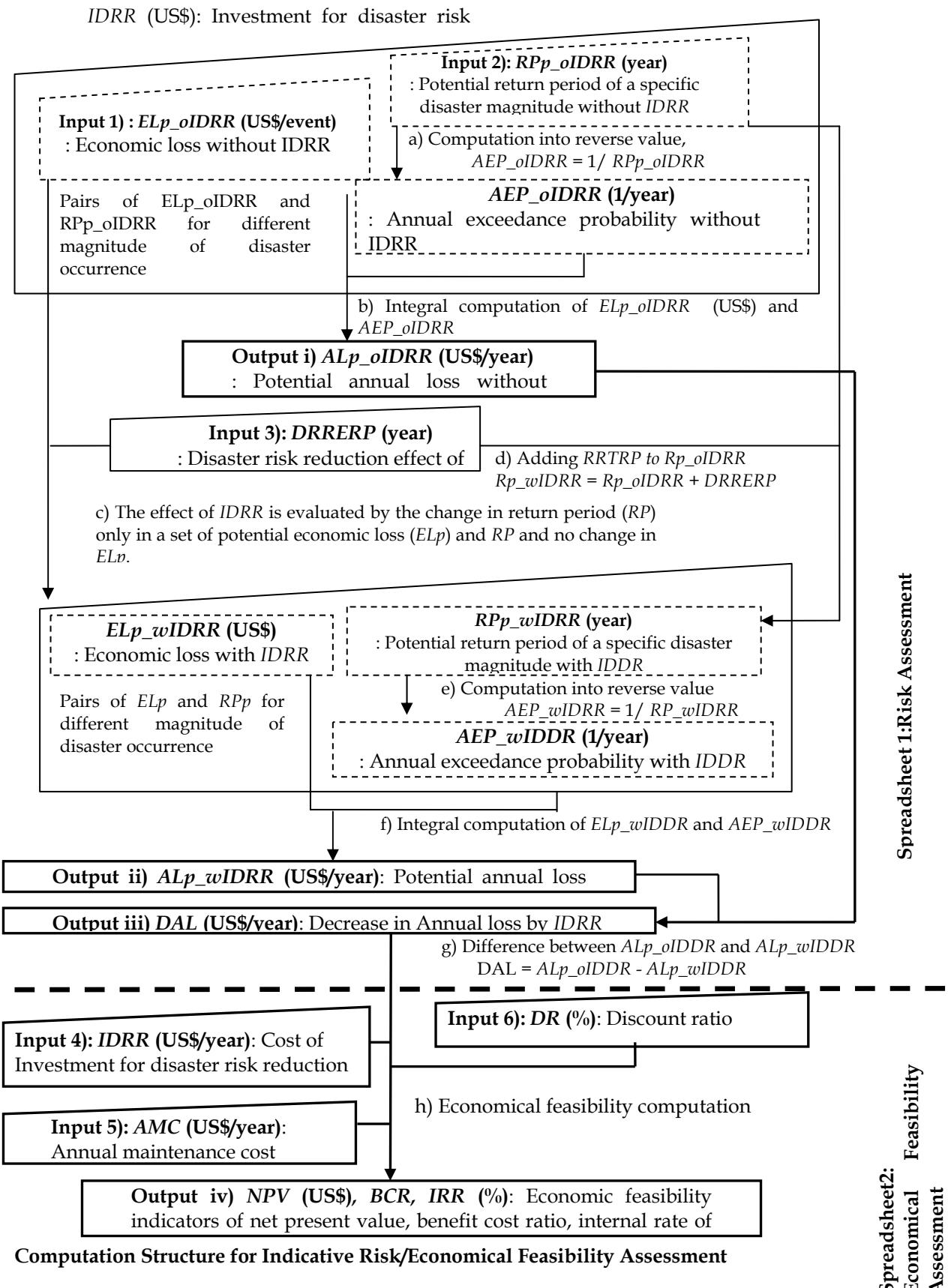
付録－4　リスクと災害対策事業の投資評価指標

1. リスクと災害対策事業の投資評価指標の算定の構造



Computation Structure for Indicative Risk/Economical Feasibility Assessment

次項以降に各国のリスク算定原単位を 2015 年数値として示す。

代表的な原単位の定義を下表に示す。

代表的な原単位の定義

用語 Terminology	略語 Abbreviation	解説 Explanation
日平均日交通量 Annual average daily traffic (vehicles /day)	*AADT*	The annual average daily volume of vehicles at a given point or a section of highway. The total daily traffic figure may vary depending on, day of the week, public holidays, seasonal trends, and climate conditions. The AADT is the average figure for the year, calculated relative to the aforementioned variables.
車輌の走行時間短縮便益原単位 Value of travel time saving for a vehicle	*VTTS*	Unit benefits from reduced travel time costs per hour. For road or road bridge disasters involving vehicles, VTTS measures the unit loss of increased travel time costs per hour.
車輌の走行費用原単位 Vehicle operating cost	*VOC*	Vehicle operating costs refer to costs that vary with vehicle usage, including fuel, tires, maintenance, repairs, and mileage-dependent depreciation costs (Booz Allen & Hamilton, 1999). VOC is calculated differently by assessing sections of road, road surface conditions and vehicle type.

(1) エルサルバドル

Reference data of road traffic economics					Since	2015					
	Category	Symbol	calculated formulates / Remark	Unit	PASS.	LOAD	PASSENGERS		LOAD		
					Normal Automobile	Pickup automobile	Microbus	Autobus	Autotruck two axis	Autotruck three axis	Trailer Truck, Head 2-3 axis
					_na	_pa	_mb	_ab	_at2	_at3	_tt
Average number of passengers of a vehicle		ANPV		persons / vehicle	2	2	12	44	2	1	1
Average number of operators, including the driver of a vehicle		ANO		persons / vehicle	1	1	1	1	1	1	1
Average number of passengers and vehicle operators		ANPVO		persons / vehicle	3	3	13	45	3	2	2
Vehicle Operation Cost	good pavement (IRI < 3.5)t	VOCgp		US$/km/vehicle	0.25	0.37	0.32	0.91	0.76	1.02	1.45
	regular pavement (3.5< IRI < 6)	VOCrp			0.25	0.39	0.45	1.08	0.87	1.17	1.62
	bad pavement (IRI > 6)	VOCbp			0.30	0.50	0.68	1.75	1.33	1.84	2.68
	without pavement	VOCwp			0.39	0.69	0.85	2.02	1.59	2.07	2.49
Vehicle Speed	good pavement (IRI < 3.5)t	VVgp		km/hour	87.40	86.87	74.20	72.18	73.60	65.45	63.42
	regular pavement (3.5< IRI < 6)	VVrp			70.75	70.10	57.35	55.39	62.80	58.63	53.40
	bad pavement (IRI > 6)	VVbp			39.53	39.51	38.90	26.81	36.73	36.58	27.14
	without pavement	VVwp			31.12	31.12	28.93	24.63	30.31	28.18	21.54
Value of Travel Time Savings of a vehicle		VTTS		US$/vehicle/ hour	5.38	5.08	16.41	70.19	5.05	4.24	5
Price of a New Vehicle		PNV		US$	20,360	25,450	34,335	100,940	49,440	61,800	111,978
Gross Domestic Product of El Salvador in 2014		GDP		US$/year	24,919,660,400						
Population of El Salvador		Pop	2015	Persons	6340000						
Average Duration of Life		ADL	2015	Years	72.4						
Unit Value of Loss of Human Lives Lost		UVHLL	=GDP/Pop x ADL/2	US$/persons	142,286						

(2) ニカラグア

Reference data of road traffic economics												Since 2015
	Category	Symbol	calculated formulates / Remark	Unit	PASS.	LOAD	PASSENGERS		LOAD			
					Normal Automobile	Pickup automobile	Microbus	Autobus	Autotruck two axis	Autotruck three axis	Trailer Truck, Head 2-3 axis	
					_na	*_pa*	*_mb*	*_ab*	*_at2*	*_at3*	*_tt*	
Average number of passengers of a vehicle		***ANPV***		persons / vehicle	1	1	9	28	1	1	1	
Average number of operators, including the driver of a vehicle		***ANO***		persons vehicle	1	1	1	1	1	1	1	
Average number of passengers and vehicle operators		***ANPVO***		persons / vehicle	2	2	10	29	2	2	2	
Vehicle Operation Cost	good pavement (IRI < 3.5)t	***VOCgp***		US$/km/vehicle	$ 0.14	$ 0.19	$ 0.27	$ 0.34	$ 0.35	$ 0.58	$ 0.90	
	regular pavement (3.5< IRI < 6)	***VOCrp***			$ 0.15	$ 0.21	$ 0.29	$ 0.38	$ 0.39	$ 0.62	$ 0.97	
	bad pavement (IRI > 6)	***VOCbp***			$ 0.17	$ 0.24	$ 0.34	$ 0.44	$ 0.45	$ 0.69	$ 1.09	
	without pavement	***VOCwp***			$ 0.21	$ 0.31	$ 0.43	$ 0.55	$ 0.55	$ 0.85	$ 1.36	
Vehicle Speed	good pavement (IRI < 3.5)t	***VVgp***		km/hour	81.36	81.36	74.20	61.70	71.60	76.83	70.30	
	regular pavement (3.5< IRI < 6)	***VVrp***			76.93	76.98	57.35	59.60	68.40	61.48	64.49	
	bad pavement (IRI > 6)	***VVbp***			66.40	66.64	38.90	53.80	60.53	36.58	54.26	
	without pavement	***VVwp***			37.24	37.08	31.09	31.30	35.77	34.59	31.37	
Value of Travel Time Savings of a vehicle		***VTTS***		US$/ vehicle/ hour	$ 2.30	$ 2.42	$ 11.50	$ 33.35	$ 3.81	$ 5.02	$ 9.02	
Price of a New Vehicle		***PNV***		US$	25,000	36,500	35,000	175,000	81,000	99,000	195,000	
Gross Domestic Product of Nicaragua in 2014		***GDP***		US$/year								11,260,000,000
Population of Nicaragua		***Pop***	2015	Persons								6189623
Average Duration of Life		***ADL***	2015	Years								72.72
Unit Value of Loss of Human Lives Lost		***UVHLL***	=GDP/*Pop* x ADL/2	US$/persons								66,145

(3) ホンジュラス

Reference data of road traffic economics Since 2015

	Category	Symbol	calculated formulates / Remark	Unit	PASS.	LOAD	PASSENGERS		LOAD		
					Normal Automobile	Pickup automobile	Microbus	Autobus	Autotruck two axis	Autotruck three axis	Trailer Truck, Head 2-3 axis
					_na	*_pa*	*_mb*	*_ab*	*_at2*	*_at3*	*_tt*
Average number of passengers of a vehicle		***ANPV***		persons / vehicle	1	1	13	42	2	2	2
Average number of operators, including the driver of a vehicle		***ANO***		persons / vehicle	1	1	1	1	1	1	1
Average number of passengers and vehicle operators		***ANPVO***		persons / vehicle	2	2	14	43	3	3	3
Vehicle Operation Cost	good pavement (IRI < 3.5)t	***VOCgp***		US$/km/ vehicle	0.19	0.28	0.29	0.63	0.56	0.80	1.18
	regular pavement (3.5< IRI < 6)	***VOCrp***			0.20	0.30	0.37	0.73	0.63	0.89	1.29
	bad pavement (IRI > 6)	***VOCbp***			0.23	0.37	0.51	1.09	0.89	1.26	1.89
	without pavement	***VOCwp***			0.30	0.50	0.64	1.29	1.07	1.46	1.93
Vehicle Speed	good pavement (IRI < 3.5)t	***VVgp***		km/hour	84.38	84.12	74.20	66.94	72.60	71.14	66.86
	regular pavement (3.5< IRI < 6)	***VVrp***			73.84	73.54	57.35	57.50	65.60	60.06	58.95
	bad pavement (IRI > 6)	***VVbp***			52.97	53.08	38.90	40.31	48.63	36.58	40.70
	without pavement	***VVwp***			34.18	34.10	30.01	27.97	33.04	31.39	26.46
Value of Travel Time Savings of a vehicle		***VTTS***		US$/vehicle/ hour	3.18	3.18	7.42	22.79	4.43	4.63	7
Price of a New Vehicle		***PNV***		US$	19,500	25,000	21,000	61,080	49,440	61,800	111,978
Gross Domestic Product of Honduras in 2014		***GDP***		US$/year							18,550,000,000
Population of Honduras		***Pop***	2015	Persons							8393624
Average Duration of Life		***ADL***	2015	Years							73
Unit Value of Loss of Human Lives Lost		***UVHLL***	=GDP/*Pop* x ADL/2	US$/persons							80,665

3. リスクと災害対策事業の投資評価指標の算定結果

E1:　サンサルバドル火山ラス・ラハス川土石流対策事業

E1.1　道路横断渓流　豪雨災害の発災脆弱性点検評価表

Risk Assessment Sheet 1:Potential Return Period of A Disaster Event — **For Crossing Stream**

