SUMMARY ECONOMIC AND DISTRIBUTIONAL ANALYSES

A. Project Area and Sub-Projects

1. Sigatoka Valley Road and Sub-Project Locations

1. The two sample sub-projects used for this analysis lie on upper Sigatoka Valley Road, a 77 kilometer (km) road with a highland hinterland, providing access through important market gardening areas to Queens Road at Sigatoka. The sample sub-projects are (i) options of repair or replacement of an existing bridge with a new structure on essentially the same site and (ii) replacement of an Irish crossing[1] with the options of a higher level bridge on the existing or a new approach alignment or replacement of the existing damaged structure on or close to the existing site.

2. Table 1 describes Sigatoka Valley Road from its start point at Queen's Road intersection in the centre of Sigatoka town to the end point at Korolevu village, broken into nine sections with the road surface, width and terrain and position of each waterway structure.

3. The existing sealed road section leads north out of Sigatoka town on the west bank of the Sigatoka River, one of the largest rivers in Fiji, 6.5km to Nacocolevu. From that point a newly constructed 14.8km section, funded by China EXIM Bank, provides a high standard alignment and generous wide sealed road with sealed shoulders as far as the base of Narewa Hill where it joins with a pre-existing narrower sealed section 1.7km in length over the hill, ending 200m short of Dreke Road turn-off and Narata village.

4. The first sample sub-project is the existing Narata Bridge, located near the start of a gravel standard 18.9km section of road which runs due east along the north bank of the river to the villages of Nalebableba and Tuvu. There are four narrow single lane bridges and one large box culvert on this section, all of which are in need of repair and are also candidates for replacement.

5. The next 13.6km section of Sigatoka Valley Road climbs out of the valley, over a hill and then returns to the valley floor at the district centre of Keiyasi. This section is on a more winding hilly alignment and includes two bridges and two large box culverts, single lane except for one of the box culverts which has been replaced in the fairly recent past with a full 7.5m width two lane structure. Again all the structures require some degree of repair and the single lane structures are candidates for replacement. Keiyasi marks the end of the rural bus route up the valley and is the location of Navosa Central College an important secondary school in the area.

6. Part way along this section Bukuya Road forks left to join with the east-west Nausori Highlands and Nanoko Roads near Bukuya Village. Bukuya Road continues a north-south crossing of Viti Levu as Ebuto and Navala Roads, emerging at Ba. Thus Sigatoka Valley Road has a potential longer term function as part of an alternative inland cross-island network that would reduce the lifeline vulnerability of reliance on the coastal Queens Road.

7. Above Keiyasi, Sigatoka Valley Road crosses the Namada a main tributary of the Sigatoka, by means of a 63m length concrete multi-arch culverted submersible crossing. Above this point all

[1] An Irish crossing is low-level submersible causeway raised above the bed of a watercourse, with culvert openings for passing the water flow under non-flood conditions; in flood the crossing is submerged and not usable. Irish crossings are a lower cost option for providing vehicle access on low traffic roads than a higher level and usually longer bridge structure.

of the crossings are of this general "Irish crossing" type. The second sample sub-project, the Matewale Crossing is one of these, located a further 6km beyond Keiyasi. Sigatoka Valley Road, also called Tubarua Road above the Namada crossing, ends at the village of Korolevu.

Table 1 - Sigatoka Valley Road – Sections and Condition

Road Section and Waterway Crossings	Distance (kms) from Sigatoka	Section Length km	Road Surface	Average Trafficable Width m	Terrain	Est IRI[a] m/km
Queens Rd - Kedrakula Br	0.5	0.5	sealed – good	8.0	flat	3
Kedrakula Bridge						
Kedrakula Br - Nacocolevu	6.5	6.0	sealed – fair	6.0	flat	4
Lakabuta Bridge						
Nacocolevu - Narewa	21.2	14.8	sealed – good	8.0	flat	2
Narewa - Dreke Rd	22.9	1.7	sealed – good	5.5	hilly	4
Dreke Road - Tuvu	41.8	18.9	gravel – fair	4.5-5.0	flat	8
Narata Bridge[b]						
Jubairata Box Culvert	*27.8*					
Raunitogo Box Culvert	*29.1*					
Qalimare Bridge	*31.5*					
Naviago Bridge	*34.6*					
Nalebaleba Bridge	*38.7*					
Tuvu - Draiba	54.9	13.1	gravel – fair	4.0-4.5	hilly	10
Waya Box Culvert	*43.0*					
Yaloku Bridge	*46.3*					
Saweta Bridge	*48.8*					
Yalawa Box Culvert	*49.6*					
Nawaidula Culvert	*52.8*					
Draiba – Korovou Jnctn			gravel – fair	4.0-4.5	hilly	12
Draiba Crossing	*54.1*					
Kalekata Crossing	*54.7*					
Matewale Crossing[b]	*57.6*					
Korovou – Draubuta Jnctn			gravel – fair	4.0-4.5	hilly	12
Savuvu Crossing						
Leqi Crossing						
Draubuta Jnctn - Korolevu		21.8	gravel – fair	3.5-4.0	hilly	12
Varelobo Crossing						
Total Distance	76.7					

km = kilometer, m = meter.

[a] Estimated roughness in meters/kilometer. The international road roughness index (IRI), is the World Bank developed, now industry standard, measure of the profile of a road. Mathematically it is the accumulated vertical deflections from a from a vehicle-mounted or towed response meter or laser measuring device.

[b] Narata Bridge and Matewale Irish crossing sub-projects

Source(s): Asian Development Bank estimates.

2. Narata Bridge Sub-Project

8. The Narata Bridge is a three span structure over Nagalitala Creek, 26.4m overall length and a very narrow 3.1m width between kerbs. There is no footpath, handrails or guard rails, no signage, bridge end marking or protection and the small kerb upstand is broken in several places.

9. The length of the bridge combined with its narrowness (3.1m between kerbs) and lack of end and side protection makes for an unsafe environment for vehicles, pedestrians and horses which are common in the valley. The safety hazard is mitigated only by the relatively low speed traffic environment and clear sightlines at the bridge approaches, as the road is unsealed and

relatively narrow (4.0 to 4.5m trafficable width). As there is only 300mm clearance per side for a full width (2.5m) vehicle, traffic speed over the structure is necessarily low.

10. The structure has a reinforced concrete deck resting on steel I-beams, supported on concrete piles with reinforced concrete pile caps. There is some minor corrosion to the steel beams. There is damage to the pile-caps and to the south pier due to log impact; this pier is leaning 100 to 150mm out-of-vertical downstream. The south abutment may have been scoured out and the approaches rebuilt judging by the stone protection that appears to have been added.

11. The bridge is not thought to be in danger of structural failure under normal load conditions in the short to medium term, provided remedial maintenance is carried out. However, the bridge is regularly flooded (once per year on average) to a level of 1.0m above the top of the deck. There is a significant risk of large debris damage to the bridge piers in a major flood event, which could result in closure of the bridge to light or all traffic. The largest recorded flood was at the time of cyclone Kina in 1993 and the entire Nagalitala Valley was flooded at the time, to a level of 2m above the bridge deck.

12. Remedial options for the Narata Bridge are:

(i) *structural repairs* - to the substructure to counter foundation scouring and to the superstructure to restore the deck strength and make the bridge safer for pedestrian and vehicular traffic, although the limitations of the very narrow width will remain. These repairs would be sufficient unless or until the road is upgraded to seal at a later date, at which time the bridge would necessarily be replaced with a two-lane structure on safety grounds; to better cater for pedestrian and animal traffic, a footbridge could be provided alongside the existing structure;

(ii) *a replacement bridge* - the concept design proposed for a replacement bridge is a long single span of 31m at a 1.0m higher level with raised approach embankments to give a larger waterway area and to reduce the damming effect of the bridge as it now stands. The new two-lane bridge would most economically be constructed alongside the existing structure with a minor realignment of the bridge approaches, one of which is on a 200m radius curve, so would facilitate an altered horizontal alignment. The existing bridge would be retained during construction, then demolished and removed. Alternatively, a temporary crossing could be provided, the existing bridge demolished and a new bridge constructed on the existing alignment. The steel beams from the existing bridge could have a potential future use as a replacement to one of the short span bridges on this road (the Qalimare or Yaloku) or stockpiled for other projects.

3. Matewale Irish Crossing Sub-Project

13. The Matewale crossing is a 22.8m long, 4.3m width low level concrete causeway, built as a reinforced concrete slab supported by stub piers on a reinforced concrete apron forming a seven bay culvert structure. Three such causeways are believed to have been constructed and washed out at this location over the past 30 years. The current structure is built on top of the base of a previous causeway.

14. The crossing is severely damaged and a high priority for replacement at the existing or an adjacent site; repairing the structure is not an option. The whole crossing has settled and rotated upstream about 200mm across the deck. The last 6m has collapsed and vehicles that still use the crossing are tipped at sharp angle, risking overturning for high centre-of-gravity loads.

15. If nothing is done, there is a high risk that the remaining structure will be washed out in flood event in the short term. This will result in the crossing becoming a ford passable only by four wheel drive vehicles and trucks in dry weather.

16. Replacement options are:

(i) *reconstruct a new Irish crossing* - of improved design at the existing site;

(ii) *reconstruct a higher level bridge* - at the same location;

(iii) *reconstruct a higher level bridge* - at a previously suggested location about 130m upstream of the present crossing, putting the road on a straighter alignment.

In the first two options a temporary crossing would be constructed alongside the existing structure while it is demolished and a new crossing or bridge constructed. Because of the nature of the crossing, this work should be carried out in the dry season May to October.

4. Other Bridges and Crossings

17. Although the economic and safeguards analysis is focused on the two selected sub-projects, the field studies reviewed the condition and repair or replacement needs of all the bridge and large culvert structures from the end of the sealed section through to the Matewale Crossing. The first two bridges out of Sigatoka, that is the Kedrakula Bridge, a two lane bridge at the edge of Sigatoka town and the single lane Lakabuta Bridge at km 3.3 were also inspected at the suggestion of ADB.

Table 2 – Sigatoka Valley Road Bridges – Repair/Replacement Needs and Costs (F$'000s)

Bridge or Crossing	Type	Reviewed Priority	Risks	Repair Cost	Replacement	
					Cost	Lanes
Kedrakula	Bridge	Med		40	-	
Lakabuta	Bridge	Med-Hi	safety - narrow	290	6,200	2 lane
Narata	Bridge	High	safety - very narrow; inadequate waterway	395	5,200	2 lane
Jubairata	Box C[1]	Med		20	-	-
Raunitogo	Box C	Med		20	-	-
Qalimare	Bridge	High	safety - very narrow; high risk of abutment washout	375	2,200	2 lane
Naviago	Bridge	Med-Hi	safety - very narrow	355	6,800	2 lane
Nalebaleba	Bridge	High	narrow; abutment washout risk	335	5,000	2 lane
Waya	Box C	High	scour, need for additional bay	600	-	-
Yaloku	Bridge	Med-Hi	safety - very narrow	395	2,200	2 lane
Saweta	Bridge	Med-Hi	safety - very narrow	335	3,200	2 lane
Yalava	Box C	Med		5	-	-
Tabarua	MBCC[2]	Med	safety - narrow	205	-	1 lane
Namada	MBCC	Med		385	-	1 lane
Kalekata	MBCC	Med		40	-	1 lane
Matewale	MBCC	High	part failed; high risk of washout	NR	2,300	1 lane

[1.] Box culvert; [2] Multi-bay culverted low level concrete causeway (Irish Crossing); NR – not repairable

18. Simplified flow modeling was done for the six sub-catchments of the Sigatoka River to assess the adequacy of the waterway area for the Lakabuta, Narata, Qalimare, Naveyago, Nalebaleba and Matewale crossings. The calculated results were compared with information obtained through interview in the field and from historic records of flooding. The Narata was the only bridge assessed to be at risk of regular overtopping, reported to occur annually, with an

insufficient waterway area compounded with relatively low approaches resulting in a frequent damming effect, inundation and overland flow across the bridge approaches. The assessment indicated the level required for a bridge at the Matewale Crossing to be effective in passing flood peaks and confirmed the general duration and frequency of closures of a low level crossing.

