the concepts of sustainable transport. However, people prefer to use private vehicles, which causes various problems, one of which is the high carbon emissions produced. This research aims to encourage programs to use passenger public transportation through a carbon tax. The method in this research is descriptive quantitative with primary data and secondary data. Secondary data was developed in the research by collecting literature study sources on the concept of sustainable transportation development as well as primary data carried out by analyzing calculations regarding the implementation of the carbon tax. There are several proposals that can significantly accelerate the achievement of goals, namely a collaborative approach through collaboration between local government agencies, a policy of progressively implementing a carbon tax as a coercive policy and supported by a program to provide supporting facilities for public transportation. Decision making in this research was carried out by looking at the percentage increase in public transportation use based on the application of a carbon tax or carbon tax.

Keywords: collaborative approach; public transportation; carbon tax; sustainable transportation

1. Introduction

Sustainable development has become an agenda for Indonesia and all member countries of the United Nations (UN) by 2030 to provide prosperity and peace for the people and the earth they live on (Megaartha, 2021). This agenda can also be applied to the transport sector by implementing sustainable transport. Sustainable transport in general is a movement concept that encourages the use of environmentally friendly technologies to meet people's transportation needs, such as the construction of pedestrian facilities, improving facilities for cyclists, and providing cheap, friendly and environmentally friendly public transport that reduces the use of private vehicles (Gusnita, 2010).

However, it is dominated by private motorcycles. In 2021, the number of motorbike vehicles in Indonesia will reach 141,996,832 units, with the following details: 120,045,878 motorbikes, 16,413,522 passenger cars, 5,299,603 trucks, and 237,829 units (Central Statistics Agency, 2021). In West Bandung Regency, the number of motorcycle users also occupies the first position with 535,359 units, passenger cars 66,197 units, trucks 20,851 units, and buses 502 units. The high use of private motorcycles can cause traffic problems in the form of congestion. Traffic congestion causes serious problems such as fuel waste, waste of time, and high pollution caused by the high amount of vehicle carbon emissions, so that it can result

in a decline in public health. Of course, this is still very contrary to the concept of sustainable transportation and there needs to be an effort to overcome it. Various efforts have been made by the government through programs, strategies, and policies to overcome these problems. The government's strategies and efforts need to be supported and encouraged by making efforts to accelerate the program so that it can be implemented immediately. Seeing the existing problems, the author has an idea to encourage the use of public transportation in urban areas through the implementation of carbon tax policies. A collaborative approach through collaboration between government agencies is carried out in the implementation of carbon taxes. Thus, it is hoped that it can reduce the use of private vehicles and switch to using public transportation as the first step in realizing sustainable transportation.

2. Theoretical perspective

2.1. Carbon tax

Carbon tax is a tax imposed by the government on fossil fuel users on their carbon emissions (Selvi and Idar, 2020). This is done in an effort to reduce the negative impact of carbon emissions on the environment and increase state revenue (Maghfirani et. al, 2022). Carbon pricing is a form of compensation that must be paid by polluters to the public for environmental damage due to carbon emissions (Saputra, 2021). The implementation of carbon taxes in the transportation sector is one way to realize sustainable transportation. Sustainable transportation is a transportation concept in which the entire continuity of the transportation system adheres to the compatibility between humans and the surrounding environment. Sustainable transportation is environmentally friendly transportation that suppresses the negative impact of its own use, such as high fuel use and vehicle emissions, safety and congestion levels, and accessibility to the community, so that it does not harm the next generation, and can continue to be used (Nugraha et al., 2020). A sustainable transportation system is guided by the fact that the resources used during mobility will not have a negative impact on people and the environment, both now and in the future (Frazila et al., 2021). To strive for a clean environment without the negative impact of transportation mobility, it is necessary to balance the use of resources in transportation, minimize environmental pollution caused, and protect habitats (Ayuningtias, 2019).

