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Logistics and Economic Development in the Caribbean Economies: Perspective from Road Network

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Abstract

Road networks have the ability to unlock the potential embedded in rural areas by enabling the transformation of subsistence farming into a commercial and dynamic farming system. This study explores the: possible predicting impact of quality road network on economic development in the Caribbean Economies, potential costs, and benefits associated with improvement in road network infrastructures, and the type(s) of road network improvement that has the least adverse effect on the sustainability of the environment.

Regression Analysis Technique with adjusted R2 and Standard Deviation Technique were utilized in the analysis of secondary data derived from nineteen (19) Caribbean Economies. Costs of upgrading and maintaining road networks within the block of nations were assessed using statistical evidence from the World Bank database.

Very strong and direct correlations are revealed between economic development, and the quality road infrastructure (QRI) (r2 = 73%). Positive correlations of less magnitude are also revealed between key factors of economic development and those of quality road infrastructure (GDP/Capita and connectivity r2 = 33.13%, per capita consumption and connectivity r2 = 37.21%, per capita consumption and % of paved road r2 = 30.94%). Traffic engineering, improvement in the design of intersections, construction and improvement of unpaved and paved roads are three of the six cost-effective and environmentally friendly procedures reveal by this study to improve and manage the Caribbean Islands' Road Network infrastructure.

Several Caribbean Islands do not have effective data collection and storage capabilities and as a result this study is limited to nineteen (19) islands. Improved road networks in the Caribbean is crucial in the fight against poverty. It opens up more areas and in doing so provides access to employment, health, and educational services and other critical services.

Improved road network in the Caribbean saves time, provides a means of access to public services, reduces insecurity caused by isolation and enables islanders' participation in social gatherings.

This study focuses on the level of impact that road network has on the Caribbean Islands' Economic Development.

Keywords: Road Networks, Economic Development, Caribbean Economies and Human Development Index

Introduction

Road networks, which is a combination of main, tertiary, secondary and local roads are vital to any development agenda in that they are responsible for linking students to school, workers to jobs, producers to markets, and those who are sick to the hospitals [1].

It can unlock the potential embedded in rural areas by enabling the transformation of subsistence farming into a commercial and dynamic farming system. Consequently, road networks are essential for eliminating or at least reducing hunger, alleviating poverty, and improving the quality of human life in both the urban and rural areas [2].

The expansion and maintenance of road networks in any economy is often the priority of the government. Crucial to the efficient management of the road infrastructural projects is the understanding of the impact that the maintenance of existing roads, and the establishment of new road infrastructures have on economic growth and development.

Economic developments in terms of agriculture, commerce, and trade etc. within The Caribbean Economies are adversely affected due to:

The inability of the road network to accommodate the volume of traffic and passengers. Mismanagement, Poor Road design and maintenance especially those connecting the urban and rural areas.

An average of fifty per cent (50%) of the roadways are unpaved, which in fact is a major problem especially during the rainy periods (World Fact book, 2021).

Increased environmental destruction.

This paper established the correlations between indicators of economic development and those of quality road infrastructure (QRI) of Caribbean Economies, as well as a range of potential costs and benefits associated with the appropriate improvement in road network infrastructures. We conclude a discussion involving road network upgrading practices that have the least negative effects on the environment.

The Literature Review

Road networks are a country's most important asset. Data depicts that the most developed and wealthy economies world-wide have the highest levels of road quality index (RQI). Ranging from a low of 5.5 to a high of 6.4 (See table 1) (World Economic Forum, nd).

Table 1: Road Quality Index of the Most Developed Countries

World most developed and wealthy countries	Road Quality Index (1 low – 7 high)
Singapore	6.4
Switzerland	6.4
Netherlands	6.2
Hong Kong	6.1
Japan	6.0
France	6.0
Oman	6.0
UAE	5.9
Austria	5.9
USA	5.5

Source: Developed Countries, nd

Quality Road Infrastructure (QRI) and Economic Development (Index)

World Economic Forum (WEF) Annual Report (2019) on road quality reveals that throughout the Caribbean Economies Road quality index range from a low of 2.1 in Haiti to a high of 5.1 in Puerto Rico. Well-built road infrastructure is one of the most important evaluative criteria when making a decision on the investment location (figure 2.0).

