ECONOMIC ANALYSIS

A. Introduction

1. Severe Tropical Cyclone Pam was a category 5 cyclone that moved through Vanuatu on 13 March 2015, causing considerable damage to the Efate ring road. The 120 kilometer (km) sealed two-way road provides transport services to the rural population around Efate Island and connects them to the capital, Port Vila. This disaster caused Vanuatu's gross domestic product (GDP) growth to contract to 1.4% in 2015, down from 2.3% in 2014.[1]

2. Under the Cyclone Pam Road Reconstruction Project, twenty damaged sites were included to be reconstructed or repaired through a comprehensive options development process to restore ring road functionality, enhance long-term disaster resilience, and improve overall road network conditions.[2] Six additional sites have been identified for upgrade as part of the additional financing of the project, to extend the improvement to the quality of rural and urban road infrastructure; and indirectly support improved public health, enhance economic activities, and raise the quality of life of residents and visitors. Through the integration of climate-resilient and sustainable design, the upgrades will lower the direct maintenance task of local authorities, while improving traffic performance and enhancing road safety.

B. Macroeconomic Context

3. Vanuatu's economy is dominated by (i) agriculture (about 25% of GDP in 2013), mainly copra and kava; (ii) tourism (about 33% of GDP in 2010), with over 250,000 cruise ship visitors per year; and (iii) commerce and industry (about 36% of GDP in 2013). Agriculture and tourism depend heavily on road transport and access to markets. It is estimated that the cyclone caused damage (direct impact) and losses (indirect impacts) amounting to $56.1 million in the agriculture sector, $88.1 million to tourism, and $47.7 million to transport infrastructure.[3]

4. Total recovery costs are estimated at about 43% of GDP (footnotes 1 and 2). This impact is reflected in the short-term downturn in economic performance: the pre-cyclone 2015 GDP forecast growth was 4.3% while post-cyclone growth was 1.4%. The most recent forecasts indicate continued strong growth (3.5% in 2016 and 3.8% in 2017). Continued growth in the tourism industry (cruise ship levels in 2016 were 30% higher than in previous years), will continue to facilitate this growth.[4]

C. Options Identification

5. A multi-criteria analysis was developed to evaluate all twenty sites included in the project. The parameters included in the analysis were weighted and scored per the significance of each element at each site. The outcomes of this analysis were presented at the options workshop held in Port Vila on 24 August 2016. During investigations, four additional damaged sites were identified and two of the sites included in the original list were required replacement against

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[1] Government of Vanuatu. 2015. *Vanuatu Post Disaster Needs Assessment: Tropical Cyclone Pam, March 2015*. Port Vila.

[2] ADB. 2015. *Report and Recommendation of the President to the Board of Directors: Proposed Loans, Grants, and Administration of Grant to the Republic of Vanuatu for the Cyclone Pam Road Reconstruction Project*. Manila.

[3] ADB. 2015. *Pacific Economic Monitor.* Manila.

[4] ADB. 2016. *Asian Development Outlook 2016 Update: Meeting the Low-Carbon Growth Challenge*. Manila.

repairs. These six sites were included in the additional financing for implementation and concept design options were assessed at another options workshop on 23 March 2017.[5]

D. Economic Analysis

6. The economic analysis was carried out per Asian Development Bank (ADB) Guidelines for the Economic Analysis of Projects.[6] It quantified the benefits and costs associated with the preferred option at each site in comparison to a without-project scenario (i.e., ongoing maintenance and replacement activities to maintain the existing level of service).[7] The project evaluation period for this cost–benefit analysis was 30 years, with construction complete by the end of 2018.[8] All benefits and costs were expressed in 2017 prices, using the domestic price numeraire (shadow exchange rate factor of 1.12 applied to tradable costs and benefits).[9] A shadow wage rate for unskilled labor of 0.75 of market wages was applied to the unskilled labor component of capital, operation and maintenance costs, and work-based road user benefits.[10] No conversion factors were applied to non-tradable goods, skilled labor, or leisure time. The exchange rate used was $1 = Vt111.35 (spot rate as of 4 April 2017).

