ANALYSIS ON SUITABILITY OF BUILT- OPERATE - TRANSFER SYSTEMS FOR SRI LANKAN EXPRESSWAYS: A CASE STUDY ON COLOMBO-KATUNAYAKE EXPRESSWAY (CKE)

Mailange Amila Prasadani Perera

(168335B)

Degree of Master in Engineering

Department of Civil Engineering

University of Moratuwa
Sri Lanka

November 2021

ANALYSIS ON SUITABILITY OF BUILT- OPERATE - TRANSFER SYSTEMS FOR SRI LANKAN EXPRESSWAYS: A CASE STUDY ON COLOMBO – KATUNAYAKE EXPRESSWAY (CKE)

Mailange Amila Prasadani Perera

(168335B)

Thesis submitted in partial fulfillment of the requirements for the degree Master of Engineering in Highway & Traffic Engineering

Department of Civil Engineering

University of Moratuwa
Sri Lanka

November 2021

DECLARATION

I declare that this is my own work and the thesis does not incorporate without acknowledgement any material previously submitted for a degree in any other University or institute of higher learning and to the best of knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date:

The above candidate has carried out research for the Master's thesis under my supervision.

Signature of the supervisor: Date:

ABSTRACT

Sri Lankan transport network achieved a significant development during the last decade by utilizing foreign concessions and local government funds for expressway development. Road Development Authority holds the authority to operate and maintain the road system periodically and mainly travel time-saving, developed infrastructure and living standards in association with social benefit are the user benefits generated with these expressways.

As a developing country, a lack of financial stability for infrastructure development by the government may lead to foreign loans and concessions. The concessions lead to rapid involvement in the fund involvement for mega infrastructure projects as the necessity and demand of the country. The Build-Operate and Transfer (BOT) concession model is becoming a trend in the privatization of infrastructure projects. For these BOT Contracts, the concession period, interest rates are becoming the critical parameters and main considerations.

In this study, a model was developed to demonstrate the potentiality of applying the BOT model for an operating expressway of Colombo-Katunayake-Expressway. The demand estimation, operational and maintenance cost, and toll revenue were used as inputs to this model and financial viability was observed with different scenarios. The concession period, interest rates, and optimality of selection of BOT were decided with different criteria based on financial viability.

As the Colombo-Katunayake Expressway (CKE) meets a considerable high demand for traffic in the Sri-Lankan highway network, input variables from CKE were used to demonstrate the potentiality of applying the BOT model, and optimum subsidy level was determined with the application of variable concessionary periods to minimization of the ridership guarantee, the gap in-between the accumulated revenue and accumulated costs.

Also, this BOT model is modified to validate any expressway network on an urban or suburban basis by considering the traffic demand by considering the unit length costs and unit length revenues in operations with the proposed analysis for functioning expressways in Sri Lanka.

By considering main operational expressways of the country, as Southern Expressway, Outer Circular Highway (OCH), and forecasted traffic on Central Expressway and proposed Ruwanpura Expressway urban and sub-urban links were defined for the developed BOT model and operational and maintenance costs and revenue for unit length basis were obtained for each link. Finally, this developed BOT model was described to define and evaluate any expressway link by considering different concessionaire types obtained.

Key words: BOT, Concession period, financial viability, Traffic demand, Ridership guarantee, Economic Analysis

DEDICATION

To

My Loving Mother

Who Always Give Me Strength toward Success

ACKNOWLEDGEMENT

I am very much grateful to all professors, senior lectures, lectures and all other supporting staff members and my dear friends for paying their time and support on me for the successful outcome of this thesis, especially for Dr. Dimantha De Silva for his great support on me for helping and guiding me throughout this research.

…………………………….

Name: M.A.P. Perera

Reg No: 168335 B

University of Moratuwa.

TABLE OF CONTENTS

DECLARATION ii

ABSTRACT iii

ACKNOWLEDGEMENT vi

Table of contents vii

List of Figures ix

List of Tables x

List of Abbreviations xii

1. Introduction 1
   - 1.1 Background 1
   - 1.2 Research Problem 2
   - 1.3 Objectives 4
2. Literature review 5
   - 2.1 Introduction 5
   - 2.2 Selection of BOT for expressways 6
   - 2.3 Defining discount rate and Concession period 7
   - 2.4 Defining vehicle growth factors for expressway 8
   - 2.5 Selection of optimal PPP Model for BOT Contracts 9
     - 2.5.1 Modified Annuity (Grant + Annuity +Toll) 9
     - 2.5.2 Hybrid PPP (Interest free Loan + Toll) 10
     - 2.5.3 BOT model, where construction is financed by Authority 10
     - 2.5.4 BOT Toll with funded EPC for Structures. 11
   - 2.6 Critical successful factors (CSF) for a BOT infrastructure projects 11
   - 2.7 Viability of the large scale BOT model/project. 12
3. Methodology 14
   - 3.1 Income - Expenditure Analysis (Financial Analysis) 14
     - 3.1.1 Actual financial status 15
     - 3.1.2 Deriving Growth factors 17

3.1.2.1 Operational costs (Expenditure) ... 17

3.1.2.2 Operational Income ... 18

3.2 BOT model ... 21

4. Data analysis and Discussion ... 24

4.1 Data Analysis for CKE ... 24

4.1.1 Financial Analysis for CKE ... 24

4.1.2 BOT analysis for CKE ... 29

4.2 Data analysis for Southern Expressway (STDP) and Outer-Circular – Highway (OCH) ... 35

4.2.1 Deriving actual revenue per kilometer ... 35

4.2.2 Deriving the actual expenditure per kilometer ... 36

4.3 Develop a common BOT model for describe any expressway link (Validation). ... 38

5. Conclusion and Recommendation ... 44

6. References ... 47

LIST OF FIGURES

Figure 1-1.1 – Completed Ongoing and Committed Expressway network in Sri Lanka (Annual Performance Report, 2017, p. 145) 2
Figure 1-2 – Location Map of CKE Project (Feasibility Study Report, CKE) 4
Figure 3-1– Net surplus/deficit of CKE project 15
Figure 3-2 -- BOT model defined for the study 21
Figure 4-1 – Comparison of Actual cost and benefits of CKE 27
Figure 4-2 – Comparison of Actual net revenue and discounted net revenue of CKE 27
Figure 4-3 - BOT analysis for different concession periods 34

LIST OF TABLES

Table 2-1 - Growth factors applied for REP 8
Table 3-1 – AADT of Sri Lankan Expressways for year 2011-2020 14
Table 3-2 – Distance between interchanges of CKE 15
Table 3-3 – Total Income Expenditure of CKE project 2013-2019........ 15
Table 3-4-Breakdown of Expenditure for CKE 16
Table 3-5- Breakdown of Income for CKE 16
Table 3-6- Operational Maintenance Cost of CKE........ 18
Table 3-7 – Vehicle categories considered in traffic income estimation 19
Table 3-8 – Yearly traffic growth rates of CKE 19
Table 3-9 – Traffic income estimation for Peliyagoda to Katunayake setion with derived growth rates 20
Table 3-10 - Total revenue estimation for for CKE beyond base year of 2019......... 21
Table 4-1 – Net present cost of CKE 24
Table 4-2 – Net Present revenue of CKE........ 25
Table 4-3 – Estimated cumulative net surplus and discounted cumulative net surplus 26
Table 4-4 – Calculated IRR for CKE project........ 28
Table 4-5 - BOT Analysis for concession period of 20 years........ 30
Table 4-6 - BOT analysis for 30 years 31
Table 4-7 - BOT analysis for 35 years 32
Table 4-8 - BOT analysis for 40 years 33
Table 4-9- Total Revenue for Urban and sub-urban sections of STDP & OCH........ 35
Table 4-10 – Calculated revenue per km for STDP & OCH 35
Table 4-11 – Actual and discounted revenue for km for STDP........ 36
Table 4-12 - Actual and discounted revenue for km for OCH........ 36
Table 4-13- Calculated expenditure per km for STDP & OCH........ 37
Table 4-14 - Actual and discounted expenditure for km for STDP 37
Table 4-15 - Actual and discounted expenditure for km for OCH 37
Table 4-16 – Summary of actual O&M cost and revenue per unit km for STDP, OCH &CKE........ 38

Table 4-17 – Average unit cost for O&M and Revenue for Urban and sub urban sections.......... 38
Table 4-18 – Comparison of BOT loans for Expressways 41
Table 4-19- Breakdown of Annual loan payment for operational periods. 42

LIST OF ABBREVIATIONS

RDA	–	Road Development Authority
CKE	–	Colombo –Katunayake – Expressway
OCH	–	Outer Circular Highway
MTC	–	Manual Toll Collecting
ETC	–	Electronic Toll Collecting
BOT	–	Built – Operate – Transfer
ITS	-	Intelligent Transport Systems
EOMU	-	Expressway Operation and Maintenance Management Unit
STDP	-	Southern Transport Development Project
SLR	-	Sri Lankan Rupees
USD	-	United State Dollars
O&M	-	Operation and Maintenance
GOSL	-	Government of Sri Lanka

1. INTRODUCTION

1.1 Background

The transport network of Sri Lanka achieved a significant development over the last decade with experience in the construction and maintenance of highway infrastructure, with the utilization of foreign concessions and loans from local banks.

The Road Development Authority (RDA) holds the authority to operate and maintain the Sri Lankan roadway network of 12,496 kilometers (Road Development Authority, 2019) of A and B class roads and expressways within the country.

The stakeholders have gained user benefits such as reduced travel time, increased mobility, lower accidental costs, and other social benefits from the corridor's social and cultural development as well as the country's infrastructure development.

Sri Lankans have experienced mega infrastructure development projects and expressway construction projects within the country in recent years. The Southern Expressway was the first expressway constructed in Sri Lanka, which was completed in 2011 (Annual Performance Report (Highway Sector), 2016, p. 235), with its length of 129 km from Kottawa to Godagama in Section 1. The Outer Circular Highway (OCH) (E02) Section 1, from Kottawa to Kaduwela, was the second, opened in 2012 and The Colombo-Katunayake Expressway (CKE) (E03) was the third expressway completed in 2013 (Annual Performance Report, 2017, pp. 36,section 2).

Mainly, the above operating expressway network in the country has been constructed with foreign funds, and the ongoing expressways such as the Northern Expressway and Ruwanpura Expressway-section 1 are being constructed with the investment of funds from local government banks.

The completed, ongoing and committed expressway network in Sri Lanka is shown in figure 1.1

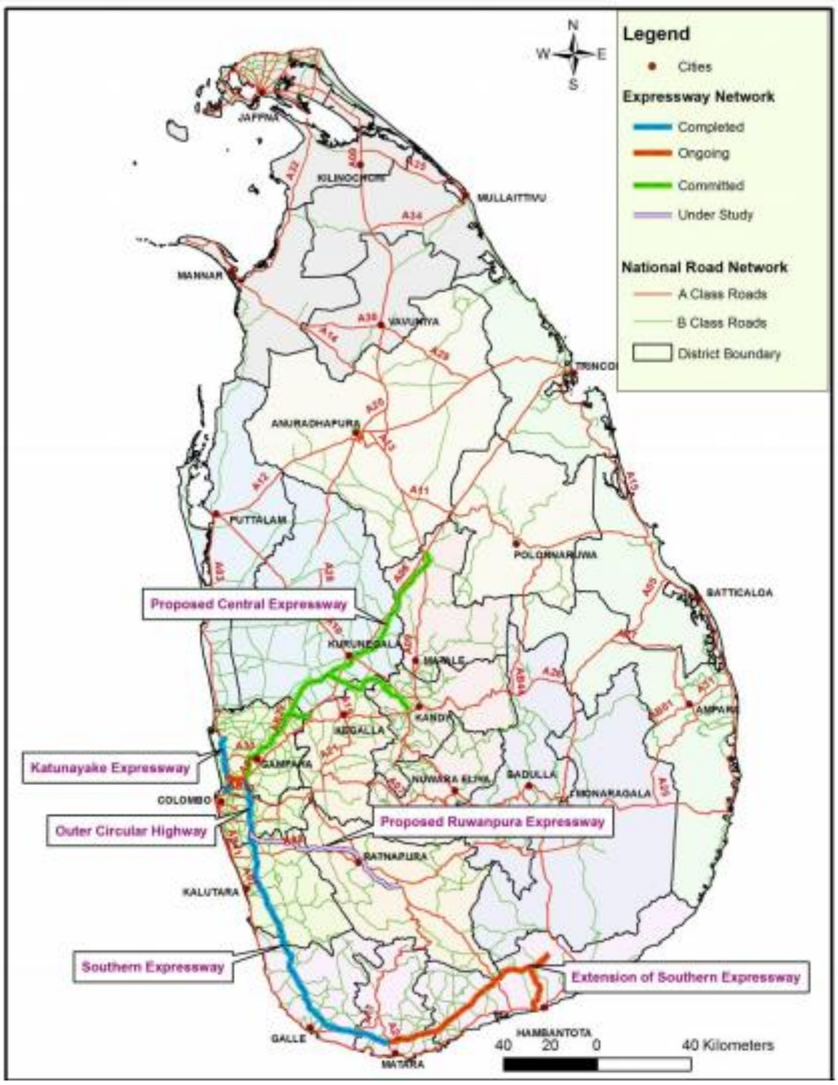

Figure 1-1.1 – Completed Ongoing and Committed Expressway network in Sri Lanka (Annual Performance Report, 2017, p. 145)

1.2 Research Problem

Recently, the national road network and existing infrastructure facilities do not meet the demand of the beneficiaries of the country. The existing national urban road system is always congested during peak and off-peak and road users are experienced delays on roads and in getting services. The Sri Lankan government, always makes an effort to mitigate delays on the road network by coordinating with service provider institutions and enhancing the quality of the roads and the quantity of investment projects on infrastructure projects by investing funds and money on them.

As Sri Lanka is a developing country, the government of Sri Lanka is not in a position to finance the mega infrastructure development projects to meet the highest demand in the country. Privatization of infrastructure facilities has become the primary solution to the necessity as; to operate or maintain an existing facility or infrastructure and build a new facility or infrastructure for a certain pre-determined period.