19. In more extreme flood events there appears to be general flooding of the Sigatoka River which backs up into some of the subsidiary catchments, including the Nagalitala, increasing the flood frequency and duration. For example the roadside interview surveys revealed the section between Bilalevu and Narewa to be prone to seasonal flooding. The greater degree of catchment flow modeling needed to assess these effects would be appropriate at sub-project design stage, particularly if a package of bridge and culvert repairs/replacements is proceeded with for the Sigatoka Valley.

5. Economic Activities

20. The Sigatoka valley is often described as the “salad bowl” of Fiji and is notable for the extent of smallholder and larger scale commercial market gardening, particularly along the flood plain on both sides of the lower reaches of the river, but with the bulk of activity on the more accessible west bank. A wide variety of produce is grown in the lower valley, for the hotel industry, the domestic market in Suva and export. There is an agricultural research station at Nacocolevu and a tobacco leaf growing station at Bialevu further up the valley. There is good access to Nadi International Airport for air freight of perishable produce, and there is a demand for fruit and vegetables from the tourist hotels along the Coral Coast.

21. Typical crops grown for the domestic and overseas market include the food crops of papaya, bananas, tomatoes, salad greens, chillies, squash and melon. Tobacco is also grown. Ascending the valley, the intensity of market gardening reduces, there is less commercial production and the crops grown are more for home consumption and local marketing, including sweet potato (kumala), dalo, maize and cassava.

22. A Participatory Guarantee Scheme (PGS) has been set up under the Pacific Agribusiness Research for Development Initiative (PARDI), an Australian Government/University of Queensland sponsored program, between small farmers as far up the valley as Tuvu and end user hotels along the Coral Coast with the aim of improving the quality of produce supplied in return for higher prices to the growers. Research conducted for PARDI demonstrates the importance of reducing the time between production and market supply and the importance of reducing vibration damage during transport for sensitive crops such as tomatoes. The completion of the EXIM Bank funded road upgrade will have made an important contribution to reducing time and vibration damage and will have opened up opportunity for increases in market gardening further up the valley.

23. There is some logging in the uppermost part of the valley, where Sigatoka Valley Road gives access to the inland highlands of Viti Levu, for example around Namoli and Nakoro. Logging trucks were observed along Sigatoka Valley Road

3. Population, Settlement and Social Infrastructure

24. Sigatoka Valley is in the province of Nadroga-Navosa, with the centre of provincial administration in Sigatoka, and the sub-centre for Navosa at Keiyasi. In the area of the sub-projects above Narewa there are about 50 villages dependent on Sigatoka Valley Road for vehicular access, including a few villages on the east bank of the Sigatoka accessed by the

Draubuta Crossing. From the village interviews, it is also clear that there is regular movement of people and goods across the Sigatoka River at low flow, either by boat or in some places by wading. While most villages are along Sigatoka Valley Road itself, a number are accessed by side roads and are situated in remote hilltop locations. Villages range in size from 10 to 50 houses, up to 250 people, and most are quite compact in form. There are also some more scattered farm-based households, but these are in the minority.

25. The total catchment population in the upper Sigatoka Valley from the intersection with Dreke Road is estimated to be around 7,500 people, based on the 2007 population census enumeration area data and allowing for growth of 3.8% between 2007 and 2104. The catchment population above Tuvu is estimated to be 4,750 and above the Draiba (Namada River) crossing, 2,500 people. The total population of the west Sigatoka valley above the main traffic count station at Nacocolevu is estimated to be around 9,850 of which some 76% live beyond the end of the existing sealed section.

26. There are several primary and secondary schools in the upper Sigatoka Valley, in order up the river from Narata: Rukuruku District School on the opposite bank of the Nagalitala Creek, Nabaka Primary School, Raunitogo Indian School, Naqalimare District School, Sigatoka Valley Junior Secondary School (at Naveyago), Bemana District School (near Nalebaleba), Navosa Central College at Keiyasi, Nasikawa District School at Korovou and Noikoro District School at Nukuilau.

27. The main hospital for the region is at Sigatoka. Medical facilities in the upper Sigatoka Valley are a health centre at Keiyasi and nursing stations at Loma, Naqalimare, Tuvu, Nukuilau and Wanosi.

4. Traffic

28. The Department of National Roads (DNR) has carried out classified traffic counts at Nacocolevu Road (km 2.9) and at Bukuya Road turn-off (km 41.1) to the Viti Levu highlands, between Tuvu and Keiyasi. The counting program ended five years ago but the record from 2000 to 2008 provides a useful history of traffic growth to that point, indicating a traffic growth rate of about 3.2% pa. An analysis carried out for the seal extension from Nacocolevu to Narewa in 2005 assessed the likely future traffic growth without upgrading to be 4.0% pa.

29. A series of traffic counts were carried out to support the preparation of the sub-projects, with count stations at Narewa, at the end of the recently completed EXIM Bank funded section, at the approach to Nalebaleba, at the approach to Keiyasi just before the turnoff left to Keiyasi village, and beyond Keiyasi at Draiba to capture traffic travelling further up the valley towards Korolevu. Pneumatic tube counters were laid at Narewa, Nalebaleba and Keiyasi with counts recorded over the period 24 July to 6 August 2014, each with a core one-week count between 27 July and 2 August. Manual 12 hour classification, vehicle occupancy and cargo load/commodity counts were carried out over one week at Nalebaleba, approximately halfway along the road section between Narewa and Keiyasi, and for one day at Keiyasi and Draiba. Roadside interview surveys including origin/destination, trip purpose and other socio-economic information, were carried out at Narewa.

30. The traffic count analysis is summarized in Table 3. The traffic volume is average over seven days; weekday counts were about 25% above weekends. The 24h/12h ratio measured by the pneumatic tube counters varied between 1.38 and 1.50, indicating a relatively high proportion of nighttime traffic.

Table 3 – Daily Traffic at Counting Stations (24h)

Station	Vehicles /Day	Cars/ Taxis	Vans 4WD	Light Trucks	Medium Trucks	Heavy Trucks	Buses
Narewa	397	21.4%	30.7%	28.0%	18.4%	1.5%	…
Nalebaleba	140	8.0%	22.6%	23.8%	29.0%	10.9%	5.1%
Keiyasi	101	2.5%	28.4%	28.4%	32.1%	1.2%	7.4%
Draiba	105*	0.0%	1.3%	37.3%	58.7%	1.3%	1.3%

* Draiba count is expanded from 12h one day survey, using 1.40 24/12h factor

31. Vehicle passenger occupancy including the driver is shown in Table 4. Light and medium trucks are frequently used for goods and passenger carriage either as licensed or informal carriers which explains the high occupancy rates. Cars, vans and buses are uncommon above Draiba crossing.

Table 4 – Vehicle Occupancy

Station	Cars/ Taxis	Vans 4WD	Light Trucks	Medium Trucks	Heavy Trucks	Buses
Narewa	1.9	2.8	3.5	2.0	2.0	n.r
Nalebaleba	1.3	2.8	8.1	11.1	3.0	19.8
Keiyasi	-	4.1	3.6	11.9	-	13.5
Draiba	-	-	3.7	8.6	2.0	-

* not separately recorded, Narewa data from machine counters plus roadside interview

32. There was a significant volume of local pedestrian and horse traffic along the roads, with the following numbers being observed at the traffic count sites. Both of the sub-project waterway crossings carry pedestrian and horse traffic, including school children. There were insignificant numbers of two-wheel vehicles (bicycles and motorcycles). Pedestrian and horse numbers are of similar magnitude to vehicular traffic.

Table 5 – Pedestrian and Horse Traffic (12h count)

Station	Motor Vehicles	Pedestrians	Horses & Bullock Carts
Nalebaleba	114	174	21
Keiyasi	81	101	6
Draiba	75	134	11

33. The traffic count data collected by DNR, for the previous economic analysis of road upgrading in 2005 and for the present sub-project analysis were compared with the 2007 census population above each traffic count station up the Sigatoka valley and the road user cost for trips to the main provincial centre of Sigatoka. A simple traffic demand relationship was calibrated of the form: *daily vehicle trips/head of population = a x (Trip Cost)*^{b} where the trip cost (F$) is the combined vehicle operating cost and travel time cost for vehicle occupants. The calibration gave a = 72.4 and b = -1.96. The exponent b can be approximated to the demand elasticity (measured over the long run). Travel demand elasticities are typically in the range -0.5 to -2.0, so this model calibration is at the more elastic end of the range. It compares with an assumed travel demand elasticity of -1.0 adopted in the 2005 analysis for Sigatoka Valley Road estimates of generated traffic for upgrading from gravel to sealed surface.

B. Summary Economic Analysis

1. Analysis Methodology for Bridge Repair and Replacement

34. Economic evaluation of road bridges is most often carried out as part of a wider analysis of road improvement, the bridge works contributing part of the overall project benefits and project costs. Road user benefits are then typically assessed from the reduction in vehicle operating costs, travel time savings and reduced accident costs over the road section.

35. Evaluating the economics of individual bridge repairs, upgrading or replacement requires a more detailed inspection of the transport service function provided by the bridge in question (or other form of waterway crossing) and the effects of repair and replacement options. Aspects of service function that may be involved are:

(i) load rating of the structure - if the allowable load on the bridge has to be reduced due to structural deterioration, then this will potentially affect goods carriage, requiring either smaller vehicles and/or payloads, or use of alternative routes (if available) – *load restrictions (and the benefits of lifting a load restriction) can be a significant factor in the economics of bridge repair or replacement.*

(ii) speed limits on the structure – as well as a load limit, bridges may also be speed limited to reduce dynamic loads; this can add a small time and vehicle operating cost penalty to each vehicle crossing the bridge – *however in the case of the structures in the Upper Sigatoka Valley the narrowness of the bridge deck is the governing influence on traffic speed*.;

(iii) queuing at single-lane bridges – single-lane bridges are normally signed so one direction of travel has precedence (although this is not currently provided on Sigatoka Valley Road), any coincident oncoming traffic must slow or stop and wait, again with time and vehicle operating cost penalties – *coincident traffic effects only become significant at relatively high levels of traffic flow, considerably greater than currently experienced on upper Sigatoka Valley Road but possibly significant for the Lakabuta Bridge closer to Sigatoka*;

(iv) traffic accidents and road safety – there is research to show that where the width of the carriageway on the bridge reduces below the width of the approach road and trafficable shoulder, then there is a statistically greater higher risk of crashes. These can include collision with bridge end walls/barriers, with the side guard rails or with other vehicles; and single lane bridges have been shown to have a higher crash risk than two-lane bridges – *the quantifiable effects are rather small and transferability of research results to Fiji is uncertain.*

(v) safety and convenience for pedestrians, animals (horses are used a lot in Sigatoka Valley) and other slow non-motorised traffic, particularly on the very narrow bridge decks (as little as 3.1m between kerbs) without any separate footpath or handrails; *reducing or removing the safety hazards of the narrow unprotected bridge decks are largely an intangible benefit*;

(vi) timely maintenance and repair will avoid greater costs at a later date, including loss of effective service life of the bridge – particularly for structural items such as scoured foundations, unrepaired impact damage, corroded steelwork, concrete cracking and spalling. Where there is a change in structural type (such as a low level crossing with a bridge) then there will likely be a change in the maintenance cost – *this is potentially of major significance in the economic analysis, particularly where the bridge structure is at risk of collapse either from structural deterioration or (as applies for a few structures in the upper Sigatoka Valley) risk of washout of foundations due to flood scour*;

(vii) where a replacement structure is an option, then there can be improvements to the approach road alignment, small changes in road distance, and increased operability of the structure – for example removing or reducing outages due to flooding. Replacing a single lane bridge with two-lane will eliminate slowing and/or queuing – *most of the approaches in the Upper Sigatoka are on straight alignments so this is of minor significance; an exception is the Narata bridge where raising the structure and approaches is a significant improvement to operability*;

(viii) again, where there is a fundamental change in the crossing type, such as a bridge replacing a low level crossing, then there may well be a major difference in the expected service life - *Low level crossings are prone to damage and, for example at the Matewale crossing, a new structure appears to have been built at about 10 year intervals, compared with potentially a 50-100 year service life for a bridge; the effect is more significant the lower the discount rate used;*

(ix) For structures that are at significant risk of washing out or having to be closed for safety reasons, there are differences in costs to users of planned versus unplanned restoration of the road link, particularly so if there is no route alternative. For an unplanned closure it will take a significant time to either construct a temporary culverted causeway or a Bailey bridge, during which period there are potentially large economic losses for users of the road, as well as additional costs for the road authority; *the avoided disruption costs from unplanned closure is a significant element in the benefit analysis.*

(x) The construction method for a replacement structure also affects both the costs for the road authority and the road user. Construction of a new structure to one side of the old which remains in use is the least disruptive to the road user and involves no temporary alignment. Putting in a temporary crossing so that the new structure can be located in the same position as the old is more expensive to the road authority and involves some road user disruption; *the lower cost option in the analysis is assumed.*

(xi) The delays and disruption to road users from flood closures are the most significant benefit when comparing a low level Irish crossing with a high level bridge; *in the case of the Narata, the existing bridge is also flood-prone and replacement with a higher level structure that removes the flood risk is a main source of road user benefit*.