Location and General Data		Site ID	E1								
Hazard Evaluation											
	Factor items/categories for return period of a disaster event		**Input '1' to only one applicable category**	**Score of return period of disaster**			**Factor items/categories for return period of a disaster event**		**Input '1' to only one applicable category**	**Score of return period of disaster**		
				edge only	**half function**	**whole function**				**edge only**	**half function**	**whole function**
Topographical situations (Choose one for the most appropriate category)	**Width of stream at the infrastructure crossing point: W**						**Gradient of stream bed at the infrastructure crossing: G**					
	W ≥ 10 m		1	3.0	6.0	12.0	G ≥ 20°			0.0	0.0	0.0
	10 m > W ≥ 5 m			2.0	4.0	8.0	20° > G ≥ 15°			1.0	2.0	4.0
	5 m > W ≥ 3 m			1.0	2.0	4.0	15° > G ≥ 10°		1	2.0	4.0	8.0
	3 m > W			0.0	0.0	0.0	10° > G			5.0	4.0	12.0
	Score of a selected category:S1			**3.0**	**6.0**	**12.0**	**Score of a selected category:S2**			**2.0**	**4.0**	**8.0**
	Area of drainage basin of the stream at the infrastructure crossing point: A						**Height from stream bottom to infrastructure at the crossing stream point: H**					
	A ≥ 1.0 km2		1	1.0	4.0	12.0	H ≥ 5 m			3.0	4.0	12.0
	1.0 km2 > A ≥ 0.2 km2			2.0	4.0	8.0	5 m > H ≥ 2 m		1	2.0	4.0	8.0
	0.2 km2 > A ≥ 0.1 km2			1.0	2.0	4.0	2 m > H ≥ 1 m			1.0	2.0	4.0
	0.1 km² > A			0.0	0.0	0.0	1 m > H			0.0	0.0	0.0
	Score of a selected category:S3			**3.0**	**4.0**	**12.0**	**Score of a selected category:S4**			**2.0**	**4.0**	**8.0**
Surface & sub-surface situations (Choose one for the most appropriate category)	**Dominant materials of stream sediments at the infrastructure crossing point**						**Dominant geology of drainage area of the stream**					
	Silt, clay			3.0	6.0	12.0	Recent	Alluvium	1	4.0	8.0	16.0
	Sand			2.0	4.0	8.0		Lava		1.0	2.0	4.0
	Gravels			1.0	2.0	4.0	Pleistocene to Holocene	Volcanic material in tectonic depressions (White)		0.0	0.0	0.0
	Cobbles, or Boulders		1	0.0	0.0	0.0		Volcanic material in tectonic depressions (Other)		0.0	0.0	0.0
	Fractured rocks			10.0	20.0	40.0		Volcanic massifs		0.0	0.0	0.0
	Weathered rock			10.0	20.0	40.0		Lava domes		0.0	0.0	0.0
	Soft fresh rock			20.0	40.0	80.0		Welded tuff		0.0	0.0	0.0
	Hard fresh rock			30.0	60.0	120.0	Pliocene	Volcanic material (Tuff)		0.0	0.0	0.0
	Score of a selected category:S5			**0.0**	**0.0**	**0.0**		Volcanic material (Other)		0.0	0.0	0.0
	Dominate vegetation of drainage of the stream						Miocene to Early	Granit		0.0	0.0	0.0
	Urban area			1.0	2.0	4.0	Cretaceous	Sedimentary Rocks		2.0	4.0	8.0
	Deforested area			0.0	0.0	0.0	**Score of a selected category:S6**			**4.0**	**8.0**	**16.0**
	Annual crops			1.0	2.0	4.0	**Stream water at crossing point of the infrastructure**					
	Moderate vegetation		1	2.0	4.0	6.0	Stream water is recognized in all seasons		1	0.0	0.0	0.0
	Intense vegetation			3.0	6.0	12.0	Stream water is recognized during rainy season only			1.0	2.0	4.0
	Score of a selected category:S7			**2.0**	**4.0**	**6.0**	Stream water is recognized during heavy rain only			2.0	4.0	8.0
	Difference of stream gradient (DEG) of crossing point, in comparison of around 30 m length of upstream and down stream areas						**Score of a selected category:S8**			**0.0**	**0.0**	**0.0**
	Upstream is steeper than downstream	**DEG < 10°**	1	2.0	5.0	10.0	**Plan shape of stream at the crossing point of infrastructure**					
		10 °≤ DEG		5.0	10.0	20.0	Straight			2.0	4.0	8.0
	Down stream is steeper than upstream	**DEG < 10°**		2.0	5.0	10.0	Curved		1	0.0	0.0	0.0
		10 °≤ DEG		3.0	7.0	15.0	**Score of a selected category:S10**			**0.0**	**0.0**	**0.0**
	Score of a selected category:S9			**2.0**	**5.0**	**10.0**						
	Slope failure situation in the drainage area of the stream											
	Newly-formed collapses (bare/no vegetation) are existing in main valley and branch valleys								1	0.0	0.0	0.0
	Newly-formed collapses (bare/no vegetation) are existing only in main valley									1.0	2.0	4.0
	Newly-formed collapses (bare/no vegetation) are existing only in branch valleys									2.0	4.0	8.0
	Newly-formed collapses (bare/no vegetation) are not recognized									3.0	6.0	12.0
	Score of a selected category:S11									**0.0**	**0.0**	**0.0**
Predictor	**Factor items/categories for return period of a disaster event**		**If applicable, Input '1'**	**Score of return period of disaster**			**Factor items/categories for return period of a disaster event**		**If applicable, Input '1'**	**Score of return period of disaster**		
				edge only	**half function**	**whole function**				**edge only**	**half function**	**whole function**
	Past debris flow deposit/trace is recognized on the infrastructure		1	-5.0	-10.0	-20.0	Past damage is recognized on the infrastructure		1	-15.0	-20.0	-25.0
							Drift wood is recognized in the stream			-8.0	-10.0	-12.0
							Score of a selected category:S12			**-20.0**	**-30.0**	**-45.0**
Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**		**Input '1' to only one applicable category**	**Score of return period of disaster**			**Factor items/categories for return period of a disaster event**		**Input '1' to only one applicable category**	**Score of return period of disaster event**		
				edge only	**half function**	**whole function**				edge only	half function	whole function
	Debris flow capturing work	Sediment smaller than 1/3 capacity		10.0	20.0	40.0	Culvert, bridge, or training levee, direction controlling works	Enough height (and length for training levee) against maximum historical disaster	1	10.0	20.0	30.0
		Sediment from 1/3-2/3 capacity		5.0	10.0	15.0		Not enough but more than 1/2 height (and length for training levee) against maximum historical disaster		5.0	10.0	15.0
	Debris flow depositing works	Sediment 2/3 capacity or more		2.0	4.0	8.0		Not enough and less than 1/2 height (and length for training levee) against maximum historical disaster		2.0	4.0	8.0
		Damaged and/or over flow history		1.0	2.0	4.0		Damaged and/or over flow history		1.0	2.0	4.0
		No countermeasures	1	0.0	0.0	0.0		No existence of culvert, bridge, or training levee		0.0	0.0	0.0
	Score of a selected category:S13			**0.0**	**0.0**	**0.0**	**Score of a selected category:S14**			**10.0**	**20.0**	**30.0**
	Debris flow occurrence controlling works	Much effective	1	2.0	4.0	8.0	Debris flow dispersing forest zone	Much effective	1	2.0	4.0	8.0
		Effective as some extent		1.0	2.0	4.0		Effective as some extent		1.0	2.0	4.0
		No existence of the measure		0.0	0.0	0.0		No existence of the measure		0.0	0.0	0.0
	Score of a selected category:S15			**2.0**	**4.0**	**8.0**	**Score of a selected category:S16**			**2.0**	**4.0**	**8.0**

Probable return period of a disaster event = Σ(S1:S16) summing up of score of return period	**Score of return period for disaster of edge only loss (year)**	**12.0**
	Score of return period for disaster of half function loss (year)	**33.0**
	Score of return period for disaster of whole function loss (year)	**52.0**

E1.2.1　被害算定表　50年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	E1 50 year					
		Item			Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	40.0
			of half functionality	**m**	***LRDh***	20.0
			of whole functionality	**m**	***LRDw***	10.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**1**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**3**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	32,098
			Pickup automobile	vehicles/day	*AADT_ap*	15,690
			Microbus	vehicles/day	*AADT_mb*	1,712
			Autobus	vehicles/day	*AADT_ab*	260
			Autotruck two axis	vehicles/day	*AADT_at2*	2,556
			Autotruck three axis	vehicles/day	*AADT_at3*	486
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	678
		Annual Average Daily Traffic		vehicles/day	***AADT***	**53,480**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.25
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.37
			Microbus	USD/km/vehicles	*VOCars_mb*	0.32
			Autobus	USD/km/vehicles	*VOCars_ab*	0.91
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.76
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	1.02
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	1.45
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.34**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.25
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.39
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.45
			Autobus	USD/km/vehicles	*VOCdrs_ab*	1.08
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.87
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	1.17
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	1.62
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.36**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	87.40
			Pickup automobile	km/hour	*VSars_pa*	86.87
			Microbus	km/hour	*VSars_mb*	74.20
			Autobus	km/hour	*VSars_ab*	72.18
			Autotruck two axis	km/hour	*VSars_at2*	73.60
			Autotruck three axis	km/hour	*VSars_at3*	65.45
			Trailer Truck	km/hour	*VSars_tt*	63.42
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**85.58**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	70.75
			Pickup automobile	km/hour	*VSas_pa*	70.10
			Microbus	km/hour	*VSas_mb*	57.35
			Autobus	km/hour	*VSas_ab*	55.39
			Autotruck two axis	km/hour	*VSas_at2*	62.80
			Autotruck three axis	km/hour	*VSas_at3*	58.63
			Trailer Truck	km/hour	*VSas_tt*	53.40
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**69.35**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	70.75
			Pickup automobile	km/hour	*VSdrs_ap*	70.10
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	55.39
			Autotruck two axis	km/hour	*VSdrs_e2*	62.80
			Autotruck three axis	km/hour	*VSdrs_e3*	58.63
			Trailer Truck	km/hour	*VSdrs_er*	53.40
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**69.35**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*	**100,000**
		Cost of Rehabilitation		US$	*Crehab*	**1,000,000**
		Cost of Reconstruction		US$	*Crecon*	**10,000,000**
		Cost of Recovery		**US$**	***Crecov =*** ***CER + CReh ab+ CRecon***	***11,100,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***62,605,840***
	III	**Vehicles Loss**		**US$**	***VL***	**4,276**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	1
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	2
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	4
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	**5.93**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =* *AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	1,185
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =* *AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	2,370
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =* *AADT x NDRw x 24/2 x AVTTSars*	60,850,161
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =* *AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	132,979
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =* lesser value between *LWw* and *LDw*	132,979
		Road Traffic Loss		US$	***RTL =*** ***PTLe + RTLh+ RTLw***	***136,534***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***	***2,731***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***	***13,653***
	VII	**Private Property Loss**		US$	***PPL***	***3,130,292***
Total Loss				**US$**	***TL =*** ***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***76,979,672***

E1.2.2 被害算定表 100年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

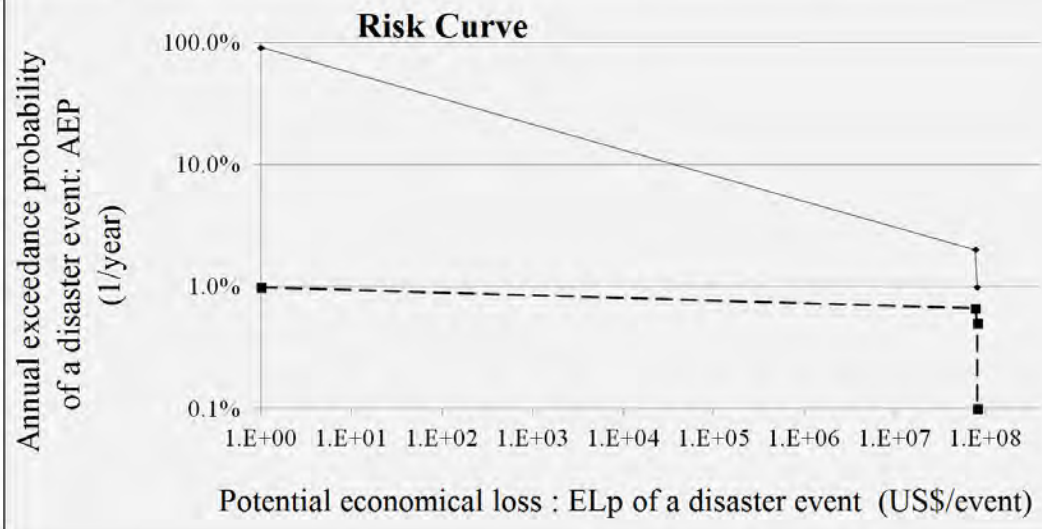
Place ID: E1 100 year

		Item			Symbol or calculated formula		Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***		41.8
			of half functionality	**m**	***LRDh***		20.9
			of whole functionality	**m**	***LRDw***		10.5
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***		**1**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***		**3**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*		32,098
			Pickup automobile	vehicles/day	*AADT_ap*		15,690
			Microbus	vehicles/day	*AADT_mb*		1,712
			Autobus	vehicles/day	*AADT_ab*		260
			Autotruck two axis	vehicles/day	*AADT_at2*		2,556
			Autotruck three axis	vehicles/day	*AADT_at3*		486
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*		678
		Annual Average Daily Traffic		vehicles/day	***AADT***		**53,480**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*		0.25
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.37
			Microbus	USD/km/vehicles	*VOCars_mb*		0.32
			Autobus	USD/km/vehicles	*VOCars_ab*		0.91
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*		0.76
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*		1.02
			Trailer Truck	USD/km/vehicles	*VOCars_tt*		1.45
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***		**0.34**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*		0.25
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.39
			Microbus	USD/km/vehicles	*VOCdrs_mb*		0.45
			Autobus	USD/km/vehicles	*VOCdrs_ab*		1.08
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*		0.87
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*		1.17
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*		1.62
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*		**0.36**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*		87.40
			Pickup automobile	km/hour	*VSars_pa*		86.87
			Microbus	km/hour	*VSars_mb*		74.20
			Autobus	km/hour	*VSars_ab*		72.18
			Autotruck two axis	km/hour	*VSars_at2*		73.60
			Autotruck three axis	km/hour	*VSars_at3*		65.45
			Trailer Truck	km/hour	*VSars_tt*		63.42
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***		**85.58**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*		70.75
			Pickup automobile	km/hour	*VSas_pa*		70.10
			Microbus	km/hour	*VSas_mb*		57.35
			Autobus	km/hour	*VSas_ab*		55.39
			Autotruck two axis	km/hour	*VSas_at2*		62.80
			Autotruck three axis	km/hour	*VSas_at3*		58.63
			Trailer Truck	km/hour	*VSas_tt*		53.40
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***		**69.35**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*		70.75
			Pickup automobile	km/hour	*VSdrs_ap*		70.10
			Microbus	km/hour	*VSdrs_mb*		57.35
			Autobus	km/hour	*VSdrs_ab*		55.39
			Autotruck two axis	km/hour	*VSdrs_c2*		62.80
			Autotruck three axis	km/hour	*VSdrs_c3*		58.63
			Trailer Truck	km/hour	*VSdrs_cr*		53.40
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***		**69.35**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*		**104,500**
		Cost of Rehabilitation		US$	*Crehab*		**1,045,000**
		Cost of Reconstruction		US$	*Crecon*		**10,450,000**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***11,599,500***
	II	**Human Lives Lost (US$)**		Persons	***HLL***		***65,423,103***
	III	**Vehicles Loss**		**US$**	***VL***		**4,468**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*		1
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*		2
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*		4
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*		8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*		17
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*		**5.93**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars*	1,352
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	2,705
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	66,449,897
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs/AVSdrs -Dars/AVSars) x AVTTSars)*	138,963
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	138,963
		Road Traffic Loss		US$	***RTL =***	***PTLe + RTLh+ RTLw***	***143,020***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***		***2,860***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***		***14,302***
	VII	**Private Property Loss**		US$	***PPL***		***3,271,155***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***80,444,106***