Basically, there are two approaches to financing projects: the borrowing method and the non-borrowing method, which are based on investment or participating in investment by its ways, such as the BOT method. There, finance and construction of the projects are done by private or foreign investors. Then, private and foreign investors finance and construct the projects through concessionaires and loans may lead the government to invest in them.

Privatization of infrastructure facilities was categorized into two categories: operating or maintaining an existing facility or infrastructure; and building and operating a new facility or infrastructure for a certain pre-determined period.

The location map of the CKE project is shown in figure 1.2, which provides a direct link to Colombo city, the central business district from Bandaranayake International Airport (BIA), Katunayake.

In developed countries, expressway operations are conducted in a technically advanced manner. However, in Sri Lanka, all operating expressways are functioning with primary technologies such as the Manual Toll Collecting (MTC) system and the Electronic Toll Collecting system (ETC), which are used only in the CKE.

Applying BOT systems for expressways leads to better performance of expressways in a technically advanced manner, which includes Intelligent Transport Systems (ITS) and other cultural development around the corridor.

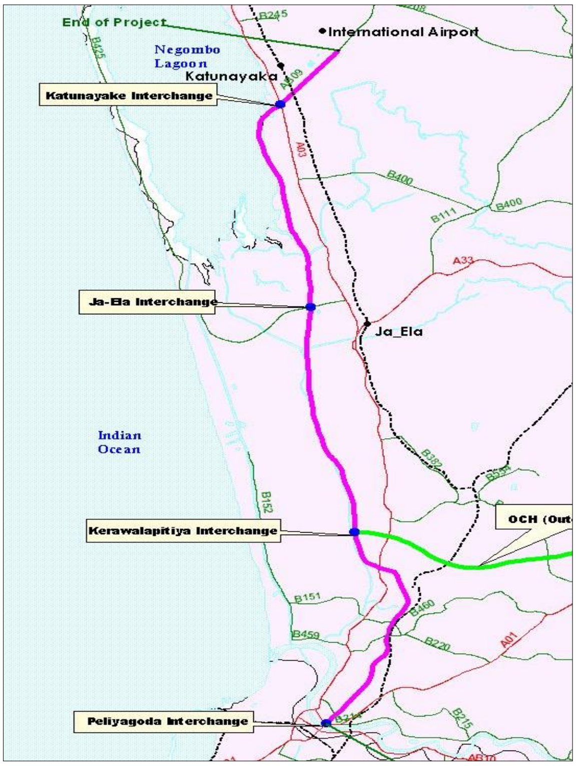

Figure 1-2 – Location Map of CKE Project (Feasibility Study Report, CKE)

Basically, this study was carried out to evaluate the possibility of applying the BOT method to CKE, by considering actual costs and revenues from CKE operations and validate an optimum BOT model to define any expressway to obtain the optimum concession period by considering this optimal BOT model.

1.3 Objectives

Objectives of the study are:

1. Develop a simple BOT model and evaluate the CKE project on an income-expenditure basis and a BOT basis.
2. Evaluate the behavior of the CKE operations on the normal BOT method with variable concessionaire periods.
3. Determine the optimum BOT model for any expressway by considering normal BOT, BOT annuity, and hybrid BOT methods for the pre-determined concession period

2. LITERATURE REVIEW

2.1 Introduction

BOT is directly involved with the Public-Private Partnership (PPP) under project financing. A BOT project is defined as the development of infrastructure with direct private financing. It is not an independent commercial project, although its developer is a public enterprise. When BOT projects are carried out by coordinating with the private and public sectors together, they are defined as conventional BOT, under the PPP method. To implement a BOT project, it should consider whether it has value from a socio-economic perspective and whether the project is financially feasible under the BOT method.

Most of the BOT projects were abandoned in the planning phase. The public sector needs to implement considerable measures when carrying out a PPP-based BOT project to avoid making incompatible expectations of the public sector with the operations of the private sector on those projects: (BOT Projects under PPP, 2002) as:

a). project clarification by addressing transport policy and defining the significance of development to achieve economic targets while achieving social benefits and

b). In the conventional BOT method allows both parties to share and allocate profits, risks, and social benefits. Also, a risk analysis and necessary measures for the risk's management should be facilitated in the project analysis.

To implement a successful BOT project, there is a need to make proper risk allocation during different stages of the project. The major types of risks in BOT projects are delay risk, tariff adjustment, Political, Currency, and foreign exchange, Cost overrun, market, operation, and also force majeure.

A BOT project has agreements for concession, loan, shareholders, construction contract, supply contract (Equipment/Material/Fuel supply contract), off-take, and O&M. The concession agreement is signed between the government and the concessionaire, and it is regarded as the "heart" of a BOT project as it determines the commercial viability and profitability (Delmon & Jeffrey, 2009).

The major characteristics of the BOT are:

a). Financed by project finance with limited resourses.

b). The private sector is fully responsible for design, construction, finance, operation and maintenance.

c). associated with uncertainties and high risk, and transfers the risk to the private sector.

d). Typically, large scale and commitment costs of average 5 to 10%

e). Complex structures with multiple interdependent agreements with various participants.

2.2 Selection of BOT for expressways

The potential selection of a BOT project by the government is affected by several criteria, such as the scope of the project, concessionaire, concession period, and interest rate.

When governments cannot facilitate large-scale projects, private financing is the primary solution observed at present. High demand and flexible BOT contracts, where the risk is minimal, were investigated with regard to demand uncertainty and the minimum attractive required rate (MARR) by addressing full and partial flexibility on the basis of the concession period, road capacity, and toll level. Here, full flexibility refers to the case in which the government guarantees an exogenous rate of return on the private investment and, in return, can freely adjust the contract (concession period, toll, subsidy, size) and partial flexibility refers to both parties where the risk is allocated in between and adjustments are made contingently by Pareto-improvement to both parties (Tan & Yang, 2012) , (Niu & Zhang, 2013).

The optimal BOT contracts were examined with the two types defined as fully flexible and partially flexible, by assuming that the government chooses the original contract variables by maximizing the expected social benefits under demand uncertainty with ex-post adjustments to the optimal contracts. It has been proven that the optimal subsidy size depends on the MARR in the private sector, and subsidies are not always bad for the optimal capacity and toll or demand choices for maximizing social welfare (Tan & Yang, 2012).

When there is a high demand, first, the government should set the best toll and define the concessionary period which equates to the project life and subsidy size which equates to the ridership guarantee, the gap between the required profit and toll revenue. In the intermediate demand domain, a concessionary period should be selected as the project life and the toll should just cover at least the investments and required profit of the private sector.

Where there is demand uncertainty, the government guarantees the rate of return; all demand risks should be borne, and full flexibility should be allowed to determine the optimum toll, subsidy level, and concession period after obtaining a demand curve. (Tan & Yang, 2012). (Lyer & Balamurugan, 2006) varied the concessionary rate between +2% and-2%, and the optimum concessionary loan rate has been defined.

(Hanaoka & Palapus, 2012), defined the reasonable concession period by considering the Monte Carlo simulation and the bargaining Game Theory. By considering the variable shares with the government and private sector and with defined uncertainty parameters such as investment cost, inflation, interest rate, weighted average of capital cost, O & M cost, traffic, toll-fee, revenues, and NPV. Here, the results seem to show that the concession periods of the case studies were higher with the Monte Carlo simulation. Also, in reality, longer concessionary periods would give a great chance to the private sector.

2.3 Defining discount rate and Concession period

The selection of the discount rate for the BOT analysis is not critical and generally, in all cases in feasibility reports, 10% of the rate was used as the discount rate (Feasibility Study of Colombo-Katunayake- Expressway , June 2008) and (Feasibility Study of the Ruwanpura Expressway , 2017).

Case studies of BOT road projects in the Philippines have been used to determine a reasonable concession period by considering different cash flow options. In determining the financial viability of the projects, the concession period is one main input parameter to the financial cash flow with NPV for the resulting viability indicator (Hanaoka & Palapus, 2012).

2.4 Defining vehicle growth factors for expressway

The choice of vehicle growth factor is crucial for this study, since it has a serious influence on the traffic forecast from the base year of 2019. The planning division of the Road Development Authority, Sri Lanka, has calculated traffic growth factors for various vehicle types in the provinces of the country.

The traffic growth factors for different provinces proposed by RDA and the national growth rates used in ADB study on Northern Road Connectivity Project (ADB) were developed for 5 years period, used in feasibility studies of Ruwanpura Expressway Project (REP) were tabulated in table 2.1 (Feasibility Study of the Ruwanpura Expressway , 2017) .

Table 2-1 - Growth factors applied for REP

Vehicle category	Vehicle type	Annual Growth Factor		
		2021-2025	2026-2035	2036-2040
1	Motor car	6.0%	5.0%	5.0%
	LC	6.0%	5.0%	5.0%
3	MEDC	5.5%	4.5%	4.5%
	HC	3.5%	3.0%	3.0%
4	MAC	3.5%	3.0%	3.0%

The TRANSPLAN model developed by the University of Moratuwa in Sri Lanka forecasts future traffic based on trip generation and the attraction of socio-economic indicators such as population, household, number of employment in various categories, and vehicle population,etc

Since it is not ethical to use normal traffic generation factors for the expressway operations, actual traffic growth was considered on each and every expressway link of the Colombo-Katunayake-Expressway and forecasted beyond the base year of 2019 for the required period.

2.5 Selection of optimal PPP Model for BOT Contracts

The development of an appropriate PPP model for greenfield and brownfield projects has been applied widely across a wide range of projects in several countries, related to new road construction and improvement. The success of the PPP projects in road construction and improvement depends on the various factors related to the host government, the economic condition, and the legal and financial framework for the offering. Private sector participation for road development of PPP projects under the BOT model is as follows (National Road Master Plan 2018-2027 -Draft Final, 2018):

a). The Engineering, Procurement and Construction (EPC) Model – this induced the private sector's strengths and is suitable for greenfield projects.

b). The BOT Toll Model – very popular and many variants of the model have been developed and are suitable for greenfield and brownfield projects.

c). BOT Annuity Model – for current development models and suitable for both operation and maintenance projects.

d). BOT Toll/Annuity Hybrid Model – A hybrid of toll and annuity concession models suitable for the development of junctions, intersections, and highway furniture.

To encourage private sector participation in PPP initiatives in the road sector, a new type of PPP contract is needed, one that balances commercial risk transfer with the country's leading factors in the road sector. The above-mentioned new PPP contracting models must then be applied to the existing issues as follows.

1. Modified Annuity model (Grant + Annuity + Toll)
2. Hybrid PPP model (Interest free Loan + Toll)
3. BOT model, where construction is financed by authority
4. BOT Toll with funded EPC for Structures.

2.5.1 Modified Annuity (Grant + Annuity +Toll)

This is a concessionary arrangement where the concerned authority has to pay part of the construction cost as a capital grant during the construction stage and the balance has to be paid as an annuity loan payment. There is a separate provision for the payment of O&M as a percentage of the project cost, and it is relinked with an annuity payment. It recommends stretching when the BOT is in traditional form, as it is unviable with high project costs and absence of appropriate revenue streams. The potential benefits gained from this model are as follows;

- Reduce the financing requirements for Authority through EPC mode;
- Reduce the amount of credit required and lending costs for the private sector when compared to BOT.-Annuity
- Improved construction quality – with long-term concession periods
- Improve the O & M as the payments are performance linked.

2.5.2 Hybrid PPP (Interest free Loan + Toll)

This is a concessionary to construct, toll, and maintain the road. The authorities have to pay a partial amount of the construction cost as an interest-free loan, during the construction period. The bidding parameter for this type of concession is the amount of interest-free loans. The donor makes repayment of this loan after predetermined-traffic in the terms of Passenger Car Units (PCU). The potential benefits are shown as follows:

- The construction project is jointly funded by the authorities and the concessionaire.
- Loan repayment after stabilization of cashflows.
- Debit requirements and the cost of lending for the private sector are reduced compared with BOT – Toll.

2.5.3 BOT model, where construction is financed by Authority

Construction is financed by the authorities, and payment terms are identical to those of EPC projects. This is the same as the BOT Toll model. In this approach, the construction, operation, maintenance, and tolling are all handled by the same concessionaire, and the concessionaire pays the annual concession amount instead of tolling throughout the concession time. The potential benefits of this model are as follows:

- Concessionaire does not own the project financing risk, allowing for lower-cost financing.

- Construction risk is balanced.
- On-time completion of projects; better management of time and cost-overruns.
- reduced outstanding default and abandonment risks.

2.5.4 BOT Toll with funded EPC for Structures.

This model is suitable for critical, complex infrastructure projects like bridges, tunnels, etc. The same developer developed the Toll-as-EPC basis and the authority funds the critical, complex projects infrastructure in separately. This combination will improve the high viability of these types of projects. The payment of EPC and the milestones of the critical structures were predetermined in the concessionary contracts and the key benefits are:

- Availability of capital to project financing and better managed the cost of finance.
- Construction risk is balanced in complex structures.
- Projects on-time completion – with better management of time and cost-overruns.

New PPP approaches for the road sector appear to reduce some issues and risks for private-sector entrepreneurs while also ensuring improved management of infrastructure operations and maintenance. Sri Lanka has experience with public-private partnerships in the ports and power industries. Therefore, implementing these BOT models in the road sector is also difficult due to possible insufficient capacity within the country.

2.6 Critical successful factors (CSF) for a BOT infrastructure projects

The BOT concept and Private Financing Initiatives (PFI), which denote privatization schemes, have been attracted by both the private and government sectors in recent years. The financial inability of the government to finance large-scale projects may increase the demand for project privatization schemes as BOT and PFI are drastically increasing in both developing and developed countries. The initial potential variables that were applied were: criticality of the project, type of project, total time for project completion, total initial cost of the project, competency of the concessionaire, revenue earned after project completion, economic condition of the users, material availability, and labor availability were the variables for the above study, and expert opinion was obtained with question ire and analyzed with MICMAC software. (Pachpute A B, 2016). The major affected PFIs were obtained as 'a type of the project', availability of the material and reliability of the data forecast.