Productivity and economic growth are important issues in the 21st-century development agenda. It affects various economic conditions such as wages and profits as well as people's overall quality of life [3]. In essence it drives the influx of Foreign Direct Investments (FDIs) into an economy, which contributes to sustainable economic growth [4].

Between 2017 and 2018, the inflows of FDI into the Caribbean increased by an average of 2% of the region's Gross Domestic Product [5]. Improved QRI reduces business total production costs and ultimately increases the level of efficiency. Emanating from improved QRI are increased levels of competition, local investments, and employment opportunities [6].

Human Development Index (HDI), Per Capita Consumption (PCC), Per Capita Gross Domestic Product and Percentage of Paved Road Network

The percentage of paved roads per capita shows a strong positive correlation with the Human Development Index. On average forty per cent (40%) of roads in the Caribbean Economies are paved [7].

Increase in the kilometers of paved roads not only improves the standards of the road networks, but also allow for improved mobility throughout the Caribbean Islands. Commuters are faced with less mud during the rainy periods and equally less dust during the dry periods. Improvement of this nature enhances accessibility to jobs, social facilities, and services such as schools, security, and hospitals as well as an increased market for agricultural goods and services (Pradhan and Bagchi, 2013; Gibson and Rozelle, 2003).

It has also been presumed that new roads and improved existing roads lead to better living conditions due to the possibilities for social development and economic opportunities such as better paying jobs, higher number of start-ups and enhancement of the welfare of communities. Land values in the vicinity of the paved road increased, hence the wealth and economic stability of the landowners [8].

Human Development Index (HDI), Per Capita Consumption (PCC), Per Capita Gross Domestic Product and Connectivity Index

Connectivity Indices are the ratio of links to nodes. The more links relative to nodes, the more connected are the different towns or cities. Nodes are intersections and links are segments between roadway intersections [9].

Road network connectivity is a crucial element of sustainable growth. In this context, roads are one of the prerequisites for equal access to health services, education and justice, and to other social and administrative services required for development with equality. Upgrading of road network reduces both transport costs and travel times considerably, which enables increased productivity and encourages the creation of more jobs with higher earning capabilities [10]. Lack of connectivity contributes to the general feeling of abandonment, which is more evident in the rural areas.

This is exacerbated in the rainy season, when roads become impassable for weeks, increasing the local population's feeling of isolation. The absence of proper road connectivity could be seen as a barrier to the full exercise and enjoyment of the rural population's human rights, as well as their economic, social, and cultural rights, and their civil and political rights. Better rural road accessibility would thus entail not only an improvement in rural dwellers' quality of life —giving them access to better education, health and communications between rural settlements and large urban centers— but would also facilitate and increase the mobility of people, and stimulate the development of more economic, social, political and cultural activities.

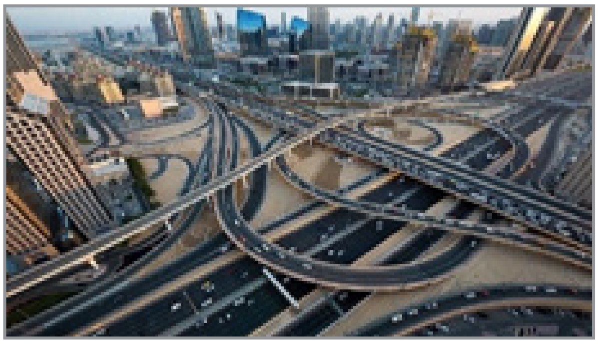

Figure 1: well-built road infrastructure, (Worldatlas.com)

Figure : Unpaved Road, (Worldatlas.com)

Theoretical Framework

A simple theoretical framework was developed with the purpose of demonstrating the relationship between quality road index and economic development. See figure 3. This section reviews two mainstream theories, namely, Neoclassical Growth Theory and Regression Analysis Method. Neoclassical Growth Theory explains growth in terms of the availability and the use of productive input factors. It clearly noted the importance of policy makers to adopt appropriate strategies that are based on their own circumstances. Neoclassical theory suggests investing in infrastructure, which is extremely necessary but not sufficient condition for regions to achieve sustainable economic development [2]. Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. It can be utilized to assess the strength of the relationship between variables and for modeling the future relationship between them [11].

