CARBON CREDIT ASSESSMENT ON MODAL SHIFT OF GOODS FROM ROADWAYS TO INLAND WATERWAYS

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Abstract - *Increase in developments has imposed heights on pollutant emission. Emissions mainly pointing towards greenhouse gases have an adverse impact environment, indirectly affecting other factors. Transportation sector has set its position among the major greenhouse gas emitting sources, of which road networks can be ranked first. The reduction in emissions in tonnes on switching of goods from roadways to waterways is referred to as carbon credit. This study mainly focuses on introduction of schemes that might reduce the amount of pollutant emission. Scenario focusing on switching of freight from road ways to inland water way shipping via national waterways 3 (West coast canal from Kollam to Kozhikode) is studied. The various freight origins, destinations and load have been assessed and Origin-Destination matrix was developed with origin destination survey data. The goods considered for switching constitutes non- perishable items as perishable items are restrained due to time factor. Micro level Feasibility studies have been done to assess the environmental and economic benefits of inland waterways. The emission in terms of carbon dioxide for both road transportation and inland waterway navigation are determined based on activity approach and different percent of load inclusion. The carbon emissions and carbon credit fluctuated directly based on load of goods. The results show a positive trend for inland waterway navigation in terms of carbon emission than road transportation. The amount of carbon credit can be used by the authorities for further pollution reducing schemes.*

Key Words: *Carbon credit, National waterways NO: 3, Origin-Destination (OD) matrix, Perishable and non-perishable goods carbon foot-print, Activity based approach*

1. INTRODUCTION

Waterways were one among the most widely used modes of transport, when developments have not struck the doors of many countries. Both passengers and freight relied on waterways for their movement from one place to another. With developments on rise roads, rail, aviation and other advanced mode of transport came into play, which lead to switching on to these modes. Rising developments has triggered the pollution rate especially focusing on air pollution.one of the major contributors of the increased GHG emissions are endless traffic, fuel burning and other activity. Air pollution has set a black mark on the rising developments.

Transportation sector has been recognized as a major source of global climatic change accounting to 23% of energy related co_2 emissions. Many experts foresee a three- to five-fold increase in carbon dioxide emissions from transportation in Asian countries by 2030 compared with emissions in 2000 if no changes are made to investment strategies and policies(1). This is driven by the anticipated six to eight-fold increases in the number of light-duty vehicles and a large increase in the number of trucks, which could overwhelm even the most optimistic forecasts of improvements in vehicle fuel efficiency .One of the low cost methods to mitigate such pollution is introduction of low emission transport modes.

Air is a necessity for every living being and uptake of polluted air can lead to chronic diseases especially lung and heart diseases (2). Many countries have adopted innovative techniques to tackle their rate of air pollution. In developing countries like India, automobile exhaust plays a vital role in causing air pollution. Specifically in Kerala, transportation is one of the most important sources of air pollution. The exponential growth of automobiles in Kerala has been considerably increased faster than the rate of population growth (3, 5). Besides the advancements in technology, such as electric vehicles and energy-efficient appliances, policies also play a vital role in stimulating commuters' behavioral changes to achieve sustainable urban environment (6). Low carbon transportation strategies can be among the least costly ways to reduce GHG emissions when they are designed to reduce the need for travel, to shift trips to often less expensive low carbon modes, and to improve system management by reducing congestion and inefficiency in the use of transport capacity.

The main focus of this study is to estimate the carbon credited, i.e. amount of Carbon dioxide emission (in tonnes) reduced as a result of switching goods from road network to inland water network (National water ways 3). A reduction of 1 tonne carbon dioxide emission constitutes 1 carbon credit.

2. MATERIALS AND METHODS

The quantity of goods transported by roadways to and from 11 station points was obtained from the origin destination survey conducted by NATPAC. The 11 origin-destination include Kollam, Alappuzha, Kottayam, Muvattupuzha, Ernakulum, Trissur, Guruvayoor, Chavakkad, Ponnani, Kuttipuram and Kozhikode. The OD matrix was developed for 44 commodities and a final OD matrix showing total goods to the different origin and destinations was also developed. The carbon footprint was determined for freight movement to these origins and destinations by an activity based approach. The vehicle kilometers travelled was taken for origin to destination and back to origin. The total distance travelled from origin to destination via roadways is 450Km.The emission on switching the same load of goods to inland waterways is studied. The West Coast Canal from Kollam to Kozhikode declared as National Waterway No.3 is taken for study area as it links to important industrial terminals and the 11 station points. It has a navigable length of 205 Kms (up to Kottapuram) now extended up to Kozhikode having a total length of 365Kms.