E1.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name　E1



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	76,976,672	80,444,106	80,444,106	80,444,106
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	50.0	100.0	100.0	100.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	2.0%	1.0%	1.0%	1.0%
	Potential annual loss (US$/year)	*ALp_oIDRR*					35,811,174
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					100.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	76,976,672	80,444,106	80,444,106	80,444,106
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	101.1	150.0	200.0	200.0	200.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	1.0%	0.7%	0.5%	0.5%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					657,511
Decrease in annual loss by IDRR (US$/year)		*DAL*					35,153,663

E1.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	E1				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	9,267,648	9,267,648
2	Consultant	LS	1	1,390,147	1,390,147
3					0
4					0
5					0
6					0
7					0
Cost total					**10,657,795**
Annual maintenance cost				***AMC***	**92,676**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	35,811,174
Disaster risk reduction range of return period (year)				*DR4P*	100.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	657,511
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	35,153,663
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	251,228,266
Benefit cost ratio				***BCR***	23.13
Internal rate of return (%)				***IRR***	283%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age}=NB/(1+DR)^{age}$
2015	0	12%	10,657,795	0	0	-10,657,795	-10,657,795
2016	1	12%		92,676	35,153,663	35,060,986	31,304,452
2017	2	12%		92,676	35,153,663	35,060,986	27,950,404
2018	3	12%		92,676	35,153,663	35,060,986	24,955,718
2019	4	12%		92,676	35,153,663	35,060,986	22,281,891
2020	5	12%		92,676	35,153,663	35,060,986	19,894,545
2021	6	12%		92,676	35,153,663	35,060,986	17,762,987
2022	7	12%		92,676	35,153,663	35,060,986	15,859,810
2023	8	12%		92,676	35,153,663	35,060,986	14,160,544
2024	9	12%		92,676	35,153,663	35,060,986	12,643,343
2025	10	12%		92,676	35,153,663	35,060,986	11,288,699
2026	11	12%		92,676	35,153,663	35,060,986	10,079,196
2027	12	12%		92,676	35,153,663	35,060,986	8,999,282
2028	13	12%		92,676	35,153,663	35,060,986	8,035,073
2029	14	12%		92,676	35,153,663	35,060,986	7,174,172
2030	15	12%		92,676	35,153,663	35,060,986	6,405,511
2031	16	12%		92,676	35,153,663	35,060,986	5,719,206
2032	17	12%		92,676	35,153,663	35,060,986	5,106,434
2033	18	12%		92,676	35,153,663	35,060,986	4,559,316
2034	19	12%		92,676	35,153,663	35,060,986	4,070,818
2035	20	12%		92,676	35,153,663	35,060,986	3,634,659
Net present value		***NPV***	10,657,795	692,242	262,578,303	251,228,266	**251,228,266**
Benefit/Cost ratio		***BCR***	$= DAL\_{NPV}/(IDRR\_{NPV}+AMC\_{NPV})$				**23.13**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20}\frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}}=0$				**283%**

N1:　国道1号線ガビラナ地区地すべり対策事業

N1.1　道路山側斜面　豪雨災害の発災脆弱性点検評価表

Risk Assessment Sheet 1: Return Period — **For Hillside Slope**

Location and General Data	Site ID	N1

Hazard Evaluation

	Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster: edge only	half function	whole
Topographical situations (Choose one for the most appropriate category)	**Length of survey slope along infrastructure: L**				
	L ≥ 300 m		0.5	1.0	2.0
	300 m > L ≥ 200 m	1	1.0	2.0	4.0
	200 m > L ≥ 100 m		2.0	4.0	8.0
	100 m > L		3.0	6.0	8.0
	Score of a selected category:S1		**1.0**	**2.0**	**4.0**
	Whole height of hillside slope: HH				
	WH ≥ 200 m		0.5	1.0	2.0
	200 m > WH ≥ 100 m		1.0	2.0	4.0
	100 m > WH ≥ 50 m	1	2.0	4.0	8.0
	50 m > WH		3.0	6.0	9.0
	Score of a selected category:S3		**2.0**	**4.0**	**8.0**
	Distance from infrastructure to toe of hill side slope :D				
	D ≥ 4 m		3.0	6.0	12.0
	4 m > D ≥ 2m		2.0	4.0	8.0
	2 m > D ≥ 1 m		1.0	2.0	4.0
	1 m > D	1	0.5	1.0	2.0
	Score of a selected category:S5		**0.5**	**1.0**	**2.0**
Surface & subsurface situations (Choose one for the most appropriate category)	**Dominant materials of slope surface**				
	Silt, clay	1	0.5	1.0	2.0
	Sand		0.8	1.6	3.2
	Gravels		1.0	2.0	4.0
	Cobbles, or Boulders		1.0	2.0	4.0
	Fractured rocks		2.0	4.0	8.0
	Weathered rock		2.0	4.0	8.0
	Soft fresh rock		4.0	8.0	16.0
	Hard fresh rock		10.0	20.0	30.0
	Score of a selected category:S7		**0.5**	**1.0**	**2.0**
	Apparent inclination of dominant discontinuity against slope surface: AI				
	AI ≥60°		1.0	2.0	4.0
	60° > AI ≥ 20°		0.5	1.0	2.0
	20° > AI ≥ 10°		1.0	2.0	4.0
	10° > AI ≥ 0°		2.0	4.0	8.0
	0° > AI ≥ -10°		3.0	6.0	9.0
	-10° > AI ≥ -20°		4.0	8.0	16.0
	-20° > AI		5.0	10.0	20.0
	No discontinuity	1	6.0	12.0	24.0
	Score of a selected category:S9		**6.0**	**12.0**	**24.0**
	Spring (groundwater) condition				
	Spring water is recognized in all seasons		0.0	0.0	0.0
	Spring water is recognized during rainy season only	1	1.0	2.0	4.0
	Spring water is recognized during heavy rain only		2.0	4.0	8.0
	Not seen		3.0	6.0	9.0
	Score of a selected category:S11		**1.0**	**2.0**	**4.0**
	Dominate vegetation				
	Urban area		0.5	1.0	2.0
	Deforested area	1	0.5	1.0	2.0
	Annual crops		0.5	1.0	2.0
	Moderate vegetation		2.0	4.0	8.0
	Intense vegetation		4.0	8.0	16.0
	Score of a selected category:S13		**0.5**	**1.0**	**2.0**
	Soil covering impervious bedrock				
	Yes		0.0	0.0	0.0
	No	1	6.0	12.0	18.0
	Score of a selected category:S15		**6.0**	**12.0**	**18.0**
Predictor	**Factor items/categories for return period of a disaster event**	**If applicable, Input '1'**	**Score of return period of disaster: edge only**	**half function**	**whole**
	Minor collapse/fall	1	-3.0	-6.0	-9.0
	Fallen/inclined trees	1	-4.0	-8.0	-12.0
	Open cracks below an over hang		-3.0	-6.0	-9.0
	Cross open cracks to cause wedge shape slide		-4.0	-8.0	-12.0
	Continuous cracks (more than 5m) on infrastructure	1	-5.0	-10.0	-15.0
	Upheaval on infrastructure	1	-5.0	-10.0	-15.0
	Erosion en surcos		-2.0	-4.0	-6.0
	Erosion en zanjas o cárcava	1	-5.0	-10.0	-15.0
Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster: edge only**	**half function**	**whole**
	Superficie principal (Main Surface)				
	Reja de concreto (Grating crib works or similar)		20.0	40.0	80.0
	Shotcrete or Pitching works		10.0	20.0	40.0
	Zacate (Grass)		1.0	2.0	4.0
	Arbustos (Bushes)		2.0	4.0	8.0
	Grand Arboles (Threes)		2.0	4.0	8.0
	No slope protection works and planting works	1	0.0	0.0	0.0
	Score of summing up of selected category :S18		**0**	**0**	**0**
	Principal obras de drenaje superficial (Main surface drainage)				
	Drenjae superficial natural (natural drainage)		0.1	0.2	0.4
	Drenaje superficial forjado (dug drainage)		2.0	4.0	8.0
	Drenaje forjado con recubrimiento (dug drainages with concrete cover)		5.0	10.0	20.0
	Drenaje Completo, canaletas, bajantes, etc., con daños o historial de sobreflujo		10.0	20.0	40.0
	Drenaje Completo, canaletas, bajantes, etc. (full drainage system, gutters, pipe drainage		15.0	30.0	60.0
	No surface drainage		0.0	0.0	0.0
	Score of summing up of selected category :S20		**0**	**0**	**0**

Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster: edge	half	whole
Slope inclination of infrastructure side slope up to inclination change point: SI				
SI ≥45°		0.5	1.0	2.0
45° > SI ≥ 30°		1.0	2.0	4.0
30° > SI ≥ 15°	1	2.0	4.0	8.0
15° > SI		3.0	6.0	9.0
Score of a selected category:S2		**2.0**	**4.0**	**8.0**
Height of infrastructure side slope up to inclination change point: H				
H ≥ 90 m		0.5	1.0	2.0
90 m > H ≥ 60 m		1.0	2.0	4.0
60 m > H ≥ 30 m	1	2.0	4.0	8.0
30 m > HS		3.0	6.0	9.0
Score of a selected category:S4		**2.0**	**4.0**	**8.0**
Slope shape of infrastructure side slope up to inclination change point				
Valley type		0.5	1.0	2.0
Straight type	1	1.0	2.0	4.0
Ridge type		2.0	4.0	8.0
Combined type		3.0	6.0	9.0
Score of a selected category:S6		**1.0**	**2.0**	**4.0**
Dominant geology				
Recent — Alluvium		1.0	2.0	4.0
Recent — Lava		2.0	4.0	8.0
Pleistocene to Holocene — Volcanic material in tectonic depressions (White)		0.5	1.0	2.0
Pleistocene to Holocene — Volcanic material in tectonic depressions (Other)	1	0.5	1.0	2.0
Pleistocene to Holocene — Volcanic massifs		3.0	6.0	12.0
Pleistocene to Holocene — Lava domes		3.0	6.0	12.0
Pleistocene to Holocene — Welded tuff		3.0	6.0	12.0
Pliocene — Volcanic material (Tuff)		2.0	4.0	8.0
Pliocene — Volcanic material (Other)		3.0	6.0	12.0
Miocene to Early Cretaceous — Granit		4.0	8.0	16.0
Miocene to Early Cretaceous — Sedimentary Rocks		3.0	6.0	12.0
Score of a selected category:S8		**0.5**	**1.0**	**2.0**
True angle of dominant discontinuity of rocky slope: D				
D ≥45°		0.5	1.0	2.0
45° > D ≥ 15°		1.0	2.0	4.0
15° > D		2.0	4.0	8.0
Not existing		10.0	20.0	40.0
Not rocky slope	1	10.0	20.0	40.0
Score of a selected category:S10		**10.0**	**20.0**	**40.0**
Surface water				
Surface water is recognized in all seasons		0.5	1.0	2.0
Surface water is recognized during rainy season only		1.0	2.0	4.0
Surface water is recognized during heavy rain only	1	2.0	4.0	8.0
Not seen		3.0	6.0	9.0
Score of a selected category:S12		**2.0**	**4.0**	**8.0**
Slope type of infrastructure side slope up to inclination change point				
Natural slope		0.0	1.0	2.0
Artificial slope of cutting	1	1.0	2.0	4.0
Artificial slope of embankment		2.5	5.0	10.0
Combined		0.5	1.0	2.0
Score of a selected category:S14		**1.0**	**2.0**	**4.0**
The rock is hard at upper part and soft at foot part				
Yes		0.0	0.0	0.0
No	1	6.0	12.0	18.0
Score of a selected category:S16		**6.0**	**12.0**	**18.0**

Factor items/categories for return period of a disaster event	If applicable, Input '1'	Score of return period of disaster: edge	half	whole
Continuous cracks (more than 5 meters) on slope		-3.0	-6.0	-9.0
Apparent deformation by land-sliding	1	-10.0	-20.0	-30.0
Open cracks by toppling		-3.0	-6.0	-9.0
Open cracks by sliding	1	-3.0	-6.0	-9.0
Depression on infrastructure	1	-5.0	-10.0	-20.0
Erosion laminar	1	-1.0	-2.0	-4.0
Erosion interna o tubificacion (piping)		-3.0	-6.0	-9.0
Score of summing up of applicable predictors:S17		**-41.0**	**-82.0**	**-129.0**

Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster: edge	half	whole
Principal obras de retención (Main retaining works)				
Anclajes Activos (anchored wall)		30.0	60.0	120.0
Tierra Armada (Reinforced Earth)		20.0	40.0	80.0
Muro Flexible (Flexible Wall)		20.0	40.0	80.0
Muro de Gravedad (Gravity Wall)		15.0	30.0	60.0
Muro de Gavión (Gabion Wall)		10.0	20.0	40.0
Soil Nailing, Rock bolts		2.0	4.0	8.0
No retaining works		0.0	0.0	0.0
Score of summing up of selected category :S19		**0**	**0**	**0**
Principal Obras de Subsurface Drainage (Main sub-surface drainage)				
En buen estado (fair state)		10.0	20.0	40.0
Not En buen estado (Not fair state)		0.2	0.4	0.8
Necesario / No hay suficiente(Needed/not enough)		0.1	0.2	0.4
Necesario / Ausente (Needed/not present)		0.0	0.0	0.0
Score of summing up of applicable measuers:S21		**0**	**0**	**0**

Potential return period of a disaster event = Σ(S1:S21) summing up of score of return period >1	**Potential return period of a disaster of edge only loss (year)**	**1.0**
	Potential return period of a disaster of half function loss (year)	**2.0**
	Potential return period of a disaster of whole function loss (year)	**12.0**