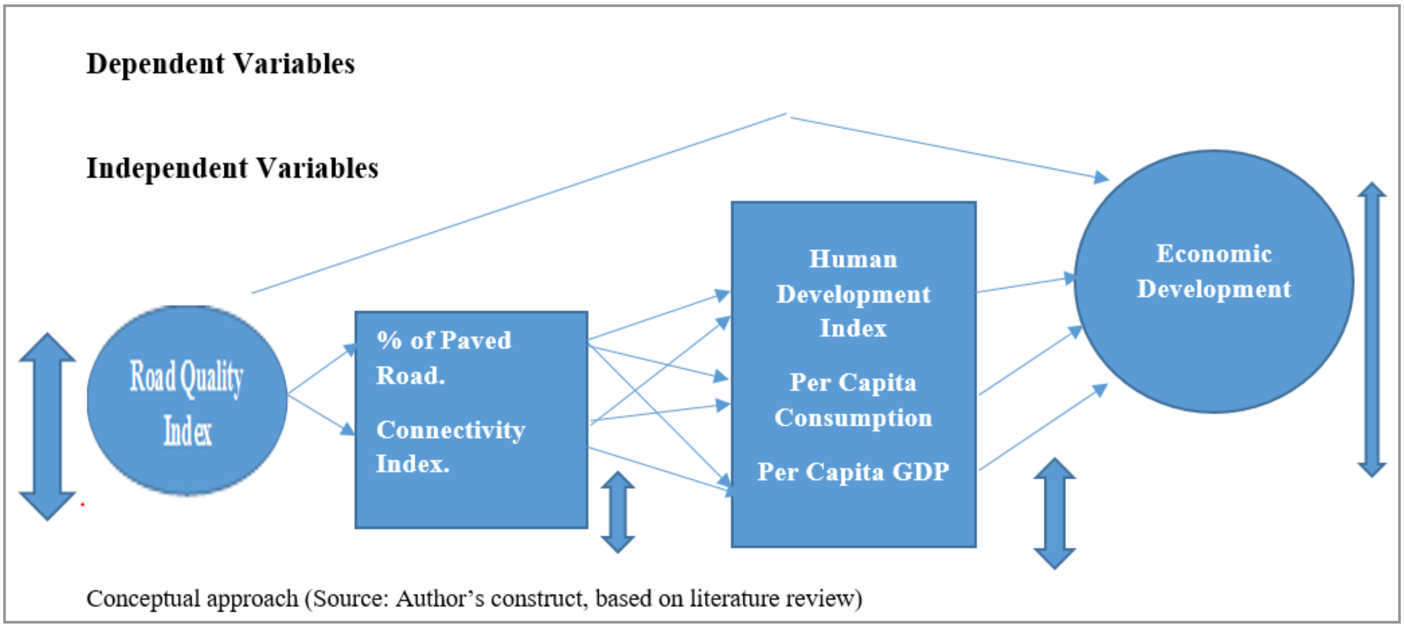

Figure 3: Changes in independent variables enable changes in dependent variables.

Methodology

Seven datasets were established from a list of nineteen (19) Caribbean Countries based on the availability of respective data. These datasets range from a minimum of ten (10 to a maximum of nineteen (19) Caribbean Islands. After the establishment of these datasets, linear regression analysis with adjusted R2 and Standard Deviation Technique were utilized to establish accurate relationships between road quality infrastructure, percentage of paved road, and connectivity (independent variables) to four explanatory variables: Economic Development, Human Development Index (HDI), Per Capita Consumption (PCC), Per Capita Gross Domestic Product. Action Research Studies of statistical evidence from the World Bank database were used to estimate the potential costs and returns of upgrading and expanding road networks within the block of nations. We concluded with a discussion involving road network upgrading practices that are cost-effective and will minimize the negative impact on the environments of the Caribbean Countries.

Results and Analysis

The correlation coefficient (r) of 0.854 between the road quality index and economic development within the Caribbean Economies is very strong and positive. An estimate of seventy-three per cent (73%) of any economic development is likely to be a result of an improvement in the quality of the road network within the region as indicated by the Correlation Determination (r^2). The correlation coefficient (r) between the percentage of paved road surface and that of the human development within the Caribbean Region is 0.478. The relationship between these two variables is estimated to be strong and positive.