In a study of BOT projects in China, three board categories of BOT success factors were analyzed as "business case, "whole-life category" and "project management," and these factors were captured in important stages of BOT project preparation, bidding, construction, operation, and transfer. Outcome: CSFs were considered on the basis of their underlying "business case" rationale and how they were linked. The reliability analysis was performed using the Relative Importance Index (RII), and the major CSF factors under the risk category were identified as reasonable risk allocation, government support, and the guarantee. The CSFs under the "whole life categories" were in the following: picking up a good project, project technical feasibility, and thorough and realistic cost-benefit assignment. Then CSFs under ‘project management’ category were in the following: transparent and competitive procurement process, a strong project management consortium, and a good contractor (Jiaju Yang, 2017).

Also, the combination of three factors - technical factors, a sound macroeconomic environment with sound economic policy (economic factors), and a stable political situation with a favorable legal framework (political and legal factors) are described as the BOT's successful factors. Therefore, the suitable CSF has to play a useful role in the phases of preparing, bidding, constructing, operating, and transferring phases of BOT projects.

2.7 Viability of the large scale BOT model/project.

The local government of the host country should ensure an environment that is conducive to the BOT project delivery method for the ultimate success of the BOT project. This can be achieved by addressing BOT feasibility factors on a country-level and project-level basis.

The country-level analysis should be performed first before assessing the project's feasibility in four categories: political and legal, financial and commercial, economic, and environmental. When the national government/its agencies decide on a BOT project, the government has to take steps to encourage private sector investment and diminish the negative impacts of existing barriers within the country. At the project level, there are three major levels that have to be analyzed as; first, the objective of the study, second as; legal and environmental, technical, financial, and commercial, and third as; relevant decision factors in respect of the above three categories.. (Ahamed F. M. Salman)

To define the viability of a BOT model, legal and environmental factors were considered as conformance to laws and regulations, conformance to environmental policies, project risk management system and project acceptance to BOT. And finally, simplicity, functionality, availability of resources, innovation level and effective and beneficial expansion and finally financial and commercial factors were forecasted as future demand, reasonable high debt/equity ratio, high-qualified professionals, high front-end cost, short construction and concession period, low construction cost, low number of bidders, and reasonable return on investment (Ahamed F. M. Salman).

But, in this study the CKE is currently operating expressway since 2013, and therefore, viability of the BOT application was validated with considering the factors of ‘forcast and future demands’ and ‘return on investment’ with comparision with the feasibility study performed for CKE and forcasted revenues as described in section 3.1.2.2 table 3.10.

3. METHODOLOGY

The study was carried out based on the available traffic data, toll revenue, and operational and maintenance data collected from the Expressway Operation and Maintenance Management Unit (EOMU) of RDA for CKE and Southern Expressway. The Average Annual Daily Traffic (AADT) of Sri Lankan expressways was tabulated in table 3.1.

Table 3-1 – AADT of Sri Lankan Expressways for year 2011-2020

Year	Southern & OCH	CKE
2011	8,531	
2012	9,536	
2013	11,733	15,194
2014	18,293	18,401
2015	27,736	20,782
2016	44,384	23,974
2017	52,977	25,844
2018	60,524	27,971
2019	65,246	27,640
2020	63,498	17,324

In accordance with the data representation, it seems that in the year 2020, traffic data was unrealistic due to the COVID-19 pandemic situation in the country. Therefore, I have not considered the data beyond 2019 for this study. Hence, 2019 was selected as the base year throughout this study, and data was forecasted accordingly.

3.1 Income - Expenditure Analysis (Financial Analysis)

Initially, actual data on income and expenditure of CKE was collected from EOMU of RDA for the period of 2011-2020. Financial analysis was carried out with the obtained data for income and expenditure of the CKE. Future data was forecasted using derived growth factors described in section 3.1.2, with the base year of 2019 as the starting point, and the financial analysis was carriedout as per the section 4.1.1.

3.1.1 Actual financial status

The total length of the CKE is 25.8 km and three interchanges were established. The lengths between each interchanges were tabulated in table 3.2.

Table 3-2 – Distance between interchanges of CKE

I-C / km	Peliyagoda	Ja-Ela	Katunayake
Peliyagoda	-	14.5	23.8
Ja-Ela	14.5	-	9.3
Katunayake	23.8	9.3	-

The actual income and expenditure data for 2013-2019 obtained for CKE project has tabulated in the table 3.2 and figure 3.1.

Table 3-3 – Total Income Expenditure of CKE project 2013-2019

Description (Rs. Mn)	2013	2014	2015	2016	2017	2018	2019
Total Income	278.56	1,897.98	2,177.20	2,535.75	2,657.17	2,799.95	2,869
Total Expenditure	34.08	362.1	423.63	582.77	539.04	633.7	636.1
Surplus/ Deficit	**244.48**	**1,535.88**	**1,753.58**	**1,952.99**	**2,118.13**	**2,166.25**	**2,232.90**

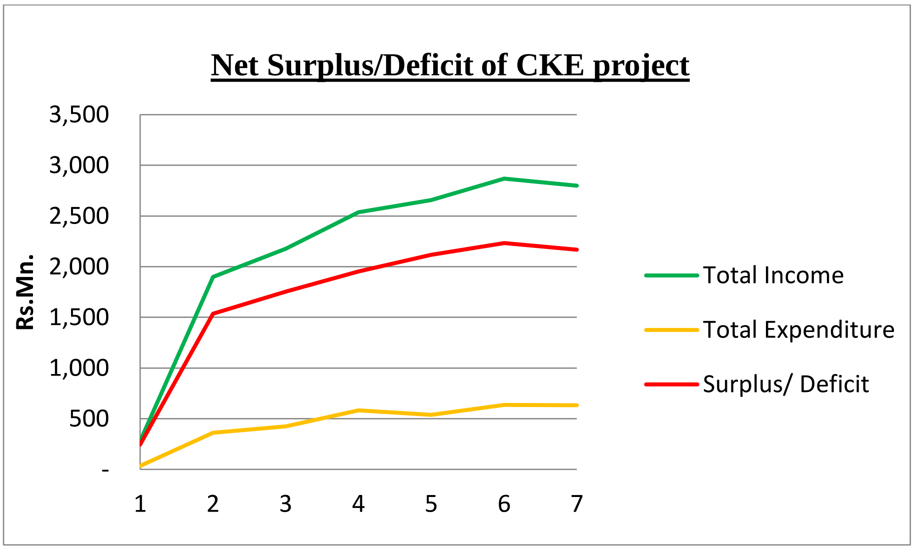

Figure 3-1– Net surplus/deficit of CKE project

As shown in the Table 3.2 and Figure 3.1, Net surplus/ deficit of the CKE project is positive from the beginning of the expressway function.

The CKE is functioning from the year 2013 and the breakdown of the total expenditure as maintenance and operations & administrative expenditures summarized in Table 3.4 and total revenue for Tolling Income, ETC Gross Income with Tag income, Towing Income, and Accident damages were collected and summarized in Table 3.5.

Table 3-4-Breakdown of Expenditure for CKE

EXPENDITURE (Rs. Mn.)	2013	2014	2015	2016	2017	2018	2019
Maintenance Expenditure	1.09	74.85	92.38	109.94	104.01	125.2	122.5
Operation & Administrative Expenditure	31.14	284.47	327.29	458.7	422.56	510.93	511.7
Total Expenditure (Without VAT)	32.23	359.32	419.67	568.65	526.57	636.13	634.2
VAT	1.85	2.77	3.96	14.12	12.47	15.28	14.38
Total Expenditure (With VAT)	**34.08**	**362.1**	**423.63**	**582.77**	**539.04**	**651.41**	**648.58**

Table 3-5- Breakdown of Income for CKE

INCOME (Rs. Mn)	2013	2014	2015	2016	2017	2018	2019
Tolling Income	277.36	1,888.63	2,101.75	2,238.15	2,271.77	2476.05	2397.65
ETC Gross Income with Tag income	-	-	67.85	289.03	375.67	382	390
Towing Income	0.41	2.42	1.94	2.09	2.25	2.85	3.2
Accident Damages	0.79	6.93	5.66	6.47	7.48	8.1	8.15
Total Income	**278.56**	**1,897.98**	**2,177.20**	**2,535.75**	**2,657.17**	**2,869.00**	**2,799.00**

3.1.2 Deriving Growth factors

3.1.2.1 Operational costs (Expenditure)

The operational cost for the expressway has three major components:

a). Day-to-day running costs, including routine maintenance costs.

b). Capital cost for major works (Periodic maintenance).

c). Operational and administrative costs

Routine maintenance for the expressway was included in the following components:

- Repair and maintenance equipment and others
- Road Maintenance
- Building repair
- Repair Vehicles & Machinery
- Direct Labors Wages & Over Time payments
- Repair and maintenance Facilities and Electricity

All costs for administrative work, including office maintenance, payment of wages, etc., and toll discounts, were included in the operational and administrative costs.

In this case, the actual estimated yearly growth for the CKE project's routine operation and maintenance expenditures was roughly 9 percent from 2014 to 2019. Then , by using this actual growth rate of 9% and the base year of 2019, as mentioned in the introduction to section 3, operational and maintainance expenditure were forecasted for the next 20 years period for financial analysis.

Periodic maintenance costs were also considered for the analysis. With past data and experience on overlay for STDP, the cost derived for overlaying of one kilometer was approximately Rs. 51.6 Mn (Feasibility Study of the Ruwanpura Expressway, 2017, pp. 101-102).

The operational and maintenance costs for CKE as per the feasibility studies are tabulated in Table 3.6. Here, item 12 represents the periodic maintenance cost of Rs.42.Mn per kilometer length derived in 2007 (Feasibility Study of Colombo-Katunayake- Expressway , June 2008 , p. 53).

Table 3-6- Operational Maintenance Cost of CKE

No	Work Item	Unit	Cost	Quantity	Annual Routine Maintenance Cost (Rs.)
1	Spot Patching	Lane - km	14,071	100.48	1,413,854.08
2	Cleaning & Obstacle Removing Work	km	596,343	24.15	14,401,683.45
3	Repair of Guard Rail	km	241,217	24.15	5,825,390.55
4	Minor Repairs	km	120,609	24.15	2,912,707.35
5	Maintenance of Lights	Light	28,142	730	20,543,660.00
6	Cleaning of Vegetation	km	2,278	24.15	55,013.70
7	Shoulder Maintenance	km	9,917	24.15	239,495.55
8	Road Furniture	km	48,913	24.15	1,181,248.95
9	Edge Repair	km	4,824	24.15	116,499.60
10	Operational Cost	km	2,750,000	24.15	**66,412,500.00**
11	**Total Routine & Operational Maintenance Cost**				**113,102,053.23**
12	**Periodic maintenance Cost**	km	42,000,000	24.15	**1,014,300,000**

Source: (Feasibility Study of Colombo-Katunayake- Expressway , June 2008 , p. 53)

Hence, the realistic periodic maintenance cost derived from the unit kilometer cost of Rs.51.6 Mn, for this 25.8 km CKE was 1,332 Mn, which was considered in this analysis. The occurrence period of this overlay was 8 years. (Feasibility Study of Colombo-Katunayake- Expressway , June 2008 , p. 53)

3.1.2.2 Operational Income

Operational income for CKE was generated from tolling, ETC, towing, and accident damage which was shown in Table 3.5,

There are six vehicle categories functioning on the expressways, depending on the number of axles and seated capacity. There were four main types of vehicle categories that were considered in the traffic income generation. These were tabulated in Table 3.7 and Vehicle Type 5 (expressway maintenance vehicles) and 6 (VIP vehicles) were not considered in the traffic income estimation.

Table 3-7 – Vehicle categories considered in traffic income estimation

Category 1	Category 2	Category 3	Category 4
1. Cars (all cars, Jeeps, saloon, Wagon) 2. Dual purpose Vehicles (double cabs) upto 9 seats 3. Light motor vehicles /2axle	4. Passenger Vehicles > 9 seats 5. Buses 33 > seats > 9 seats	6.Motor coaches (buses >33 seats) 7.Light motor lorries (2 axle 6 tyres) 8.Motor lorries	9. Heavy motor coaches 10. Heavy motor lorries

Source : (Expressway Maintainance and Management Division, Expressway Maintainance and Management Division,RDA, 2019)

Considering the actual traffic volumes on CKE, estimated actual growth factors for vehicle category 1, 2, 3 and 4 for 2015 to 2019 period were tabulated in Table 3.8.

Table 3-8 – Yearly traffic growth rates of CKE

	Year				
Vehicle category	**2015**	**2016**	**2,017**	**2018**	**2019**
1	13%	15%	6%	8%	7%
2	25%	21%	12%	9%	6%
3	13%	20%	13%	12%	12%
4	60%	26%	17%	11%	10%

When CKE operations commenced in October 2013, traffic growth for the year 2014 was substantially greater, and this was not taken into account when traffic growth rates were estimated. Also, as shown in the above table, there was significant traffic increase from 2014 to 2015 and 2015 to 2016, which was not taken into account in the traffic growth rate calculation.

Then, considering the traffic growth rates of the years 2017, 2018, and 2019, the estimated average annual growth rates were calculated as; for vehicle category 1, it was 7%, category 2 was 9%, category 3 was 12%, and category 4 was 7%.

Then , the tolling income was calculated by applying the above growth factors in Table 3.8, using the base year of 2019, and tolling income was forecasted for another 20 years.

The EOMU have published the defined user fee for the vehicle categories (Expressway Maintainance and Management Division, Expressway Maintainance and Management Division,RDA, 2019) and then tolling income were estimated in accordance with the user fee rate at unit lengths as shown in the Table 3.9. Here, vehicle type 3 and 4 were considered as similar user fee rates at the exists from expressway.