2. Considerations for Multiple Structures and Emergency Reinstatement

36. Where multiple structures can be combined together into a single contract package, then there should be economies of scale arising from common use of concrete batching, gravel sources and/or precasting yards and lesser impact of contract set-up costs and preliminary and general items. For bridge and low level crossing repair and replacement works, it is estimated that savings for a remote isolated project, such as the Matewale crossing, could be as much as 25% if part of a larger contract to restore or upgrade most or all of the crossings in the upper Sigatoka Valley, and around 15% for a structure lower down the valley such as the Narata bridge.

37. If a waterway crossing has to be reinstated as a matter of urgency due to washout following a storm event, there is conversely likely to be a premium required over replacement as part of a planned program of works due to the relatively small isolated nature of the contract and requirement for fast reinstatement; again a premium is estimated to be around 15% but could be greater.

38. Another consideration is the reclaim value of structural components when an old or damaged structure is replaced with another. In-situ concrete work will have little alternative use other than as hard core for fill but the steel I-section girders that have been commonly used on bridges in Fiji can be reused provided they are not badly corroded – inland bridges are less corrosion prone, while older bridges at coastal sites are often heavily corroded. In this project, the possibility exists for re-using steel beams from deconstructed longer bridges, such as the Narata as part of the construction in replacement shorter bridges such as the Qalimare.

39. Where a series of waterway crossings are improved and as a result there is a significant improvement of route reliability, this may induce additional economic activity and generated traffic; research in recent years has found travel time reliability improvement to be of similar or even greater value to road users as travel time savings; however the supporting research base in developing economies is very limited.

3. Economic Costs and Benefits

40. **Costs:** the economic costs are those faced by the Government agency, in this case the FRA and include land, construction, operation and maintenance costs of the road and bridge infrastructure. All costs are expressed in national resource cost terms, that is excluding indirect taxes such as value added tax (VAT) and import and excise duty; while FRA pays VAT on new construction, all base construction and maintenance costs here are initially estimated in financial terms and net of VAT. Whether or not the investment project enjoys tax exemptions is therefore not of concern in the economic analysis.

41. The cost reduction for multiple structures constructed as part of a geographical group of sub-projects combined into a single contract has been applied (i.e. for the construction options) except where structures are reinstated as isolated structures under emergency conditions following structural failure or flood washout (i.e. for the do minimum).

42. As for previous ADB projects in Fiji, a shadow exchange rate factor (SERF) of 0.986 has been used to revalue goods and services at world prices into national currency and a shadow wage rate factor of 0.86 has been applied to local unskilled labor. These factors are applied to capital and maintenance costs and to elements of vehicle operating and passenger time costs.

43. **Benefits:** the economic benefits are principally reductions in costs faced by road users, and comprise vehicle operating cost savings, travel time savings and reduction in perceived and actual safety risks. The input values used in the analysis are summarized in Tables 10 to 12 at the end of this appendix.

44. The analysis uses built-up vehicle operating costs for the different classes of vehicle commonly surveyed in traffic counts in Fiji. The vehicle operating costs, traffic speed modeling and economic evaluations were performed using a spreadsheet-based version of the World Bank Highway Development and Management (HDM) vehicle operating cost and speed models in the World Bank open access software package HDM4RUC. Vehicle operating costs are sensitive to

road surface condition, but this is only a factor in the bridge evaluation if there is (i) a change in the bridge approaches; (ii) a road diversion is in place when the bridge is closed to traffic or (iii) there is a need to calculate trip-related costs when assessing the disruption caused by bridge closures. Otherwise, it is the time and cost associated with vehicle speed changes and while stopped that is needed for the analysis of bridge delays; and the vehicle operating costs in these cases are dominated by additional fuel consumption over the speed change cycle and while queuing.

45. For evaluating safety impacts, the data requirements are a measure of the change in risk of fatal, serious or minor crashes and the economic costs associated with each. These costs include medical and hospitalization costs, emergency services attendance, court and other administration costs and damage costs to vehicles and other property. However the largest contributor to road accident costs is the social cost of the fatality or injury, measured either as societal willingness-to-pay (WTP) to avoid a statistical fatality or injury, or using the net value of the lost economic output of the injured person (gross output or human capital value approach). The WTP method is now widely regarded as the most appropriate. A practical difficulty lies in estimating the crash risk between bridges with differing safety features – for example between a two-lane bridge with footway, hand and guard rails versus a minimal width shared concrete deck without any handrails. To some extent drivers will perceive clearly unsafe situations and adjust their speed accordingly, trading off a risk reduction for time and cost. For this analysis, the HDM4RUC inbuilt estimate of fatal injury cost at 70 x GDP/capita and serious injury cost at 25% of fatal injury cost was used.

46. The value of travel time savings is the final unit cost element in the valuation of road user savings. Travel during paid work time is generally valued at the employer's cost of labour, while other "non-work" time is a lower value that individuals, through the travel choices that they make, are inferred to place on time spent in travel versus time spent in another activity. Two broad income groups have been used to value working passenger time: a low income group who travel primarily by bus or as passengers on trucks or in light vehicles, and a high income group who travel primarily by private car. The non-work time value is commonly expressed as a percentage of the work time value, drawing on international research, although there is no direct relationship, and a value of 40% has been used in previous road economic evaluation in Fiji.

47. An important benefit of bridge or causeway repair and replacement is the removal of periods of unplanned closure of the waterway crossing due to flooding. In most cases, if there is a practical diversion alternative, it will be longer and incur a higher road user cost. Also some travel demand will be suppressed by the higher cost as some people will decide not to delay their travel until the crossing re-opens or not to travel at all. Where there is no diversion alternative at all then road users are faced with either rescheduling or cancelling their trip and the welfare losses suffered are specific to the circumstances of each trip and in some cases could be very high if the need to travel is urgent (such as for urgent medical reasons); conversely delaying a trip one or two days may be of small consequence for some other trips.

48. In the case of the Narata Bridge, there are very long alternative inland routes via Bukuya Road to either the Nausori Highlands Road, leading to Nadi, the Navala Road leading north to Ba or the Monosavu and Wailoa Roads leading east to Suva. The cost of taking one of these alternatives is used as the cap on road user cost, with short-run demand elasticity of -0.5 applied to the trip suppression. In the case of the Matewale Crossing there are no alternative routes and a cap has been placed on the cost at which all travel is suppressed to avoid unrealistically high estimates of the cost of trip suppresssion.

4. Economic Indicators and Discounting

49. Bridges are long-lived infrastructure with an economic service life of 100 years for permanent steel and concrete structures if properly maintained. Submersible bridges and Irish Crossings are more prone to shifting watercourses and flood damage and the experience with these is for a lesser service life depending on the local conditions. From past experience the Matewale crossing has had an average service life of around 10 years. A time horizon for discounting of 30 years has been used which is sufficient to minimize the effects of residual values at the end of the discount period when the required ADB discount rates of 12% or 10% are applied.

50. The bridges have a degree of unquantified social benefit, including (i) improved reliability for short distance pedestrian and animal trips, (ii) the full benefit of improved safety of two lane bridges with a footpath compared with the very narrow single lane bridge decks, lack of handrails and associated collision risk with motor vehicles, (iii) improvements to reliability over all of the bridges up the valley that may induce additional agricultural production; (iv) for the Matewale crossing and beyond, some change in the mix of vehicles, allowing more two-wheel drive vehicles and vans in place of four wheel drive and light trucks; and (v) for the Narata Bridge, the effect of a new higher level single lane structure reducing the damming effect upstream and the resultant costs of crop damage and flood damage to buildings close to the river. For these reasons, the 10% EIRR criterion should be applied rather than 12% as the minimum for sub-project acceptance. However, a 12% discount rate has been used in the discounted cash flow calculations.

5. Results for Narata Bridge

51. **Options:** The base or do minimum case is a continuation of the minimal maintenance regime that has applied in the past, where major maintenance has essentially been reactive to damage sustained rather than preventive to avoid major closures resulting from failure of structural components or foundation erosion. In the do minimum case, the annual risk of a washout of one or other abutment or flood debris damage to supporting piers increases to a maximum of 50% over a period of 10 years. The load bearing capacity of the structure also decreases, the capacity of the bridge deck in terms of axle load and the capacity of the steel beams in terms of gross vehicle mass, causing the bridge to become load-limited in about 10 years. The consequences of washout are the greater, and if this were to occur, it is assumed that a temporary, probably Bailey Bridge, crossing would be installed as an emergency measure while a new two-lane structure was designed and constructed. The costs of a temporary crossing and the premium on construction cost of the new bridge would be significant costs, together with the loss in road user benefits from the period of closure.

52. In the Do Minimum, the probability that the existing bridge is washed out is estimated in each year, being the probability that the structure survives from the previous year multiplied by the probability of loss in the current year. This probability of loss is then multiplied by the costs that are incurred which include the provision of a temporary structure, either a Bailey bridge (preferred and assumed) or a temporary pipe culvert and fill, together with the costs of replacement with a new bridge as in Option 2. There are traffic disruption costs while the temporary crossing is put in place but once construction is complete the new structure then performs as for Option 2, removing the road user costs associated with flood closures, loading limits (if the bridge survives long enough for these to be triggered), single lane operation and safety risks.

53. Option 1: The first remedial option is to repair the bridge, estimated at F$395,000 (exc VAT) base financial cost, including replacement of missing end posts and guardrails, kerb repairs,

steelwork protection/painting, concrete deck repair, scour protection and deck bracing to protect the damaged pier. With these repairs the bridge should be able to give several decades of further useful service although the safety limitations of the structure would remain, given the very narrow deck, lack of handrails (which cannot be retrofitted due to annual submergence of the bridge), and absence of pedestrian facilities. The cost to construct a parallel footbridge, at F$450,000 (exc VAT) financial cost has been added, giving a total of F$845,000 total.

54. Option 2: The second option is to replace the existing bridge with a longer two-lane single-span structure at a 1m higher level, along with raising the level of the road approaches. The cost of the new 31m length structure is estimated at F$5.6 million financial cost if constructed alongside, or F$5.9 million if constructed on the existing site with a temporary crossing. Acquisition of a narrow strip of 0.8 hectares of cropping land alongside the existing road is required as described in the sub-project Land Acquisition and Resettlement Plan (LARP), the economic cost of which is small and included within the construction cost (the land and crop compensation cost is about F$20,000). A two-lane bridge is more appropriate to the traffic function of Sigatoka Valley Road between the end of seal at Narewa and the administrative sub-centre of Keiyasi and future-proofs the road in anticipation of upgrading to seal at a later date, in which case a wider bridge deck with footpath would be essential for safe operation. A higher level structure will also reduce the flood risk, providing a compromise between designing for the most extreme flood events, which is unlikely to be economically feasible, while increasing the waterway area, reducing the risk of flood debris damage and more regular flood closures that currently occur on an annual basis.

55. Note that in both the Repair Option 1 and the Replacement Option 2, the road user benefits in future years are reduced to the extent that the Do Minimum allows for the eventual replacement of the bridge as the structure deteriorates over time and the probability mounts that a major flood event will render the bridge unserviceable.

56. **Economic analysis results**: these are summarized in Table 6. Discounted cash flows are shown in the tables at the rear of this appendix. For the road user costs, only those costs contributing to differences between the options are shown, with the highest road user costs being for incurred for the Do Minimum and arising primarily from disruption costs during seasonal flood closure and the risk-adjusted disruption cost of bridge failure. In the repair option the seasonal flood closure costs remain although the disruption from unexpected washout and reinstatement is avoided. Option 2 removes the flood closure and washout disruption costs together with other safety, speed change and coincident traffic costs which are of smaller significance.