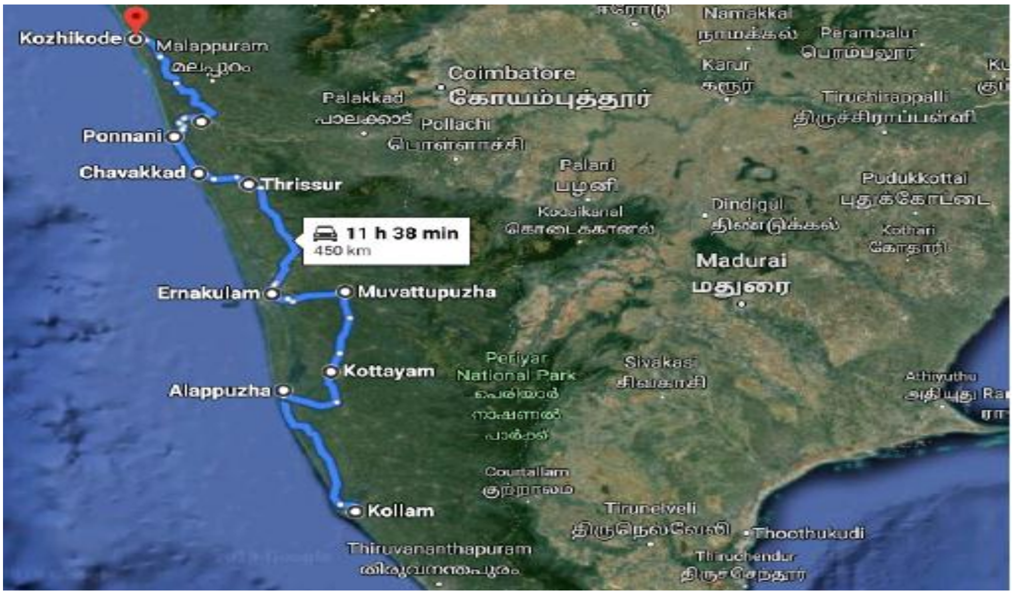


Fig -1: Route map showing origins and destinations

As per the Economic review 2018 the various commodities being exported from Kerala are cashew, coir, coir products, tea, coffee, pepper, cardamom, ginger, other spices, spice oils, marine products and miscellaneous items including POL. Those items imported to Kerala are fertilizer, raw materials, iron, steel and machinery, Newsprint, raw cashewnut, chemicals and food grain. To be more precise the individual commodity and the respective load that is transferred between different origin and destination were collected from the origin- destination survey data. This data is utilized to identify which commodity shall be chosen for diverting to waterways and to develop the individual and combined OD matrix.

Table-1: Details of Study Area

STUDY AREA	DISTANCE
Kollam- Kottapuram	168 Kms
Kottapuram –Kozhikode	160 Kms
Udyogmandal canal	23 Kms
Chempakkara canal	14 Kms

The 44 commodities are classified into perishable and non- perishable goods. The perishable commodities being degradable with time cannot be considered in switching to waterways. Another criteria that have been considered is goods that are liable to breakage and other damages have also been exempted from the present work. In this work all the items exempted has been labelled as perishable although not literally. Two cases are considered in this study, one in which all goods are considered for diversion to inland waterways and second in which the perishable items are exempted and carbon dioxide emission and carbon credit are determined in both scenarios.

An activity based approach was used to measure the carbon dioxide emission or carbon footprint. The total load of goods to be diverted and kilometers travelled are considered for the emission calculation. The fuel consumed for various percentage of load inclusion was also determined based on the data that fuel consumption for road ways is 24 tonne-Km/litres and for waterways is 105 tonne-Km/litres.

$$Emission_{Carbon\text{-}Dioxide} = L \times D \times EF_{Carbon\text{-}dioxide} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where L is the total load of goods diverted in Tonnes, D is the Kms travelled and EF is the emission factor of carbon dioxide which has been adopted as per ECTA guidelines, since there are no standard emission factors for co_2 in India. The average CO_2-emission for road transport operations is 62g CO_2/tonne-km and emission factors for barge movements on inland waterways is 31 g CO_2/tonne-km This value is based on an average load factor of 80% of the maximum vehicle payload and 25% of empty running.

3. RESULTS AND DISCUSSION

3.1 Origin-Destination matrix (OD matrix)

The OD matrix was developed for 44 commodities that are transported to and from 11 stations based on the origin destination survey data collected. The OD matrix of each commodity represents the load of that commodity transported to and from 11 stations and the total load of that commodity transported by roadways. The final OD matrix was developed which represents the total flow of goods from one origin to its destination.