Table 3-9 – Traffic income estimation for Peliyagoda to Katunayake setion with derived growth rates

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2	Project	Colombo - Katunayake Expressway													
3	Section	*From*	***Peliyagoda***		*To*	***Katunayeke***					distance		23.8	km	
4	Length	***23.8***	*km*												
5	Annual Tra	***7,800,276***	*vpd in Year 2019*				Design Capacity =		2800 veh/hr/lane		Toll Charges	**Peliyagoda to Katunayeke**			toll cost/km
6															
7	Traffic Data										type 1		300		12.6
8	**Year**	**1**	**2**	**3**	**4**	**Annual Traffic Volume**	**Toll Income (Rs.)**		**Operating capacity veh/hr/ln**		type 2		**450**		18.9
9	**cost/km**	12.60%	18.90%	25.20%	25.20%						type 3		**600**		25.2
10	**2019**	7069223	414731	293239	23083	7,800,276			445		type 4		**600**		25.2
11	**Growth Rate**	7.00%	9.00%	12.00%	13.00%										
12	**2020**	7,564,069	452,057	328,428	26,084	8,370,636.87		26,842,788.79	478						
13	**2021**	8,093,553	492,742	367,839	29,475	8,983,609.00		28,870,328.15	513						
14	**2022**	8,660,102	537,089	411,980	33,306	9,642,476.90		31,056,494.35	550						
15	**2023**	9,266,309	585,427	461,417	37,636	10,350,789.42		33,414,297.57	591						
16	**2024**	9,914,951	638,115	516,787	42,529	11,112,382.25		35,957,879.15	634						
18	**2026**	10,381,534	668,144	541,107	44,530	11,635,314.42		37,650,003.42	664						
19	**2027**	10,870,073	699,586	566,570	46,626	12,182,854.99		39,421,756.53	695						
20	**2028**	11,381,603	732,507	593,232	48,820	12,756,162.01		41,276,885.71	728						
21	**2029**	11,917,204	766,978	621,149	51,117	13,356,448.01		43,219,314.51	762						
22	**2030**	12,478,010	803,071	650,379	53,523	13,984,982.57		45,253,151.11	798						
24	**2032**	13,066,687	840,957	681,062	56,048	14,644,754.32		47,388,066.25	836						
25	**2033**	13,683,136	880,631	713,193	58,692	15,335,652.24		49,623,700.62	875						
26	**2034**	14,328,668	922,177	746,839	61,461	16,059,144.75		51,964,805.86	917						
27	**2035**	15,004,654	965,683	782,073	64,361	16,816,769.59		54,416,357.81	960						
28	**2036**	15,712,530	1,011,241	818,969	67,397	17,610,137.01		56,983,567.01	1005						

The CKE was designed as a dual carriageway with inner and outer shoulders, with a design capacity of 2800 vehicles per hour per lane (veh/hr per lane), and the operating vehicle capacities were calculated in each expressway link to ensure that they did not exceed the design capacity (Expressway Maintainance and Management Division, Expressway Maintainance and Management Division, 2019). Upto now there were only Rs. 50 to 100 change on tall fees, 20% toll increase was considered in the toll income estimation, every 5 year period.

As the other revenue obtained from ETC, towing, and accident damage is small compared with the total revenue, a 0.5% percentage increase was considered in the analysis.

Then, total revenue collected for the year 2019 was tabulated in figure 3.3 and forecasted for another 20 years and discounted revenue was obtained. The discounted rate in transport feasibility study reports by ADB was 10-12% (Economic feasibility Report for Central Expressway Project, 2016). Hence, the discount rate applied was 10% for this study.

Table 3-10 - Total revenue estimation for for CKE beyond base year of 2019.

		ic 1	ic 2	ic 3	traffic income	other revenue(towing, accident damages, etc)	Total Income	mn	usD
year									
2013					277,364,250.00	1,198,390.00	278,562,640.00	278.56	1.56
2014					1,888,633,930.00	9,342,868.04	1,897,976,798.04	1,897.98	10.66
2015					2,169,603,996.00	7,600,795.00	2,177,204,791.00	2,177.20	12.23
2016					2,527,188,954.45	8,564,510.00	2,535,753,464.45	2,535.75	14.25
2017					2,647,436,423.89	9,730,606.00	2,657,167,029.89	2,657.17	14.93
2018					2,799,952,759.10	6,782,942.01	2,806,735,701.11	2,806.74	15.77
2019					2,869,953,426.01	6,929,837.00	2,876,883,263.01	2,876.88	16.16
2020		69,440,697.81	613,779,020.81	2,684,278,879.29	3,367,498,597.91			3,367.50	18.92
2021		74,826,216.22	659,496,435.08	2,887,032,814.65	3,621,355,465.95			3,621.36	20.34
2022		80,644,763.50	705,661,185.53	3,105,649,435.04	3,891,955,384.07			3,891.96	21.86
2023		86,932,777.67	755,057,468.52	3,341,429,757.20	4,183,420,003.38			4,183.42	23.50
2024		111,621,686.52	969,493,789.58	4,314,945,497.86	5,396,060,973.96			5,396.06	30.31
2025		119,435,204.58	1,037,358,354.85	4,616,991,682.71	5,773,785,242.14			5,773.79	32.44
2026		127,795,668.90	1,109,973,439.69	4,940,181,100.50	6,177,950,209.09			6,177.95	34.71

Also, the total expenditure derived as per the section 3.1.2.1 was forcasted for another 20 years period using the actual growth rate of 9% as described in above section and Finally, the economic analysis were performed as per the section 4.1.1.

3.2 BOT model

In this study, a basic model was defined as the BOT model and it is shown in figure 3.4 as follows.

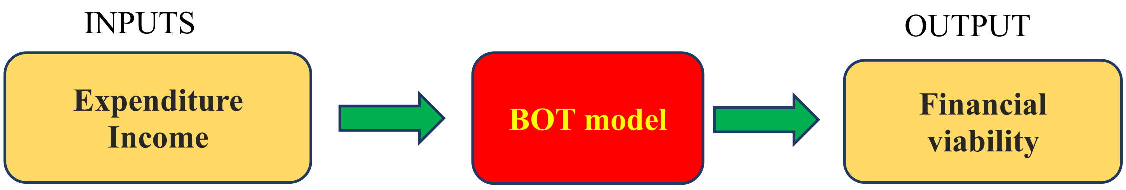

Figure 3-2 -- BOT model defined for the study

Initially, the CKE project was evaluated with this BOT model with the available and forecasted data, with the pre-determined concessionary period of 20 years and then the analysis was performed for variable concessionary periods to eliminate the optimum concessionaire period with an interest rate of 5.45% (BOT Proposal for Ruwanpura Expressway, 2017)

The year of 2019 was used as the base year for the analysis and forcasted income and expenditure data as described in the table section 3 with Table 3.1.

The annual interest rate was obtained for BOT analysis was 5.45% (BOT Proposal for Ruwanpura Expressway, 2017) and annual loan repayment installment (P) was calculated using following equation.

$$P = \frac{r\,(PV)}{1 - (\frac{1}{(1+r)^n})}$$

Where,

P = Payment r = annual interest rate

PV = Present Value n = no of years

The model was expanded to evaluate any expressway with an urban or suburban basis. Depending on the traffic demand for expressway usage, urban and suburban links were evaluated and rates for a kilometer as costs and expenditure were derived from the operating expressways.

Finally, the BOT model was furnished to define an expressway in any network with the type of concession obtained as per the budgetary provisions of the government. Here, the feasibility of the BOT project was evaluated as the normal BOT, hybrid BOT, or BOT annuity. Here, the developed BOT model directly addresses the budgetary availability and application of government funds and the application of ROI (Return On Investmets) and IRR (Internal Rate of Return).

The ROI was calculated by using the following equation; (Investopedia, 2021)

$$\mathrm{ROI} = \frac{\text{current value of investment} - \text{Cost of Investment}}{\text{Cost of the Investment}}$$

ROI can be calculated for nearly, for any activity into which an investment has been made and an the outcome can be measured. However, ROI is not necessarily the most helpful for the lengthy time frames and it has limitations in capital budgeting, where the focus is on periodic cash flows and returns and also in business analysis, ROI and other cash flow measures, such as internal rate of return (IRR) and net present value (NPV) are key metrics that evaluate and rank the attractiveness of a number of different investment alternatives. Although ROI is a ratio, it is typically expressed as a percentage rather than as a ratio.

The IRR was calculated using the following equation; (Investopedia, 2021).

$$\text{NPV} = \sum_{t=1}^{T} [(1 + IRR)t\ Ct] - Co$$

Where ;

C_t = Net cash inflow during the period t

C_o = Total initial investment costs

IRR = The internal rate of return

.t = The number of time periods

By using the above formula, IRR comes as the rate where the Net present value becomes zero. Where, the initial investment get always zero, as it is represented an outflow of cash. Then each subsequent net flows can be positive or negative depending on the nature of the investment.

The CKE project analysed with the above paramaters and validation of BOT models were described in section 4.4.

4. DATA ANALYSIS AND DISCUSSION

4.1 Data Analysis for CKE

4.1.1 Financial Analysis for CKE

As described in section 3.2, initially financial analysis was performed for the CKE project. The growth factors were used in the analysis as described in section 3.2.2 and forecasted revenue and costs were estimated and discounted for another 20 years and tabulated in Tables 4.1 and 4.2 and considered in the income-expenditure analysis.

Table 4-1 – Net present cost of CKE

		ACTUAL COSTS (Rs.Mn)					ESTIMATED COST (Rs.Mn)			
		9%	10%							
	Year	Growth factor	PV factor 10%	Routine	OP &Admin	Total routine cost	Estimated routine cost	Periodic	TOTAL	Discounted
1	2013			1.09	32.99	34.08			34.08	
2	2014			74.85	287.25	362.10			362.10	
3	2015			92.38	331.25	423.63			423.63	
4	2016			109.94	472.83	582.77			582.77	
5	2017			104.01	435.03	539.04			539.04	
6	2018			125.20	523.41	648.61	-		648.61	
7	2019	1.000	1.000	180.55	523.84	704.39	704.39		704.39	704.39
1	2020	1.090	1.100			-	767.79	1332	2,169.00	1,971.82
2	2021	1.188	1.210			-	836.82		994.00	821.49
3	2022	1.295	1.331			-	912.19		1,181.00	887.30
4	2023	1.412	1.464			-	994.60		1,404.00	959.02
5	2024	1.539	1.611			-	1,084.06		1,668.00	1,035.38
6	2025	1.677	1.772			-	1,181.26		1,981.00	1,117.95
7	2026	1.828	1.949			-	1,287.62		2,354.00	1,207.80
8	2027	1.993	2.144			-	1,403.85		2,798.00	1,305.04
9	2028	2.172	2.358			-	1,529.94	1332	4,655.00	1,974.13
10	2029	2.367	2.594			-	1,667.29		3,946.00	1,521.20
11	2030	2.580	2.853			-	1,817.33		4,689.00	1,643.53
12	2031	2.813	3.138			-	1,981.45		5,574.00	1,776.29
13	2032	3.066	3.452			-	2,159.66		6,622.00	1,918.31
14	2033	3.342	3.797			-	2,354.07		7,867.00	2,071.90
15	2034	3.642	4.177			-	2,565.39		9,343.00	2,236.77
16	2035	3.970	4.595			-	2,796.43		11,102.00	2,416.10
17	2036	4.328	5.054			-	3,048.60	1332	14,526.00	2,874.16
18	2037	4.717	5.560			-	3,322.61		15,673.00	2,818.88
19	2038	5.142	6.116			-	3,621.97		18,624.00	3,045.13
20	2039	5.604	6.727			-	3,947.40		22,121.00	3,288.39
21	2040	6.109	7.400			-	4,303.12		26,288.00	3,552.43

In this study, as described in the section 3.1.2.1, periodic maintenance cost for asphalt overlay of Rs. 1, 332 Mn was considered within every 8 years were used for the analysis.

Table 4-2 – Net Present revenue of CKE

		ACTUAL Revenue (Rs.Mn)				ESTIMATED REVENUE (Rs.Mn)			
		10%							
	Year	PV factor 10%	Tolling Income	Other Income	Total Income	Estimated Traffic Income	Estimated other Income	TOTAL	Discounted
1	2013		277.36	1.20	278.56			278.56	
2	2014		1,888.63	9.34	1,897.97			1,897.97	
3	2015		2,169.60	7.60	2,177.20			2,177.20	
4	2016		2,527.19	8.56	2,535.75			2,535.75	
5	2017		2,647.44	9.73	2,657.17			2,657.17	
6	2018		2,799.95	6.78	2,806.73		-	2,806.73	
7	2019	1.000	2,869.95	6.93	2,876.88		-	2,876.88	2,876.88
1	2020	1.100			-	3,367.50	168.37	3,535.87	3,214.43
2	2021	1.210			-	3,621.36	181.07	3,802.42	3,142.50
3	2022	1.331			-	3,891.96	194.60	4,086.55	3,070.29
4	2023	1.464			-	4,183.42	209.17	4,392.59	3,000.40
5	2024	1.611			-	5,396.06	269.80	5,665.86	3,516.99
6	2025	1.772			-	5,773.79	288.69	6,062.47	3,421.26
7	2026	1.949			-	6,177.95	308.90	6,486.85	3,328.30
8	2027	2.144			-	6,610.41	330.52	6,940.93	3,237.37
9	2028	2.358			-	7,073.14	353.66	7,426.79	3,149.61
10	2029	2.594			-	9,081.91	454.10	9,536.00	3,676.18
11	2030	2.853			-	9,717.64	485.88	10,203.52	3,576.42
12	2031	3.138			-	10,397.87	519.89	10,917.77	3,479.21
13	2032	3.452			-	11,125.72	556.29	11,682.01	3,384.13
14	2033	3.797			-	11,904.53	595.23	12,499.75	3,292.01
15	2034	4.177			-	15,285.41	764.27	16,049.68	3,842.39
16	2035	4.595			-	16,355.39	817.77	17,173.16	3,737.36
17	2036	5.054			-	17,500.27	875.01	18,375.28	3,635.79
18	2037	5.560			-	18,725.29	936.26	19,661.55	3,536.25
19	2038	6.116			-	20,036.06	1,001.80	21,037.86	3,439.81
20	2039	6.727			-	25,726.30	1,286.31	27,012.61	4,015.55
21	2040	7.400			-	27,527.14	1,376.36	28,903.49	3,905.88

The actual total revenue and total costs were obtained from table 4.1 and 4.2 and net surplus were calculated and tabulated in table no 4.3.