57. Option 1, bridge repair, provides a net cost saving to the road authority as the high costs of reinstating the bridge following an eventual loss of the structure are avoided. The net discounted road user savings are in fact negative as the do minimum case includes eventual replacement with a two lane bridge which generates higher road user savings that more than balance those from the repaired bridge which continues to suffer from flood closure and single lane limitations.

Table 6: Narata Bridge – Economic Summary

Option	**Agency Costs** (F$million)	**Road User Costs** (F$ million)		
Do Minimum – reactive maintenance	3.46	1.15		
Option 1 - Bridge repairs	0.80	1.58		
Option 2 - Bridge replacement, 2 lane	4.94	-		
	Costs	**Benefits**	**NPV**	**EIRR**

	(F$ million)	(F$ million)	(F$ million)	(%)
Option 1 compared with Do Min	-2.66	-0.42	2.24	113.4%
Option 2 compared with Do Min	1.29	1.15	-0.14	11.1%

Source: Asian Development Bank estimates; all costs are discounted at 12% over a 30 year evaluation period.

58. Option 2, bridge replacement, delivers the higher road user savings as it greatly reduces the incidence of flood closures, and provides the full safety and operability benefits of a two-lane structure. It should be noted that the seasonal flood closure risks arise partly from flooding in the Naqitalita Creek sub-catchment and partly from water back-up from the main Sigatoka River catchment. To obtain the full flood reduction benefit would likely require the Qalimare Bridge and possibly the Naviago and Nalebaleba Bridges also to be replaced and raised as part of a larger contract package of several sub-project bridges. This would most likely be in the context of a future project that also included upgrading of the road section between Narata and Tuvu to sealed standard.

59. **Sensitivity Testing**: Option 1, bridge repairs, is sensitive to the estimated annual probability of bridge failure due to progressive scour of the abutments and piers in the Do Minimum. However, even if this probability is reduced to zero, other deterioration of the structure will still result in an EIRR greater than 20%. Similarly if the rate of structural deterioration of the deck and beams is reduced there is only a very small effect on the EIRR. Option 1 is very robust to a wide range of future possibilities in regard to structural deterioration.

60. Option 2, bridge replacement, is more sensitive to the range of input assumptions, in particular the number of flood closure days per year which is mitigated by the higher level bridge, longer clear single span and raised approaches (see Table 7).

Table 7 - Narata Bridge Replacement - Sensitivity and Switching Values

Scenario	**Increase / Decrease**	**EIRR**	**Switching Value (12% EIRR)**
Base Case		11.1%	
Sensitivity Tests			
Capital cost (F$ 5.3 million)	+25% / -25%	9.5% / 13.8%	-10%
Base traffic	+25% / -25%	13.0% / 9.3%	+12%
Normal Traffic growth rate (base = 4%)	+1 pp / -1 pp	11.4% / 10.8%	+2.7 pp
Flood closure days/year (base = 2)	+ 1 / - 1	14.3% / 7.9%	2.3 days

pp = percentage point

6. Results for Matewale Crossing

61. **Options:** for Matewale, continuing to “patch up” the partially failed existing crossing is not really a feasible option; it is only a matter of time, possibly the next wet season before the crossing is completely lost in a flood event. However, replacement only when a washout occurs and the crossing becomes impassable except as a ford to high wheelbase vehicles in the dry has been taken as the Do Minimum case for comparison purposes. An annual probability of washout of 50% has been applied, with the survival of the crossing after one year being 50%, after two years 25% and so on. When a washout occurs, the crossing is replaced as in Option 1 but at a cost premium (15% assumed) as the reinstatement becomes an emergency work and furthermore does not attract any economy of scale that would arise from the crossing being constructed as part of a package of bridge replacement works. There is also an added cost of providing a temporary crossing while the new one is constructed and additional user costs from disruption to traffic access until a temporary crossing is provided. The pattern of costs is replicated at 12 year

intervals, the base assumption of the economic life of the crossing, in view of the previous vulnerability of similar structures at this site and the flooding characteristics of the catchment

62. Option 1 is replacement of the existing failed structure with a new low level Irish crossing to an improved design in the existing location at a cost of F$2.0 million (financial excluding VAT) is used as the Do Minimum. The new crossing would be 22m in length with a deck elevation 0.5m higher than the existing structure so should provide improved performance and less flood outage compared with the existing design. It is assumed that the crossing would be one of a package of bridge and crossing replacement sub-projects in the catchment and would attract some economy of scale in construction cost as a result, estimated at 25% less than an isolated project in this location.

63. Option 2 is then to construct a higher level bridge at the or closely adjoining site for F$5.6 million (financial excluding VAT). The bridge would be 44m in length and with a top deck elevation approximately 6m above that of the existing crossing and should be able to pass all but 100 year return period floods.

64. Options 1 or 2 require acquisition of a narrow strip of 0.8 hectares of cropping land alongside the existing road as described in the sub-project Land Acquisition and Resettlement Plan (LARP), the economic cost of which is small and included within the construction cost (the land and crop compensation cost is approximately F$20,000).

65. Option 3 is to construct a bridge on the alternative suggested alignment which provides a small reduction in travel distance of 180m but comes at a considerably higher construction cost of F$8.9 million. The bridge would be single-lane single span, also 44m in length, with a similar top deck elevation. A higher level alignment with lesser approach gradients was also considered but rejected due to the additional earthworks and associated cost. In the case of Option 3 there is a net release of land along the existing crossing approaches offset by a smaller area of land acquisition on the new alignment. The economic cost saving of the net land release is small and is included within the construction cost.

66. **Economic analysis results**: these are shown in Table 8. Constructing a new Irish Crossing is the lowest cost remediation option and provides net savings to the transport agency in lower costs of a planned replacement in dry weather and as part of a contract package with other waterway crossings to give economy of scale. There are also road user savings from reduced flood closure, the existing crossing being out of service an estimated 5 to 10 times per year with outages of up to week (from village interview surveys).

Table 8: Matewale Crossing – Economic Summary

Option	**Agency Costs** (F$million)	**Road User Costs** (F$ million)		
Do Minimum – no action	2.51	0.78		
Option 1 – Construct new Irish crossing	1.96	0.20		
Option 2 – Construct bridge at existing site	4.84	0.00		
Option 3 – Construct bridge at alternative site	5.76	-0.07 [1]		
	Costs (F$ million)	**Benefits** (F$ million)	**NPV** (F$ million)	**EIRR** (%)

Option 1 Irish Crossing compared with Do Min	-0.55	1.05	1.59	v. large [(2)]
Option 2 Bridge compared with Do Min	2.34	1.42	-0.92	8.3%
Option 3 Bridge compared with Do Min	3.26	1.89	-1.77	6.3%

Source: Asian Development Bank estimates; all costs are discounted at 12% over a 30 year evaluation period; (1) the negative road user costs is the effect of route shortening for the bridge on an alternative alignment

67. Option1, construction of a new Irish crossing at the existing site shows a very high rate of return[2] due to: (i) there is a net saving in costs to road authority from a planned replacement in dry weather as part of an organized program as opposed to emergency reinstatement if the crossing becomes impassable; (ii) plus the benefits from avoiding a period of outage with no road access to the Sigatoka Valley above this point if the crossing were to be washed out and (iii) the high vulnerability of the existing crossing.

68. Option 2, construction of a higher level bridge at the same site gives an EIRR of 8.3% compared with the Do Minimum. A bridge is the strongly preferred solution of the residents of nearby Wema village who have seen three Irish Crossings constructed at the same or adjacent site since 1977 when the road was first built; each have eventually washed out. However, the relatively small population living above the Matewale Crossing and limited traffic generation potential coupled with the need to provide bridges at the lower crossings of the Kalekata and more importantly the Draiba (Namada River) make general bridging of waterways an uneconomic investment for the road above Keiyasi.

69. Option 3, a bridge on the alternative alignment proposed is considerably more expensive than at the existing crossing point, requires land acquisition and considerable earthworks and delivers only a minor additional advantage in road user costs.

70. **Sensitivity Testing**: Sensitivity for the Bridge Option 2 compared against Option 1 has been tested. The size of the EIRR for Option 1 and the unsuitability of the crossing in its existing state makes sensitivity testing unnecessary and uninformative (see Table 9).

[2] The base assumption is a 50% annual probability of losing the crossing, which does not provide a soluble EIRR. If this is reduced to 25% probability the EIRR is 97%, and for 10% probability the EIRR is 38%.

Table 9: Matewale Crossing, Bridge Replacement - Sensitivity and Switching Values

Scenario	Increase / Decrease	EIRR	Switching Value (12%)
Opt 2 - Bridge vs Opt 1 Irish Crossing			
Base Case		2.8%	
Sensitivity Tests			
Capital cost (F$ 5.6 million)	+25% / -25%	1.0% / 5.5%	-53%
Base traffic (50 vpd)	+25% / -25%	3.2% / 2.3%	+680%
Normal Traffic growth rate (base = 4%)	+1 pp / -1 pp	3.1% / 2.5%	+ 15 pp
Flood closure days/year (base = 5)	+ 1d / - 1d	3.1% / 2.4%	39 days

pp = percentage point

71. The low EIRR of the base case requires high switching values for all of the main input parameters. The number of flood closure days is one of the least certain estimates, as the limited catchment modeling does not agree well with field information. However, it would require the crossing to be impassable for more than 10% of the year to justify constructing a bridge instead, all else being equal. The second least certain estimate is the base traffic but again it would require a much greater level of traffic to make the bridge option viable.

7. Wider Economic Considerations for the Sigatoka Valley

72. The economic analysis of the selected example sub-projects makes some assumptions about the grouping of sub-projects into contract packages for international competitive bidding (ICB) procurement. The costs of repair have been estimated on an individual structure basis without any allowance for cost savings for a combined contract covering all 16 of the structures inspected. There should be savings in establishment costs for a combined contract using common design features within a geographic area compared with a series of isolated repair and replacements scattered across the country. Savings are estimated to range from 15% to 25% of the individual capital costs depending on remoteness.

73. Two of the structures are considered to be at high risk of flood damage and loss of service due to abutment scour – the Qalimare and the Nalebaleba. Although it would be possible to repair both structures, either repair or replacement should be done at the earliest possible date to avoid the upper valley becoming isolated. Both structures are very narrow and if not replaced, construction of parallel footbridges for people and animals to use should be considered, particularly for the longer Nalebaleba bridge. If any of the longer span bridges in the Sigatoka Valley are replaced, the relatively good condition of the steel beams would warrant these being cleaned, painted and reused, for example on the short span Qalimare.

74. During the fieldwork, it became clear that there are significant flooding problems in the Sigatoka Valley and that these arise within the main river valley, with back-up of floodwater up certain of the tributaries, the Narata, Qalimare, Naviago and to a lesser extent the Nalebaleba being four affected structures. Portions of the road flood through this general area. The catchment modeling for the two selected sub-project catchments of the Nagalitala and Matewale indicated higher flood volumes than for the others examined (the Lakabuta, Qalimare, Naveyago and Nalebaleba) and the inadequate waterway area at Narata bridge. Although not examined, the roadside interview surveys also included reports of road flooding between Narewa and Bialevu lower down the valley.

75. Climate change effects were considered. A country report for Fiji[3] anticipates a decrease in dry season rainfall and an increase in wet season rainfall over the course of the 21st century. Extreme rainfall days are likely to occur more often with the present 1:20 year daily rainfall occurring 4 to 5 times per year by 2090. The FRA is designing for an 8% increase in rainfall by 2090. A small annual increment in the number of days of flooding per year has been applied to allow for the climate change induced changes in rainfall over the 30 year evaluation period.

76. The sub-project analysis did not include any consideration of upgrading of the road surface from gravel to seal. As part of the longer term network development together with the importance of the Sigatoka Valley for agricultural development, it is highly likely that further seal extension first to Tuvu and eventually to Keiyasi will be part of the 20 year development plan. In this case, if not replaced earlier, two-lane replacement of some or all of the bridges would likely form part of such upgrading.