Approximately twenty-three per cent (22.84%) of improvement in human development is driven by improvement in the number of kilometers of road that are paved as indicated by the Correlation Determination (r^2). The percentage of the road surface that is paved and per capita consumption share a strong and positive correlation coefficient (r) of 0.5562. Within the Caribbean Region, approximately thirty-one per cent (30.94%) of improvement in per capita consumption is driven by improvement in the number of kilometers of road that is paved.

Similarly, the percentage of the road surface that is paved and per capita gross domestic product share a strong and positive correlation coefficient (r) of 0.536. An estimate of 28.77 percent of per capita GDP is driven by improvement in the number of kilometers of road that are paved as indicated by the correlation determination (r^2). The correlation coefficient (r) between the connectivity index and that of per capita consumption is (0.61).

This depicts a strong and negative relationship between the two variables. 37.21 percent of per capita consumption in the Caribbean Economy is driven by the level of connectivity as indicated by the Correlation Determination (r^2). Correlation coefficient (r) between the connectivity index and the per capita gross domestic product within each Caribbean Economy is (0.601). The relationship between these two variables is strong and negative. Approximately thirty-three per cent (33.13%) of per capita GDP is driven by the level of connectivity index within each Caribbean Island as indicated by the Correlation Determination (r^2).

However, the correlation coefficient (r = 0.165) between the level of connectivity and human development within each Caribbean Economy is estimated to be positive and weak. Analysis of the data depicts that approximately three per cent (2.73%) of improvement in HDI is driven by improvement in the countries' connectivity index. See table 2.

The adverse relationships between per capita consumption, per capita gross domestic product and connectivity index, the weak positive relationship between connectivity index and human development index are explained by the fact that an excess of seventy per cent of the islands in this study have very high population density. Most economic activities are concentrated in small geographical areas and as such the importance of connectivity in economic development has been reduced significantly.

Seven (7) Statistical Regression Models ($\hat{y} = b_0 + b_1X + e_0$) describing the relationship between road quality infrastructure, percentage of paved road, and connectivity (independent variables) to four explanatory variables: Economic Development, Human Development Index (HDI), Per Capita Consumption (PCC), Per Capita Gross Domestic Product. See table 3. The level of impact on the Caribbean Economies varied slightly from island to island. This may be due to institutional failures, weak and inefficient governments and widespread corruption mitigating the growth effects of public capital expenditures [12].

Presently Jamaica's Road Quality Index (RQI) and Economic Development (ED) are 3.9 and 5.4 respectively. An improvement in RQI to 4.0 would generate a corresponding increase in ED to 5.51. A similarly improvement in RQI for the Bahamas results in increased ED from 4.52 to 4.934 (using regression model 1) table 3).

Table 2: Correlation & Correlation Determination Values

Variables	Economic Development	HDI	PCC	Per Capita GDP
i. Road Quality Index	r = 0.854 r^2 = 73%			
ii. % of Paved Road		r = 0.478 r^2 = 22.84%	r = 0.478 r^2 = 22.84%	r = 0.536 r^2 = 28.77%
iii. Connectivity Index		r = 0.165 r^2 = 2.73%	r = (0.61) r^2 = 37.21 %	r = (0.601) r^2 = 33.13%

Source: Author's construct, based on research findings.

Table 3: Statistical Regression Models

	b_0	b_1	e_0
Model 1: Quality Road Infrastructure (QRI) and Economic Development (Index)	2.2627	0.7627	0.1929
Model 2: Percentage (%) of Paved Road Network and Human Development Index (HDI)	0.6855	0.1586	0.0909
Model 3: Percentage (%) of Paved Road Network and Per Capita Consumption (PCC)	-2159.31	24111.74	10.861
Model 4: Percentage (%) of Paved Road Network and per capita gross domestic product	-4914.17	37667.62	17.558
Model 5: Connectivity Index and Human Development Index (HDI)	0.72495	0.00086	0.13
Model 6: Connectivity Index and Per Capita Consumption (PCC)	21622.84	-214.01	97.7
Model 7: Connectivity Index and per capita gross domestic product	28979.47	-290.82	161.37

Source: Author's construct, based on research findings.