Table 4-3 – Estimated cumulative net surplus and discounted cumulative net surplus

	CUMILATIVE			DISCOUNTED		
Year	Cumilative Income (Rs.$ Mn.)	Cumilative cost (Rs. $ Mn.)	Cumilative Net Surplus (Rs.$ Mn.)	Discounted Cum. Income (Rs.$ Mn.)	Discounted Cum. Cost (Rs.$ Mn.)	Discounted Net surplus (Rs.$ Mn.)
2013	1.56	0.19	1.37	-	-	-
2014	12.23	2.23	10.00	-	-	-
2015	24.46	4.61	19.85	-	-	-
2016	38.70	7.88	30.83	-	-	-
2017	53.63	10.91	42.72	-	-	-
2018	69.40	14.55	54.85	-	-	-
2019	85.56	18.51	67.05	16.16	3.96	12.21
2020	105.43	30.69	74.73	34.22	15.03	19.19
2021	126.79	36.28	90.51	51.88	19.65	32.23
2022	149.75	42.91	106.83	69.12	24.63	44.49
2023	174.43	50.80	123.62	85.98	30.02	55.96
2024	206.26	60.17	146.08	105.74	35.84	69.90
2025	240.31	71.30	169.01	124.96	42.12	82.84
2026	276.76	84.53	192.23	143.66	48.91	94.75
2027	315.75	100.25	215.51	161.85	56.24	105.61
2028	357.48	126.40	231.08	179.54	67.33	112.21
2029	411.05	148.57	262.48	200.19	75.87	124.32
2030	468.37	174.91	293.46	220.28	85.11	135.18
2031	529.71	206.22	323.48	239.83	95.09	144.74
2032	595.34	243.42	351.91	258.84	105.86	152.98
2033	665.56	287.62	377.94	277.34	117.50	159.83
2034	755.73	340.11	415.62	298.92	130.07	168.85
2035	852.21	402.48	449.72	319.92	143.64	176.28
2036	955.44	484.09	471.35	340.35	159.79	180.56
2037	1,065.90	572.14	493.76	360.21	175.63	184.59
2038	1,184.09	676.77	507.32	379.54	192.73	186.80
2039	1,335.84	801.04	534.80	402.10	211.21	190.89
2040	1,498.22	948.73	549.49	424.04	231.17	192.87

The cumulative figures were calculated in the net surplus and plotted with reference to the considered years up to 2040 is shown in the figure 4.1 (estimated figures) and 4.2 (discounted figures).

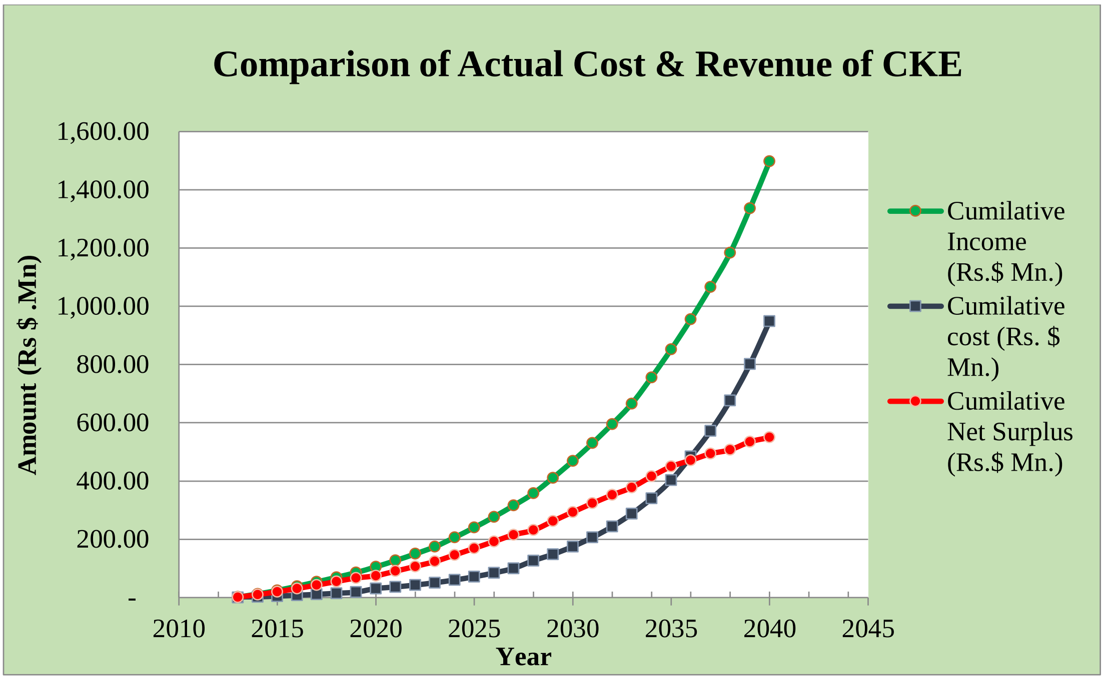

Figure 4-1 – Comparison of Actual cost and benefits of CKE

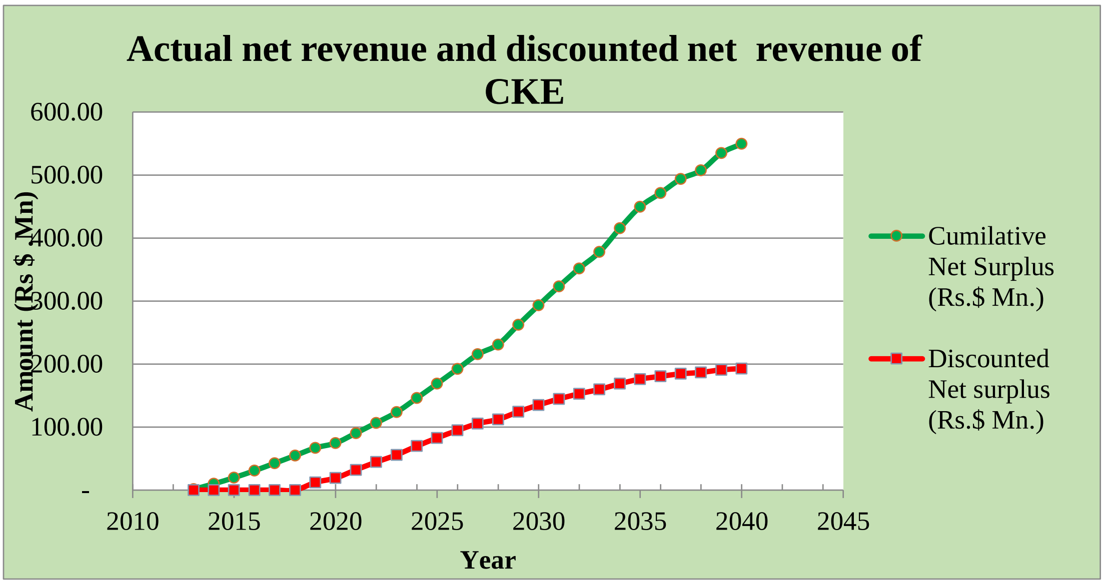

Figure 4-2 – Comparison of Actual net revenue and discounted net revenue of CKE

As shown in figure 4.1, the cumulative net surplus becomes positive up to 2040, and it seems the operations of the CKE gain income from the beginning of their operations. This demonstrates that CKE operations were profitable at the beginning of the opening and throughout the predicted period of 20 years. The IRR and MIRR was then calculated, considering the actual costs and benefits of the CKE project, and tabulated in Table 4.4.

The construction of CKE was completed in 2013 and the net revenues were converted to USD with a conversion factor of Rs. 130.8/USD. The IRR and MIRR calculated were 6% and 4% with the dollor conversion factor of Rs. 130.8 per USD, as shown in Table 4.4. Here, discount rate was used as 10% as described in the section 3.1.2.2.

Table 4-4 – Calculated IRR for CKE project

	ACTUAL					
					Rs.130.8/USD at 2013	**Rs.178/USD at 2019**
	Year	Estimated Income (Rs. Mn.)	Estimated cost (Rs. Mn.)	Net Surplus (Rs.Mn.)	Net Surplus (USD Mn.)	
					130	178
	Construction cost (USD. Mn.)				**-292.0**	**-292.0**
1	2013	278.6	34.08	244.48	1.88	1.37
2	2014	1,898.0	362.10	1,535.87	11.81	8.63
3	2015	2,177.2	423.63	1,753.57	13.49	9.85
4	2016	2,535.8	582.77	1,952.98	15.02	10.97
5	2017	2,657.2	539.04	2,118.13	16.29	11.90
6	2018	2,806.7	648.61	2,158.12	16.60	12.12
7	2019	2,876.9	704.39	2,172.49	16.71	12.21
8	2020	3,535.9	2,169.00	1,366.87	10.51	7.68
9	2021	3,802.4	994.00	2,808.42	21.60	15.78
10	2022	4,086.6	1,181.00	2,905.55	22.35	16.32
11	2023	4,392.6	1,404.00	2,988.59	22.99	16.79
12	2024	5,665.9	1,668.00	3,997.86	30.75	22.46
13	2025	6,062.5	1,981.00	4,081.47	31.40	22.93
14	2026	6,486.8	2,354.00	4,132.85	31.79	23.22
15	2027	6,940.9	2,798.00	4,142.93	31.87	23.27
16	2028	7,426.8	4,655.00	2,771.79	21.32	15.57
17	2029	9,536.0	3,946.00	5,590.00	43.00	31.40
18	2030	10,203.5	4,689.00	5,514.52	42.42	30.98
19	2031	10,917.8	5,574.00	5,343.77	41.11	30.02
20	2032	11,682.0	6,622.00	5,060.01	38.92	28.43
21	2033	12,499.8	7,867.00	4,632.75	35.64	26.03
22	2034	16,049.7	9,343.00	6,706.68	51.59	37.68
23	2035	17,173.2	11,102.00	6,071.16	46.70	34.11
24	2036	18,375.3	14,526.00	3,849.28	29.61	21.63
25	2037	19,661.5	15,673.00	3,988.55	30.68	22.41
26	2038	21,037.9	18,624.00	2,413.86	18.57	13.56
27	2039	27,012.6	22,121.00	4,891.61	37.63	27.48
28	2040	28,903.5	26,288.00	2,615.49	20.12	14.69
	IRR Calculated			=	**6%**	**4%**
	MIRR Calculated				**4%**	**3%**

The benefit/cost ratio calculated using the data in above Table 4-4 and it was 1.8, and this is financially viable for operations with this benefit/cost ratio. Hence, CKE operations were profitable, and the reliability of the application of the BOT model for CKE was described in section 4.1.2.

4.1.2 BOT analysis for CKE

As described in the previous section, CKE is financially viable for income generation from the beginning of the operations of the expressway. The viability of the BOT model was examined with the pre-derived BOT model as explained in section 3.2.

The CKE project's construction cost was determined at USD 292 million. Initially, the concession period was selected for 20 years as the minimum concession period selected for the expressways (PricewaterhouseCoopers Advisory S.p.A., 2014) was 20 years, and later the analysis was performed for 30, 35, and 40 years of concessionary periods.

Annual loan repayment installments were calculated using the equation, described in section 3.3. The total net income or net surplus obtained from Expressway operations was used in the analysis as a loan settlement amount. The conversion factor for Sri Lankan Rupees to USD was Rs.178 /USD for year 2019. The analysis was performed as shown in Table 4-5.

The results of the analysis for various concession periods of 30, 35, and 40 years are shown in Tables 4-5, 4-6, and 4-7.

Table 4-5 - BOT Analysis for concession period of 20 years

	Loan Calculation	for CKE				
		GoSL Obtains Loan for Construction				
	Initial Loan Value(USD. Mn)	292.0000				
	Management Fee (USD. Mn)	0.7300	0.25%			
	Commitment Fee (USD. Mn)	0.7300	0.25%			
	Other Fees	0.7300	0.25%			
	Total Loan Obtained	294.1900				
	Interest Rate Used	5.45%				
	Concession Period (yrs)	20				
	Annual Loan Payment (USD. M	24.5200				
	Total Cost of Loan (USD. Mn	490.4000				
	Cash Flow	Loan for Construction				
	Years	Construction Cost (USD. Mn)	Loan Repayment(USD. Mn)	Total Cash Outflow (Rs.$ Mn)	**Loan settlement from Net Income (USD. Mn)**	**Balance to be settled by the Treasury (Rs.$ Mn)**
	Y0	-		-		
	Y1	-		-		
	Y2	-		-		
	Y3	-		-		
	Y4	-		-		
1	2013		24.52	24.52	1.37	23.15
2	2014		24.52	24.52	8.63	15.89
3	2015		24.52	24.52	9.85	14.67
4	2016		24.52	24.52	10.97	13.55
5	2017		24.52	24.52	11.9	12.62
6	2018		24.52	24.52	12.12	12.40
7	2019		24.52	24.52	12.21	12.31
8	2020		24.52	24.52	7.68	16.84
9	2021		24.52	24.52	15.78	8.74
10	2022		24.52	24.52	16.32	8.20
11	2023		24.52	24.52	16.79	7.73
12	2024		24.52	24.52	22.46	2.06
13	2025		24.52	24.52	22.93	1.59
14	2026		24.52	24.52	23.22	1.30
15	2027		24.52	24.52	23.27	1.25
16	2028		24.52	24.52	15.57	8.95
17	2029		24.52	24.52	31.4	(6.88)
18	2030		24.52	24.52	30.98	(6.46)
19	2031		24.52	24.52	30.02	(5.50)
20	2032		24.52	24.52	28.43	(3.91)
	Total Cost to Government			**490.4**	**351.90**	**138.50**

The above Table 4-5 showed that after the 16th year of operations (after 2028), the expressway generates income from the operations. The ROI calculated was 28% and it is a considerable return gained from a infrastructure project, as the ROI of a business to be laid between 15 and 30 percent (neat.com, 2021). Therefore the CKE can be operate as a BOT project with the basic BOT model.