C. Distribution Analysis and Poverty Impact Ratios

77. **Distribution of benefits:** the distribution of benefits for road investment projects relies upon the degree to which initial savings in vehicle operating costs are passed on from the transport operator to vehicle passengers and to the producers and end users of transported goods. Where vehicles are being used for transporting the owner, family members and their goods, then the operator and end user are one and the same. Where there is a high degree of reliance on commercial passenger transport services such as buses, rural passenger/goods carriers and freight operators, then the vehicle operating costs savings accrues initially to the transport operator and the extent to which the benefits are passed on to users depends upon the degree of competition in the industry.

78. If Fiji, the majority of passenger carriage is by licensed and unlicensed route bus, minivan and rural carrier. These are heavily price- and service-regulated and it is likely that the majority of the benefits from a road improvement will be captured by the transport operator and passed on only in small part and probably with a time lag as it will require the LTA to recognize that there has been a reduction in cost to the operator which should be reflected in lower fares. However the travel time savings and the personal injury component of safety benefits are captured directly by the traveler.

79. For Sigatoka Valley Road, the majority of marketed produce that is grown is transported by commercial freight services, although these are not price regulated and the presence of co-operatives should assist in the flow-through of road user savings to the growers and end buyers, which in turn will lower input and marketing costs and stimulate production. Unfortunately it is too soon to identify the effect that the new section of sealed road in the mid-Sigatoka Valley has had on stimulating new agricultural production which might demonstrate the extent of this transmission of road improvement benefits.

80. **Identifying the poor:** the proportion of residents who can be classified as poor[4] in the project area of influence, and the number of public transport trips made by them and by the rest of the population living in the sub-project area were determined from statistical data and responses to the social impact site surveys. In the middle to upper Sigatoka Valley, 70% of the population is

[3] *Current and Future Climate of the Fiji Islands*, 2011. Fiji Meteorological Service, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO),

[4] Native Fijians believe that, as every villager has the necessities of life (food, shelter, and family support), no poverty exists in the Fiji Islands. The term hardship is preferred.

ethnic Fijian and 30% are Indo-Fijian, Rotuman and other ethnicities. However, there was no significant difference in poverty/hardship with 55% of the population in this category.

81. The poverty impact ratio was estimated by determining what proportion of the benefits to each class of user in the distribution analysis are passed on to the poor. Details of the calculation are in Table 22 at the end of this appendix. Without taking account of the redistribution of taxes and duties arising from changes in vehicle operating costs and capital and maintenance flows, which impact on the poor in general, the PIR is estimated at 21.5%. With the tax and duty redistribution effects, the PIR reduces to 16.3%[5].

[5] The favourable borrowing of the Project Loan will generate an additional net financial inflow to the Fiji Government when discounted at 12% over the period of the loan and further dilute the PIR, but this has not been included in the calculation

Table 10: Vehicle Input Costs

Financial and Economic Vehicle Prices | **Cost Base 2014** | **VAT 15%**

	Fin to Econ	Car		Light Vehicles		Large Buses		Light Truck		Medium Truck		Heavy Truck	
	Con Factor	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
Vehicle													
Import Price	1.00	18,487	18,487	14,789	14,789	60,474	60,474	32,660	32,660	43,136	43,136	94,283	94,283
Import duty (%)		27%		27%		10%		27%		27%		27%	
Duty	0.00	4,991	0	3,993	0	6,047	0	8,818	0	11,647	0	25,456	0
Sub-total		23,478		18,783		66,522		41,478		54,783		119,739	
Local costs	0.80	2,609	2,087	2,087	1,670	7,391	5,913	4,609	3,687	6,087	4,870	13,304	10,643
Sub-total		26,087		20,870		73,913		46,087		60,870		133,043	
VAT (15%)	0.00	3,913	0	3,130	0	11,087	0	6,913	0	9,130	0	19,957	0
Showroom Price		30,000	20,574	24,000	16,459	85,000	66,387	53,000	36,347	70,000	48,005	153,000	104,926
Body/Conversion													
Imported Materials	1.00			1,391	1,113	59,130	47,304	5,565	4,452	8,348	6,678	12,870	10,296
Duty (%)	0.00			15%		15%		15%		15%		15%	
Duty				209		8,870		835	0	1,252	0	1,930	0
Sub-total				1,600		68,000		6,400		9,600		14,800	
Local costs	0.80			178	142	7,556	6,044	711	569	1,067	853	1,644	1,316
Sub-total				1,778		75,556		7,111		10,667		16,444	
VAT (12.5%)	0.00			222		9,444		889	0	1,333	0	2,056	0
Total				2,000	1,255	85,000	53,349	8,000	5,021	12,000	7,532	18,500	11,611
Total Vehicle Price		30,000	20,574	26,000	17,714	170,000	119,736	61,000	41,368	82,000	55,537	171,500	116,537
Age (Years)		5	5	5	5	5	5	5	5	5	5	5	5
Tyre													
Size/Type		185 SR 14		205 R 16		825*16*14PRR		700*16*12PRR		825*16*14PRR		1000*20*16PRR	
Import Price	1.00	51	51	74	74	214	214	134	134	214	214	256	256
Import duty (%)		27%		27%		27%		27%		27%		27%	
Duty	0.00	14	0	20	0	58	0	36	0	58	0	69	0
Sub-total		65		94		272		171		272		325	
Local costs	0.80	11	9	17	13	48	38	30	24	48	38	57	46
Sub-total		76		111		320		201		320		382	
VAT (12.5%)	0.00	10	0	14	0	40	0	25	0	40	0	48	0
Total		86	60	125	88	360	253	226	159	360	253	430	302

Table 11: Vehicle and Occupant Parameter Values

Parameter	Car Taxi	Light Vehicle	Bus	Light Truck	Medium Truck	Heavy Truck
Physical						
No of wheels	4	4	6	4	6	10
No of axles	2	2	2	2	2	3
Tyre type						
Base no of retreads (no)	2	2	3	3	3	3
Retread cost (%)	65%	65%	35%	48%	35%	28%
Utilisation						
Annual km	23,000	30,000	70,000	30,000	40,000	86,000
Working hours	550	1,300	1,750	1,300	1,200	2,050
Average life (yrs)	7	5	9	5	9	11
Private use %	53.0%	23.0%	0.0%	0.0%	0.0%	0.0%
Passengers (no)	2.0	2.3	17.7	4.0	5.2	1.0
Work related pass trips (%)	11.1%	24.6%	5.5%	35.1%	33.3%	100.0%
Loading						
ESAL	0	0	0.5	0	4.2	4.6
Operating weight	1.0	1.2	10.0	2.4	5.1	12.0
Time Values						
Passenger working time	9.22	2.76	2.76	2.76	2.76	2.76
Passenger non-working time	3.69	1.11	1.11	1.11	1.11	1.11

Table 12: Unit Road User Costs for Existing Gravel Road – from HDM4RUC Model

	Medium Car	Van/4x4	Light Truck	Medium Truck	Heavy Truck	Large Bus	Total
Road User Costs ($/vehicle-km)	0.722	0.668	1.330	1.542	2.443	2.332	1.073
Vehicle Operating Cost ($/vehicle-km)	0.536	0.581	1.169	1.319	2.337	1.763	0.909
Fuel ($/vehicle-km)	0.173	0.161	0.205	0.294	0.700	0.537	0.219
Lubricants ($/vehicle-km)	0.004	0.006	0.011	0.012	0.025	0.020	0.009
Tire ($/vehicle-km)	0.006	0.008	0.015	0.022	0.037	0.033	0.013
Maintenance Parts ($/vehicle-km)	0.094	0.052	0.121	0.251	0.754	0.337	0.118
Maintenance Labor ($/vehicle-km)	0.038	0.030	0.111	0.139	0.208	0.133	0.071
Crew Time ($/vehicle-km)	0.000	0.089	0.097	0.130	0.191	0.127	0.090
Depreciation ($/vehicle-km)	0.161	0.214	0.503	0.278	0.223	0.345	0.312
Interest ($/vehicle-km)	0.061	0.021	0.054	0.088	0.125	0.150	0.050
Overhead ($/vehicle-km)	0.000	0.000	0.052	0.106	0.072	0.083	0.028
Value of Time Cost ($/vehicle-km)	0.166	0.063	0.136	0.195	0.074	0.546	0.140
Passenger Time ($/vehicle-km)	0.166	0.063	0.134	0.193	0.072	0.546	0.139
Cargo Time ($/vehicle-km)	0.000	0.000	0.002	0.002	0.003	0.000	0.001
Emissions Cost ($/vehicle-km)	0.004	0.004	0.005	0.007	0.016	0.012	0.005
Road Safety Cost ($/vehicle-km)	0.016	0.021	0.021	0.021	0.016	0.011	0.019
Road User Cost (%)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Vehicle Operating Cost (%)	74.3%	86.9%	87.9%	85.6%	95.7%	75.6%	84.7%
Value of Time Cost (%)	23.0%	9.4%	10.2%	12.6%	3.0%	23.4%	13.0%
Emissions Cost (%)	0.5%	0.5%	0.3%	0.4%	0.6%	0.5%	0.5%
Road Safety Cost (%)	2.2%	3.1%	1.6%	1.3%	0.7%	0.5%	1.8%
Vehicle Speed (km/hr)	51.7	55.2	50.4	44.7	38.5	38.8	51.4
Traffic Composition %	9.4	46.0	30.8	4.5	1.3	8.0	100
Passengers/vehicle (inc driver/crew)	2.0	2.3	4.0	5.2	1.0	17.7	
Percentage working	11.1%	24.6%	35.1%	33.3%	100.0%	5.5%	
Paid driver/crew	0.2	0.6	1.4	1.7	1.0	1.0	
Other passengers	1.8	1.7	2.6	3.5	0.0	16.7	

Table 13: Sub-Project Cost Estimates

Narata Bridge - Repair Option

Item	Description of	M/ment	Quantity	Financial Cost		Foreign Cost		Local Cost		Duty/Tax Cost		Economic Cost		Conversion
No.	Main Work Items	Unit	x 1000	Rate	Cost	FCF	Cost	LCF	Cost	D/TCF	Cost		Cost	Factor
	Bridge repair	sum			395	0.195	77	0.708	280	0.097	38		345	0.873
	Add footbridge	sum			450	0.195	88	0.708	319	0.097	44		393	0.873
	Sub Totals of Main Work Items (ST of MWI)				845		165		598		82		738	
	Physical contingencies			0%	0		0		0		0		0	
	Add Value Added Tax (VAT)			15%	127						12			
	Add Design Cost % of MWI			4%	34	0.400	14	0.400	14	0.200	7	0.800	27	0.800
	Add Supervision Costs % of MWI			7%	59	0.400	24	0.400	24	0.200	12	0.800	47	0.800
	Land acquisition/resettlement				0	0.000	0	1.000	0	0.000	0	0.892	0	
ESTIMATED TOTAL COSTS					1,065		202		635		113		812	0.763

Narata Bridge - Replacement Option

Item	Description of	M/ment	Quantity	Financial Cost		Foreign Cost		Local Cost		Duty/Tax Cost		Economic Cost		Conversion
No.	Main Work Items	Unit	x 1000	Rate	Cost	FCF	Cost	LCF	Cost	D/TCF	Cost		Cost	Factor
	Two lane bridge	sum			5,600									
	Recovery value of steel beams				100									
	Net cost				5,500	0.195	1,073	0.708	3,894	0.097	534		4,803	0.873
	Sub Totals of Main Work Items (ST of MWI)				5,500		1,073		3,894		534		4,803	
	Physical contingencies (inc above)			0%	0		0		0		0		0	
	Add Value Added Tax (VAT)			15%	825						80			
	Add Design Cost % of MWI			4%	220	0.400	88	0.400	88	0.200	44	0.800	176	0.800
	Add Supervision Costs % of MWI			7%	385	0.400	154	0.400	154	0.200	77	0.800	308	0.800
	Land acquisition/resettlement				0	0.000	0	1.000	0	0.000	0	0.892	0	
ESTIMATED TOTAL COSTS					6,930		1,315		4,136		735		5,287	0.763

Note 1 : Design & Supervision Costs are split nominally between Foreign and Local Costs.