N1.2.1　被害算定表　2年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID		N1-2year					
Item					Symbol or calculated formula		Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***		0.0
			of half functionality	**m**	***LRDh***		200.0
			of whole functionality	**m**	***LRDw***		0.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***		**186**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***		**243**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*		1,364
			Pickup automobile	vehicles/day	*AADT_ap*		2,028
			Microbus	vehicles/day	*AADT_mb*		94
			Autobus	vehicles/day	*AADT_ab*		262
			Autotruck two axis	vehicles/day	*AADT_at2*		703
			Autotruck three axis	vehicles/day	*AADT_at3*		39
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*		312
		Annual Average Daily Traffic		vehicles/day	***AADT***		**4,802**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*		0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.19
			Microbus	USD/km/vehicles	*VOCars_mb*		0.27
			Autobus	USD/km/vehicles	*VOCars_ab*		0.34
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*		0.35
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*		0.58
			Trailer Truck	USD/km/vehicles	*VOCars_tt*		0.90
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***		**0.26**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*		0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.19
			Microbus	USD/km/vehicles	*VOCdrs_mb*		0.27
			Autobus	USD/km/vehicles	*VOCdrs_ab*		0.34
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*		0.35
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*		0.58
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*		0.90
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*		**0.26**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*		81.36
			Pickup automobile	km/hour	*VSars_pa*		81.36
			Microbus	km/hour	*VSars_mb*		74.20
			Autobus	km/hour	*VSars_ab*		61.70
			Autotruck two axis	km/hour	*VSars_at2*		71.60
			Autotruck three axis	km/hour	*VSars_at3*		76.83
			Trailer Truck	km/hour	*VSars_tt*		70.30
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***		**77.96**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*		81.36
			Pickup automobile	km/hour	*VSas_pa*		81.36
			Microbus	km/hour	*VSas_mb*		74.20
			Autobus	km/hour	*VSas_ab*		61.70
			Autotruck two axis	km/hour	*VSas_at2*		71.60
			Autotruck three axis	km/hour	*VSas_at3*		76.83
			Trailer Truck	km/hour	*VSas_tt*		70.30
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***		**77.96**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*		81.36
			Pickup automobile	km/hour	*VSdrs_ap*		81.36
			Microbus	km/hour	*VSdrs_mb*		74.20
			Autobus	km/hour	*VSdrs_ab*		61.70
			Autotruck two axis	km/hour	*VSdrs_c2*		71.60
			Autotruck three axis	km/hour	*VSdrs_c3*		76.83
			Trailer Truck	km/hour	*VSdrs_cr*		70.30
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***		**77.96**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*		**0**
		Cost of Rehabilitation		US$	*Crehab*		**0**
		Cost of Reconstruction		US$	*Crecon*		**971,000**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***971,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***		***30,808***
	III	**Vehicles Loss**		**US$**	***VL***		**1,565**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*		0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*		8
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*		0
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*		8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*		16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*		**4.90**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	7,734
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	0
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars).*	0
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	0
		Road Traffic Loss		US$	***RTL =***	***PTLe + RTLh+ RTLw***	***7,734***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***		***0***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***		***0***
	VII	**Private Property Loss**		US$	***PPL***		***0***
Total Loss				US$	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***1,011,107***

N1.2.2　被害算定表　12年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

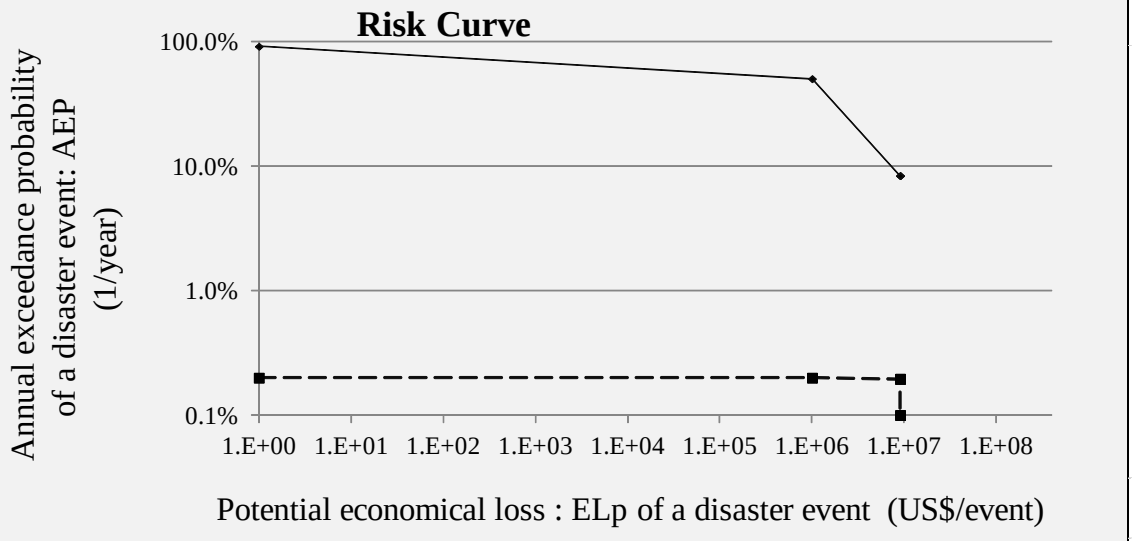
Place ID: N1- 12year

		Item			Symbol or calculated formula		Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***		0.0
			of half functionality	**m**	***LRDh***		0.0
			of whole functionality	**m**	***LRDw***		200.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***		**186**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***		**243**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*		1,364
			Pickup automobile	vehicles/day	*AADT_ap*		2,028
			Microbus	vehicles/day	*AADT_mb*		94
			Autobus	vehicles/day	*AADT_ab*		262
			Autotruck two axis	vehicles/day	*AADT_at2*		703
			Autotruck three axis	vehicles/day	*AADT_at3*		39
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*		312
		Annual Average Daily Traffic		vehicles/day	***AADT***		**4,802**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*		0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.19
			Microbus	USD/km/vehicles	*VOCars_mb*		0.27
			Autobus	USD/km/vehicles	*VOCars_ab*		0.34
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*		0.35
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*		0.58
			Trailer Truck	USD/km/vehicles	*VOCars_tt*		0.90
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***		**0.26**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*		0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*		0.19
			Microbus	USD/km/vehicles	*VOCdrs_mb*		0.27
			Autobus	USD/km/vehicles	*VOCdrs_ab*		0.34
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*		0.35
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*		0.58
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*		0.90
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*		**0.26**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*		81.36
			Pickup automobile	km/hour	*VSars_pa*		81.36
			Microbus	km/hour	*VSars_mb*		74.20
			Autobus	km/hour	*VSars_ab*		61.70
			Autotruck two axis	km/hour	*VSars_at2*		71.60
			Autotruck three axis	km/hour	*VSars_at3*		76.83
			Trailer Truck	km/hour	*VSars_tt*		70.30
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***		**77.96**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*		81.36
			Pickup automobile	km/hour	*VSas_pa*		81.36
			Microbus	km/hour	*VSas_mb*		74.20
			Autobus	km/hour	*VSas_ab*		61.70
			Autotruck two axis	km/hour	*VSas_at2*		71.60
			Autotruck three axis	km/hour	*VSas_at3*		76.83
			Trailer Truck	km/hour	*VSas_tt*		70.30
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***		**77.96**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*		81.36
			Pickup automobile	km/hour	*VSdrs_ap*		81.36
			Microbus	km/hour	*VSdrs_mb*		74.20
			Autobus	km/hour	*VSdrs_ab*		61.70
			Autotruck two axis	km/hour	*VSdrs_c2*		71.60
			Autotruck three axis	km/hour	*VSdrs_c3*		76.83
			Trailer Truck	km/hour	*VSdrs_cr*		70.30
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***		**77.96**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*		0
		Cost of Rehabilitation		US$	*Crehab*		0
		Cost of Reconstruction		US$	*Crecon*		2,480,000
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***2,480,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***		***61,616***
	III	**Vehicles Loss**		**US$**	***VL***		**3,130**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*		0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*		0
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*		75
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*		8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*		16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*		**4.90**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	0
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	1,589,767,425
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	6,593,348
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	6,593,348
		Road Traffic Loss		US$	***RTL =***	***PTLe + RTLh+ RTLw***	***6,593,348***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***		***0***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***		***0***
	VII	**Private Property Loss**		US$	***PPL***		***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***9,138,095***

N1.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name N1



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	1,011,107.0	9,138,095.0	9,138,095.0	9,138,095.0
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	2.0	12.0	12.0	12.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	50.0%	8.3%	8.3%	8.3%
	Potential annual loss (US$/year)	*ALp_oIDRR*					3,082,742
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					500.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	1,011,107	9,138,095	9,138,095	9,138,095
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	501.1	502.0	512.0	512.0	512.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	0.2%	0.2%	0.2%	0.2%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					18,047
Decrease in annual loss by IDRR (US$/year)		*DAL*					3,064,695

N1.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	N1				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	2,825,600	2,825,600
2	Consultant	LS	1	423,840	423,840
3					0
4					0
5					0
6					0
7					0
Cost total					**3,249,440**
Annual maintenance cost				***AMC***	**28,256**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	3,082,742
Disaster risk reduction range of return period (year)				*DR4P*	500.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	18,047
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	3,064,695
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	19,431,067
Benefit cost ratio				***BCR***	6.62
Internal rate of return (%)				***IRR***	73%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age} = NB/(1+DR)^{age}$
2015	0	12%	3,249,440	0	0	-3,249,440	-3,249,440
2016	1	12%		28,256	3,064,695	3,036,439	2,711,106
2017	2	12%		28,256	3,064,695	3,036,439	2,420,630
2018	3	12%		28,256	3,064,695	3,036,439	2,161,277
2019	4	12%		28,256	3,064,695	3,036,439	1,929,712
2020	5	12%		28,256	3,064,695	3,036,439	1,722,957
2021	6	12%		28,256	3,064,695	3,036,439	1,538,354
2022	7	12%		28,256	3,064,695	3,036,439	1,373,531
2023	8	12%		28,256	3,064,695	3,036,439	1,226,367
2024	9	12%		28,256	3,064,695	3,036,439	1,094,970
2025	10	12%		28,256	3,064,695	3,036,439	977,652
2026	11	12%		28,256	3,064,695	3,036,439	872,904
2027	12	12%		28,256	3,064,695	3,036,439	779,378
2028	13	12%		28,256	3,064,695	3,036,439	695,873
2029	14	12%		28,256	3,064,695	3,036,439	621,315
2030	15	12%		28,256	3,064,695	3,036,439	554,746
2031	16	12%		28,256	3,064,695	3,036,439	495,309
2032	17	12%		28,256	3,064,695	3,036,439	442,240
2033	18	12%		28,256	3,064,695	3,036,439	394,857
2034	19	12%		28,256	3,064,695	3,036,439	352,551
2035	20	12%		28,256	3,064,695	3,036,439	314,778
Net present value		***NPV***	3,249,440	211,057	22,891,563	19,431,067	**19,431,067**
Benefit/Cost ratio		***BCR***	$= DAL_{\_NPV}/(IDRR_{\_NPV}+AMC_{\_NPV})$				**6.62**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20} \frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}} = 0$				**73%**

N2:

N2.1　道路山側斜面　豪雨災害の発災脆弱性点検評価表

DIRECCION DE ADAPTABILIDAD AL CAMBIO CLIMATICO Y GESTION ESTRATEGICA DEL RIESGO

Risk Assessment Sheet 1: Return Period — **For Hillside Slope**

Location and General Data		**Site ID**	N2		
Technician:		Date:	Time:	Department:	Municipality:
Village/Neighborhood:			Address/Road Name and Station		
Observations:					

Position Data		**Information related to probable damage**					
Geodetic Coordinates		**Damage type**		**Dimension**	edge only	half function	whole function
Latitude:		Cárcava	Flujos	Length (m):			
Longitude:		Slope Erosion	Otro	Height (m):			
Elevation:		Scour		Depth (m):			
Lambert Coordinates		Slides		Scarp height (m):			
North:		Detachments		Perimeter (m):			
West:		Belonging basin		Rain gauge station			
Elevation:							

Past disaster event	Hazard level	Event type	Date of event			Evaluated return period of the event (year)	Description
			Date	Month	Year		
	edge only loss						
	half function loss						
	whole function loss						

Hazard Evaluation

	Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster			Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster		
			edge only	half function	whole			edge	half	whole
Topographical situations (Choose one for the most appropriate category)	**Length of survey slope along infrastructure: L**					**Slope inclination of infrastructure side slope up to inclination change point: SI**				
	L ≥ 300 m	1	0.5	1.0	2.0	SI ≥45°		0.5	1.0	2.0
	300 m > L ≥ 200 m		1.0	2.0	4.0	45° > SI ≥ 30°	1	1.0	2.0	4.0
	200 m > L ≥ 100 m		2.0	4.0	8.0	30° > SI ≥ 15°		2.0	4.0	8.0
	100 m > L		3.0	6.0	8.0	15° > SI		3.0	6.0	9.0
	Score of a selected category:S1		**0.5**	**1.0**	**2.0**	**Score of a selected category:S2**		**1.0**	**2.0**	**4.0**
	Whole height of hillside slope: HH					**Height of infrastructure side slope up to inclination change point: H**				
	WH ≥ 200 m	1	0.5	1.0	2.0	H ≥ 90 m	1	0.5	1.0	2.0
	200 m > WH ≥ 100 m		1.0	2.0	4.0	90 m > H ≥ 60 m		1.0	2.0	4.0
	100 m > WH ≥ 50 m		2.0	4.0	8.0	60 m > H ≥ 30 m		2.0	4.0	8.0
	50 m > WH		3.0	6.0	9.0	30 m > HS		3.0	6.0	9.0
	Score of a selected category:S3		**0.5**	**1.0**	**2.0**	**Score of a selected category:S4**		**0.5**	**1.0**	**2.0**
	Distance from infrastructure to toe of hill side slope :D					**Slope shape of infrastructure side slope up to inclination change point**				
	D ≥ 4 m		3.0	6.0	12.0	Valley type		0.5	1.0	2.0
	4 m > D ≥ 2m		2.0	4.0	8.0	Straight type		1.0	2.0	4.0
	2 m > D ≥ 1 m		1.0	2.0	4.0	Ridge type	1	2.0	4.0	8.0
	1 m > D	1	0.5	1.0	2.0	Combined type		3.0	6.0	9.0
	Score of a selected category:S5		**0.5**	**1.0**	**2.0**	**Score of a selected category:S6**		**2.0**	**4.0**	**8.0**
Surface & subsurface situations (Choose one for the most appropriate category)	**Dominant materials of slope surface**					**Dominant geology**				
	Silt, clay		0.5	1.0	2.0	Recent — Alluvium		1.0	2.0	4.0
	Sand		0.8	1.6	3.2	Recent — Lava	1	2.0	4.0	8.0
	Gravels		1.0	2.0	4.0	Pleistocene to Holocene — Volcanic material in tectonic depressions (White) (Other)		0.5	1.0	2.0
	Cobbles, or Boulders		1.0	2.0	4.0			0.5	1.0	2.0
	Fractured rocks	1	2.0	4.0	8.0	Pleistocene to Holocene — Volcanic massifs		3.0	6.0	12.0
	Weathered rock		2.0	4.0	8.0	Pleistocene to Holocene — Lava domes		3.0	6.0	12.0
	Soft fresh rock		4.0	8.0	16.0	Pleistocene to Holocene — Welded tuff		3.0	6.0	12.0
	Hard fresh rock		10.0	20.0	30.0	Pliocene — Volcanic material (Tuff)		2.0	4.0	8.0
	Score of a selected category:S7		**2.0**	**4.0**	**8.0**	Pliocene — Volcanic material (Other)		3.0	6.0	12.0
	Apparent inclination of dominant discontinuity against slope surface: AI					Miocene to Early — Granit		4.0	8.0	16.0
	AI ≥60°		1.0	2.0	4.0	Cretaceous — Sedimentary Rocks		3.0	6.0	12.0
	60° > AI ≥ 20°		0.5	1.0	2.0	**Score of a selected category:S8**		**2.0**	**4.0**	**8.0**
	20° > AI ≥ 10°		1.0	2.0	4.0	**True angle of dominant discontinuity of rocky slope: D**				
	10° > AI ≥ 0°		2.0	4.0	8.0	D ≥45°		0.5	1.0	2.0
	0° > AI ≥ -10°		3.0	6.0	9.0	45° > D ≥ 15°		1.0	2.0	4.0
	-10° > AI ≥ -20°		4.0	8.0	16.0	15° > D		2.0	4.0	8.0
	-20° > AI		5.0	10.0	20.0	Not existing		10.0	20.0	40.0
	No discontinuity	1	6.0	12.0	24.0	Not rocky slope	1	10.0	20.0	40.0
	Score of a selected category:S9		**6.0**	**12.0**	**24.0**	**Score of a selected category:S10**		**10.0**	**20.0**	**40.0**
	Spring (groundwater) condition					**Surface water**				
	Spring water is recognized in all seasons		0.0	0.0	0.0	Surface water is recognized in all seasons		0.5	1.0	2.0
	Spring water is recognized during rainy season only	1	1.0	2.0	4.0	Surface water is recognized during rainy season only		1.0	2.0	4.0
	Spring water is recognized during heavy rain only		2.0	4.0	8.0	Surface water is recognized during heavy rain only	1	2.0	4.0	8.0
	Not seen		3.0	6.0	9.0	Not seen		3.0	6.0	9.0
	Score of a selected category:S11		**1.0**	**2.0**	**4.0**	**Score of a selected category:S12**		**2.0**	**4.0**	**8.0**
	Dominate vegetation					**Slope type of infrastructure side slope up to inclination change point**				
	Urban area		0.5	1.0	2.0	Natural slope	1	0.0	1.0	2.0
	Deforested area	1	0.5	1.0	2.0	Artificial slope of cutting		1.0	2.0	4.0
	Annual crops		0.5	1.0	2.0	Artificial slope of embankment		2.5	5.0	10.0
	Moderate vegetation		2.0	4.0	8.0	Combined		0.5	1.0	2.0
	Intense vegetation		4.0	8.0	16.0					
	Score of a selected category:S13		**0.5**	**1.0**	**2.0**	**Score of a selected category:S14**		**0.0**	**1.0**	**2.0**
	Soil covering impervious bedrock					**The rock is hard at upper part and soft at foot part**				
	Yes		0.0	0.0	0.0	Yes		0.0	0.0	0.0
	No	1	6.0	12.0	18.0	No	1	6.0	12.0	18.0
	Score of a selected category:S15		**6.0**	**12.0**	**18.0**	**Score of a selected category:S16**		**6.0**	**12.0**	**18.0**