Table 4-6 - BOT analysis for 30 years

Loan Calculation	**for CKE**					
	GoSL Obtains Loan for Construction					
Initial Loan Value (Rs. $ Mn)	292.0000					
Management Fee (Rs. $ Mn)	0.7300	0.25%				
Commitment Fee (Rs. $ Mn)	0.7300	0.25%				
Other Fees	0.7300	0.25%				
Total Loan Obtained	294.1900					
Interest Rate Used	5.45%					
Concession Period (yrs)	**30**					
Annual Loan Payment (Rs. $ Mn	20.1300					
Total Cost of Loan (Rs. $ Mn)	402.6000					
Cash Flow	**Loan for Construction**					
Years	Construction Cost (Rs. Mn)	Loan Repayment (Rs. $ Mn)	Total Cash Outflow (Rs.$ Mn)	**Loan settlement from Net Income (Rs. $ Mn)**	**Balance to be settled by the Treasury (Rs.$ Mn)**	
Y0	-		-			
Y1	-		-			
Y2	-		-			
Y3	-		-			
Y4	-		-			
2013		20.13	20.13	1.37	18.76	1
2014		20.13	20.13	8.63	11.50	2
2015		20.13	20.13	9.85	10.28	3
2016		20.13	20.13	10.97	9.16	4
2017		20.13	20.13	11.9	8.23	5
2018		20.13	20.13	12.12	8.01	6
2019		20.13	20.13	12.21	7.92	7
2020		20.13	20.13	7.68	12.45	8
2021		20.13	20.13	15.78	4.35	9
2022		20.13	20.13	16.32	3.81	10
2023		20.13	20.13	16.79	3.34	11
2024		20.13	20.13	22.46	(2.33)	12
2025		20.13	20.13	22.93	(2.80)	13
2026		20.13	20.13	23.22	(3.09)	14
2027		20.13	20.13	23.27	(3.14)	15
2028		20.13	20.13	15.57	4.56	16
2029		20.13	20.13	31.4	(11.27)	17
2030		20.13	20.13	30.98	(10.85)	18
2031		20.13	20.13	30.02	(9.89)	19
2032		20.13	20.13	28.43	(8.30)	20
2033		20.13	20.13	26.03	(5.90)	21
2034		20.13	20.13	37.68	(17.55)	22
2035		20.13	20.13	34.11	(13.98)	23
2036		20.13	20.13	21.63	(1.50)	24
2037		20.13	20.13	22.41	(2.28)	25
2038		20.13	20.13	13.56	6.57	26
2039		20.13	20.13	27.48	(7.35)	27
2040		20.13	20.13	14.69	5.44	28
2041		20.13	20.13	16.59	3.54	29
2042		20.13	20.13	20.23	(0.10)	30
Total Cost to Government			**603.9000**	**586.3100**	**17.5900**	

The above Table 4-6 showed that after the 11th year of operations (after 2023), the expressway generates income from the operations. The ROI was calculated for 30 year period was 3%.

Table 4-7 - BOT analysis for 35 years

Loan Calculation	for CKE	
GoSL Obtains Loan for Construction		
Initial Loan Value (Rs. $ Mn)	292.0000	
Management Fee (Rs. $ Mn)	0.7300	0.25%
Commitment Fee (Rs. $ Mn)	0.7300	0.25%
Other Fees	0.7300	0.25%
Total Loan Obtained	294.1900	
Interest Rate Used	5.45%	
Concession Period (yrs)	**35**	
Annual Loan Payment (Rs. $ Mn)	19.0000	
Total Cost of Loan (Rs. $ Mn)	380.0000	

Cash Flow	Loan for Construction					
Years	Construction Cost (Rs. Mn)	Loan Repayment (Rs. $ Mn)	Total Cash Outflow (Rs.$ Mn)	**Loan settlement from Net Income (Rs. $ Mn)**	**Balance to be settled by the Treasury (Rs.$ Mn)**	
Y0	-		-			
Y1	-		-			
Y2	-		-			
Y3	-		-			
Y4	-		-			
2013		19.00	19.00	1.37	17.63	1
2014		19.00	19.00	8.63	10.37	2
2015		19.00	19.00	9.85	9.15	3
2016		19.00	19.00	10.97	8.03	4
2017		19.00	19.00	11.9	7.10	5
2018		19.00	19.00	12.12	6.88	6
2019		19.00	19.00	12.21	6.79	7
2020		19.00	19.00	7.68	11.32	8
2021		19.00	19.00	15.78	3.22	9
2022		19.00	19.00	16.32	2.68	10
2023		19.00	19.00	16.79	2.21	11
2024		19.00	19.00	22.46	(3.46)	12
2025		19.00	19.00	22.93	(3.93)	13
2026		19.00	19.00	23.22	(4.22)	14
2027		19.00	19.00	23.27	(4.27)	15
2028		19.00	19.00	15.57	3.43	16
2029		19.00	19.00	31.4	(12.40)	17
2030		19.00	19.00	30.98	(11.98)	18
2031		19.00	19.00	30.02	(11.02)	19
2032		19.00	19.00	28.43	(9.43)	20
Total Cost to Government			**380.0000**	**351.9000**	**28.1000**	

The above Table 4-7 showed that after the 11th year of operations (after 2023), the expressway generates income from the operations. The ROI calculated was 3%.

Table 4-8 - BOT analysis for 40 years

Loan Calculation	for CKE					
	GoSL Obtains Loan for Construction					
Initial Loan Value (Rs. $ Mn)	292.0000					
Management Fee (Rs. $ Mn)	0.7300	0.25%				
Commitment Fee (Rs. $ Mn)	0.7300	0.25%				
Other Fees	0.7300	0.25%				
Total Loan Obtained	294.1900					
Interest Rate Used	5.45%					
Concession Period (yrs)	**40**					
Annual Loan Payment (Rs. $ Mn)	18.2100					
Total Cost of Loan (Rs. $ Mn)	364.2000					
Cash Flow	**Loan for Construction**					
Years	Construction Cost (Rs. Mn)	Loan Repayment (Rs. $ Mn)	Total Cash Outflow (Rs.$ Mn)	**Loan settlement from Net Income (Rs. $ Mn)**	**Balance to be settled by the Treasury (Rs.$ Mn)**	
Y0	-		-			
Y1	-		-			
Y2	-		-			
Y3	-		-			
Y4	-		-			
2013		18.21	18.21	1.37	16.84	1
2014		18.21	18.21	8.63	9.58	2
2015		18.21	18.21	9.85	8.36	3
2016		18.21	18.21	10.97	7.24	4
2017		18.21	18.21	11.9	6.31	5
2018		18.21	18.21	12.12	6.09	6
2019		18.21	18.21	12.21	6.00	7
2020		18.21	18.21	7.68	10.53	8
2021		18.21	18.21	15.78	2.43	9
2022		18.21	18.21	16.32	1.89	10
2023		18.21	18.21	16.79	1.42	11
2024		18.21	18.21	22.46	(4.25)	12
2025		18.21	18.21	22.93	(4.72)	13
2026		18.21	18.21	23.22	(5.01)	14
2027		18.21	18.21	23.27	(5.06)	15
2028		18.21	18.21	15.57	2.64	16
2029		18.21	18.21	31.4	(13.19)	17
2030		18.21	18.21	30.98	(12.77)	18
2031		18.21	18.21	30.02	(11.81)	19
2032		18.21	18.21	28.43	(10.22)	20

The above Table 4-8 showed that after the 11th year of operations (after 2023), the expressway generates income from the operations

The comparison for loan periods of 20, 30, 35, and 40 years was tabulated in the same graph as shown in figure 4.3.

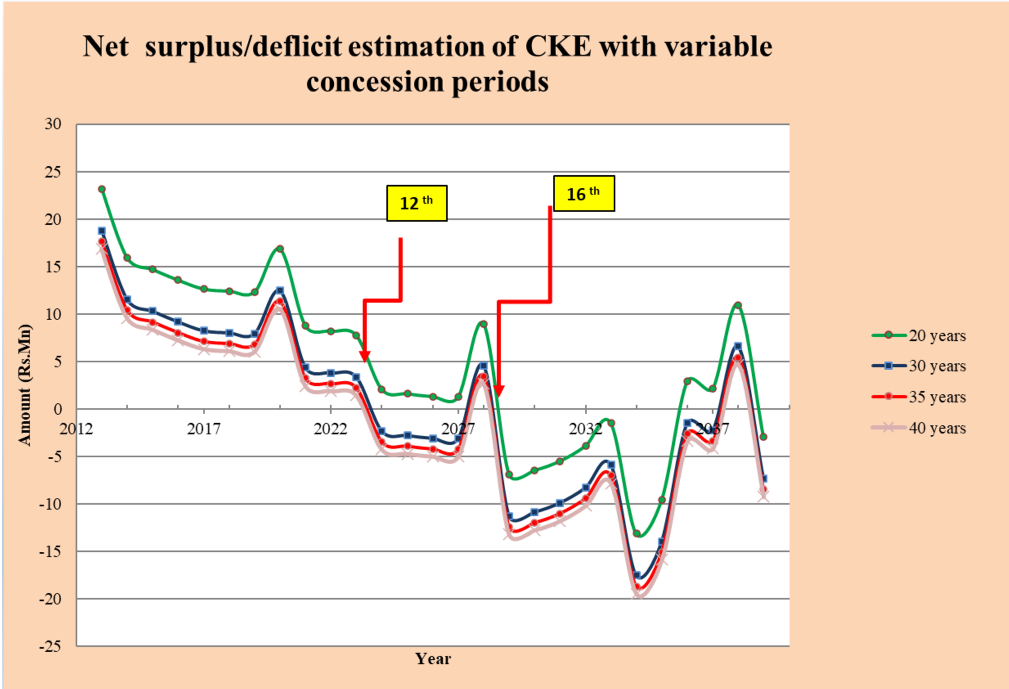

Figure 4-3 - BOT analysis for different concession periods

There is no change in the profit generation year for 30, 35, and 40 year concessionaire periods as per Tables 4-6, 4-7, and 4-8. It seems that the application of higher concession periods for this BOT model did not change the profit generating year slightly.

As a result, the BOT model was feasible for the CKE, and with this BOT project implementation, a highly advanced technology-based system and infrastructure development can be established on the expressway corridor. The application of technologies can be varied depending on the donor and implementation agency.

4.2 Data analysis for Southern Expressway (STDP) and Outer-Circular – Highway (OCH)

Initially, data analyzed for the entire Southern Expressway (E01) and Outer-Circular-Highway (E02) were categorized as an urban and suburban basis. Here the entire OCH and Kottawa to Gelanigama sections were defined as the urban sections and Gelanigama to Pinnaduwa was defined as suburban, later Gelanigama to Godagama with the opening of the later sections for the Southern Expressway.

4.2.1 Deriving actual revenue per kilometer

The Southern Expressway has been open to the public since November 2011 and data for the year 2011 was not used for the analysis. Data obtained for the year 2011 to 2019 periods were used for the analysis. The length between each considered urban and suburban links of the CKE, Southern Expressway & OCH and annual total revenue are displayed in Table 4-9 and revenue for km length was calculated and tabulated in Table 4-10. The entire CKE was considered an urban expressway link.

Table 4-9- Total Revenue for Urban and sub-urban sections of STDP & OCH

				Yearly Income Rs.MN								
		I-C / Rs.Mn	**Length (m)**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
OCH	Urban	Kadawatha - Kottawa	**20.8**					685.9	1399.6	1715.4	2009.1	2226.5
STDP	Urban	Kottawa-Gelanigama	**19.1**	40.5	512.9	648.2	791.3	991.9	1264.7	1404.6	1577.1	1717.6
STDP	Sub-Urban	Gelanigama -Pinnaduwa	**82**	42.7	504.2	608.5	660.9	832.8	1091.3	1212.2	1352.3	1399.5
STDP	Sub-Urban	Gelanigama - Godagama	**120.2**			-	1206.9	1700.1	2246.7	2509.7	2791.2	2926.2

(Source -EO&MU Division, RDA)

Table 4-10 – Calculated revenue per km for STDP & OCH

		I-C / Rs.Mn per km	**Length (m)**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
OCH	Urban	Kadawatha - Kottawa	**20.8**					33	67.3	82.5	96.6	107
STDP	Urban	Kottawa-Gelanigama	**19.1**	2.1	26.9	33.9	41.4	51.9	66.2	73.5	82.6	89.9
STDP	Sub-Urban	Gelanigama -Pinnaduwa	**82.0**	0.5	6.1	7.4	8.1	10.2	13.3	14.8	16.5	17.1
STDP	Sub-Urban	Gelanigama - Godagama	**120.2**			-	10	14.1	18.7	20.9	23.2	24.3

(Source -EO&MU Division, RDA)

As per section 4.1.1, the base year was selected as 2019 and the PV factor was used as 10%, and the calculated revenue per km was discounted up to year 2019 and tabulated in Table 4.11.

Table 4-11 – Actual and discounted revenue for km for STDP

		ACTUAL						DISCOUNTED		
		Urban		sub Urban				Urban	Sub-urban	
Year / Rs.Mn	PV Factor	Kottawa-Gelanigama		Gelanigama - pinnaduwa		Gelanigama - Godagama		Kottawa-Gelanigama	Gelanigama - pinnaduwa	Gelanigama - Godagama
	10%	19.1	growth %	82.0	growth %	120.2	growth %	19.1	82.0	120.2
2011		2.1		0.5						
2012	1.95	26.9		6.1					11.9	
2013	1.77	33.9	26.02	7.4	21.31	-		60	13.1	-
2014	1.61	41.4	22.12	8.1	9.46	10		66.65	13.04	16.1
2015	1.46	51.9	25.36	10.2	25.93	14.1	41	75.77	14.89	20.59
2016	1.33	66.2	27.55	13.3	30.39	18.7	32.62	88.05	17.69	24.87
2017	1.2	73.5	11.03	14.8	11.28	20.9	11.76	88.94	17.91	25.29
2018	1.1	82.6	12.38	16.5	11.49	23.2	11	75.09	15	21.09
2019	1	89.9	8.84	17.1	3.64	24.3	4.74	89.9	17.1	24.3
	Average	62.8		13.3		20.2		77.8	16.5	23.2

Similarly, the discounted revenue for OCH was calculated and tabulated in Table 4.12.