2.2. Public transportation

Passenger public transportation is public transportation that is used as passenger transportation and is subject to tariffs or fees. There are several types of vehicles that are commonly used as public transportation, including taxis, public transportation, and buses (Sugianto and Kurniawan, 2020). Public transportation is one of the facilities that must be provided by the government to be able to serve the transportation needs of the community. This is because public transportation is a much more efficient mode than private transportation, especially to avoid traffic problems. The existence of public transportation equipped with good supporting

facilities will certainly attract people to use or switch to public transportation instead of private transportation so that traffic problems can be solved.

2.3. Collaborative approach

A collaborative approach requires stakeholders with different goals to work together if learning is to yield reliable knowledge (Buck et al., 2001). The collaborative approach emphasizes the importance of building a new policy discourse on the quality of a place, developing collaboration between stakeholders in policy development and delivery, expanding stakeholder engagement beyond the traditional power elite, recognizing different forms of local knowledge, and building rich social networks as resources (Healey, 1998). The entire collaborative process involves many people and several parties, many of whom work within a certain period of time (Helling, 1998). A collaborative approach will work if all parties bargain in good faith and will be less effective if they do not (Daniels, 2001). In the implementation of a policy, a collaborative approach is needed as the basis of a plan, so that in this case the implementation of the policy is carried out for the community to be able to move to public transportation because of a policy related to carbon taxes that are considered detrimental to the community if they use private vehicle modes.

3. Materials and methods

This research was conducted in the West Bandung Regency area. The target in this study is areas with routes that have been passed by public transportation, namely 7 routes. The data needed in this study is divided into 2 (two) data groups, namely primary data and secondary data with the location of the research in the West Bandung Regency area.

This study uses a quantitative descriptive method where in the process of collecting secondary data is carried out using comparative or comparative techniques, while the primary data uses data from the survey results of private transportation that passes on public transportation routes in West Bandung Regency.

a) Problem identification

The problem was found in the research area after direct observation. After finding the existing problems, the next stage is to take several problems to be formulated.

b) Data collection

In this study, the data are grouped into 2 (two), namely:

1) Primary data

In this study, primary data is data on the number of private vehicles in the form of motorcycles and cars that pass on every public transportation route in the West Bandung Regency area.

2) Secondary data

Secondary data in this study came from related agencies and scientific articles.

c) Data analysis

Data analysis is used to assist in solving problems through the data processing process.

1) Recapiting the policy of restricting private vehicles through the implementation of a carbon tax.
2) Calculate the amount of emissions produced from each private vehicle that passes on each AU route in the West Bandung Regency area.
3) Calculate revenue from the imposition of carbon tax in the study area.
4) Formulate government policies that are implemented through a collaborative approach and record the percentage increase in public transportation use due to the implementation of carbon tax.

d) Output

The output of this research is in the form of the implementation of the carbon tax policy and the presentation of the increase in the use of public transportation caused by the implementation of this policy.

4. Results and discussion

4.1. Analysis of private vehicle restriction policy through carbon tax

The implementation of the carbon tax is an effort to reduce exhaust gas emissions in fossil fuel motor vehicles and is currently set on a national scale as a fiscal policy. The implementation of carbon tax in Indonesia has been implemented since the promulgation of Law Number 7 of 2021 concerning the Harmonization of Tax Regulations and Presidential Regulation Number 98 of 2021 concerning the Application of Carbon Economic Value for the Achievement of National Contribution Targets and Greenhouse Gas Emission Control in Indonesia. National Development at a rate of IDR 30 per kg of CO2e. However, until now, the implementation of carbon taxes has not been implemented in all fields and regions in Indonesia. Seeing the problem of high carbon emissions, the local government of West Bandung Regency should immediately overcome it by utilizing the right to regional autonomy. Regional autonomy is the right, authority, and obligation of autonomous regions to regulate and manage their own regions.

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4.2. Analysis of the amount of emissions and potential local revenue from carbon tax

The following are the emission factors of vehicles in Indonesia can be seen in **Table 1**.

Table 1. Vehicle emission factors in Indonesia.