Predictor	**Factor items/categories for return period of a disaster event**	**If applicable, Input '1'**	**Score of return period of disaster**			**Factor items/categories for return period of a disaster event**	**If applicable, Input '1'**	**Score of return period of disaster**		
			edge only	**half function**	**whole**			**edge**	**half**	**whole**
	Miner collapse/fall	1	-3.0	-6.0	-9.0	Continuous cracks (more than 5 meters) on slope	1	-3.0	-6.0	-9.0
	Fallen/inclined trees	1	-4.0	-8.0	-12.0	Apparent deformation by land-sliding	1	-10.0	-20.0	-30.0
	Open cracks below an over hang	1	-3.0	-6.0	-9.0	Open cracks by toppling	1	-3.0	-6.0	-9.0
	Cross open cracks to cause wedge shape slide	1	-4.0	-8.0	-12.0	Open cracks by sliding	1	-3.0	-6.0	-9.0
	Continuous cracks (more than 5m) on infrastructure		-5.0	-10.0	-15.0	Depression on infrastructure		-5.0	-10.0	-20.0
	Upheaval on infrastructure		-5.0	-10.0	-15.0	Erosion laminar		-1.0	-2.0	-4.0
	Erosion en surcos	1	-2.0	-4.0	-6.0	Erosion interna o tubificacion (piping)		-3.0	-6.0	-9.0
	Erosion en zanjas o cárcava	1	-5.0	-10.0	-15.0	**Score of summing up of applicable predictors:S17**		**-40.0**	**-80.0**	**-120.0**

Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster**			**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster**		
			edge only	**half function**	**whole**			**edge**	**half**	**whole**
	Superficie principal (Main Surface)					**Principal obras de retención (Main retaining works)**				
	Reja de concreto (Grating crib works or similar)		20.0	40.0	80.0	Anclajes Activos (anchored wall)		30.0	60.0	120.0
	Shotcrete or Pitching works		10.0	20.0	40.0	Tierra Armada (Reinforced Earth)		20.0	40.0	80.0
	Zacate (Grass)		1.0	2.0	4.0	Muro Flexible (Flexible Wall)		20.0	40.0	80.0
	Arbustos (Bushes)		2.0	4.0	8.0	Muro de Gravedad (Gravity Wall)		15.0	30.0	60.0
	Grand Arboles (Threes)		2.0	4.0	8.0	Muro de Gavión (Gabion Wall)		10.0	20.0	40.0
	No slope protection works and planting works	1	0.0	0.0	0.0	Soil Nailing, Rock bolts		2.0	4.0	8.0
	Score of summing up of selected category :S18		**0**	**0**	**0**	No retaining works	1	0.0	0.0	0.0
	Principal obras de drenaje superficial (Main surface drainage)					**Score of summing up of selected category :S19**		**0**	**0**	**0**
	Drenjae superficial natural (natural drainage)		0.1	0.2	0.4	**Principal Obras de Subsurface Drainage (Main sub-surface drainage)**				
	Drenaje superficial forjado (dug drainage)		2.0	4.0	8.0	En buen estado (fair state)		10.0	20.0	40.0
	Drenaje forjado con recubrimiento (dug drainages with concrete cover)		5.0	10.0	20.0	Not En buen estado (Not fair state)		0.2	0.4	0.8
	Drenaje Completo, canaletas, bajantes, etc., con daños o historial de sobreflujo		10.0	20.0	40.0	Necesario / No hay suficiente(Needed/not enough)		0.1	0.2	0.4
	Drenaje Completo, canaletas, bajantes, etc. (full drainage system, gutters, pipe drainage		15.0	30.0	60.0	Necesario / Ausente (Needed/not present)	1	0.0	0.0	0.0
	No surface drainage	1	0.0	0.0	0.0					
	Score of summing up of selected category :S20		**0**	**0**	**0**	**Score of summing up of applicable measuers:S21**		**0**	**0**	**0**

Potential return period of a disaster event = Σ(S1:S21) summing up of score of return period >1	**Potential return period of a disaster of edge only loss (year)**	**1.0**
	Potential return period of a disaster of half function loss (year)	**2.0**
	Potential return period of a disaster of whole function loss (year)	**17.0**

N2.2.1　被害算定表　2年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	N2-2years					
Item					Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	0.0
			of half functionality	**m**	***LRDh***	100.0
			of whole functionality	**m**	***LRDw***	0.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**186**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**243**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	670
			Pickup automobile	vehicles/day	*AADT_ap*	1,226
			Microbus	vehicles/day	*AADT_mb*	25
			Autobus	vehicles/day	*AADT_ab*	215
			Autotruck two axis	vehicles/day	*AADT_at2*	560
			Autotruck three axis	vehicles/day	*AADT_at3*	58
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	259
		Annual Average Daily Traffic		vehicles/day	***AADT***	**3,013**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.19
			Microbus	USD/km/vehicles	*VOCars_mb*	0.27
			Autobus	USD/km/vehicles	*VOCars_ab*	0.34
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.35
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	0.58
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	0.90
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.29**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.15
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.21
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.29
			Autobus	USD/km/vehicles	*VOCdrs_ab*	0.38
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.39
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	0.62
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	0.97
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.32**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	81.36
			Pickup automobile	km/hour	*VSars_pa*	81.36
			Microbus	km/hour	*VSars_mb*	74.20
			Autobus	km/hour	*VSars_ab*	61.70
			Autotruck two axis	km/hour	*VSars_at2*	71.60
			Autotruck three axis	km/hour	*VSars_at3*	76.83
			Trailer Truck	km/hour	*VSars_tt*	70.30
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**77.05**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	81.36
			Pickup automobile	km/hour	*VSas_pa*	81.36
			Microbus	km/hour	*VSas_mb*	74.20
			Autobus	km/hour	*VSas_ab*	61.70
			Autotruck two axis	km/hour	*VSas_at2*	71.60
			Autotruck three axis	km/hour	*VSas_at3*	76.83
			Trailer Truck	km/hour	*VSas_tt*	70.30
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**77.05**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	76.93
			Pickup automobile	km/hour	*VSdrs_ap*	76.98
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	59.60
			Autotruck two axis	km/hour	*VSdrs_c2*	68.40
			Autotruck three axis	km/hour	*VSdrs_c3*	61.48
			Trailer Truck	km/hour	*VSdrs_cr*	64.49
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**72.60**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*	0
		Cost of Rehabilitation		US$	*Crehab*	**500,000**
		Cost of Reconstruction		US$	*Crecon*	0
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***500,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***10,759***
	III	**Vehicles Loss**		**US$**	***VL***	**572**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	4
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	0
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	5.55
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	1,389
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	0
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs – AVOCars x Dars) ÷ (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	0
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	0
		Road Traffic Loss		**US$**	***RTL =***	***PTLe + RTLh+ RTLw***	***1,389***
	V	**Other Public Property or Infrastructure Direct Loss**		**US$**	***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		**US$**	***OIIDL***	***0***
	VII	**Private Property Loss**		**US$**	***PPL***	***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***512,721***

N2.2.2　被害算定表　17年確率

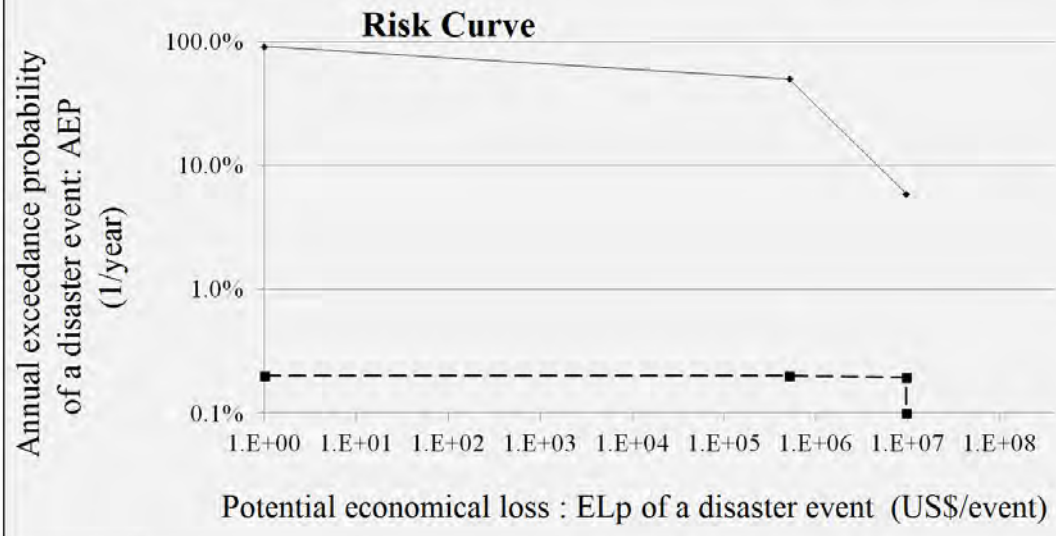
Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	N2-17 years					
		Item			Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	0.0
			of half functionality	**m**	***LRDh***	0.0
			of whole functionality	**m**	***LRDw***	150.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**186**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**243**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	670
			Pickup automobile	vehicles/day	*AADT_ap*	1,226
			Microbus	vehicles/day	*AADT_mb*	25
			Autobus	vehicles/day	*AADT_ab*	215
			Autotruck two axis	vehicles/day	*AADT_at2*	560
			Autotruck three axis	vehicles/day	*AADT_at3*	58
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	259
		Annual Average Daily Traffic		vehicles/day	***AADT***	**3,013**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.14
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.19
			Microbus	USD/km/vehicles	*VOCars_mb*	0.27
			Autobus	USD/km/vehicles	*VOCars_ab*	0.34
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.35
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	0.58
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	0.90
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.29**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.15
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.21
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.29
			Autobus	USD/km/vehicles	*VOCdrs_ab*	0.38
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.39
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	0.62
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	0.97
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.32**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	81.36
			Pickup automobile	km/hour	*VSars_pa*	81.36
			Microbus	km/hour	*VSars_mb*	74.20
			Autobus	km/hour	*VSars_ab*	61.70
			Autotruck two axis	km/hour	*VSars_at2*	71.60
			Autotruck three axis	km/hour	*VSars_at3*	76.83
			Trailer Truck	km/hour	*VSars_tt*	70.30
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**77.05**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	81.36
			Pickup automobile	km/hour	*VSas_pa*	81.36
			Microbus	km/hour	*VSas_mb*	74.20
			Autobus	km/hour	*VSas_ab*	61.70
			Autotruck two axis	km/hour	*VSas_at2*	71.60
			Autotruck three axis	km/hour	*VSas_at3*	76.83
			Trailer Truck	km/hour	*VSas_tt*	70.30
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**77.05**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	76.93
			Pickup automobile	km/hour	*VSdrs_ap*	76.98
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	59.60
			Autotruck two axis	km/hour	*VSdrs_e2*	68.40
			Autotruck three axis	km/hour	*VSdrs_c3*	61.48
			Trailer Truck	km/hour	*VSdrs_cr*	64.49
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**72.60**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*	**1,000,000**
		Cost of Rehabilitation		US$	*Crehab*	**7,360,000**
		Cost of Reconstruction		US$	*Crecon*	**0**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***8,360,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***16,139***
	III	**Vehicles Loss**		**US$**	***VL***	**859**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	0
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	14
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	**5.55**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	0
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	39,340,987
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	1,195,153
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	1,195,153
		Road Traffic Loss		**US$**	***RTL =***	***PTLe + RTLh+ RTLw***	***1,195,153***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***	***0***
	VII	**Private Property Loss**		US$	***PPL***	***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***9,572,150***

N2.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name N2



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	512,721.0	9,572,150.0	9,572,150.0	9,572,150.0
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	2.0	17.0	17.0	17.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	50.0%	5.9%	5.9%	5.9%
	Potential annual loss (US$/year)	*ALp_oIDRR*					2,892,546
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					500.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	512,721	9,572,150	9,572,150	9,572,150
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	501.1	502.0	517.0	517.0	517.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	0.2%	0.2%	0.2%	0.2%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					18,807
Decrease in annual loss by IDRR (US$/year)		*DAL*					2,873,738