2 : Costs are recorded in Fiji dollars x 1000

3: Economic Costs are foreign costs plus local costs adjusted by Shadow Exchange Rate factor of 0.986 and Shadow Wage Rate Factor of 0.86 - in line with other recent ADB Projects

Matewale Crossing - New Irish Crossing

Item	Description of	M/ment	Quantity	Financial Cost		Foreign Cost		Local Cost		Duty/Tax Cost		Economic Cost		Conversion
No.	Main Work Items	Unit	x 1000	Rate	Cost	FCF	Cost	LCF	Cost	D/TCF	Cost		Cost	Factor
	Irish Crossing	sum			2,000	0.195	390	0.708	1,416	0.097	194		1,747	0.873
	Sub Totals of Main Work Items (ST of MWI)				2,000		390		1,416		194		1,747	
	Physical contingencies			0%	0		0		0		0		0	
	Add Value Added Tax (VAT)			15%	300						29			
	Add Design Cost % of MWI			4%	80	0.400	32	0.400	32	0.200	16	0.800	64	0.800
	Add Supervision Costs % of MWI			7%	140	0.400	56	0.400	56	0.200	28	0.800	112	0.800
	Land acquisition/resettlement				0	0.000	0	1.000	0	0.000	0	0.892	0	
ESTIMATED TOTAL COSTS					2,520		478		1,504		267		1,923	0.763

Matewale Crossing - Bridge at Same Crossing Point

Item	Description of	M/ment	Quantity	Financial Cost		Foreign Cost		Local Cost		Duty/Tax Cost		Economic Cost		Conversion
No.	Main Work Items	Unit	x 1000	Rate	Cost	FCF	Cost	LCF	Cost	D/TCF	Cost		Cost	Factor
	Bridge Existing Crossing	sum			5,600	0.195	1,092	0.708	3,965	0.097	543		4,890	0.873
	Sub Totals of Main Work Items (ST of MWI)				5,600		1,092		3,965		543		4,890	
	Physical contingencies			0%	0		0		0		0		0	
	Add Value Added Tax (VAT)			15%	840						81			
	Add Design Cost % of MWI			4%	224	0.400	90	0.400	90	0.200	45	0.800	179	0.800
	Add Supervision Costs % of MWI			7%	392	0.400	157	0.400	157	0.200	78	0.800	314	0.800
	Land acquisition/resettlement				0	0.000	0	1.000	0	0.000	0	0.892	0	
ESTIMATED TOTAL COSTS					7,056		1,338		4,211		748		5,383	0.763

Matewale Crossing - Bridge at Alternative Crossing Point

Item	Description of	M/ment	Quantity	Financial Cost		Foreign Cost		Local Cost		Duty/Tax Cost		Economic Cost		Conversion
No.	Main Work Items	Unit	x 1000	Rate	Cost	FCF	Cost	LCF	Cost	D/TCF	Cost		Cost	Factor
	Bridge Alternative Crossing Point	sum			8,900	0.195	1,736	0.708	6,301	0.097	863		7,772	0.873
	Sub Totals of Main Work Items (ST of MWI)				8,900		1,736		6,301		863		7,772	
	Physical contingencies			0%	0		0		0		0		0	
	Add Value Added Tax (VAT)			15%	1,335						129			
	Add Design Cost % of MWI			4%	356	0.400	142	0.400	142	0.200	71	0.800	285	0.800
	Add Supervision Costs % of MWI			7%	623	0.400	249	0.400	249	0.200	125	0.800	498	0.800
	Land acquisition/resettlement				0	0.000	0	1.000	0	0.000	0	0.892	0	
ESTIMATED TOTAL COSTS					11,214		2,127		6,693		1189		8,555	0.763

Note 1 : Design & Supervision Costs are split nominally between Foreign and Local Costs.

2 : Costs are recorded in Fiji dollars x 1000

3: Economic Costs are foreign costs plus local costs adjusted by Shadow Exchange Rate factor of 0.986 and Shadow Wage Rate Factor of 0.86 - in line with other recent ADB Projects

Table 14: Narata Bridge, Traffic and Risk Inputs

		Narata Bridge - Economic Analysis of Repair and Replacement Options							
	Flood	Traffic Growth		Do Minimum Option					
Time	Incidence	Calendar	Normal	Risk of Loss through Flood Washout			Structural Deterioration		
Period	Increase	Year	Traffic	Annual	Probability	Probability	Deck Axle	Beam	Load
	% pa			Risk	Loss in Yr	Remaining	Loads	GV Loads	Derated
	0.5%						40%	40%	
0			514			1.000	0.750	0.900	
1	1.005	2015	535	0.0250	0.025	0.975	0.715	0.875	
2	1.010	2016	556	0.0750	0.073	0.902	0.680	0.850	
3	1.015	2017	578	0.1250	0.113	0.789	0.645	0.825	
4	1.020	2018	602	0.1750	0.138	0.651	0.610	0.800	
5	1.025	2019	626	0.2250	0.146	0.505	0.575	0.775	
6	1.030	2020	651	0.2750	0.139	0.366	0.540	0.750	
7	1.035	2021	677	0.3250	0.119	0.247	0.505	0.725	
8	1.040	2022	704	0.3750	0.093	0.154	0.470	0.700	
9	1.045	2023	732	0.4250	0.066	0.089	0.435	0.675	
10	1.050	2024	761	0.4750	0.042	0.047	0.400	0.650	D
11	1.055	2025	792	0.5000	0.023	0.023	0.365	0.625	D
12	1.060	2026	823	0.5000	0.012	0.012	0.330	0.600	D
13	1.065	2027	856	0.5000	0.006	0.006	0.295	0.575	D
14	1.070	2028	891	0.5000	0.003	0.003	0.260	0.550	D
15	1.075	2029	926	0.5000	0.001	0.001	0.225	0.525	D
16	1.080	2030	963	0.5000	0.001	0.001	0.190	0.500	D
17	1.085	2031	1002	0.5000	0.000	0.000	0.155	0.475	D
18	1.090	2032	1042	0.5000	0.000	0.000	0.120	0.450	D
19	1.095	2033	1083	0.5000	0.000	0.000	0.085	0.425	D
20	1.100	2034	1127	0.5000	0.000	0.000	0.050	0.400	D
21	1.105	2035	1172	0.5000	0.000	0.000	0.015	0.375	D
22	1.110	2036	1219	0.5000	0.000	0.000	-0.020	0.350	D
23	1.115	2037	1268	0.5000	0.000	0.000	-0.055	0.325	D
24	1.120	2038	1318	0.5000	0.000	0.000	-0.090	0.300	D
25	1.125	2039	1371	0.5000	0.000	0.000	-0.125	0.275	D
26	1.130	2040	1426	0.5000	0.000	0.000	-0.160	0.250	D
27	1.135	2041	1483	0.5000	0.000	0.000	-0.195	0.225	D
28	1.140	2042	1542	0.5000	0.000	0.000	-0.230	0.200	D
29	1.145	2043	1604	0.5000	0.000	0.000	-0.265	0.175	D
30	1.150	2044	1668	0.5000	0.000	0.000	-0.300	0.150	D

Table 15: Narata Bridge – Discounted Cash Flow, Do Minimum

Narata Bridge - Economic Analysis of Repair and Replacement Options — **Discount Rate** 12%

	Do Minimum Option													
	Road Agency Costs						Road User Costs							Total Costs
	Bridge Maint.	Temporary Crossing Bailey	Temporary Crossing Culverts	B Maint	Replace Cost	Total Costs	Load Restriction	Flood Closure	Bridge Loss	Coincident Traffic	Excess Safety Cost	Speed Change	Total RUC	
	0	7,500	2,500	1,000	152,000	159,500	-	136,219	24,328	249	25,017	8,157	193,969	353,469
	0	21,938	7,313	2,925	444,600	466,537	-	131,694	74,005	243	24,066	7,847	237,856	704,393
	0	33,820	11,273	4,509	685,424	719,245	-	120,435	118,655	224	21,900	7,140	268,355	987,600
	0	41,430	13,810	5,524	839,645	881,075	-	103,842	151,167	194	18,790	6,126	280,120	1,161,195
	0	43,945	14,648	5,859	890,623	934,569	-	84,107	166,759	158	15,145	4,938	271,106	1,205,675
	0	41,626	13,875	5,550	843,618	885,244	-	63,726	164,276	120	11,419	3,723	243,264	1,128,508
	0	35,666	11,889	4,755	722,827	758,493	-	44,953	146,385	84	8,016	2,614	202,052	960,545
	0	27,778	9,259	3,704	562,971	590,750	-	29,361	118,571	55	5,211	1,699	154,897	745,646
	0	19,676	6,559	2,623	398,771	418,448	-	17,642	87,348	33	3,116	1,016	109,154	527,602
	0	12,645	4,215	1,686	256,269	268,914	14,745	9,679	58,379	18	1,701	555	85,077	353,991
	0	6,988	2,329	932	141,622	148,610	7,667	5,057	33,553	9	885	288	47,459	196,070
	0	3,494	1,165	466	70,811	74,305	3,987	2,642	17,447	5	460	150	24,691	98,997
	0	1,747	582	233	35,406	37,153	2,073	1,380	9,073	2	239	78	12,846	49,999
	0	873	291	116	17,703	18,576	1,078	721	4,718	1	124	41	6,683	25,260
	0	437	146	58	8,851	9,288	561	377	2,453	1	65	21	3,477	12,765
	0	218	73	29	4,426	4,644	292	197	1,276	0	34	11	1,809	6,453
	0	109	36	15	2,213	2,322	152	103	663	0	17	6	941	3,263
	0	55	18	7	1,106	1,161	79	54	345	0	9	3	490	1,651
	0	27	9	4	553	581	41	28	179	0	5	2	255	835
	0	14	5	2	277	290	21	15	93	0	2	1	133	423
	0	7	2	1	138	145	11	8	49	0	1	0	69	214
	0	3	1	0	69	73	6	4	25	0	1	0	36	108
	0	2	1	0	35	36	3	2	13	0	0	0	19	55
	0	1	0	0	17	18	2	1	7	0	0	0	10	28
	0	0	0	0	9	9	1	1	4	0	0	0	5	14
	0	0	0	0	4	5	0	0	2	0	0	0	3	7
	0	0	0	0	2	2	0	0	1	0	0	0	1	4
	0	0	0	0	1	1	0	0	0	0	0	0	1	2
	0	0	0	0	1	1	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-	300,000	100,000	40,000	6,079,995	6,379,995	30,719	752,247	1,179,773	1,398	136,224	44,415	2,144,777	8,524,771
NPV	$0	$162,760	$54,253	$21,701	$3,298,598	$3,461,358	$8,862	$502,732	$621,500	$933	$91,307	$29,770	$1,255,104	$4,716,462

Table 16: Narata Bridge – Discounted Cash Flow, Repair and Replacement Options

	Narata Bridge - Economic Analysis of Repair and Replacement Options								**Discount Rate**		**12%**	
	Option 1 - Bridge Repairs + Footbridge							Option 2 - Bridge Replacement				
	Road Agency Costs			Road User Costs				Road Agency Costs			Road User Costs	
	Bridge Repairs	Bridge Maint	Total	Flood Closure	Coincident Traffic	Speed Change	Total RUC	Bridge Constr.	Bridge Maint	Total	Speed Change	Total RUC
	812,268	0	812,268	139,711	255	8,366	148,333	5,286,952	0	5,286,952	0	0
	0	10,000	10,000	146,023	270	8,700	154,993	0	5,000	5,000	0	0
	0	10,000	10,000	152,615	284	9,048	161,948	0	5,000	5,000	0	0
	0	10,000	10,000	159,502	299	9,410	169,211	0	5,000	5,000	0	0
	0	10,000	10,000	166,695	313	9,787	176,795	0	5,000	5,000	0	0
	0	10,000	10,000	174,209	327	10,178	184,714	0	5,000	5,000	0	0
	0	10,000	10,000	182,056	342	10,585	192,983	0	5,000	5,000	0	0
	0	10,000	10,000	190,253	356	11,009	201,618	0	5,000	5,000	0	0
	0	10,000	10,000	198,815	370	11,449	210,634	0	5,000	5,000	0	0
	0	10,000	10,000	207,757	385	11,907	220,048	0	5,000	5,000	0	0
	0	10,000	10,000	217,096	399	12,383	229,878	0	5,000	5,000	0	0
	0	10,000	10,000	226,850	413	12,879	240,142	0	5,000	5,000	0	0
	0	10,000	10,000	237,037	428	13,394	250,858	0	5,000	5,000	0	0
	0	10,000	10,000	247,675	442	13,930	262,047	0	5,000	5,000	0	0
	0	10,000	10,000	258,786	456	14,487	273,729	0	5,000	5,000	0	0
	0	10,000	10,000	270,389	471	15,066	285,926	0	5,000	5,000	0	0
	0	10,000	10,000	282,507	485	15,669	298,661	0	5,000	5,000	0	0
	0	10,000	10,000	295,161	500	16,296	311,956	0	5,000	5,000	0	0
	0	10,000	10,000	308,376	514	16,947	325,837	0	5,000	5,000	0	0
	0	10,000	10,000	322,175	528	17,625	340,329	0	5,000	5,000	0	0
	0	10,000	10,000	336,585	543	18,330	355,458	0	5,000	5,000	0	0
	0	10,000	10,000	351,632	557	19,064	371,253	0	5,000	5,000	0	0
	0	10,000	10,000	367,345	571	19,826	387,742	0	5,000	5,000	0	0
	0	10,000	10,000	383,752	586	20,619	404,957	0	5,000	5,000	0	0
	0	10,000	10,000	400,884	600	21,444	422,928	0	5,000	5,000	0	0
	0	10,000	10,000	418,772	614	22,302	441,688	0	5,000	5,000	0	0
	0	10,000	10,000	437,450	629	23,194	461,273	0	5,000	5,000	0	0
	0	10,000	10,000	456,952	643	24,121	481,717	0	5,000	5,000	0	0
	0	10,000	10,000	477,315	658	25,086	503,058	0	5,000	5,000	0	0
	0	10,000	10,000	498,575	672	26,090	525,337	0	5,000	5,000	0	0
Total	812,268	290,000	1,102,268	8,512,951	13,910	469,190	469,190	5,286,952	145,000	5,431,952	0	0
NPV	$725,239	$71,623	$796,863	$1,629,837	$2,902	$93,251	$1,725,989	$4,720,493	$35,812	$4,756,304	$0	$0