Vehicle category	CO (g/km)	NOx (g/km)	PM10 (g/km)	CO2 (g/kg BBM)	SO2 (g/km)	Total emissions (gr/km)
Motorcycle	14	0.29	0.24	3180	0.008	3194.52
Car (Gasoline)	40	2	0.01	3180	0.026	3222.03
Car (Diesel)	2.8	3.5	0.53	3172	0.44	3179.27

Source: State Minister for the Environment, 2010.

Carbon monoxide (CO) emissions of motorcycle vehicles in this study are influenced by the length of the road section, the number of motorcycle vehicles, and vehicle emission factors. The emission factor is the mass of pollutants (grams) emitted by motorcycles per km traveled (Tarigan, 2009). Vehicle emission factors are listed in **Table 1.** This emission factor is based on the Regulation of the Minister of Environment Number 12 of 2010 concerning the Implementation of Air Pollution Control in the Region which is divided into 5 groups, namely motorcycles, diesel cars (diesel vans/minibuses, diesel jeeps), gasoline-fueled cars (sedans, taxis, and pickups), buses, and truck (State Minister for the Environment, 2010). In this study, the emission factor used is CO gas, and the vehicles whose emission burden is calculated are only motorcycles, gasoline cars, and diesel cars. Based on the emission factors issued, the emission burden emitted by motorcycles, gasoline-fueled cars, and diesel cars can be calculated based on the type of pollutant using the formula regulated in the Regulation of the Minister of Environment Number 12 of 2010 concerning the Implementation of Air Pollution Control in the Region. The emission load formula can be seen as follows:

$$E = \mathrm{V.Vehicle} \times \mathrm{VKT} \times \mathrm{FE} \times 10^{-6}$$

Information:

E: Emission load (tons/year)

V.Vehicle: Vehicle number/year

VKT: Total length of journey covered (km)

FE: Emission Factor (g/km/vehicle)

The following is the result of the analysis of the calculation of emission loads on motorcycles, which can be seen in **Table 2**.

From **Table 2**, it can be seen that the emission burden of motorcycle type vehicles is the highest, namely on the A05 route of 1,873,136.70 tons/year. While the lowest on the route is 370,731.97 tons/year. This is influenced by the length of the road passed by motorcycles and the volume of vehicles in units of vehicles per year.

The following is the result of calculating the emission burden on cars with gasoline fuel can be seen in **Table 3**.

Table 2. Emission load on motorcycles.

Route	Motorcycle (liters/h)	Motor (vehicle/year)	Road length (km)	Emission load (tons/year)
a	*b*	$c = b \times 8760$	*d*	*e*
A01 (Padalarang-Cipendeuy)	2813	24,641,880	20	1,574,379.57
A02 (Padalarang-Gunung Bentang)	1520	13,315,200	9	382,821.05
A04 (Padalarang-Parompong)	1201	10,520,760	48	1,613,221.36
A05(Padalarang-Rajamandala	2789	24,431,640	24	1,873,136.70
B01 (Cililin-Gunung Halu)	1630	14,278,800	18	821,050.42
B02 (Cililin-Baranangsiang)	1340	11,738,400	21	787,469.62
C06 (Lembang-Cisarua)	1104	9,671,040	12	370,731.97

Source: Analysis Results, 2024.

Table 3. Emission burden on gasoline cars.

Route	Gasoline car (vehicle/h)	Gasoline cars (vehicle/year)	Road length (km)	Emission load (tons/year)
a	*b*	$c = b \times 8760$	*d*	*e*
A01 (Padalarang-Cipendeuy)	654	5,729,040	20	366,030.66
A02 (Padalarang-Gunung Bentang)	454	3,977,040	9	114,342.60
A04 (Padalarang-Parompong)	654	5,729,040	48	878,473.58
A05(Padalarang-Rajamandala	610	5,343,600	24	409,685.69
B01 (Cililin-Gunung Halu)	453	3,968,280	18	228,181.50
B02 (Cililin-Baranangsiang)	398	3,486,480	21	233,890.23
C06 (Lembang-Cisarua)	364	3,188,640	12	122,234.09

Source: Analysis Results, 2024.