N2.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	N2				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	4,659,712	4,659,712
2	Consultant	LS	1	698,957	698,957
3					0
4					0
5					0
6					0
7					0
Cost total					**5,358,669**
Annual maintenance cost				***AMC***	**46,597**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	2,892,546
Disaster risk reduction range of return period (year)				*DR4P*	500.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	18,807
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	2,873,738
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	15,758,504
Benefit cost ratio				***BCR***	3.76
Internal rate of return (%)				***IRR***	36%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age} = NB/(1+DR)^{age}$
2015	0	12%	5,358,669	0	0	-5,358,669	-5,358,669
2016	1	12%		46,597	2,873,738	2,827,141	2,524,233
2017	2	12%		46,597	2,873,738	2,827,141	2,253,780
2018	3	12%		46,597	2,873,738	2,827,141	2,012,303
2019	4	12%		46,597	2,873,738	2,827,141	1,796,699
2020	5	12%		46,597	2,873,738	2,827,141	1,604,196
2021	6	12%		46,597	2,873,738	2,827,141	1,432,318
2022	7	12%		46,597	2,873,738	2,827,141	1,278,855
2023	8	12%		46,597	2,873,738	2,827,141	1,141,835
2024	9	12%		46,597	2,873,738	2,827,141	1,019,496
2025	10	12%		46,597	2,873,738	2,827,141	910,264
2026	11	12%		46,597	2,873,738	2,827,141	812,736
2027	12	12%		46,597	2,873,738	2,827,141	725,657
2028	13	12%		46,597	2,873,738	2,827,141	647,908
2029	14	12%		46,597	2,873,738	2,827,141	578,489
2030	15	12%		46,597	2,873,738	2,827,141	516,508
2031	16	12%		46,597	2,873,738	2,827,141	461,168
2032	17	12%		46,597	2,873,738	2,827,141	411,757
2033	18	12%		46,597	2,873,738	2,827,141	367,640
2034	19	12%		46,597	2,873,738	2,827,141	328,250
2035	20	12%		46,597	2,873,738	2,827,141	293,081
Net present value		***NPV***	5,358,669	348,055	21,465,227	15,758,504	**15,758,504**
Benefit/Cost ratio		***BCR***	$= DAL_{\_NPV}/(IDRR_{\_NPV}+AMC_{\_NPV})$				**3.76**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20} \frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}} = 0$				**36%**

H1:　国道6号線地すべり対策（Sta.14.7km）

H1.1　道路谷側斜面　豪雨災害の発災脆弱性点検評価表

Risk Assessment Sheet 1:Potential Return Period of A Disaster Event　　For Valley Side Slope

Location and General Data					Site ID:		H3		
Hazard Evaluation									
	Factor items/categories for return period of a disaster event	Input '1' to only one applicable category	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event	Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
Topographical situations (Choose one for the most appropriate category)	**Length of survey slope along infrastructure: L**					**Slope inclination of infrastructure side slope up to inclination change point: SI**				
	L ≥ 300 m		0.5	1.0	2.0	SI ≥45°		0.5	1.0	2.0
	300 m > L ≥ 200 m		1.0	2.0	4.0	45° > SI ≥ 30°		1.0	2.0	4.0
	200 m > L ≥ 100 m		2.0	4.0	8.0	30° > SI ≥ 15°	1	2.0	4.0	8.0
	100 m > L	1	3.0	6.0	8.0	15° > SI		3.0	6.0	9.0
	Score of a selected category:S1		**3**	**6**	**8**	**Score of a selected category:S2**		**2**	**4**	**8**
	Whole Height of valley side slope: WH					**Height of infrastructure side slope up to inclination change point: H**				
	WH ≥ 90 m	1	0.5	1.0	2.0	HS ≥ 90 m	1	0.5	1.0	2.0
	90 m > WH ≥ 60 m		1.0	2.0	4.0	90 m > HS ≥ 60 m		1.0	2.0	4.0
	60 m > WH ≥ 30 m		2.0	4.0	8.0	60 m > HS ≥ 30 m		2.0	4.0	8.0
	30 m > WH		3.0	6.0	9.0	30 m > HS		3.0	6.0	9.0
	Score of a selected category:S3		**0.5**	**1**	**2**	**Score of a selected category:S4**		**0.5**	**1**	**2**
	Distance from infrastructure to shoulder of valley side slope					**Height from high water to infrastructure (such as road surface)**				
	D ≥ 2.0 m		3.0	6.0	12.0	HW ≥ 2.0 m	1	0.5	1.0	2.0
	2.0 m > D ≥ 1.0 m		2.0	4.0	8.0	2.0 m > HW ≥ 1.0 m		1.0	2.0	4.0
	1.0 m > D ≥ 0.5 m		1.0	2.0	4.0	1.0 m > HW ≥ 0.0 m		2.0	4.0	8.0
	0.5 m > D	1	0.5	1.0	2.0	0.0 m > HW		3.0	6.0	9.0
	Score of a selected category:S5		**0.5**	**1**	**2**	**Score of a selected category:S6**		**0.5**	**1**	**2**
	Slope shape					**Rain water flow infrastructure to valley side slope**				
	Valley type	1	0.5	1.0	2.0	Yes	1	0.00	0.00	0.00
	Straight type		1.0	2.0	4.0	No		2.00	4.00	6.00
	Ridge type		2.0	4.0	8.0					
	Combined type		3.0	6.0	9.0					
	Score of a selected category:S7		**0.5**	**1**	**2**	**Score of a selected category:S8**		**0**	**0**	**0**
Surface & subsurface situations (Choose one for the most appropriate category)	**Dominant materials of slope surface**					**Dominant geology**				
	Silt, clay	1	0.5	1.0	2.0	Recent: Alluvium		1.0	2.0	4.0
	Sand		0.8	1.6	3.2	Recent: Lava		2.0	4.0	8.0
	Gravels		1.0	2.0	4.0	Pleistocene to Holocene: Volcanic material in tectonic depressions (White) (Other)	1	0.5	1.0	2.0
	Cobbles, or Boulders		1.0	2.0	4.0					
	Fractured rocks		2.0	4.0	8.0	Pleistocene to Holocene: Volcanic massifs		3.0	6.0	12.0
	Weathered rock		2.0	4.0	8.0	Pleistocene to Holocene: Lava domes		3.0	6.0	12.0
	Soft fresh rock		4.0	8.0	16.0	Pleistocene to Holocene: Welded tuff		3.0	6.0	12.0
	Hard fresh rock		10.0	20.0	30.0	Pliocene: Volcanic material (Tuff)		2.0	4.0	8.0
	Score of a selected category:S9		**0.5**	**1**	**2**	Pliocene: Volcanic material (Other)		3.0	6.0	12.0
	Apparent inclination of dominant discontinuity against slope surface: AI					Miocene to Early Cretaceous: Granit		4.0	8.0	16.0
	AI ≥60°		1.0	2.0	4.0	Miocene to Early Cretaceous: Sedimentary Rocks		3.0	6.0	12.0
	60° > AI ≥ 20°		0.5	1.0	2.0	**Score of a selected category:S10**		**0.5**	**1**	**2**
	20° > AI ≥ 10°		1.0	2.0	4.0	**True angle of dominant discontinuity of rocky slope: D**				
	10° > AI ≥ 0°		2.0	4.0	8.0	D ≥45°		0.5	1.0	2.0
	0° > AI ≥ -10°		3.0	6.0	9.0	45° > D ≥ 15°		1.0	2.0	4.0
	-10° > AI ≥ -20°		4.0	8.0	16.0	15° > D		2.0	4.0	8.0
	-20° > AI		5.0	10.0	20.0	Not existing		10.0	20.0	40.0
	No discontinuity	1	6.0	12.0	24.0	Not rocky slope	1	10.0	20.0	40.0
	Score of a selected category:S11		**6**	**12**	**24**	**Score of a selected category:S12**		**10**	**20**	**40**
	Spring (groundwater) condition					**Surface water**				
	Spring water is recognized in all seasons		0.0	0.0	0.0	Surface water is recognized in all seasons		0.5	1.0	2.0
	Spring water is recognized during rainy season only		1.0	2.0	4.0	Surface water is recognized during rainy season only		1.0	2.0	4.0
	Spring water is recognized during heavy rain only	1	2.0	4.0	8.0	Surface water is recognized during heavy rain only		2.0	4.0	8.0
	Not seen		3.0	6.0	9.0	Not seen	1	3.0	6.0	9.0
	Score of a selected category:S13		**2**	**4**	**8**	**Score of a selected category:S14**		**3**	**6**	**9**
	Dominate vegetation					**Slope type of infrastructure side slope up to inclination change point**				
	Urban area		0.5	1.0	2.0	Natural slope	1	0.0	1.0	2.0
	Deforested area		0.5	1.0	2.0	Artificial slope of cutting		1.0	2.0	4.0
	Annual crops		0.5	1.0	2.0	Artificial slope of embankment		2.5	5.0	10.0
	Moderate vegetation	1	2.0	4.0	8.0	Combined or unknown		0.5	1.0	2.0
	Intense vegetation		4.0	8.0	16.0					
	Score of a selected category:S15		**2**	**4**	**8**	**Score of a selected category:S16**		**0**	**1**	**2**
	Soil covering impervious bedrock					**The rock is hard at upper part and soft at foot part**				
	Yes		0	0	0	Yes		0	0	0
	No	1	5	10	20	No	1	4	8	16
	Score of a selected category:S17		**5**	**10**	**20**	**Score of a selected category:S18**		**4**	**8**	**16**
Predictor	Factor items/categories for return period of a disaster event	If applicable, Input '1'	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event	If applicable, Input '1'	Score of return period of disaster event edge only	half	whole
	Miner collapse/fall	1	-3.0	-6.0	-9.0	Continuous cracks (more than 5 meters) on slope	1	-3.0	-6.0	-9.0
	Fallen/inclined trees	1	-4.0	-8.0	-12.0	Apparent deformation by land-sliding	1	-10.0	-20.0	-30.0
	Open cracks below an over hang		-3.0	-6.0	-9.0	Open cracks by toppling		-3.0	-6.0	-9.0
	Cross open cracks to cause wedge shape slide		-4.0	-8.0	-12.0	Open cracks by sliding		-3.0	-6.0	-9.0
	Continuous cracks (more than 5m) on infrastructure		-5.0	-10.0	-15.0	Depression on infrastructure	1	-5.0	-10.0	-20.0
	Upheaval on infrastructure		-5.0	-10.0	-15.0	Erosion laminar	1	-1.0	-2.0	-4.0
	Erosion en surcos	1	-2.0	-4.0	-6.0	Erosion interna o tubificacion (piping)	1	-3.0	-6.0	-9.0
	Erosion en zanjas o cárcava	1	-5.0	-10.0	-15.0	**Score of summing up of applicable predictors:S19**		**-36**	**-72**	**-114**
Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster edge only**	**half function**	**whole**	**Factor items/categories for return period of a disaster event**	Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
	Superficie principal (Main Surface)					**Principal obras de retención (Main retaining works)**				
	Reja de concreto (Grating crib works or similar		20.0	40.0	80.0	Anclajes Activos (anchored wall)		30.0	60.0	120.0
	Shotcrete or Pitching works		10.0	20.0	40.0	Tierra Armada (Reinforced Earth)		20.0	40.0	80.0
	Zacate (Grass)		1.0	2.0	4.0	Muro Flexible (Flexible Wall)		20.0	40.0	80.0
	Arbustos (Bushes)		2.0	4.0	8.0	Muro de Gravedad (Gravity Wall)		15.0	30.0	60.0
	Grand Arboles (Threes)		2.0	4.0	8.0	Muro de Gavión (Gabion Wall)		10.0	20.0	40.0
	No slope protection works and planting works	1	0.0	0.0	0.0	Soil Nailing, Rock bolts		2.0	4.0	8.0
	Score of selected category :S20		**0**	**0**	**0**	No retaining works	1	0.0	0.0	0.0
	Principal obras de drenaje superficial (Main surface drainage)					**Score of selected category :S21**		**0**	**0**	**0**
	Drenaje superficial natural (natural drainage)		0.1	0.2	0.4	**Principal Obras de Sub Surface Drainage (Main Sub surface drainage)**				
	Drenaje superficial forjado (dug drainage)		2.0	4.0	8.0	En buen estado (fair state)		10.0	20.0	40.0
	Drenaje forjado con recubrimiento (dug drainag		5.0	10.0	20.0	Not En buen estado (Not fair state)		0.2	0.4	0.8
	Drenaje Completo, canaletas, bajantes, etc., con daños o historial de sobreflujo (full		10.0	20.0	40.0	Necesario / No hay suficiente(Needed/not enough)		0.1	0.2	0.4
	Drenaje Completo, canaletas, bajantes, etc. (full drainage system, gutters, pipe drainage.		15.0	30.0	60.0	Necesario / Ausente (Needed/not present)	1	0.0	0.0	0.0
	No surface drainage	1	0.0	0.0	0.0					
	Score of selected category :S22		**0**	**0**	**0**	**Score of applicable measuers:S23**		**0**	**0**	**0**

Probable return period of a disaster event = Σ(S1:S23) summing up of score of return period > 1	**Score of return period for disaster of edge only loss (year)**	**4.5**
	Score of return period for disaster of half function loss (year)	**10**
	Score of return period for disaster of whole function loss (year)	**43**

H1.2.1　被害算定表　3年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H1-3year					
Department:			Municipality			
Address/ Street name and station						
		Item			Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	0.0
			of half functionality	**m**	***LRDh***	80.0
			of whole functionality	**m**	***LRDw***	0.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	742
			Pickup automobile	vehicles/day	*AADT_ap*	2,086
			Microbus	vehicles/day	*AADT_mb*	0
			Autobus	vehicles/day	*AADT_ab*	344
			Autotruck two axis	vehicles/day	*AADT_at2*	578
			Autotruck three axis	vehicles/day	*AADT_at3*	63
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	157
		Annual Average Daily Traffic		vehicles/day	***AADT***	**3,970**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCars_mb*	0.37
			Autobus	USD/km/vehicles	*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.42**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles	*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.42**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	73.84
			Pickup automobile	km/hour	*VSars_pa*	73.54
			Microbus	km/hour	*VSars_mb*	57.35
			Autobus	km/hour	*VSars_ab*	57.50
			Autotruck two axis	km/hour	*VSars_at2*	65.60
			Autotruck three axis	km/hour	*VSars_at3*	60.06
			Trailer Truck	km/hour	*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**70.26**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	73.84
			Pickup automobile	km/hour	*VSas_pa*	73.54
			Microbus	km/hour	*VSas_mb*	57.35
			Autobus	km/hour	*VSas_ab*	57.50
			Autotruck two axis	km/hour	*VSas_at2*	65.60
			Autotruck three axis	km/hour	*VSas_at3*	60.06
			Trailer Truck	km/hour	*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**70.26**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	73.84
			Pickup automobile	km/hour	*VSdrs_ap*	73.54
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	57.50
			Autotruck two axis	km/hour	*VSdrs_c2*	65.60
			Autotruck three axis	km/hour	*VSdrs_c3*	60.06
			Trailer Truck	km/hour	*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**70.26**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*	**0**
		Cost of Rehabilitation		US$	*Crehab*	**2,800,000**
		Cost of Reconstruction		US$	*Crecon*	**0**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***2,800,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***21,854***
	III	**Vehicles Loss**		**US$**	***VL***	**343**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	210
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	0
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	.8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	**5.24**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	79,528
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	0
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	0
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	0
		Road Traffic Loss		**US$**	***RTL =***	***PTLe + RTLh+ RTLw***	***79,528***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***	***0***
	VII	**Private Property Loss**		US$	***PPL***	***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***2,901,725***