Costs and Returns for Road Network Maintenance

There are many factors influencing the maintenance requirements and expansion cost of any road, and as result it is impossible to quote a single, all-encompassing figure for the Caribbean Economies. Maintenance needs and costs of road network will depend on a wide range of factors, such as: Traffic characteristics and loading, road width, surface type, Pavement (if any) and foundation characteristics, Drainage regime, quality of construction, maintenance regime, logistics of the network, technologies adopted, labor, intermediate equipment or heavy plant methods mix, Availability of materials (local and imported) and their costs and Market or established manpower costs etc.

According to UK and the African Community Access Programme (AFCAP) Steering Group, (2013), 2% – 5% of the country's gross domestic product or 2.5% of the country's road network values are two "rules of thumb" that are used to determine road network maintenance costs and expansion. Averages road network maintenance cost and return derived from a dataset of twelve (12) Caribbean Economies are $593.1617M - $1,487.13M, and $2.797B - $6.9929B respectively. Cuba and Dominica required the highest and least road network maintenance costs of $2,148M - $5,370M and $10.92M - $22.3M respectively. They also share in the same order returns on their investments of $16.6B - $41.51B and $0.05524B - $0.1128B respectively. Table 4.

Table 4: Road Network Maintenance Costs and Returns

Caribbean Countries (1)	GDP (2)	Maintenance Costs (2% - 5%) (3)	Investment Multiplier (4)	Returns (5)
Bahamas	$11,209M	$224.18M - $560.45M	2.81	$0.6297B - $1.575B
Barbados	$4,901M	$98.02M - $245.05M	8.58	$0.841B - $2.103B
Belize,	$1,790M	$35.8M - $89.5M	4.09	$0.1464B - $0.3661B
Cuba	$107,400M	$2,148M - $5,370M	7.73	$16.6B - $41.51B
Dominica	$546M	$10.92M - $22.3M	5.058	$0.05524B - $0.1128B
Dominican Republic	$78,840M	$1,576.8M - $3,942M	3.27	$5.1513B - $12.89B
Grenada	$1,115M	$22.3M - $55.75M	9.8	$0.2186B - $0.5464B
Guyana,	$7,717M	$154.34M - $385.85M	2.871	$0.4431B - $1.1078B
Jamaica,	$13,638M	$272.76M - $681.9M	4.52	$1.2329B - $3.082B
Puerto Rico	$103,000M	$2,060M - $5,150M	3.356	$6.9128B - $17.283B
Suriname	$2,862M	$57.24M - $143.1M	1.61	$0.09216B - $0.2304B
Trinidad and Tobago,	$23,994M	$479.88M - $1,199.7M	2.591	$1.2434B - $3.1084B
AVERAGE	$29,751M	$593.1617M - $1,487.13M	4.691	$2.797B - $6.9929B

Source: Author's construct, based on research findings. & https://countryeconomy.com/countries/groups/caribbean-community & Globaleconomy.com

Improve the Road Network Infrastructure and Traffic Flow in Caribbean Countries

Traffic congestion has been increasing in many of the Caribbean Islands' Towns and Cities and from all indications it will continue to get worst. conservative calculations, show that an increase in the average speed of private car journeys by 1 km/hr and that of public transport by 0.5 km/hr would give a reduction in journey times and operating costs worth the equivalent of 0.1% of the gross domestic product (GDP) [13].

From all indications, traffic congestion will not be eliminated but it can be reduced considerably in many areas throughout the towns, cities and roads connecting urban and rural areas. Proper procedures are required to reduce conflict points on the roadways. These conflict points can be reduced by the employment of a variety of methods.

Traffic Engineering

This management tool is usually not very costly and has proven to reduce conflict points from 30 to 16 at intersections. It involves measures such as:

i. improvement in the design of intersections. The use of non-traditional intersections such as single point urban interchanges, quadrant intersections, continuous flow intersections, median U-turn intersections and para flow intersections and interchanges. These designs are able to reduce conflict points from 30 to a minimum of 16 (WSP, nd).

ii. make the traffic flow in the main avenues reversible during rush hours.

iii. mark roads properly and provide suitable signs along the roadway.

iv. Synchronization of traffic lights.