Table 4-12 - Actual and discounted revenue for km for OCH

				Urban
Year / Rs.Mn	PV Factor	Kottawa- Kadawatha		
		ACTUAL		DISCOUNTED
	10%	20.8	growth %	20.8
2011				
2012	1.95			
2013	1.77			0
2014	1.61			0
2015	1.46	33		48.18
2016	1.33	67.3	103.94	89.51
2017	1.21	82.5	22.59	99.83
2018	1.1	96.6	17.09	87.82
2019	1.0	107	10.77	107
	Average	88.4		96

4.2.2 Deriving the actual expenditure per kilometer

As per the same method discussed in section 4.2.1, the actual expenditure for the unit kilometer was calculated in Table 4.13 and then actual and discounted figures were calculated using the 10% PV factor, with the base year of 2019 and average unit expenditures were calculated were represented in Table 4-14 for STDP and Table 4.15 for OCH.

Table 4-13- Calculated expenditure per km for STDP & OCH

Expenditure		I-C / Rs.Mn per km	Length (m)	2011	2012	2013	2014	2015	2016	2017	2018	2019
OCH	Urban	Kadawatha - Kottawa	20.8					12.7	20.5	24	28	37.3
STDP		Kottawa-Gelanigama	19.1	0	13.4	18.7	18	19.5	20.2	21.4	24.2	32
	Sub-Urban	Gelanigama -Pinnaduwa	82.0	0	3.2	4.2	3.5	4	4	4.4	4.8	6.1
		Gelanigama - Godagama	120.2			-	3.8	5.4	5.6	6.3	6.8	8.7

Table 4-14 - Actual and discounted expenditure for km for STDP

		ACTUAL						DISCOUNTED		
		Urban		sub Urban				Urban	Sub-urban	
Year / Rs.Mn	PV Factor	Kottawa-Gelanigama		Gelanigama - pinnaduwa		Gelanigama - Godagama		Kottawa-Gelanigama	Gelanigama - pinnaduwa	Gelanigama - Godagama
	10%	19.1	growth %	82.0	growth %	120.2	growth %	19.1	82.0	120.2
2011										
2012	1.61	15.5		3.8					7.41	
2013	1.46	18.7	20.65	4.2	10.53	-		33.1	7.43	-
2014	1.33	18	-3.74	3.5	-16.67	3.8		28.98	5.64	6.12
2015	1.21	51.7	187.22	10.5	200	14.3	276.32	75.48	15.33	20.88
2016	1.1	20.2	-60.93	4	-61.9	5.6	-60.84	26.87	5.32	7.45
2017	1.0	21.4	5.94	4.4	10	6.3	12.5	25.89	5.32	7.62
2018	1.1	24.2	13.08	4.8	9.09	6.8	7.94	22	4.36	6.18
2019	1.0	32	32.23	6.1	27.08	8.7	27.94	32	6.1	8.7
	Average	26.6		5.6		8.3		34.9	7.3	10.2

Table 4-15 - Actual and discounted expenditure for km for OCH

				Urban
Year / Rs.Mn	PV Factor	Kottawa- Kadawatha		
		ACTUAL		DISCOUNTED
	10%	20.8	growth %	20.8
2011				
2012	1.95			
2013	1.77			0
2014	1.61			0
2015	1.46	33.7		49.2
2016	1.33	20.5	-39.17	27.27
2017	1.21	24	17.07	29.04
2018	1.1	28	16.67	25.45
2019	1.0	37.3	33.21	37.3
	Average	27.5		29.8

The expenditure was calculated as the operation and maintenance (O & M) cost for the expressway, as described in section 3.1.1. The summarized average actual and discounted operational and maintenance costs and expenditure per km for STDP, OCH, and CKE were tabulated in Tables 4.16 and the derived average annual operational and maintenance costs and revenues for urban and suburban links were tabulated in Table 4.17.

Table 4-16 – Summary of actual O&M cost and revenue per unit km for STDP, OCH &CKE

AVERAGE values		I-C / Rs.Mn per km	Length (m)	O&M Cost		Revenue	
				Actual	Discounted	Actual	Discounted
CKE	Urban	Peliyagoda Katunayeka	25.8	24	24.3	101.2	121.6
OCH		Kadawatha - Kottawa	20.8	27.5	29.8	88.4	96
STDP		Kottawa-Gelanigama	19.1	26.6	34.9	62.8	77.8
	Sub-Urban	Gelanigama - Pinnaduwa	82.0	5.6	7.3	13.3	16.5
		Gelanigama - Godagama	120.2	8.3	10.2	20.2	23.2

Table 4-17 – Average unit cost for O&M and Revenue for Urban and sub urban sections

AVERAGE values		I-C / Rs.Mn per km	Length (m)	O&M Cost				Revenue			
				Actual	AVERAGE	Discounted	AVERAGE	Actual	AVERAGE	Discounted	AVERAGE
CKE	Urban	Peliyagoda Katunayeka	25.8	24	26	24.3	29.7	101.2	84.1	121.6	98.5
OCH		Kadawatha - Kottawa	20.8	27.5		29.8		88.4		96	
STDP		Kottawa-Gelanigama	19.1	26.6		34.9		62.8		77.8	
	Sub-Urban	Gelanigama - Pinnaduwa	82.0	5.6	7.0	7.3	8.8	13.3	16.8	16.5	19.9
		Gelanigama - Godagama	120.2	8.3		10.2		20.2		23.2	

On an urban basis, the annual average operational and maintenance cost obtained was Rs. Mn. 26/km and the annual average revenue was Rs. Mn. 84.1/km. On a suburban basis, the derived annual average operational and maintenance cost is Rs. Mn 7.0/km and the annual average revenue was Rs. Mn 16.5/km. These obtained values were directly used as inputs to the modified BOT, which was developed to describe any expressway network within Sri Lanka, as described in section 4.3.

4.3 Develop a common BOT model for describe any expressway link (Validation).

From this section, a common BOT model was described to validate any expressway link on an urban or suburban basis with the application of annual average unit length expenditures and average annual unit length revenues, which were represented in Table 4.17, which were derived in the above section 4.2.2.

The following types of BOT models were described with BOT concessionaire analysis as briefly described in sections 2.4.1, 2.4.2, 2.4.3, and 2.4.4.

The following options were analyzed with this modified BOT model.

1. Normal BOT -option 1
2. Modified Annuity (Grant + Annuity +Toll) -option 2(a)
3. Hybrid PPP (Interest free loan + Toll) -option 2(b)
4. Concessionaire Loan -Option 3

Here, a spreadsheet was developed with the BOT category applied. Initially, the physical condition of the expressway has to be decided as whether the expressway construction has been planned on an urban expressway or a suburban expressway basis. Then the concessionaire period and concessionaire loan requirement period have to be determined, as whether the concessionaire loan is required for the construction period only or together with the construction and operational periods, it has to be defined.

With this BOT model, a pre-determined percentage of the initial loan amount was applied as the loan requirement for the construction period. It was applied directly to the initial loan amount. Then, it has to determine the amount of loan installment required for the pre-determined period from the operational period. The loan repayment installment was then calculated as per section 3.2.

When privatizing infrastructure with BOT, toll operations were followed by the BOT obtained institute for the agreed period. Table 4.19 clearly describes the breakdown of loan payments for pre-determined concessionaire periods. The initial loan amount has to be determined, depending on the engineering estimate/ tendered BOQ.

For the above-considered options 1, 2 (a), and 2 (b), when analyzing the loan amount for the construction period, a specified percentage of the initial loan amount was determined for the entire construction period and equally distributed for construction years. Then another concessionaire was obtained for operations of the expressway for another specific period, and an annual loan amount for operations has to be obtained, and this amount may vary with the institution, type of operations performed, and behaviors of the institution. For option 1, this specified period was 15 years, and for options 2 (a) and 2 (b), it was 20 years.

Option 3 involved obtaining a concessionaire loan from the local bank, and management fees and other commitment fees were not added to the initial loan amount. Then there was a 5-year grace period and obtained loans had to be settled every year starting from the 6th year of road operations. Here, the local company has to bear the operational and maintenance costs on its own and when the net surplus gets below zero, that company generates its income from the toll operations of the expressway. From that year onwards, it generates its income from the toll operations of the expressway.

For option 1, 2(a) and 2(b) total loan to be obtained was calculated as follows;

$$\textbf{Total Loan to be obtained} = \begin{pmatrix}\textbf{Concessionaire for}\\ \textbf{Construction}\end{pmatrix} + \begin{pmatrix}\textbf{Concessionaire for}\\ \textbf{Operations}\end{pmatrix} + \begin{pmatrix}\textbf{Concessionaire for}\\ \textbf{O\&M}\end{pmatrix}$$

When calculating 40 years of income in section D of Table 4.17, pre-estimated income for urban and suburban areas derived from section 4.2.2 was used and directly predicted for 40 years with a discounted rate of 10%.

A brief comparison of the above three options was analyzed with Table 4.19 and a minimum loan has to be obtained from option 3 as obtaining a concessionary loan from the government.

The sample comparison of BOT loans as per the above defined four types was represented in table 4.18. The expressway was considered with a USD Bn 2.809 loan amount for a 20 km length expressway to be described on a BOT basis with four years of construction period and variable concession periods and loan repayment periods.

As represented in Table 4.18, inputs for section A are pre-defined and directly applied to this modified BOT model. The defined percentage of the initial loan period should be applied to section B-construction period financing. Here, it was 45% of the loan amount and therefore USD Bn. 1.264 (2.809 x 0.45 = 1.264) initial loan was required for the construction period, and annually it was USD Bn. 0.3161 (1.264/4 = 0.3161) as represented in Table 4.19.

Table 4-18 – Comparison of BOT loans for Expressways

	Expressway Cost Analysis	Option 1	Option 2 (a)	Option 2 (b)	GoSL - Concessionary Loan
	Project Financing Description				
A	**Project Value - USD.Bn**	**2.809**	**2.809**	**2.809**	**2.809**
	Expressway Type	**Urban**	**Urban**	**Urban**	**Urban**
	Length of Expressway -Km	**20**	**20**	**20**	**20**
	Construction Period -years	**4**	**4**	**4**	**4**
	Project Type	**BOT**	**Hybrid Annuity**	**Hybrid Annuity**	**Concessionary Loan+EPC Contract**
	Concession Period- Years	10	20	20	N/A
	ROI Expected (USD)	**15%**	**15%**	**15%**	**N/A**
B	**Construction Period Financing**				
	Subsidy as a percentage (%) of Investment	**45%**	**45%**	**45%**	**100%**
	GoSL Subsidy Required during Construction - USD.BN	**1.264**	**1.264**	**1.264**	**2.809**
	GoSL Source of Funds	**Loan taken by Government**	**Loan taken by Government**	**Loan taken by Government**	**Concessionary Loan**
	Period of Subsidy	**Construction Period of 4 years**	**Construction Period of 4 years**	**Construction Period of 4 years**	**Loan obtained by GoSL**
	Loan to be obtained by PRIVATE COMPANY (USD Bn)	1.081647			
	Loan to be obtained by PRIVATE COMPANY as % of Project Value		38.50%	38.50%	
	INTERST of Loan	**6 month LIBOR+ 4%**	**6 month LIBOR+ 4%**	**6 month LIBOR+ 4%**	**2%**
	Period of Loan	15years	15 years	15 years	5 year grace period + 20 years
	Sovereign Guarantee		Required	Required	Required
	Equity by **PRIVATE COMPANY**		16.50%	16.50%	
C	**Operation Period financing**				
	Subsidy Required during Operation (Total) - USD Bn.	**2.829**	**4.514**	**4.751**	
	Subsidy Required during Operation (p.a.) -USD. Bn.	**0.2829**	**0.2257**	**0.2376**	
	Subsidy as a percentage (%) of Investment	101%	161%	169%	
	Period of Subsidy	10 years	20 years	20 years	
	Source of Funds	Loan taken by Government	Loan taken by Government	Loan taken by Government	
D	**Total Cost to Government over Project Life- USD**	**5.9834**	**7.6684**	**7.9054**	**3.4616**
	Toll Revenue Earned	**Private company**	**Private company**	**GoSL**	**GoSL**
	Value of Toll Income over 40 years -USD Bn.	0.491	0.491	0.491	0.491
	Net Cost to GoSL (Cost + Lost Income) - USD Bn,	**6.475**	**8.160**	**7.414**	**2.971**
	Other Factors				
	Taxation (Cost to Government)	Exemption from WHT, Dividend Tax, VAT, Income Tax, etc and any new taxes	Exemption from WHT, Dividend Tax, VAT, Income Tax, etc and any new taxes	Exemption from WHT, Dividend Tax, VAT, Income Tax, etc and any new taxes	Exemption from WHT, Dividend Tax, VAT, Income Tax, etc and any new taxes
	Maintenance (Cost to Government)	Additionally Borne by Government	Additionally Borne by Government	Additionally Borne by Government	Additionally Borne by Government

Therefore, this construction loan had to be repaid for a 15-year period and annual loan repayment was calculated as per section 3.2, and it was USD Bn. 0.1260 for an interest rate 5.45% (6 months LIBOR +4) of 15 years of repayment period, with the total requirement of USD. Bn 1.8900 (0.1260 x15). As described in section C- Operational period financing, loan requirements for the operational period have to be determined by the BOT initiating contractor, and in this sample it was USD.Bn 0.2829 for option-1 (for 10 years) and for the operational period of 10 years it was USD Bn. 2.829 (0.2829x10). Hence, the total loan requirement from these sections of A, B and C was USD.Bn 5.9833 (1.264 + 1.8900 + 2.829).

Table 4-19- Breakdown of Annual loan payment for operational periods.