From **Table 3**, it can be seen that the emission burden of Car-type vehicles with the highest gasoline fuel is on the A04 route of 878,473.58 tons/year. While the lowest on the B01 route is 228,181.50 tons/year. This is influenced by the length of the road or route passed by motorcycles and the volume of vehicles in units of vehicles per year.

Then for the emission burden of car type vehicles with diesel fuel can be seen in the calculation results in **Table 4**.

Table 4. Emission load on diesel cars.

Route	Diesel car (vehicle/hour)	Diesel car (vehicle/year)	Road length (km)	Emission load (tons/year)
a	*b*	$c = b \times 8760$	*d*	*e*
A01 (Padalarang-Cipendeuy)	478	4,187,280	20	267,526.99
A02 (Padalarang-Gunung Bentang)	398	3,486,480	9	100,238.67
A04 (Padalarang-Parompong)	533	4,669,080	48	715,942.53
A05(Padalarang-Rajamandala	576	5,045,760	24	386,850.75
B01 (Cililin-Gunung Halu)	387	3,390,120	18	194,936.51
B02 (Cililin-Baranangsiang)	302	2,645,520	21	177,474.50
C06 (Lembang-Cisarua)	298	2,610,480	12	100,070.77

Source: Analysis Results, 2024.

From **Table 4**, it can be seen that the emission burden of Car-type vehicles with the highest gasoline fuel is on the A05 route of 386,850.75 tons/year. Meanwhile, the lowest on the C06 route is 100,070.77 tons/year. This is influenced by the length of the road or route passed by motorcycles and the volume of vehicles in units of vehicles per year.

Then, from the results of the calculation of the emission load on each vehicle, it can be known that the total emissions produced on the roads passed by public transportation in West Bandung Regency can be seen in **Table 5**.

Table 5. Total emission production in West Bandung Regency.

Route	Motorcycle	Gasoline car	Diesel car	Total emissions (tons/year)
a	*b*	*c*	*d*	$e = b + c + d$
A01 (Padalarang-Cipendeuy)	1,574,379.57	366,030.66	267,526.99	2,207,937.22
A02 (Padalarang-Gunung Bentang)	382,821.05	114,342.60	100,238.67	597,402.33
A04 (Padalarang-Parompong)	1,613,221.36	878,473.58	715,942.53	3,207,637.47
A05(Padalarang-Rajamandala	1,873,136.70	409,685.69	386,850.75	2,669,673.14
B01 (Cililin-Gunung Halu)	821,050.42	228,181.50	194,936.51	1,244,168.43
B02 (Cililin-Baranangsiang)	787,469.62	233,890.23	177,474.50	1,198,834.35
C06 (Lembang-Cisarua)	370,731.97	122,234.09	100,070.77	593,036.83

Source: Analysis Results, 2024.

From **Table 5**, it can be known that the total vehicle emissions of each route are in tons per year. One of them is the highest on the A04 route of 3,207,637.47 tons/year.

4.3. Analysis collaborative approach

The analysis of the collaboration approach requires synergy or influence by several local government institutions in West Bandung Regency, starting from the West Bandung Regency Transportation Office, the West Bandung Regency Environment Agency and regional revenue potential. The potential regional revenue from the carbon tax is the regional revenue obtained during the implementation of the carbon tax policy in West Bandung Regency. The calculation can be done by multiplying the total vehicle emission burden in kilograms per year by the predetermined carbon tax rate, which is Rp. 30. Thus, the calculation of potential regional revenue from carbon tax can be seen in **Table 6**.

Table 6. Potential regional revenue from carbon tax.

Route	Total emissions (ton/year)	Total emissions (kg/year)	Revenue from carbon tax/year (IDR)
a	*b*	$c = b \times 1000$	$d = c \times$ Rp. 30
A01 (Padalarang-Cipendeuy)	2,207,937.22	2,207,937,221.28	66,238,116,638.40
A02 (Padalarang-Gunung Bentang)	597,402.33	597,402,329.53	17,922,069,885.89
A04 (Padalarang-Parompong)	3,207,637.47	3,207,637,465.80	96,229,123,974.14
A05(Padalarang-Rajamandala	2,669,673.14	2,669,673,142.08	80,090,194,262.40
B01 (Cililin-Gunung Halu)	1,244,168.43	1,244,168,426.59	37,325,052,797.76
B02 (Cililin-Baranangsiang)	1,198,834.35	1,198,834,354.37	35,965,030,631.04
C06 (Lembang-Cisarua)	593,036.83	593,036,826.28	17,791,104,788.35

Source: Analysis Results, 2024.