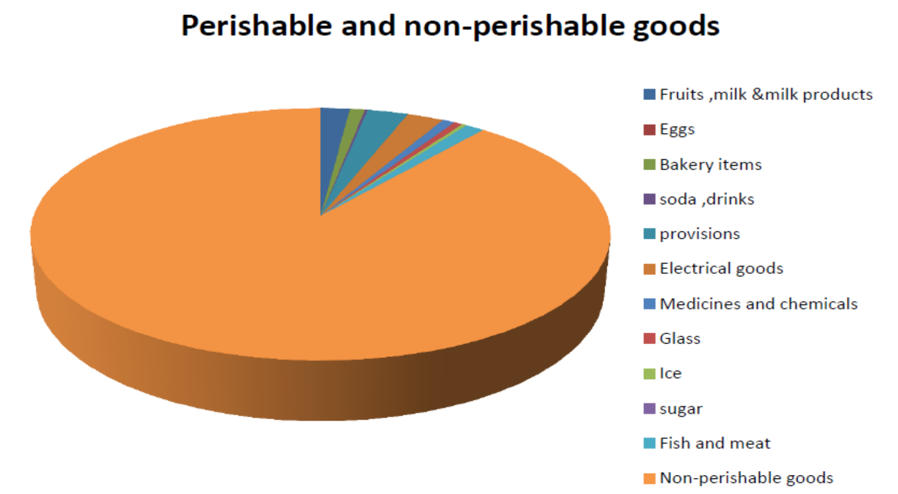
Table- 2: OD Matrix representing total Goods (Tonnes)

OD	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	Total (T)
S1	0	0	0	0	0	2.41	0	0	0	0	345.07	347.481
S2	0	0	501.80	0	0	465.07	0	180	0	0	93.62	1240.49
S3	0	1801.26	0	0	2197.75	2413.36	482.67	1296.57	187.57	10.81	3844.44	12234.45
S4	0	0	16.92	0	0	0	0	8	0	0	0	24.92
S5	0	0	1631.63	0	0	0	0	0	0	0	139.87	1771.50
S6	129.76	0	1661.59	0	0	0	0	0	0	0	427.61	2218.97
S7	0	350.959	198.112	0	0	0	0	0	0	0	0	549.07
S8	0	11.679	264.165	0	0	0	0	0	0	0	0	275.85
S9	0	0	61.422	0	0	0	0	0	0	0	0	61.43
S10	0	44.582	99.54	0	148.61	0	0	0	0	0	0	292.73
S11	91.64	261.082	2317.23	0	230.59	1256.97	0	0	0	2.16	544.26	4703.95
Total (T)	221.40	2469.57	6752.41	0	2576.95	4137.82	482.67	1484.57	187.57	12.97	5394.87	23720.83

From the individual OD matrix for 44 commodities it was found that miscellaneous items had the greatest quantity of 3732.14 T, followed by bricks and tiles with weight of 3079.752 T that was transported by road ways. The final OD matrix shown above represents the total load of goods to different stations. The 11 station points Kollam, Alappuzha, Ernakulum, Muvattupuzha, Trissur, Chavakkad, Guruvayoor, Ponnani, Kuttipuram and Kozhikode are represented as s1 to s11 in the above order. The final OD matrix showed that the highest quantity of goods flow took place from Ernakulum to Kozhikode with a load of 3844.44 T. The highest amount of goods was transported to Ernakulum from 11 origins with a total of 6752.413 T.

3.2 Perishable and Non-Perishable Goods

Chart-1: Pie Chart Representing Perishable and Non-Perishable Goods



The commodities selected as perishable are fruits, vegetables, milk products, bakery items, provisions, fish and meat, ice, sugar, glass, medicines, chemicals, electrical goods etc.. A total load of 2593.93 T of perishable commodities was found to be transported from different origins and destinations in OD matrix. 12 commodities have been considered as perishable items although all items are literally not perishable. The perishable commodities have been represented in the chart above. The load of non-perishable items constitute to a total of 2593.93T. The non-perishable items constituted to a total of 21126.892T.

3.3 Carbon Foot Print

The carbon footprint or carbon dioxide emission was determined by an activity based approach. The emission factor for co_2 road and inland navigation was considered as per ECTA guidelines. The vehicle kilometers travelled was taken for up and down journey for both roadways and inland waterways. In both scenarios diversion of goods to waterways showed lower carbon dioxide emission compared to roadways. The co_2 emission showed a direct variation with the percentage load diversion. The co_2 emission reduced with decrease in load and was found to be highest for 100% load inclusion. The highest amount of co_2 emission was in case of roadways for scenario 1 and accounted to 43679.527T. The lowest amount of emission was found to occur in waterways for scenario 2 which accounted to 15777.354 T.