7. The analysis examined both non-incremental and incremental benefits of preferred options. Since the works under the additional financing will not provide a new route or infrastructure, but rather improved performance and reliability of the existing network, most of the benefits are likely to be non-incremental. This improved performance will generate a non-incremental producer surplus to existing road users through operating cost reductions. However, per assumed income and price elasticities of demand, the potential for generated and induced trips to occur because of these cost reductions was also assessed and the associated incremental consumer surplus estimated. Per ADB guidelines, the discount rate and economic internal rate of return (EIRR) adopted within the analysis was 9%. The results of the cost–benefit analysis were subjected to sensitivity tests to ascertain the robustness of the project’s economic viability.

E. Economic Costs

8. The project economic costs were those predominantly associated with the capital construction works, including earthworks and ground improvement (e.g., embankments, fill, and grading); road base and subbase materials; bitumen; removal of existing bridge structures; piling; bridge structures (e.g., truss steel works, pre-cast decking, and footways); drainage and erosion control; and road furniture and markings. Construction phase costings also considered consulting services for design, tendering, training, and project supervision during 2017–2018. No price contingencies were included. Similarly, all taxes and import duties were excluded.

9. The ongoing operation and maintenance task was quantified for each of the individual project sites for the base case (without-project) and project case scenarios. Maintenance costs considered included routine annual maintenance and periodic maintenance (e.g., clearance of

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[5] Options Workshop Report (accessible from the list of linked documents in Appendix 2).
[6] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.
[7] A without-project scenario in which the Efate ring road becomes permanently disconnected by bridge failure was not considered a realistic base case scenario.
[8] The assessment period is considered appropriate given the proposed design life of 100 years for most of the proposed infrastructure.
[9] ADB. 2011. *Report and Recommendation of the President to the Board of Directors: Proposed Loan and Administration of Grants to the Republic of Vanuatu for the Port Vila Urban Development Project*. Manila. (Economic Analysis [accessible from the list of linked documents in Appendix 2]).
[10] Adopted as a standard estimate for wage in data-scarce countries, consistent with ADB. 2013. *Cost–Benefit Analysis for Development: A Practical Guide.* Manila.

storm debris every 5 years, scour protection works every 10 years, and road resurfacing costs every 15 years). In addition, the maintenance regime for the base case scenario assumed the like-for-like replacement of existing infrastructure per existing conditions. All bridge and culvert locations were assumed to have a 20-year remaining service life. The project assumed a 100-year design life for all bridge and culvert sites. The road upgrade at Tassikiri was assumed 20-year design life.

10. Total capital economic costs for the works under the additional financing were estimated at Vt1.02 billion ($9.18 million equivalent) to be expended in 2018.[11] Project costs is in Table 1.

Table 1: Project Economic Costs (Vt)

	Capital Cost		Average Annual Operation and Maintenance Cost	
	Base Case	Project Case	Base Case	Project Case
Epule Bridge	0	388,470,698	3,495,968	318,346
Saama Culvert	0	5,928,352	285,448	186,423
Tanoliu Bridge	0	37,894,485	679,919	457,092
Ulei Bridge	0	23,064,941	457,092	186,423
Prima Bridge	0	40,668,617	1,690,264	186,423
Tassikiri Road	0	526,460,638	1,731,802	1,349,787
Total	**0**	**1,022,487,732**	**8,340,493**	**2,684,494**

Note: Numbers may not sum precisely because of rounding.
Source: Vanuatu Cyclone Pam Road Reconstruction Project consultants' estimates.

F. Economic Benefits

11. Economic benefits were derived from road users and evaluated per their incremental and non-incremental demand.[12] Incremental demand was estimated per forecast uptake in vehicle trips generated because of the project, and calculated by using a standard growth function that captured the growth in traffic in proportion to the forecast GDP growth.[13] The value of incremental traffic growth was estimated using the "rule of half."[14] Based on available traffic counts, Table 2 summarizes the estimated traffic volumes and vehicle kilometers travelled (VKT) for 2018.[15]

Table 2: Traffic Performance Estimates

	Prima		Tassikiri		Other Sections	
Cases	**AADT**	**VKT**	**AADT**	**VKT**	**AADT**	**VKT**
2018						
Base Case	4,558	763,481	15,212	14,269,231	176	29,341
Project Case	4,570	765,608	15,663	14,692,351	176	29,423

AADT = annual average daily traffic, VKT = vehicle kilometers travelled.
Source: Vanuatu Cyclone Pam Road Reconstruction Project consultants' estimates.