From **Table 6**, it can be seen that the results of the calculation of the potential regional revenue from the carbon tax in West Bandung Regency will be generated within one year. Route A04 has the highest revenue potential compared to other routes in West Bandung Regency, which is Rp. 96,229,123,974.14.

In the analysis of the collaborative approach in this study, the standard scale of tax determination in Indonesia for motor vehicles, including motorcycles and cars is regulated in Law Number 28 of 2009 concerning Regional Taxes and Regional Levies. Where for motor vehicle tax is a tax that is imposed every year on motor vehicle owners. The amount of Motor Vehicle Tax (PKB) is usually regulated by the local government of each province, so the rate can vary slightly between provinces. In general, the scale of motor vehicle tax determination can be seen as follows:

1) New vehicles:
    a) Motor vehicle tax rate for cars: 2% of the selling value of motor vehicles.
    b) Motor vehicle tax rate for motorcycles: 2% of the selling value of motor vehicles.
2) Used vehicles:
    a) Motor vehicle tax rate for cars: The base rate is 1.5% of the selling value of motor vehicles, increasing by 0.5% annually until it reaches a maximum of 2.5%.
    b) Motor vehicle tax rate for motorcycles: The basic rate is 1.5% of the selling value of motor vehicles, increasing by 0.5% annually until it reaches a maximum of 2.5%.

With the implementation of the carbon tax policy, of course, it can attract interest in moving people to switch to using public transportation, because the implementation of the carbon tax is very burdensome for people who use private vehicles. The following is the percentage of potential displacement of people from private vehicles who want to use and move to public transportation can be seen in **Table 7**.

Table 7. The willingness to move people to move using public transportation.

The will to move	Total	Percentage
Willing (Motorcycle)	105	25.7%
Willing (Car Gasoline)	129	31.6%
Willing (Car Diesel)	94	23.1%
Not willing	80	19.6%
Total	408	100%

Source: West Bandung Regency PKL Team, 2023.

Based on **Table 7**, data on the percentage of people's willingness to use public transportation can be obtained. The data was obtained from a sample of motorcycle and car users in the study area of West Bandung Regency. From the total sample, it was found that for motorcycles it was 25.7% and for gasoline cars it was 54.7%, and diesel cars as much as 23.1% were willing to use public transportation. As for people who are not willing to use public transportation, it is 19.6%. This is because in the West Bandung regency area there is often congestion, therefore people who use car vehicles want to move more than those who use motorcycles.

From the data in **Table 7**, it can be known that the total number of passengers who want to move using public transportation can be calculated, then based on the occupancy factor and the volume of each existing vehicle, the total number of passengers who want to move using public transportation can be calculated by multiplying the volume of vehicles, occupancy factors and the percentage of willingness to move from each type of vehicle. The following is the total number of passengers who want to transfer by using public transportation can be seen in **Table 8**.

Table 8. Total number of passengers who want to transfer using public transportation.

Vehicle category	Volume (vehicle/h)	Occupancy factor	Percentage	Total passengers who want to transfer (person/h)
Motorcycle	12,397	2	25.7%	6199
Car (Gassoline)	3587	8	31.6%	9068
Car (Diesel)	2972	8	23.1%	5492
Total				20,759

Source: Analysis Results, 2024.

From **Table 8**, it can be seen that the results of the calculation of the total number of passengers who want to move using public transportation in West Bandung Regency are 20.756 people/h. and from this data, the decrease in the volume of vehicles in each vehicle in West Bandung Regency can be calculated by using the following formula:

Volume after carbon tax = Volume before carbon tax − (Volume before carbon tax × Percentage Willing to Switch to Public Transportation)

From the results of the calculation analysis carried out, it was obtained that the decrease after the implementation of the carbon tax in West Bandung Regency can be seen in **Table 9**.