H1.2.2　被害算定表　34年確率

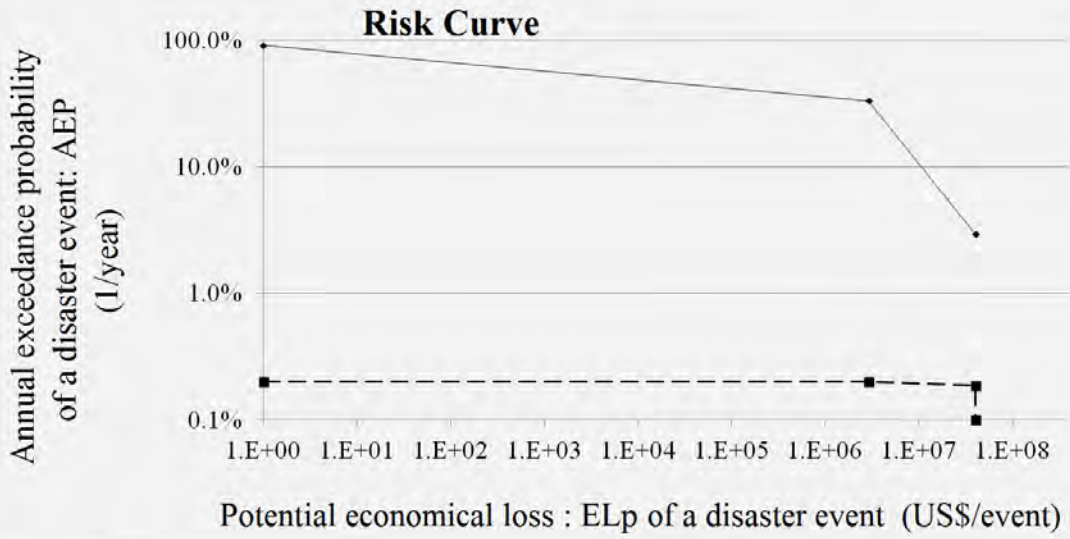
Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H1-34 years						
Department:				Municipality			
Address/ Street name and station							
		Item				Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**		***LRDe***	0.0
			of half functionality	**m**		***LRDh***	0.0
			of whole functionality	**m**		***LRDw***	80.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**		***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**		***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day		*AADT_na*	742
			Pickup automobile	vehicles/day		*AADT_ap*	2,086
			Microbus	vehicles/day		*AADT_mb*	0
			Autobus	vehicles/day		*AADT_ab*	344
			Autotruck two axis	vehicles/day		*AADT_at2*	578
			Autotruck three axis	vehicles/day		*AADT_at3*	63
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day		*AADT_tt*	157
		Annual Average Daily Traffic		vehicles/day		***AADT***	**3,970**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles		*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCars_mb*	0.37
			Autobus	USD/km/vehicles		*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles		***AVOCarc***	**0.42**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles		*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles		*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles		*AVOCdrs*	**0.42**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour		*VSars_na*	73.84
			Pickup automobile	km/hour		*VSars_pa*	73.54
			Microbus	km/hour		*VSars_mb*	57.35
			Autobus	km/hour		*VSars_ab*	57.50
			Autotruck two axis	km/hour		*VSars_at2*	65.60
			Autotruck three axis	km/hour		*VSars_at3*	60.06
			Trailer Truck	km/hour		*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**		***AVSars***	**70.26**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour		*VSas_na*	73.84
			Pickup automobile	km/hour		*VSas_pa*	73.54
			Microbus	km/hour		*VSas_mb*	57.35
			Autobus	km/hour		*VSas_ab*	57.50
			Autotruck two axis	km/hour		*VSas_at2*	65.60
			Autotruck three axis	km/hour		*VSas_at3*	60.06
			Trailer Truck	km/hour		*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**		***AVSas***	**70.26**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour		*VSdrs_na*	73.84
			Pickup automobile	km/hour		*VSdrs_ap*	73.54
			Microbus	km/hour		*VSdrs_mb*	57.35
			Autobus	km/hour		*VSdrs_ab*	57.50
			Autotruck two axis	km/hour		*VSdrs_c2*	65.60
			Autotruck three axis	km/hour		*VSdrs_e3*	60.06
			Trailer Truck	km/hour		*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**		***AVSdrs***	**70.26**
Loss Estimation	I	Cost of Emergency Response		US$		*CER*	**0**
		Cost of Rehabilitation		US$		*Crehab*	**3,800,000**
		Cost of Reconstruction		US$		*Crecon*	**0**
		Cost of Recovery		**US$**		***Crecov =***	***CER + CReh ab+ CRecon***	***3,800,000***
	II	**Human Lives Lost (US$)**		Persons		***HLL***	***43,709***
	III	**Vehicles Loss**		**US$**		***VL***	**686**
	IV	Number of Days for Recovery of damages of edge only in width		days		*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days		*NDRh*	0
		Number of Days for Recovery of damage of whole functionality in width		days		*NDRw*	400
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional		*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional		*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle		*AVTTSars*	**5.24**
		Road Traffic Loss due to edge-only damage in width		US$		*RTLe =*	*AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$		*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	0
		Loss for Waiting due to whole-functionality road damage in width		US$		*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	39,911,257,586
		Loss for Detour loss due to whole-functionality road damage in width		US$		*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	36,545,748
		Road Traffic loss due to whole-functionality damage in width		US$		*RTLw =*	lesser value between *LWw* and *LDw*	36,545,748
		Road Traffic Loss		**US$**		***RTL =***	***PTLe + RTLh+ RTLw***	***36,545,748***
	V	**Other Public Property or Infrastructure Direct Loss**		US$		***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		US$		***OIIDL***	***0***
	VII	**Private Property Loss**		US$		***PPL***	***0***
Total Loss				**US$**		***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***40,390,142***

H1.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name　H1: CA6 14_7km



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	2,901,725.0	40,390,142.0	40,390,142.0	40,390,142.0
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	3.0	34.0	34.0	34.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	33.3%	2.9%	2.9%	2.9%
	Potential annual loss (US$/year)	*ALp_oIDRR*					8,601,956
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					500.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	2,901,725	40,390,142	40,390,142	40,390,142
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	501.1	503.0	534.0	534.0	534.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	0.2%	0.2%	0.2%	0.2%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					78,146
Decrease in annual loss by IDRR (US$/year)		*DAL*					8,523,810

H1.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	H1: CA6 14_7km				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	2,083,840	2,083,840
2	Consaltant	LS	1	312,576	312,576
3					0
4					0
5					0
6					0
7					0
Cost total					**2,396,416**
Annual maintenance cost				***AMC***	**20,838**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	8,601,956
Disaster risk reduction range of return period (year)				*DR4P*	500.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	78,146
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	8,523,810
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	61,116,049
Benefit cost ratio				***BCR***	24.95
Internal rate of return (%)				***IRR***	306%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age}=NB/(1+DR)^{age}$
2015	0	12%	2,396,416	0	0	-2,396,416	-2,396,416
2016	1	12%		20,838	8,523,810	8,502,971	7,591,939
2017	2	12%		20,838	8,523,810	8,502,971	6,778,517
2018	3	12%		20,838	8,523,810	8,502,971	6,052,247
2019	4	12%		20,838	8,523,810	8,502,971	5,403,792
2020	5	12%		20,838	8,523,810	8,502,971	4,824,814
2021	6	12%		20,838	8,523,810	8,502,971	4,307,870
2022	7	12%		20,838	8,523,810	8,502,971	3,846,312
2023	8	12%		20,838	8,523,810	8,502,971	3,434,208
2024	9	12%		20,838	8,523,810	8,502,971	3,066,257
2025	10	12%		20,838	8,523,810	8,502,971	2,737,729
2026	11	12%		20,838	8,523,810	8,502,971	2,444,401
2027	12	12%		20,838	8,523,810	8,502,971	2,182,501
2028	13	12%		20,838	8,523,810	8,502,971	1,948,662
2029	14	12%		20,838	8,523,810	8,502,971	1,739,876
2030	15	12%		20,838	8,523,810	8,502,971	1,553,461
2031	16	12%		20,838	8,523,810	8,502,971	1,387,019
2032	17	12%		20,838	8,523,810	8,502,971	1,238,410
2033	18	12%		20,838	8,523,810	8,502,971	1,105,723
2034	19	12%		20,838	8,523,810	8,502,971	987,253
2035	20	12%		20,838	8,523,810	8,502,971	881,476
Net present value		***NPV***	2,396,416	155,651	63,668,116	61,116,049	**61,116,049**
Benefit/Cost ratio		***BCR***	$= DAL_{\_NPV}/(IDRR_{\_NPV}+AMC_{\_NPV})$				**24.95**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20}\frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}} = 0$				**306%**

H2: 国道6号線地すべり対策 (Sta.63.0km)

H2.1 道路谷側斜面 豪雨災害の発災脆弱性点検評価表

Risk Assessment Sheet 1:Potential Return Period of A Disaster Event — **For Valley Side Slope**