12. The quantified economic benefits were considered as follows:

(i) **Vehicle operating costs.** Benefits were derived from vehicle operating costs (VOC). Reductions in operating costs were based on estimated existing road international roughness index (IRI) conditions (generally good: 3–5) and future road conditions (IRI 2). Using the traffic composition and the Highway Design and

[11] This is equivalent to a financial cost of $8.73 million.
[12] Txt=(Tx0*(1+gt)^y)*(Cxt/Cx0)^n. ADB. 2013. *Cost–Benefit Analysis for Development: A Practical Guide*. Manila.
[13] GDP growth was held at 4.0% until 2021 and decreased by 0.5% increments every 5 years to 2031.
[14] The rule of half is a standard methodology for measuring the benefit associated with generated trips arising from a project. ADB. 2013. *Cost Benefit Analysis for Development: A Practical Guide.* Manila.
[15] The four sites outside Port Vila have low traffic volumes. In the absence of traffic counts at each location, an average rural ring road traffic volume was used based on relevant traffic counts.

Maintenance system (HDM4) vehicle cost data established as part of the Port Vila Urban Development Project (footnote 9), weighted average VOCs (Vt/veh-km) were established for Prima (58.4), Tassikiri (39.2), and the rural sites (58.4). Improvements to the road surface through the upgrades were seen to result in minor (1%–5%) improvements in VOCs. These improved rates were applied to the calculated annual VKT to identify the present value of VOC savings to existing users (Vt427 million) and incremental benefits (Vt100 million).

(ii) **Travel time.** The upgrades generated minor speed improvements (5 km/hour) for road users at most sites through the provision of improved sight lines, additional capacity, and an improved road surface. For Tassikiri, SIDRA intersection modeling was also undertaken for key intersections to assess project improvements to intersection performance. Significant travel time benefits were observed at the Bellevue (Tassikiri Road–Montmartre Road) intersection.[16] The weighted average value of travel time per hour (Prima Vt442, Tassikiri Vt490, and rural sites Vt450) was estimated based on traffic composition, the minimum wage,[17] and a 10% adjustment to freight vehicles to capture the perishable nature of goods. A present value of travel time savings to existing users of Vt1.1 billion and incremental benefits of Vt38.0 million was observed.

(iii) **Flood immunity.** Many of the upgrades address local flooding impacts—the upgrades will reduce the frequency and duration of road closures or detours. Using the annual frequency of flooding observed, the calculated road closure times, and length of average detour routes and speeds, the expected annual delay was estimated for the base case and project case scenarios. Weighted average values of travel time were used to quantify the value of delay time. For Tassikiri, this was supplemented by reductions in annual flood damages to residences and commercial properties. Damage to commercial properties were estimated using average rental costs per square meter per month (Vt1,586). The calculation of the present value of flood immunity improvements identified non-incremental benefits of Vt438.0 million and incremental benefits of Vt3.4 million.

(iv) **Reduced crash costs.** Crash data at the proposed works locations are scarce. Community consultation identified infrequent crashes at Epule and Tanoliu. Based on annual average daily traffic and vehicle kilometers travelled (VKT), an estimated crash rate of 0.33 crashes per 100,000 VKT was assumed. For Tassikiri, it was assumed that the road would have a similar crash rate to other major roads within the central business district:[18] 0.17 crashes per 100,000 VKT. No other crash data were available. The project will improve road safety through improved sight lines, design, and landscaping and signage. For the rural sites, a 50% reduction in the crash rate was assumed and a 20% reduction was assumed for Tassikiri in the project case. Benefits were valued using an average crash cost value of Vt557,762. The present value of crash benefits was Vt36.5 million to the existing road and Vt2.0 million as incremental benefit.