Loan Calculation

	Option 1			Option 2 (a)			Option 2 (b)			GoSL Obtains Concessionary Loan for Construction			
Initial Loan Value (USD Bn)	1.2640			1.2640			1.2640			2.8090			
Management Fee (USD Bn)	0.0013	0.10%		0.0013	0.10%		0.0013	0.10%		0.0070	0.25%		
Commitment Fee (USD Bn)	0.0013	0.10%		0.0013	0.10%		0.0013	0.10%		0.0070	0.25%		
Other Fees	0.0025	0.20%		0.0025	0.20%		0.0025	0.20%		0.0070	0.25%		
Total Loan Obtained	1.2691			1.2691			1.2691			2.8301			
Interest Rate Used	5.45%			5.45%			5.45%			2.00%			
Annual Loan Payment (USD Bn)	0.1260			0.1260			0.1260			0.1731			
Total Cost of Loan (USD Bn)	1.8900			1.8902			1.8902			3.4616			
Cash Flow	**Option 1**			**Option 2 (a)**			**Option 2 (b)**			**Loan for Construction**			
	Construction Cost 45% + Subsidy (USD Bn)	Loan Repayment (USD Bn)	Total Cash Outflow (USD Bn)	Construction Cost 45% + Subsidy (USD Bn)	Loan Repayment (USD Bn)	Total Cash Outflow (USD Bn)	Construction Cost 45% + Subsidy (USD Bn)	Loan Repayment (USD Bn)	Total Cash Outflow (USD Bn)	Construction Cost (USD Bn)	Loan Repayment (USD Bn)	Total Cash Outflow (USD Bn)	
Y0	0.3161		0.3161	0.3161		0.3161	0.3161		0.3161	0.3161			
Y1	0.3161		0.3161	0.3161		0.3161	0.3161		0.3161	0.3161			
Y2	0.3161	0.1260	0.4421	0.3161	0.1260	0.4421	0.3161	0.1260	0.4421	0.3161			5 yr
Y3	0.3161	0.1260	0.4421	0.3161	0.1260	0.4421	0.3161	0.1260	0.4421	0.3161			grace
Y4	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636			-	period
Y5	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y6	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y7	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y8	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y9	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y10	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y11	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y12	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y13	0.2829	0.1260	0.4089	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y14		0.1260	0.1260	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y15		0.1260	0.1260	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y16		0.1260	0.1260	0.2257	0.1260	0.3517	0.2376	0.1260	0.3636		0.1731	0.1731	
Y17				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y18				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y19				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y20				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y21				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y22				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y23				0.2257		0.2257	0.2376		0.2376		0.1731	0.1731	
Y24											0.1731	0.1731	
Total Cost to Government	2.82900	1.8900	5.9833	4.5140		**7.6683**	4.7510	1.8900	**7.9053**			**3.4616**	
Toll Considerations													
	***15 years of Toll Income to Concessionaire**			***No income for Government for 20 years**			***Toll income for Government**			***Toll income for Government**			
	***No income for Government for 15 years**												

As described in Table 4-19, option 1 (fully privatized) was to obtain a foreign concessionary loan for both the construction phase (repayment period of 15 years) and the operational period (of 10 years), and the host capital (client) had to repay the total loan (USD Bn. 6.475) to the concessionaire as agreed. The government won't get a toll income for 15 years' time.

Option 2 (a) was to obtain a foreign concessionary (fully privatized) for the four years of the construction period (repayment period of 15 years) and the operational period (of 20 years), then host capital (client) had to repay the total loan (USD Bn. 8.160) to the concessionaire as agreed. The government won't get a toll income for 20 years.

Option 2 (b) was to obtain a foreign concessionary (fully privatized) for the four years of the construction period (repayment period of 15 years) and the operational period (of 20 years) and the client get the toll income from the beginning of the operations and the host capital (client) had to repay the total loan concessionaire as agreed (USD Bn. 7.414).

Option 3 was to obtain a concessionary loan from the local banks for the construction and repayment period of 20 years. The client has ownership of the developed highway infrastructure and, therefore, the total income for the client. Therefore, the client only has to pay the construction loan for the 20-year period that he has obtained for the construction loan. Then he has to pay USD Bn. 2.971.

By considering the four options above, it seems that the most worthwhile option was option 3, with the lowest cost to the client. But with the financial inability to obtain loans from local banks, the current trend is getting foreign concessions. In this sense, by privatizing the highway infrastructure, highly technologically advanced operating systems and toll collecting systems for expressways can be established rather than the current methods of digital sign boards and manual toll collecting systems.

5. CONCLUSION AND RECOMMENDATION

As shown in table 4.3, the cumulative net surplus is positive from the beginning of the traffic operations of CKE. It seems that the CKE project has been functioning at a profitable margin since the beginning of the expressway operations in 2013. It simply meant that the net income gained from the expressway operations was much higher than the cost incurred for the expressway operations and maintenance activities, and the calculated benefit/cost ratio was 1.8. Hence, the economic viability of the CKE operations was examined by performing the financial analysis in section 4.1.1, which was viable.

The primary objective of this study was to evaluate the potential of applying the BOT analysis to the CKE project, which became positive in section 4.1.2, for 20 years of the concessionary period, initially for a USD 292 million loan period. The calculated ROI was 28%, which is a significant return gained from an infrastructure project, as a business is expected to be down between 15% and 30%. Therefore, the CKE can be operated as a BOT project with the basic BOT model as explained in Section 4.1.2.

Then, during variable concessionary periods of 20, 30, 35, and 40 years, it was observed that the net surplus of the analysis became positive, which means the CKE generates its income from the 16th year of the 20-year concessionary period, and for other considered years, it was the 12th year. Hence, the optimum loan period was observed to be 20 years. It clearly showed that the annual loan repayment amounts decreased with the increase of the concessionary period, and the loans could be settled with the earned income from expressway operations. In this scenario, the client can directly attend to the optimum concessionary period of 20 years rather than obtaining short-term loans with higher interest rates. Also, obtaining concessionary loans for longer periods means losing the operational income from these infrastructure developments.

When developing a common BOT model for defining any expressway from the model described in section 3.2, operational and maintainance costs and revenue for unit lengths on an urban and suburban basis have been derived from the actual data obtained for operating expressways in Sri Lanka as described in section 4.2.2. Then a common spreadsheet was developed as described in section 4.3. Only urban and suburban sections were considered in this study by considering the AADT of each section of these expressways.

When calculating the amount of concessionary loan for the operational period, the annual installment requirement for operation and maintainance should be determined by the private company. As shown in the Table 4.19, it was varied as for option 1 it was 0.2829, 0.2257 for option 2(a) and 0.2376 for option 2(b). Here, the amount estimated as the annual loan amount obtained for the operational period varies with the concessionaire and performance of the concessioner. This highly affects for defining of the concessionaire requirement for the operational period. Therefore, a specific method should be followed in future studies to prevent this difficulty in the determination of subsidy requirements for the operational period of the BOT loan.

In developing countries, like Sri Lanka, their governments are not in a position to invest a large amount of money in mega infrastructure projects. On such occasions, this infrastructure privatization may provide more benefits to a country than it has in the past, such as: providing a comfortable solution to traffic congestion and demand for expressways, saving travel time and traveling costs as described in section 4.3.

The selection of BOT type depends on the type of concessionaire on a local or foreign basis, and the amount of concessionary loan obtained depends on the type of privatization method adopted. It can adhere to highly advanced techniques with Intelligent Transportation Systems (ITS) based on toll and expressway operations and can be adopted by privatizing the infrastructure with foreign authorities rather than at present. Because Sri Lanka's toll operation has not incorporated technologically advanced systems, toll collection has been done manually, with ETC based solely in CKE.

The project privatizing method of BOT can be analyzed as either normal BOT, or BOT Annuity, as briefly described in Section 4.3. The selection of the project privatizing method depends on the financing capacity of the government. Hence, with this capability of application of the loans, it has been observed that a minimum amount of loans can be obtained from the "concessionary loan from the local government'. The concessionary rate considered was 2% and was comparatively low and reasonable compared to the rate of 5.45% (6-month LIBOR + 4%) used in other options.

And application of normal BOT method for expressways is very expensive for developing countries and derivatives of BOT such as BOT annuity and Hybrid BOT methods are feasible than the normal BOT method.

In the BOT analysis, a 5.45% (6-month LIBOR +4%) interest rate was used, and it was realistic in the year 2019 base year period, as the dollar was deflating due to various situations. Then, when obtaining foreign concessions, it is a requirement to consider the interest rate for dollars when the donor is a foreign agency; while obtaining foreign concessions.

As shown in figure 4.14, an additional 0.6% has been added to the initial loan amount, considering commitment fee, management fee, and other fees with 0.2% for each, that are unavoidable in determining the total concessionaire amount. Here, the percentages used for each category in determining this additional fee can vary depending on political ethics, actual direct costs for documentary purposes, nature of management involvement, etc.

For future studies, this common BOT model can be further developed with unit length costs and revenues derived based on the physical features of the expressways such as the number of lanes, AADT, and expressways constructed on viaducts or embankments. And also, in the same way, the initial construction cost can be varied to this spreadsheet input as the physical features of the expressway, as the expressway can be constructed on the embankment on a ground treated basis, via duct basis, or tunnel basis depending on the basic features of the construction requirements of the expressway.

6. REFERENCES

PricewaterhouseCoopers Advisory S.p.A. (2014). *Evaluation and future of road toll concessions, Final Report.* France: ASECAP.

ADB. (n.d.). *Economic Analysis- Nothern Road Connectivity project,Sri Lanka.* Retrieved 05 20, 2020, from www.adb.org: http://www.adb.org/sites/default/files/linked-documents/42254-01-sri-ea.pdf

Ahamed F. M. Salman, M. J. (n.d.). BOT viability Model for Large Scale Infrastructure Projects. Retrieved from https://shaghool.ir/Files/2007-019.pdf

(2016). *Annual Performance Report (Highway Sector).* Ministry of Highways & Road Development and Petroleum Resource Development. Retrieved 04 25, 2021, from https://mohsl.gov.lk/downloads/1565995182.pdf

(2017). *Annual Performance Report.* Ministry of Higher Education and Highways, Sri Lanka. Retrieved 04 25, 2021, from https://mohsl.gov.lk/downloads/1565995162.pdf

Boeing Singh, Satyanarayana N, Kalidindi. (2006). Traffic revenue risk management through Annuity Model of PPP road projects in INDIA. *International Journal of Project Managemant 24*, 605-613.

(2002). *BOT Projects under PPP.* Japan: Ministry of land, Infrastructure and Transportation.

(2017). *BOT Proposal for Ruwanpura Expressway.* china: CINTEC PVT Ltd.

Chen, C., & Doloi, H. (2008). BOT application in China: Driving and impeding factors. *International Journal of Project management*, 388-398.

Delmon, & Jeffrey. (2009). *Introduction to PPP through BOT Projects.*

(2016). *Economic feasibility Report for Central Expressway Project.* University of Moratuwa, Department of Civil Engineering. Transport Engineering Division.

Expressway Maintainance and Management Division, R. (2019). *Expressway Maintainance and Management Division.* Retrieved 2020, from http://www.exway.rda.gov.lk/index.php?page=announcements/20190401

Expressway Maintainance and Management Division, R. (2019). *Expressway Maintainance and Management Division,RDA.* Retrieved September 22, 2018, from Expressway Maintainance and Management Division,RDA web site: http://www.exway.rda.gov.lk/expressway/resources/pdf/ug/e01_userguide_eng.pdf

(June 2008). *Feasibility Study of Colombo-Katunayake- Expressway* . Planning Division, RDA.

(2017). *Feasibility Study of the Ruwanpura Expressway* . Maga Neguma Consultancy & Project management Services Company (pvt) Ltd.

Hanaoka, S., & Palapus, H. (2012). Reasonable concession period for build-operate-transfer road projects in the Philippines. *International Journal of Project Management,30*, 938-949.

Investopedia. (2021). Retrieved from https://www.investopedia.com/terms/r/returnoninvestment.asp

Investopedia. (2021). *Investopedia*. Retrieved from investopedia.com: https://www.investopedia.com/terms/i/irr.asp

Jiaju Yang, T. M. (2017). Critical successful factors for build-operate-tansfer (BOT) projets in China. *Irish Journal of Management*, 147-161. Retrieved from https://sciendo.com/pdf/10.1515/ijm-2017-0016

Lyer, K., & Balamurugan, R. (2006). Evaluvation of Private sector Participation models in Highway Infrastructure in India-A Systematic Dynamic Approach. *Journal of Advances in Management Research, Vol 3(I)*, 44-58.

Mampearachchi, W K; Gunasinghe, P H. (2011). Effectiveness of Traffic Forecasting on Pavement designs for Sri Lankan roads. *ENGINEER Vol. XXXXIV, No. 04, Institute of Engineers, Sri Lanka*, PP[17-28].

(2018). *National Road Master Plan 2018-2027 -Draft Final.* Road Development Authority. Retrieved 04 30, 2018, from Road Development Authority: www.rda.gov.lk/source/publications.html

neat.com. (2021). Retrieved from neat: https://www.neat.com/blog/how-to-calculate-roi-before-buying-a-business/

Niu, B., & Zhang, J. (2013). Price, capacity and concession period decisions of Pareto efficient BOT contracts with demand uncertainity. *Elsevier,53*, 1-14.

Pachpute A B, T. S. (2016, February). Analysis of Critical factors for BOT Highway Projects. *Global Journal of Engineering Science and Researches*, 17-21. Retrieved OCtober 2021, from http://www.gjesr.com/Issues%20PDF/TECHNOPHILIA-2016%20-%20Jaihind%20Polytechhnic,%20Kuran,%20February,%202016/4.pdf

Road Development Authority. (2019). Retrieved 09 22, 2018, from Road Development Authority web site: https://www.rda.gov.lk/source/rda_roads.htm

Robert L K Tiong, Jahidul Alum. (1997). Evaluation of proposals for BOT. *International Journal of Project Management Vol. 15, No. 2*, 67-72.

Tan, Z., & Yang, H. (2012). Flexible Build -operator- transfer contracts for road franchising under demand unceratinity. *Elsevier,46*, 1419-1439.

(2003). *Technical assistance to the Democratic Socialist Republic of Sri Lanka for preparing a public-private partnership expressway project.* Asian Development Bank.

Xiangdong Xu, Anthony Chen, Wong S C, Lin Cheng. (2005). Selection bias in build-operate-transfer transportation project. *ELSEVIER, Transportation research Part A-75*, 245-251.

Yatanwala Y W S R, Jayasena H S. (n.d.). Failure of Applying PFI in Colombo Katunayake Expressway. 1601-1612.