Table 17: Narata Bridge – Options Comparison and EIRR

	Option 1 - Repair + Footbridge vs Do Min			Option 2 -Replace vs Do Min		
	Net Costs	Net Benefits	NPV @ 12%	Net Costs	Net Benefits	NPV @ 12%
	652,768	43,742	-609,026	5,127,452	179,374	-4,948,079
	-456,537	77,437	533,975	-461,537	219,156	680,693
	-709,245	98,546	807,790	-714,245	246,619	960,864
	-871,075	102,227	973,302	-876,075	256,937	1,133,012
	-924,569	86,660	1,011,228	-929,569	248,300	1,177,869
	-875,244	53,660	928,904	-880,244	222,537	1,102,781
	-748,493	8,225	756,718	-753,493	184,658	938,151
	-580,750	-42,874	537,875	-585,750	141,448	727,198
	-408,448	-92,950	315,497	-413,448	99,610	513,058
	-258,914	-122,272	136,642	-263,914	78,890	342,804
	-138,610	-166,193	-27,582	-143,610	43,949	187,560
	-64,305	-196,654	-132,349	-69,305	22,865	92,170
	-27,153	-217,414	-190,261	-32,153	11,896	44,048
	-8,576	-233,342	-224,766	-13,576	6,189	19,765
	712	-246,984	-247,695	-4,288	3,220	7,508
	5,356	-259,670	-265,026	356	1,675	1,319
	7,678	-272,107	-279,785	2,678	871	-1,806
	8,839	-284,670	-293,509	3,839	453	-3,386
	9,419	-297,567	-306,986	4,419	236	-4,184
	9,710	-310,917	-320,627	4,710	123	-4,587
	9,855	-324,796	-334,650	4,855	64	-4,791
	9,927	-339,253	-349,181	4,927	33	-4,894
	9,964	-354,330	-364,294	4,964	17	-4,946
	9,982	-370,061	-380,043	4,982	9	-4,973
	9,991	-386,479	-396,470	4,991	5	-4,986
	9,995	-403,615	-413,611	4,995	2	-4,993
	9,998	-421,503	-431,501	4,998	1	-4,996
	9,999	-440,175	-450,174	4,999	1	-4,998
	9,999	-459,666	-469,665	4,999	0	-4,999
	10,000	-480,011	-490,011	5,000	0	-5,000
Total	-5,277,726	-6,253,008	-975,281	-948,043	1,969,139	2,917,181
NPV	-$2,664,496	-$424,921	$2,239,575	$1,294,946	$1,152,901	-$142,045

	Option 1	Option 2
B/C	-ve	0.89
EIRR	113.4%	11.1%

Table 18: Matewale Crossing – Traffic and Risk Inputs

Matewale Crossing - Economic Analysis of Replacement Options

	Traffic Growth		Do Minimum Option - Existing Structure		
			Risk of Loss through Flood Washout		
Time Period	Calendar Year	Normal Traffic	Annual Risk	Probability Loss in Yr	Probability Remaining
0		55.86223			1.000
1	2015	58	0.5000	0.500	0.500
2	2016	60	0.5000	0.250	0.250
3	2017	63	0.5000	0.125	0.125
4	2018	65	0.5000	0.063	0.063
5	2019	68	0.5000	0.031	0.031
6	2020	71	0.5000	0.016	0.016
7	2021	74	0.5000	0.008	0.008
8	2022	76	0.5000	0.004	0.004
9	2023	80	0.5000	0.002	0.002
10	2024	83	0.5000	0.001	0.001
11	2025	86	0.5000	0.000	0.000
12	2026	89	0.5000	0.000	0.000
13	2027	93	0.5000	0.000	0.000
14	2028	97	0.5000	0.000	0.000
15	2029	101	0.5000	0.000	0.000
16	2030	105	0.5000	0.000	0.000
17	2031	109	0.5000	0.000	0.000
18	2032	113	0.5000	0.000	0.000
19	2033	118	0.5000	0.000	0.000
20	2034	122	0.5000	0.000	0.000
21	2035	127	0.5000	0.000	0.000
22	2036	132	0.5000	0.000	0.000
23	2037	138	0.5000	0.000	0.000
24	2038	143	0.5000	0.000	0.000
25	2039	149	0.5000	0.000	0.000
26	2040	155	0.5000	0.000	0.000
27	2041	161	0.5000	0.000	0.000
28	2042	168	0.5000	0.000	0.000
29	2043	174	0.5000	0.000	0.000
30	2044	181	0.5000	0.000	0.000

Table 19: Matewale Crossing – Discounted Cash Flow, Do Minimum

Matewale Crossing - Economic Analysis of Replacement Options | **Discount Rate** 12%

	Do Minimum Option														
	Road Agency Costs							Road User Costs							Total
	Crossing Maint.	Temp Crossing Capex	Temp Crossing Maint	Replace Cost	Subsequent Replmnt	Subsequent Replmnt	Total Costs	Ex Flood Closure	Crossing Loss	New Flood Closure	New Xing Loss	New Xing Loss	Speed Ch Costs	Total RUC	Costs
	0	50,000	20,000	1,105,454	-	-	1,175,454	99,825	349,388	16,638	-	-	245	466,095	1,641,548
	0	25,000	10,000	552,727	-	-	587,727	25,955	181,682	25,955	-	-	127	233,718	821,444
	0	12,500	5,000	276,363	-	-	293,863	13,496	94,474	31,491	-	-	66	139,528	433,392
	0	6,250	2,500	138,182	-	-	146,932	7,018	49,127	35,090	-	-	34	91,270	238,201
	0	3,125	1,250	69,091	-	-	73,466	3,649	25,546	37,711	-	-	18	66,924	140,390
	0	1,563	625	34,545	-	-	36,733	1,898	13,284	39,852	-	-	9	55,042	91,775
	0	781	313	17,273	-	-	18,366	987	6,908	41,775	-	-	5	49,674	68,040
	0	391	156	8,636	-	-	9,183	513	3,592	43,617	-	-	3	47,724	56,907
	0	195	78	4,318	-	-	4,592	267	1,868	45,450	-	-	1	47,586	52,178
	0	98	39	2,159	-	-	2,296	139	971	47,314	-	-	1	48,425	50,721
	0	49	20	1,080	-	-	1,148	72	505	49,231	-	-	0	49,809	50,957
	0	24	10	540	-	-	574	38	263	51,213	-	-	0	51,513	52,087
	0	12	5	270	1,175,454	-	1,175,741	20	137	53,268	581,756	-	0	635,180	1,810,920
	0	6	2	135	587,727	-	587,870	10	71	55,402	314,614	-	0	370,097	957,967
	0	3	1	67	293,863	-	293,935	5	37	57,620	170,143	-	0	227,805	521,740
	0	2	1	34	146,932	-	146,968	3	19	59,925	92,013	-	0	151,961	298,928
	0	1	0	17	73,466	-	73,484	1	10	62,323	49,761	-	0	112,095	185,579
	0	0	0	8	36,733	-	36,742	1	5	64,816	26,911	-	0	91,733	128,475
	0	0	0	4	18,366	-	18,371	0	3	67,409	14,553	-	0	81,965	100,336
	0	0	0	2	9,183	-	9,185	0	1	70,105	7,870	-	0	77,977	87,163
	0	0	0	1	4,592	-	4,593	0	1	72,910	4,256	-	0	77,167	81,759
	0	0	0	1	2,296	-	2,296	0	0	75,826	2,302	-	0	78,128	80,425
	0	0	0	0	1,148	-	1,148	0	0	78,859	1,245	-	0	80,104	81,252
	0	0	0	0	574	-	574	0	0	82,013	673	-	0	82,687	83,261
	0	0	0	0	287	1,175,454	1,175,741	0	0	85,294	364	931,410	0	1,017,068	2,192,809
	0	0	0	0	143	587,727	587,870	0	0	88,706	197	503,706	0	592,609	1,180,479
	0	0	0	0	72	293,863	293,935	0	0	92,254	106	272,404	0	364,765	658,700
	0	0	0	0	36	146,932	146,968	0	0	95,944	58	147,316	0	243,318	390,286
	0	0	0	0	18	73,466	73,484	0	0	99,782	31	79,669	0	179,482	252,965
	0	0	0	0	9	36,733	36,742	0	0	103,773	17	43,085	0	146,875	183,617
Total	-	100,000	40,000	2,210,907	2,350,898	2,314,174	7,015,980	153,897	727,891	1,831,565	1,266,870	1,977,591	510	5,958,323	12,974,303
NPV	$0	$80,645	$32,258	$1,782,990	$486,628	$123,917	$2,506,438	$127,752	$582,313	$343,180	$257,807	$104,602	$408	$1,416,062	$3,922,499

Table 20: Matewale Crossing – Discounted Cash Flow, Crossing Replacement and Bridge Options

Matewale Crossing - Economic Analysis of Replacement Options **Discount Rate** **12%**