Construction of Underpasses and Overpasses

This method is not only costly, but it can increase congestion in the short to medium term. However, in the long-term conflict points will be drastically lowered, hence congestion (WSP, nd).

Construction and Improvement of Unpaved and Paved Roads in Caribbean Countries

The three most important factors affecting the life of the road network are drainage, drainage, and drainage (Kitchell, A et al.,2011).

An average of fifty per cent of the road network in the Caribbean are unpaved. Most of which are secondary access roads (World

Fact book, 2021). The steepness of the road, the position of the road on the hill and the size of the contributing drainage area, all influence the volume of runoff on each road segment hence, erosion and blockage of the road (Kitchell, A et al.,2011). The longevity of the road network can be improved if the focus is placed on:

i. international recommended design standards

ii. appropriate practices to minimize erosion, improve drainage and accessibility.

The above focuses will reduce the long-term burden of road maintenance.

International Recommended Design Standards

Unpaved roads with a slope exceeding 20 – 30% are too hard to maintain and must be paved by mixing waste rubber from scrap tires into asphalt binder which is one way to make pavement more environmentally friendly.

The maintenance costs and the longevity of unpaved roads can be improved with the utilization of multiple solutions developed by Midwest. These include EcoPave, EK35, EnviroKleen and Soil Segment Engineered Formulas. These products work:

i. to keep fines from being stirred up as dust.

ii. to stabilize the road surface, making it more resistant to damage from vehicles and inclement weather. As more traffic travels over a road surface with the multiple solutions applied to it, the road surface compacts and becomes stronger over time. It has a cumulative effect, including when you add more products periodically on a maintenance basis. The effect is a road surface that maintains the strength and durability of a paved surface [14].

The road should slope by 2 – 3% on each side. This allows for proper water runoff to the sides.

Fissures and potholes are frequent problems to the road network. Instead of ripping up the surface and then lay down new black top, Maltene Rejuvenators when sprayed penetrate the road surface and restore the Maltene in the asphalt. When used preventatively, the rejuvenators can extend the life of a road surface by decades [15].

When constructing or improving paved road networks, the thickness of the asphalt paving material is dependent on the frequency in which the road segment is utilized. Roads that received more than three thousand (3000) vehicles daily required two lifts of 2 ½ inches of asphalt, which when compact would become four inches thick. Less than three thousand vehicles daily, only one lift of 3 inches of asphalt material is required, which when compact would be 2 ½ inches [16-20].

Appropriate Practices to Minimize Erosion, Improved Drainage and Accessibility

According to Kitchell, A, et al., "Drainage" is the main factor affecting the life of a road. Therefore, applying the following common drainage control techniques would increase the longevity of the road:

i. Grade Breaks

Intentional grade interruption on a downhill slope creates undulations that redirect flows off of the road surface to one or both sides into ditches or dispersal areas. It should be incorporated during the early stages of road design and must be big enough to shed water, but gentle enough in order to allow traffic passage. The spacing of the Grade Breaks needed is based on the slope. Slope steeper than 10% require closer Grade Breaks. Grade Breaks are most effective and should be used in conjunction with cross-drains to divert flows into pipe inlets and to provide needed pipe cover. Figure 4.

ii. Dips and Low Water Crossings

Is a wide, shallow reinforced depression designed to intercept water flowing down the road surface and ditch and transfer to a stable outlet. Sizing of the dips will vary depending on road slope and traffic volume. Dips on roads that are flat may be relatively small (fill transitions as short as 12 ft and as low as 6 in). Dips on steeper roads will require more fill transitions>100 ft long and up to 18 in deep). Fully extend to both edges of road. The dip must be 20-40-degree angle to road in order to promote self-flushing. Bottom of dip must be reinforced with 3-4" stone, geo-grid, or concrete. The spacing of multiple dips is based on the slope. Figure 5.