Table 9. Volume comparison before and after the implementation of the carbon tax.

Vehicle category	Willingness to change public transportation (%)	Volume before (vehicle/h)	Volume after (vehicle/h)	Decline after carbon tax (%)
Motorcycle	25.7%	12,397	9211	25.69%
Car (Gassoline)	31.6%	3587	2368	33.98%
Car (Diesel)	23.1%	2972	2285	23.11%

Source: Analysis Results, 2024.

From **Table 9**, it can be seen that the carbon tax implementation scheme is better implemented compared to before the implementation of the carbon tax. This makes the change in the volume of each vehicle, namely motorcycles, decrease by 25.69%, and for gasoline cars by 33.98%, and for diesel cars by 23.11%.

Then in implementing policies and developing public transportation, it must be balanced with the provision of infrastructure in the form of supporting public transportation. The provision of public transportation support facilities in West Bandung Regency already exists, but these conditions need to be improved and developed to help the community in using public transportation later. The step taken by the government is to plan the construction of facilities in the form of public transportation facilities and infrastructure contained in the West Bandung Regency

Regional Spatial Plan 2009–2029. In the field of traffic infrastructure and road transportation, the government has planned several developments, namely the construction of terminals, the construction of transportation system support facilities, and the placement of motorcycle testing units. The construction of type B passenger terminals is carried out on Jalan Gedong Lima, Padalarang District, and the construction of type C passenger terminals will be developed in 12 (twelve) districts, including Lembang, Cikalongwe-tan, Cililin, Parongpong, Cisarua, Ngamprah, Cipatat, Batujajar, Cihampelas, Cipeundeuy, Sindangkerta, Cipongkor, Gununghalu, and Rongga.

The plan to develop supporting facilities for the transportation system is in the form of the construction of public transportation bays and bus stop facilities on several roads. The placement of the motorcycle vehicle testing unit is located in Padalarang District. With the construction and development of terminals and bus stops, it is hoped that it can support the use of public transportation and accelerate the development of passenger public transportation lines later. In addition, the placement of motorcycle vehicle testing units is expected to accelerate the process of implementing the carbon tax policy. So that with the existence of several supporting facilities, it is easier for people to use public transportation and start using private motorcycles.

5. Conclusion

The results show that to encourage the use of public transportation in urban areas, several proposals are proposed that can significantly accelerate its implementation, namely:

1) The implementation of the carbon tax in Indonesia, which is regulated by Law Number 7 of 2021 and Presidential Regulation Number 98 of 2021, is a step to reduce exhaust emissions from fossil fuel motor vehicles. While it has not been implemented evenly across the region, the carbon tax should be implemented progressively with annual rate increases to reduce the use of private vehicles and improve the use of public transport. So, it is hoped that West Bandung Regency can immediately adopt this policy through regional autonomy to overcome the problem of high carbon emissions. So that it can accelerate the development of public transportation lines, and achieve sustainable transportation.
2) The potential for local revenue from the carbon tax in the West Bandung Regency area will be generated within one year. Route A04 has the highest revenue potential compared to other routes in West Bandung Regency, which is Rp. 96,229,123,974.14.
3) The decrease in vehicle volume with the implementation of carbon tax compared to before the reduction in each vehicle volume, namely motorcycles decreased by 25.69%, and for gasoline cars by 33.98%, and for diesel cars by 23.11%. So that the carbon tax implementation scheme is better implemented compared to before the carbon tax.
4) With the collaboration between institutions, the policy of implementing a carbon tax, and the provision of public transportation support facilities, the use

of private motorcycles can be significantly reduced, and the acceleration of the public transportation lane development program can be implemented, so that the implementation of public transportation in an effort to meet the needs of safe, peaceful, comfortable, and affordable transportation can be met and sustainable transportation can be realized.

6. Recommendation

Based on the limitations of this study, further research is needed on the type of vehicle based on the year or type of vehicle that is allowed to operate and the need for advanced technology regarding innovations in reducing public transportation in addition to the implementation of carbon tax.

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