(v) **Greenhouse gas emissions.** Road usage generates emissions of greenhouse gases that contribute to climate change. Based on a Vt4,123 cost of carbon dioxide per ton emissions (footnote 6, inflation adjusted), the estimated vehicle kilometers

[16] SIDRA modeling indicates that existing congestion is so bad that operational conditions are forecast to move outside of model parameters. Benefits were held constant from 2027 because of the lack of reliable model data.

[17] Motorbikes, bus passengers and drivers, and truck drivers and passengers were assumed to have a work trip time value equivalent to the minimum wage (Vt170). Cars and pickups were assumed to have a higher value of time (a factor of 1.5 of minimum wage). These values were adjusted to reflect the frequency of work and leisure trips (90% for trucks and pickups, 60% for other vehicles) and occupancies.

[18] Roughton International. 2014. *Port Vila Urban Development Project: Progress Report*. Port Vila.

travelled (VKT), and an average emission factor of 84 grams per passenger VKT,[19] the costs of greenhouse gas emissions under the base case and project case were estimated. The incremental traffic generated by the project caused the overall cost of greenhouse gas emissions to increase (present value of Vt7.3 million).

(vi) **Residual asset value**. The upgrade works will continue to provide benefits beyond the economic assessment period. The capital costs of the project and proportionate remaining service life was used as a proxy to value the post-evaluation benefit of the project. A present value benefit of Vt38.6 million was estimated.

G. Economic Evaluation: Cost–Benefit Analysis

13. Economic analysis was undertaken for all the proposed activities and aggregated at the component level. Project viability was assessed based on benefits from all components and the cost of proposed physical works, costs for implementation, technical support, allocation for operation and maintenance, and repairs of the structures and other cost elements. The EIRR of the works under the additional financing over the 30-year evaluation period is 20%. The economic net present value is Vt1.3 billion ($11.8 million). The economic costs and benefits over the project life are in Table 3. The incremental benefit component is about 7% of the total benefit.

Table 3: Economic Costs and Benefits (Vt)

Items	***6%***	***9%***	***12%***
Present value cost	839,812,331	844,712,628	840,835,387
Present value benefit (incremental)	198,550,090	135,609,224	98,048,570
Present value benefit (non-incremental)	3,006,763,109	2,050,189,173	1,482,333,650
NPV	2,365,500,868	1,341,085,769	739,546,833
BCR	3.82	2.59	1.88
NPVI	2.5	1.4	0.8
FYRR	14.75%	12.48%	12.15%
IRR	20.16%	20.16%	20.16%

NPV = net present value, BCR = benefit–cost ratio, NPVI = net present value indicator, FYRR = first year rate of return, IRR = internal rate of return.
Source: Vanuatu Cyclone Pam Road Reconstruction Project consultants' estimates.

14. The results of the economic analysis indicate the project to be strongly economically viable, with an EIRR greater than 9%. Sensitivity analysis carried out to analyze the impact of the main variables on the project economic results (Table 4) shows that project feasibility is not sensitive to many factors. As travel times represent the major benefit, the results indicate that assumptions regarding calculation of travel time benefits have the largest influence on feasibility.

Table 4: Economic Sensitivity Analysis

Scenario	**Economic Net Present Value** (Vt million)	**Economic Internal Rate of Return** (%)	**Switching Value** (%)
Base Case	1,341	20.16	
20% increase in investment costs	1,172	17.41	157
20% reduction in net benefits	904	16.84	(60)
40% reduction in travel time savings	882	16.70	(120)
No generated traffic	1,205	19.10	
No GDP growth	1,301	19.93	
50% reduction in vehicle occupancy	794	15.96	

( ) = negative, GDP = gross domestic product.
Source: Vanuatu Cyclone Pam Road Reconstruction Project consultants' estimates.

[19] Independent Evaluation Department. 2010. *Evaluation Study: Reducing Carbon Emissions from Transport Projects*. Manila: ADB.