Road Grade (%)	Distance (ft)
2 - 4	300 - 200
5 -- 7	180 - 160
8 –10	150 –140

iii. Water bars

Narrow berms installed diagonally across the road to reduce the amount of time and distance runoff travels on the road surface. It intercepts shallow flows from the road surface and direct them towards an outlet structure (out sloping) on one side of the road. Water bars should be shown at a 30-45-degree angle across road in order to promote self-flushing and improve drivability. Outlet must be unobstructed and protected against erosion. This can be best accomplished with the use of local materials such as coarse rocks. The spacing of multiple dips is based on the slope. Figure 6

Road Grade (%)	Distance (ft)
2	250
5	135
10	80
15	60
20	45

iv. Cross-drains & Culverts

Cross-drains also known as cross-pipes, ditch relief drains and culverts are pipes, or open-topped structures used to transfer flows from ditches to the other side of a road. Cross-drains are needed at regular intervals to prevent ditches from overflowing. The required intervals are similar to that of the water bar. Culvert pipe sizing is based on drainage area, anticipated rainfall, soils, and slope. An area of two acres or less requires a culvert with diameter of 18 inches. A large diameter is required for areas more than two acres.

Cross drains and Culverts should be best aligned at least 30-45 degrees across road. Pitch on the pipe needs to have a minimum of 1-2% slope. Cover requirements are based on the pipe and road material. Rules of thumb is at least 1 ft of cover or ½ pipe diameter. Plastic pipes should have 1.5 ft of cover. Cross-drains should discharge away from streams whenever possible to keep sediment-laden road runoff away from the watercourse. Figure 7.

v. Ditches

Road network ditches collect and convey road runoff, to adequate outlets without causing erosion. If properly constructed, ditches will remove runoff quickly and reduce seepage into the road subgrade. Ditches on the up-slope side of the road to prevent water from flowing onto the road from uphill. Excavate a ditch deep enough to drain the road base, generally 1.5 to 2 feet deep. Consider the impracticalities of using ditches where bedrock is close to the surface and excavation of ditches challenging. Low maintenance ditches have wide (at least 2 ft), shallow, parabolic-shaped (not v-shaped). Vegetate ditches that have < 5% slope with grass in order to filter sediments. Use check dams or line ditch clear and stable, and to maintain the capacity of channel. Figure 8.

vi. Geosynthetics

Permeable synthetic fabrics, 2D grids, and 3D containment cells are used to add strength to road surfaces. It enables the distribution of vehicle loads and reduces erosion. The strategic use of these materials can help eliminate soft spots, potholes, ruts, and another surface deformities.

Separating subsoil layers with densely woven geotextile fabrics can prevent the upward migration of fines into surface layers. If installed correctly, there is relatively little maintenance. There are many types and uses of Geosynthetics. Manufacturers can help in selecting the correct material and design support for your specific need. Figure 9.

vii. Soil/Aggregate Stabilization

Cement-treated base (CTB) is a relatively cost-effective alternative to paving. CTB is cement treated with compounds such as lime or fly ash. This is then applied to the native soils and/ or aggregates. Water is then used to harden the mixture and after compaction a strong, and durable, water-resistant base course is the end result. The proper cement content, compaction, and water requirements of the soil material to be used can be established with a simple lab test. All soil types can be stabilized with this compound, except where there is a high organic content or clay content. However, Sandy, gravely soils with 10-35% silt and clay are ideal. Figure 10.

viii. Slope Stabilization

Slope stabilization is the prevention of erosion of road cuts and fills slopes by way of shaping, vegetation, or structural fortification to prevent erosion or failure of any slope. Selection of the type of road stabilization depends on what materials are readily available, cost, and steepness of the slope in question. Most slopes would benefit from a combination of grading, vegetation, and "hard" structures. When stabilizing slopes with vegetation, it is important to use native species with extended root structures in order to hold the soil. This process should be combined with surface grading techniques on steep slopes such as terracing or bank benches to break slopes and provide planting shelves. Other techniques available are several Bioengineering alternatives that incorporate plants into traditional "hard." structures. Figure 11.