	Option 1 - Crossing Replacement					Option 2 - Bridge Replacement on Site					Option 3 - Bridge Replacement on Alternative Alignment					
	Road Agency Costs			Road User Costs		Road Agency Costs			Road User Costs		Road Agency Costs			Road User Costs		
	Crossing Repl'ment	Crossing Maint	Total	Flood Closure	Total RUC	Bridge Constr.	Bridge Maint	Total	Flood Closure	Total RUC	Bridge Constr.	Bridge Maint	Total	Flood Closure	Distance Saving	Total RUC
	1,441,896	0	1,441,896	33,275	33,275	5,383,078	0	5,383,078	0	0	6,416,437	0	6,416,437	0	-6,195	-6,195
	0	5,000	5,000	34,606	34,606	0	5,000	5,000	0	0	0	5,000	5,000	0	-6,443	-6,443
	0	5,000	5,000	35,990	35,990	0	5,000	5,000	0	0	0	5,000	5,000	0	-6,700	-6,700
	0	5,000	5,000	37,430	37,430	0	5,000	5,000	0	0	0	5,000	5,000	0	-6,968	-6,968
	0	5,000	5,000	38,927	38,927	0	5,000	5,000	0	0	0	5,000	5,000	0	-7,247	-7,247
	0	5,000	5,000	40,484	40,484	0	5,000	5,000	0	0	0	5,000	5,000	0	-7,537	-7,537
	0	5,000	5,000	42,103	42,103	0	5,000	5,000	0	0	0	5,000	5,000	0	-7,839	-7,839
	0	5,000	5,000	43,788	43,788	0	5,000	5,000	0	0	0	5,000	5,000	0	-8,152	-8,152
	0	5,000	5,000	45,539	45,539	0	5,000	5,000	0	0	0	5,000	5,000	0	-8,478	-8,478
	0	5,000	5,000	47,361	47,361	0	5,000	5,000	0	0	0	5,000	5,000	0	-8,817	-8,817
	0	5,000	5,000	49,255	49,255	0	5,000	5,000	0	0	0	5,000	5,000	0	-9,170	-9,170
	0	5,000	5,000	51,225	51,225	0	5,000	5,000	0	0	0	5,000	5,000	0	-9,537	-9,537
	2,210,907	5,000	2,215,907	53,274	53,274	0	5,000	5,000	0	0	0	5,000	5,000	0	-9,918	-9,918
	0	5,000	5,000	55,405	55,405	0	5,000	5,000	0	0	0	5,000	5,000	0	-10,315	-10,315
	0	5,000	5,000	57,622	57,622	0	5,000	5,000	0	0	0	5,000	5,000	0	-10,728	-10,728
	0	5,000	5,000	59,926	59,926	0	5,000	5,000	0	0	0	5,000	5,000	0	-11,157	-11,157
	0	5,000	5,000	62,323	62,323	0	5,000	5,000	0	0	0	5,000	5,000	0	-11,603	-11,603
	0	5,000	5,000	64,816	64,816	0	5,000	5,000	0	0	0	5,000	5,000	0	-12,067	-12,067
	0	5,000	5,000	67,409	67,409	0	5,000	5,000	0	0	0	5,000	5,000	0	-12,550	-12,550
	0	5,000	5,000	70,105	70,105	0	5,000	5,000	0	0	0	5,000	5,000	0	-13,052	-13,052
	0	5,000	5,000	72,910	72,910	0	5,000	5,000	0	0	0	5,000	5,000	0	-13,574	-13,574
	0	5,000	5,000	75,826	75,826	0	5,000	5,000	0	0	0	5,000	5,000	0	-14,117	-14,117
	0	5,000	5,000	78,859	78,859	0	5,000	5,000	0	0	0	5,000	5,000	0	-14,681	-14,681
	0	5,000	5,000	82,013	82,013	0	5,000	5,000	0	0	0	5,000	5,000	0	-15,269	-15,269
	2,210,907	5,000	2,215,907	85,294	85,294	0	5,000	5,000	0	0	0	5,000	5,000	0	-15,879	-15,879
	0	5,000	5,000	88,706	88,706	0	5,000	5,000	0	0	0	5,000	5,000	0	-16,515	-16,515
	0	5,000	5,000	92,254	92,254	0	5,000	5,000	0	0	0	5,000	5,000	0	-17,175	-17,175
	0	5,000	5,000	95,944	95,944	0	5,000	5,000	0	0	0	5,000	5,000	0	-17,862	-17,862
	0	5,000	5,000	99,782	99,782	0	5,000	5,000	0	0	0	5,000	5,000	0	-18,577	-18,577
	0	5,000	5,000	103,773	103,773	0	5,000	5,000	0	0	0	5,000	5,000	0	-19,320	-19,320
Total	5,863,710	145,000	6,008,710	1,866,226	1,866,226	5,383,078	145,000	5,528,078	0	0	6,416,437	145,000	6,561,437	0	-347,442	-347,442
NPV	$1,924,143	$35,812	$1,959,955	$370,909	$370,909	$4,806,320	$35,812	$4,842,132	$0	$0	$5,728,962	$35,812	$5,764,773	$0	-$69,053	-$69,053

Table 21: Matewale Crossing – Option Comparison and EIRR

	Option 1 - Irish Crossing vs Do Min			Option 2 - Bridge Ex Site vs Do Min			Option 3 - Bridge New Site vs Do Min		
	Net Costs	Net Benefits	NPV @ 12%	Net Costs	Net Benefits	NPV @ 12%	Net Costs	Net Benefits	NPV @ 12%
	266,442	432,820	166,377	4,207,625	466,095	- 3,741,530	5,240,984	472,290	- 4,768,694
	- 582,727	199,112	781,838	- 582,727	233,718	816,444	- 582,727	240,160	822,887
	- 288,863	103,538	392,401	- 288,863	139,528	428,392	- 288,863	146,229	435,092
	- 141,932	53,840	195,772	- 141,932	91,270	233,201	- 141,932	98,238	240,170
	- 68,466	27,997	96,463	- 68,466	66,924	135,390	- 68,466	74,171	142,637
	- 31,733	14,558	46,291	- 31,733	55,042	86,775	- 31,733	62,579	94,312
	- 13,366	7,570	20,937	- 13,366	49,674	63,040	- 13,366	57,512	70,879
	- 4,183	3,937	8,120	- 4,183	47,724	51,907	- 4,183	55,876	60,060
	408	2,047	1,639	408	47,586	47,178	408	56,064	55,656
	2,704	1,064	- 1,640	2,704	48,425	45,721	2,704	57,242	54,538
	3,852	554	- 3,299	3,852	49,809	45,957	3,852	58,979	55,127
	4,426	288	- 4,138	4,426	51,513	47,087	4,426	61,050	56,624
	1,040,167	581,906	- 458,261	- 1,170,741	635,180	1,805,920	- 1,170,741	645,098	1,815,839
	- 582,870	314,691	897,562	- 582,870	370,097	952,967	- 582,870	380,412	963,282
	- 288,935	170,183	459,119	- 288,935	227,805	516,740	- 288,935	238,533	527,468
	- 141,968	92,034	234,002	- 141,968	151,961	293,928	- 141,968	163,117	305,085
	- 68,484	49,772	118,256	- 68,484	112,095	180,579	- 68,484	123,698	192,182
	- 31,742	26,916	58,658	- 31,742	91,733	123,475	- 31,742	103,800	135,542
	- 13,371	14,556	27,927	- 13,371	81,965	95,336	- 13,371	94,515	107,886
	- 4,185	7,872	12,057	- 4,185	77,977	82,163	- 4,185	91,029	95,215
	407	4,257	3,850	407	77,167	76,759	407	90,741	90,333
	2,704	2,302	- 401	2,704	78,128	75,425	2,704	92,245	89,541
	3,852	1,245	- 2,607	3,852	80,104	76,252	3,852	94,786	90,934
	4,426	673	- 3,753	4,426	82,687	78,261	4,426	97,955	93,530
	1,040,167	931,774	- 108,393	- 1,170,741	1,017,068	2,187,809	- 1,170,741	1,032,947	2,203,688
	- 582,870	503,903	1,086,774	- 582,870	592,609	1,175,479	- 582,870	609,124	1,191,994
	- 288,935	272,511	561,446	- 288,935	364,765	653,700	- 288,935	381,940	670,875
	- 141,968	147,374	289,342	- 141,968	243,318	385,286	- 141,968	261,180	403,148
	- 68,484	79,700	148,184	- 68,484	179,482	247,965	- 68,484	198,058	266,542
	- 31,742	43,102	74,844	- 31,742	146,875	178,617	- 31,742	166,195	197,936
Total	-1,007,269	4,092,097	5,099,366	-1,487,901	5,958,323	7,446,224	-454,543	6,305,764	6,760,307
NPV	-$546,483	$1,045,153	$1,591,636	$2,335,694	$1,416,062	-$919,632	$3,258,336	$1,485,115	-$1,773,221
	B/C	-ve		B/C	0.61		B/C	0.46	
	EIRR	N/A		EIRR	8.3%		EIRR	6.3%	

Table 22: Calculation of Poverty Impact Ratio

Narata Bridge Sub-Project (Matewale Crossing similar)

	Mode Use %			Poor's Share of Use		NPV of Costs (12%) F$ million			Savings Allocation to Groups, F$ million NPV						
	for Public Transport	for Freight Transport	Vehicle Owner's Private Use	for Public Transport	for Freight Transport	Financial	Economic	Economic *minus* Financial	PT Passengers: Poor	PT Passengers: Non-Poor	Freight Users: Poor	Freight Users: Non-Poor	Motor Vehicle Owners (Non-Poor)	Govern-ment/ Economy	Total
Road User Cost Savings:							*1.153*								
Vehicle Operating Cost Savings:							*0.899*	*-0.303*	*0.055*	*0.047*	*0.098*	*0.160*	*0.539*	*-0.303*	0.596
Cars & Taxis	10%		90%	0%	0%	0.067	0.050	-0.017		0.001			0.048	-0.017	
Vans and 4x4	40%	40%	20%	55%	38%	0.353	0.264	-0.089	0.015	0.012	0.032	0.052	0.153	-0.089	
Light Trucks	40%	40%	20%	55%	38%	0.476	0.356	-0.120	0.020	0.016	0.043	0.071	0.207	-0.120	
Medium Trucks	25%	75%		55%	38%	0.078	0.058	-0.020	0.002	0.002	0.013	0.022	0.020	-0.020	
Heavy Trucks		100%			38%	0.041	0.031	-0.010			0.009	0.015	0.006	-0.010	
Buses	100%			55%		0.187	0.140	-0.047	0.019	0.016			0.105	-0.047	
Travel Time Savings:							*0.138*	*0.138*	*0.040*	*0.035*	*0.013*	*0.022*	*0.028*	*0.000*	0.138
Cars & Taxis	10%		90%				0.015	0.015		0.002			0.014		
Vans and 4x4	40%	40%	20%	55%	38%		0.029	0.029	0.006	0.005	0.004	0.007	0.006		
Light Trucks	40%	40%	20%	55%	38%		0.041	0.041	0.009	0.007	0.006	0.010	0.008		
Medium Trucks	25%	75%		55%	38%		0.009	0.009	0.001	0.001	0.002	0.004	0.000		
Heavy Trucks		100%			38%		0.001	0.001			0.000	0.001	0.000		
Buses	100%			55%			0.043	0.043	0.024	0.020			0.000		
Accident Savings							*0.110*	*0.110*	*0.023*	*0.020*	*0.016*	*0.026*	*0.026*	*0.000*	0.110
Cars & Taxis	10%						0.009	0.009		0.001			0.008		
Vans and 4x4	40%	40%	20%	55%	38%		0.054	0.054	0.012	0.010	0.008	0.013	0.011		
Light Trucks	40%	40%	20%	55%	38%		0.036	0.036	0.008	0.007	0.005	0.009	0.007		
Medium Trucks	25%	75%	0%	55%	38%		0.005	0.005	0.001	0.001	0.001	0.002	0.000		
Heavy Trucks		100%	0%		38%		0.001	0.001			0.000	0.001	0.000		
Buses	100%			55%			0.005	0.005	0.003	0.002			0.000		
Maintenance Costs (Savings)						3.426	3.289	-0.137						-0.137	-0.137
Capital Costs						-6.188	-4.720	1.467						1.467	1.467
Total Gains and Losses									0.119	0.101	0.127	0.208	0.593	1.027	2.175
Share of Savings to the Poor %									100%	0%	100%	0%	0%	10.5%	
Net Savings to the Poor									0.119	0.000	0.127	0.000	0.000	0.108	0.354
Poverty Impact Ratio (PIR)											PIR including redistribution of taxes and duties				**16.3%**
											PIR excluding redistribution of taxes and duties				**21.5%**

Parameters:

ESP	Economic shadow price	74.8%	VOCs, ratio of economic to financial costs from HDM4RUC modelling
PPRP	Poor as Percentage of Resident Population........	55%	Source: from LARP; no significant differences between Fijian and other ethnicity
PPPT	Poor's Propensity to use Public Transport	100%	Compared to non-poor, from village and roadside interview surveys and prior studies; but more use of private vehicles by non-poor
PPFT	Poor's Propensity to use Freight Transport.........	50%	Compared to non-poor, from village and roadside interview surveys and prior studies
PVOCS	Proportion of PT VOC savings to users.............	25%	Price control rigidities make savings slow to pass through to users until road is upgraded to seal; most savings captured by vehicle owners
FVOCS	Proportion of Freight Savings to users..........	80%	Produce marketing is done by companies some of which are part of cooperative ventures with farmer ownership, most savings passed on;
			Also no price control on freight leads to a more competitive market for freight services
PSGE	Poors' share of government expenditure............	10.5%	Government budget allocation to social services and a proportion of other line services (30%) **x** percentage of poor in the national population (35%)
	Vehicle Ownership - village surveys and other sources indicate very little motorized transport ownership by village residents and zero ownership by poor assumed		