Table - 3: CO_2 Emission for Scenario 1

Scenario 1 : Total goods including perishable goods			
Divertible traffic (%)	**Load of Goods (T)**	**Emission in Road ways (T)**	**Emission in waterways (T)**
100%	23720.825	43679.527	17714.475
50%	11860.413	21839.764	8857.237
40%	9488.330	17471.811	7085.790
30%	7116.247	13103.858	5314.342
25%	5930.206	10919.882	4428.618
20%	4744.165	8735.9056	3542.895

Table-4: CO_2 Emission for Scenario 2

Scenario 2 : Total goods without perishable goods			
Divertible traffic (%)	**Load of Goods (T)**	**Emission in Road ways (T)**	**Emission in waterways (T)**
100%	21126.895	38903.065	15777.354
50%	10563.448	19451.533	7888.677
40%	5281.724	9725.766	3944.338
30%	2640.862	4862.883	1972.169
25%	1320.431	2431.442	986.0846
20%	660.215	1215.721	493.042

3.4 Carbon Credit

The reduction of carbon dioxide emission in Tonnes for both the scenarios was determined and is referred to as carbon credit. The carbon credit complete diversion of goods to waterways i.e. in scenario 1 accounted to 25965.052 T and decreased gradually for decreasing load percentage and taking scenario 2 in which perishable items was not considered the carbon credit for complete diversion was found to be 23125.711 T. Many countries utilize these carbon credits or trade these credits for further carbon reducing projects leading to greener developments.

Table-5 Carbon Credit for scenario1

Divertible traffic (%)	**Emission in Road ways (T)**	**Emission in waterways (T)**	**Carbon credit (T)**
100%	43679.528	17714.475	25965.052
50%	21839.764	8857.237	12982.526
40%	17471.811	7085.790	10386.021
30%	13103.858	5314.342	7789.515
25%	10919.882	4428.619	6491.263
20%	8735.905	3542.895	5193.010

Table-6 Carbon Credit for scenario 2

Divertible traffic (%)	**Emission in Road ways (T)**	**Emission in water ways (T)**	**Carbon Credit (T)**
100%	38903.065	15777.354	23125.711
50%	19451.533	7888.677	11562.855
40%	9725.766	3944.338	5781.428
30%	4862.883	1972.169	2890.714
25%	2431.441	986.0846	1445.357
20%	1215.721	493.0423	722.6785

3.5 Feasibility study

A micro level feasibility analysis was carried out to determine the feasibility of inland waterway transport compared to other modes of transport. Taking the case of a goods truck which carries 10 T a vessel in waterways can carry a load range of 30-40 T. The fuel consumption of waterways is lest compared to that of road and rail. The fuel consumption for the load of goods has been determined. The result showed that inland waterways were feasible in terms of fuel consumption and freight charges.

Table-7: Comparison of Different Modes

Mode	Road	Rail	Inland Waterways
Energy usage (movement kg. per unit HP)	150	500	4000
Fuel consumption (T-km / litre)	24	85	105
Freight (Rs/T.km)	2.5	1.36	1.06

Table-8: Fuel consumption in sceario1

Divertible Traffic (%)	Fuel consumption for Waterways(L)	Fuel consumption for Road ways(L)
100%	74551.165	326161.348
50%	37275.582	163080.674
40%	29820.466	130464.539
30%	22365.349	97848.404
25%	18637.791	81540.337
20%	14910.233	65232.269

Table-9: Fuel consumption in scenario 2

Divertible Traffic (%)	Fuel consumption for Waterways(L)	Fuel consumption for Road ways(L)
100 %	66398.814	290494.811
50%	33199.406	145247.405
40%	16599.703	72623.702
30%	8299.851	36311.851
25%	4149.925	18155.925
20%	2074.962	9077.962

The above fuel consumption value shows that road ways consume higher amount of fuel compared to inland waterway navigation in both scenarios. Considering the cost of fuel a large reduction in fuel cost and freight cost can be obtained on switching of goods from roadways to inland waterways.

4. CONCLUSION

Carbon reduction schemes are least costly ways that can be adopted to reduce carbon dioxide emission. The modal shift from road ways to waterways was found to be both environmentally and technically feasible in both scenarios. Although scenario 1 was found to be robust scenario 2 is much more practicable considering time constrain. The difficulty further pertains to the complete development of inland waterways from Kottapuram to Kozhikode which is ongoing. Fullest utilization of natural gifts like waterways can lead to developments with least environment effects. Compared to other modes the fuel consumption, freight charges and maintenance are less for inland waterway navigation. The carbon credit obtained can be utilized for further carbon reduction schemes or traded as done by European countries.

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