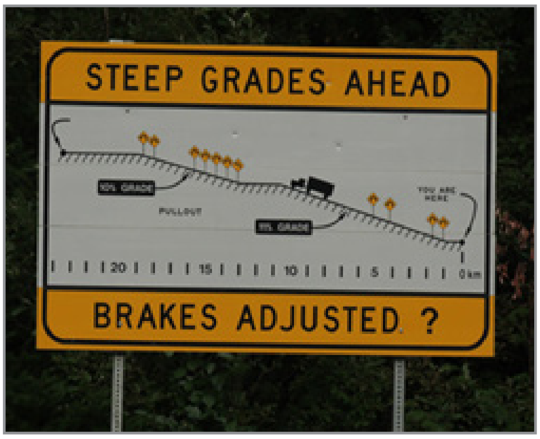

Figure 4

Figure 5

Figure 6

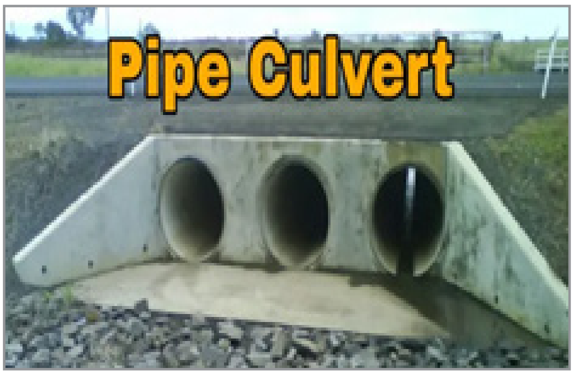

Figure 7

Figure 8

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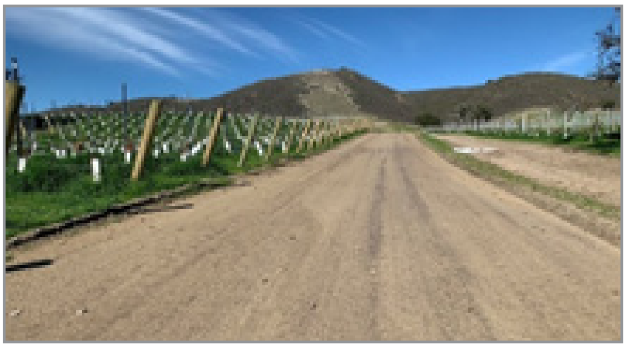

Figure 10

Figure 11

Source: iStockphoto & https://www.istockphoto.com

Conclusion

Road network infrastructure is no doubt one of the most important of all public assets within the Caribbean Countries. The nineteen countries studied highlight the provision of good quality road networks as a prerequisite for both social and economic progress. It stimulates economic development through reductions in transportation and trade costs, adequate access to markets and social services (health, education, and leisure), improves the export competitiveness of agricultural produce, tourism, and manufactured goods [21-24].

Road networks also accentuate the opportunity for employment, business development, as well as human development efforts in health and education. An average of US$1 invested in the Caribbean Road network resulted in an average return of US$4.72. However, much of the road network infrastructure in many of the Caribbean Countries suffer from a lack of maintenance, disregard for internationally recommended design standards, appropriate practices to minimize erosion, improved drainage and accessibility, inadequate management practices, corruption, accumulated debt and a history of political interference.

These problems are further enhanced due to the islands' vulnerabilities to natural disasters such as hurricanes and erosions. Road network asset management involves the application of engineering, financial and management practices to optimize the level-of-service outcome in return for the most cost-effective and environmentally friendly financial inputs.

Recommendations

Within the Caribbean Islands, an excess of 95% of the road network infrastructure is in the public domain. The decision-makers within the governments of the Caribbean need to recognize the importance of road maintenance, upgrade and expansion needs and in so doing implement appropriate road asset management programs or systems so that the right treatment can be applied at the right time in order to achieve quality, reliable, sustainable and resilient infrastructure, consistent with the United Nations Sustainable Development Goal 9.

More sustainable road construction and restoration techniques must be used in the Caribbean to develop more durable roads that will ultimately improve economic factors.

Construction of overpasses, underpasses, dips, low water crossings, water bars, cross-drains, culverts, slope stabilization, and ditches.

International recommended design standards must be followed to minimize erosion, improved drainage, and accessibility.

A more technologically complex option is a centralized traffic-light control system that opens up the possibility of using different modes of control to meet given areas' differing requirements. This means that, for example, a dynamic control system could be used in a city's downtown area but need not be applied to the entire traffic light system or to intersections that should not be coordinated with others because they do not form part of any functional network.

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