Location and General Data				Site ID:		H2 : C6 Sta. 63 km					
Hazard Evaluation											
	Factor items/categories for return period of a disaster event	Input '1' to only one applicable category	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event		Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
Topographical situations (Choose one for the most appropriate category)	**Length of survey slope along infrastructure: L**					**Slope inclination of infrastructure side slope up to inclination change point: SI**					
	L ≥ 300 m		0.5	1.0	2.0	SI ≥45°			0.5	1.0	2.0
	300 m > L ≥ 200 m		1.0	2.0	4.0	45° > SI≥ 30°		1	1.0	2.0	4.0
	200 m > L ≥ 100 m	1	2.0	4.0	8.0	30° > SI≥ 15°			2.0	4.0	8.0
	100 m > L		3.0	6.0	8.0	15° > SI			3.0	6.0	9.0
	Score of a selected category:S1		**2**	**4**	**8**	**Score of a selected category:S2**			**1**	**2**	**4**
	Whole Height of valley side slope: WH					**Height of infrastructure side slope up to inclination change point: H**					
	WH ≥ 90 m	1	0.5	1.0	2.0	HS ≥ 90 m		1	0.5	1.0	2.0
	90 m > WH ≥ 60 m		1.0	2.0	4.0	90 m > HS ≥ 60 m			1.0	2.0	4.0
	60 m > WH ≥ 30 m		2.0	4.0	8.0	60 m > HS ≥ 30 m			2.0	4.0	8.0
	30 m > WH		3.0	6.0	9.0	30 m > HS			3.0	6.0	9.0
	Score of a selected category:S3		**0.5**	**1**	**2**	**Score of a selected category:S4**			**0.5**	**1**	**2**
	Distance from infrastructure to shoulder of valley side slope					**Height from high water to infrastructure (such as road surface)**					
	D ≥ 2.0 m		3.0	6.0	12.0	HW ≥ 2.0 m		1	0.5	1.0	2.0
	2.0 m > D ≥ 1.0 m		2.0	4.0	8.0	2.0 m > HW ≥ 1.0 m			1.0	2.0	4.0
	1.0 m > D ≥ 0.5 m		1.0	2.0	4.0	1.0 m > HW ≥ 0.0 m			2.0	4.0	8.0
	0.5 m > D	1	0.5	1.0	2.0	0.0 m > HW			3.0	6.0	9.0
	Score of a selected category:S5		**0.5**	**1**	**2**	**Score of a selected category:S6**			**0.5**	**1**	**2**
	Slope shape					**Rain water flow infrastructure to valley side slope**					
	Valley type	1	0.5	1.0	2.0	Yes		1	0.00	0.00	0.00
	Straight type		1.0	2.0	4.0	No			2.00	4.00	6.00
	Ridge type		2.0	4.0	8.0						
	Combined type		3.0	6.0	9.0						
	Score of a selected category:S7		**0.5**	**1**	**2**	**Score of a selected category:S8**			**0**	**0**	**0**
Surface & subsurface situations (Choose one for the most appropriate category)	**Dominant materials of slope surface**					**Dominant geology**					
	Silt, clay	1	0.5	1.0	2.0	Recent	Alluvium		1.0	2.0	4.0
	Sand		0.8	1.6	3.2		Lava		2.0	4.0	8.0
	Gravels		1.0	2.0	4.0	Pleistocene to Holocene	Volcanic material in (White)		0.5	1.0	2.0
	Cobbles, or Boulders		1.0	2.0	4.0		tectonic depressions (Other)	1	0.5	1.0	2.0
	Fractured rocks		2.0	4.0	8.0		Volcanic massifs		3.0	6.0	12.0
	Weathered rock		2.0	4.0	8.0		Lava domes		3.0	6.0	12.0
	Soft fresh rock		4.0	8.0	16.0		Welded tuff		3.0	6.0	12.0
	Hard fresh rock		10.0	20.0	30.0	Pliocene	Volcanic material (Tuff)		2.0	4.0	8.0
	Score of a selected category:S9		**0.5**	**1**	**2**		Volcanic material (Other)		3.0	6.0	12.0
	Apparent inclination of dominant discontinuity against slope surface: AI					Miocene to Early Cretaceous	Granit		4.0	8.0	16.0
	AI ≥60°		1.0	2.0	4.0		Sedimentary Rocks		3.0	6.0	12.0
	60° > AI ≥ 20°		0.5	1.0	2.0	**Score of a selected category:S10**			**0.5**	**1**	**2**
	20° > AI ≥ 10°		1.0	2.0	4.0	**True angle of dominant discontinuity of rocky slope: D**					
	10° > AI ≥ 0°		2.0	4.0	8.0	D ≥45°			0.5	1.0	2.0
	0° > AI ≥ -10°		3.0	6.0	9.0	45° > D≥ 15°			1.0	2.0	4.0
	-10° > AI ≥ -20°		4.0	8.0	16.0	15° > D			2.0	4.0	8.0
	-20° > AI		5.0	10.0	20.0	Not existing			10.0	20.0	40.0
	No discontinuity	1	6.0	12.0	24.0	Not rocky slope		1	10.0	20.0	40.0
	Score of a selected category:S11		**6**	**12**	**24**	**Score of a selected category:S12**			**10**	**20**	**40**
	Spring (groundwater) condition					**Surface water**					
	Spring water is recognized in all seasons		0.0	0.0	0.0	Surface water is recognized in all seasons			0.5	1.0	2.0
	Spring water is recognized during rainy season only		1.0	2.0	4.0	Surface water is recognized during rainy season only			1.0	2.0	4.0
	Spring water is recognized during heavy rain only	1	2.0	4.0	8.0	Surface water is recognized during heavy rain only			2.0	4.0	8.0
	Not seen		3.0	6.0	9.0	Not seen		1	3.0	6.0	9.0
	Score of a selected category:S13		**2**	**4**	**8**	**Score of a selected category:S14**			**3**	**6**	**9**
	Dominate vegetation					**Slope type of infrastructure side slope up to inclination change point**					
	Urban area		0.5	1.0	2.0	Natural slope		1	0.0	1.0	2.0
	Deforested area	1	0.5	1.0	2.0	Artificial slope of cutting			1.0	2.0	4.0
	Annual crops		0.5	1.0	2.0	Artificial slope of embankment			2.5	5.0	10.0
	Moderate vegetation		2.0	4.0	8.0	Combined or unknown			0.5	1.0	2.0
	Intense vegetation		4.0	8.0	16.0						
	Score of a selected category:S15		**0.5**	**1**	**2**	**Score of a selected category:S16**			**0**	**1**	**2**
	Soil covering impervious bedrock					**The rock is hard at upper part and soft at foot part**					
	Yes		0	0	0	Yes			0	0	0
	No	1	5	10	20	No		1	4	8	16
	Score of a selected category:S17		**5**	**10**	**20**	**Score of a selected category:S18**			**4**	**8**	**16**
Predictor	Factor items/categories for return period of a disaster event	If applicable, Input '1'	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event		If applicable, Input '1'	Score of return period of disaster event edge only	half	whole
	Miner collapse/fall	1	-3.0	-6.0	-9.0	Continuous cracks (more than 5 meters) on slope		1	-3.0	-6.0	-9.0
	Fallen/inclined trees	1	-4.0	-8.0	-12.0	Apparent deformation by land-sliding		1	-10.0	-20.0	-30.0
	Open cracks below an over hang		-3.0	-6.0	-9.0	Open cracks by toppling			-3.0	-6.0	-9.0
	Cross open cracks to cause wedge shape slide		-4.0	-8.0	-12.0	Open cracks by sliding			-3.0	-6.0	-9.0
	Continuous cracks (more than 2m) on infrastructure		-5.0	-10.0	-15.0	Depression on infrastructure		1	-5.0	-10.0	-20.0
	Upheaval on infrastructure		-5.0	-10.0	-15.0	Erosion laminar		1	-1.0	-2.0	-4.0
	Erosion en surcos	1	-2.0	-4.0	-6.0	Erosion interna o tubificacion (piping)		1	-3.0	-6.0	-9.0
	Erosion en zanjas o cárcava	1	-5.0	-10.0	-15.0	**Score of summing up of applicable predictors:S19**			**-36**	**-72**	**-114**
Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster edge only**	**half function**	**whole**	**Factor items/categories for return period of a disaster event**		Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
	Superficie principal (Main Surface)					**Principal obras de retención (Main retaining works)**					
	Reja de concreto (Grating crib works or similar		20.0	40.0	80.0	Anclajes Activos (anchored wall)			30.0	60.0	120.0
	Shotcrete or Pitching works		10.0	20.0	40.0	Tierra Armada (Reinforced Earth)			20.0	40.0	80.0
	Zacate (Grass)		1.0	2.0	4.0	Muro Flexible (Flexible Wall)			20.0	40.0	80.0
	Arbustos (Bushes)		2.0	4.0	8.0	Muro de Gravedad (Gravity Wall)			15.0	30.0	60.0
	Grand Arboles (Threes)		2.0	4.0	8.0	Muro de Gavión (Gabion Wall)			10.0	20.0	40.0
	No slope protection works and planting works	1	0.0	0.0	0.0	Soil Nailing, Rock bolts			2.0	4.0	8.0
	Score of selected category :S20		**0**	**0**	**0**	No retaining works		1	0.0	0.0	0.0
	Principal obras de drenaje superficial (Main surface drainage)					**Score of selected category :S21**			**0**	**0**	**0**
	Drenjae superficial natural (natural drainage)		0.1	0.2	0.4	**Principal Obras de Sub Surface Drainage (Main Sub surface drainage)**					
	Drenaje superficial forjado (dug drainage)		2.0	4.0	8.0	En buen estado (fair state)			10.0	20.0	40.0
	Drenaje forjado con recubrimiento (dug drainag		5.0	10.0	20.0	Not En buen estado (Not fair state)			0.2	0.4	0.8
	Drenaje Completo, canaletas, bajantes, etc., con daños o historial de sobreflujo (full		10.0	20.0	40.0	Necesario / No hay suficiente(Needed/not enough)			0.1	0.2	0.4
	Drenaje Completo, canaletas, bajantes, etc. (full drainage system, gutters, pipe drainage.		15.0	30.0	60.0	Necesario / Ausente (Needed/not present)		1	0.0	0.0	0.0
	No surface drainage	1	0.0	0.0	0.0						
	Score of selected category :S22		**0**	**0**	**0**	**Score of applicable measuers:S23**			**0**	**0**	**0**

Probable return period of a disaster event = Σ(S1:S23) summing up of score of return period > 1	**Score of return period for disaster of edge only loss (year)**	**1**
	Score of return period for disaster of half function loss (year)	**3**
	Score of return period for disaster of whole function loss (year)	**33**

H2.2.1　被害算定表　3年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H2-3year						
Department:				Municipality			
Address/ Street name and station							
Item						**Symbol or calculated formula**	**Quantity**
Traffic Economies Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**		***LRDe***	0.0
			of half functionality	**m**		***LRDh***	80.0
			of whole functionality	**m**		***LRDw***	0.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**		***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**		***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day		*AADT_na*	345
			Pickup automobile	vehicles/day		*AADT_ap*	1,260
			Microbus	vehicles/day		*AADT_mb*	0
			Autobus	vehicles/day		*AADT_ab*	161
			Autotruck two axis	vehicles/day		*AADT_at2*	417
			Autotruck three axis	vehicles/day		*AADT_at3*	55
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day		*AADT_tt*	153
		Annual Average Daily Traffic		vehicles/day		***AADT***	**2,391**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles		*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCars_mb*	0.37
			Autobus	USD/km/vehicles		*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles		***AVOCarc***	**0.45**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles		*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles		*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles		*AVOCdrs*	**0.45**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour		*VSars_na*	73.84
			Pickup automobile	km/hour		*VSars_pa*	73.54
			Microbus	km/hour		*VSars_mb*	57.35
			Autobus	km/hour		*VSars_ab*	57.50
			Autotruck two axis	km/hour		*VSars_at2*	65.60
			Autotruck three axis	km/hour		*VSars_at3*	60.06
			Trailer Truck	km/hour		*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**		***AVSars***	**69.87**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour		*VSas_na*	73.84
			Pickup automobile	km/hour		*VSas_pa*	73.54
			Microbus	km/hour		*VSas_mb*	57.35
			Autobus	km/hour		*VSas_ab*	57.50
			Autotruck two axis	km/hour		*VSas_at2*	65.60
			Autotruck three axis	km/hour		*VSas_at3*	60.06
			Trailer Truck	km/hour		*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**		***AVSas***	**69.87**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour		*VSdrs_na*	73.84
			Pickup automobile	km/hour		*VSdrs_ap*	73.54
			Microbus	km/hour		*VSdrs_mb*	57.35
			Autobus	km/hour		*VSdrs_ab*	57.50
			Autotruck two axis	km/hour		*VSdrs_c2*	65.60
			Autotruck three axis	km/hour		*VSdrs_c3*	60.06
			Trailer Truck	km/hour		*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**		***AVSdrs***	**69.87**
Loss Estimation	**I**	Cost of Emergency Response		US$		*CER*	**0**
		Cost of Rehabilitation		US$		*Crehab*	**3,000,000**
		Cost of Reconstruction		US$		*Crecon*	**0**
		Cost of Recovery		**US$**		***Crecov = CER + CReh ab+ CRecon***	**3,000,000**
	II	**Human Lives Lost (US$)**		Persons		***HLL***	***11,552***
	III	**Vehicles Loss**		**US$**		***VL***	**223**
	IV	Number of Days for Recovery of damages of edge only in width		days		*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days		*NDRh*	30
		Number of Days for Recovery of damage of whole functionality in width		days		*NDRw*	0
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional		*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional		*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle		*AVTTSars*	**5.00**
		Road Traffic Loss due to edge-only damage in width		US$		*RTLe =*	*AADT x NDR e x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$		*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	6,566
		Loss for Waiting due to whole-functionality road damage in width		US$		*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	0
		Loss for Detour loss due to whole-functionality road damage in width		US$		*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	0
		Road Traffic loss due to whole-functionality damage in width		US$		*RTLw =*	lesser value between *LWw* and *LDw*	0
		Road Traffic Loss		**US$**		***RTL = PTLe + RTLh+ RTLw***	***6,566***
	V	**Other Public Property or Infrastructure Direct Loss**		**US$**		***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		**US$**		***OIIDL***	***0***
	VII	**Private Property Loss**		**US$**		***PPL***	***0***
Total Loss				**US$**		***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***3,018,342***

H2.2.2　被害算定表　33年確率

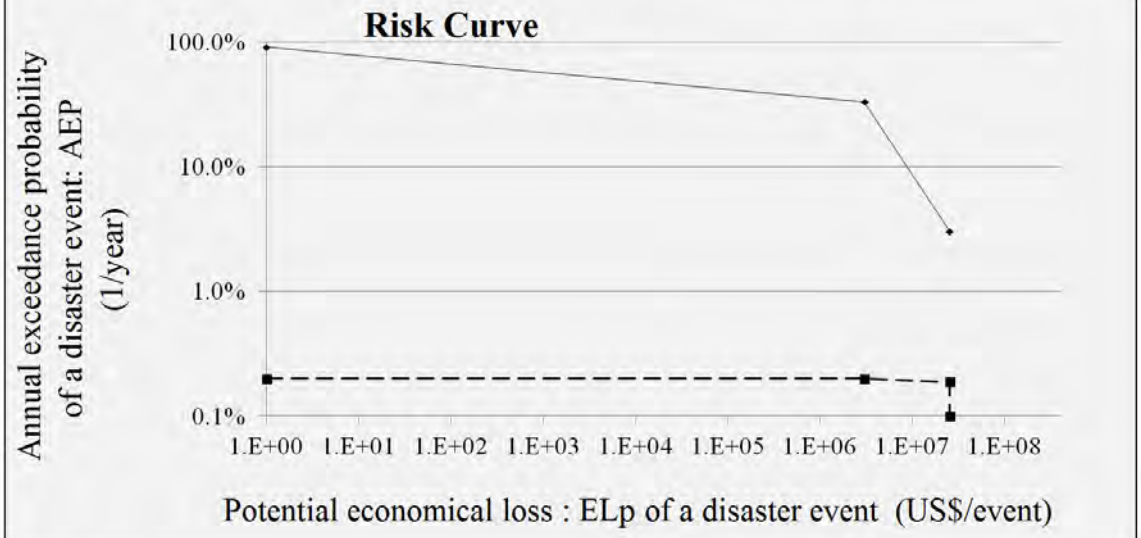
Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H2-33year						
Department:				Municipality			
Address/ Street name and station							
	Item					Symbol or calculated formula	Quantity
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**		***LRDe***	0.0
			of half functionality	**m**		***LRDh***	0.0
			of whole functionality	**m**		***LRDw***	80.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**		***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**		***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day		*AADT_na*	345
			Pickup automobile	vehicles/day		*AADT_ap*	1,260
			Microbus	vehicles/day		*AADT_mb*	0
			Autobus	vehicles/day		*AADT_ab*	161
			Autotruck two axis	vehicles/day		*AADT_at2*	417
			Autotruck three axis	vehicles/day		*AADT_at3*	55
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day		*AADT_tt*	153
		Annual Average Daily Traffic		vehicles/day		***AADT***	**2,391**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles		*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCars_mb*	0.37
			Autobus	USD/km/vehicles		*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles		***AVOCarc***	**0.45**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles		*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles		*VOCars_pa*	0.30
			Microbus	USD/km/vehicles		*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles		*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles		*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles		*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles		*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles		*AVOCdrs*	**0.45**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour		*VSars_na*	73.84
			Pickup automobile	km/hour		*VSars_pa*	73.54
			Microbus	km/hour		*VSars_mb*	57.35
			Autobus	km/hour		*VSars_ab*	57.50
			Autotruck two axis	km/hour		*VSars_at2*	65.60
			Autotruck three axis	km/hour		*VSars_at3*	60.06
			Trailer Truck	km/hour		*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**		***AVSars***	**69.87**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour		*VSas_na*	73.84
			Pickup automobile	km/hour		*VSas_pa*	73.54
			Microbus	km/hour		*VSas_mb*	57.35
			Autobus	km/hour		*VSas_ab*	57.50
			Autotruck two axis	km/hour		*VSas_at2*	65.60
			Autotruck three axis	km/hour		*VSas_at3*	60.06
			Trailer Truck	km/hour		*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**		***AVSas***	**69.87**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour		*VSdrs_na*	73.84
			Pickup automobile	km/hour		*VSdrs_ap*	73.54
			Microbus	km/hour		*VSdrs_mb*	57.35
			Autobus	km/hour		*VSdrs_ab*	57.50
			Autotruck two axis	km/hour		*VSdrs_c2*	65.60
			Autotruck three axis	km/hour		*VSdrs_c3*	60.06
			Trailer Truck	km/hour		*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**		***AVSdrs***	**69.87**
Loss Estimation	I	Cost of Emergency Response		US$		*CER*	**0**
		Cost of Rehabilitation		US$		*Crehab*	**4,000,000**
		Cost of Reconstruction		US$		*Crecon*	**0**
		Cost of Recovery		**US$**		***Crecov = CER + CReh ab+ CRecon***	***4,000,000***
	II	**Human Lives Lost (US$)**		Persons		***HLL***	***23,104***
	III	**Vehicles Loss**		**US$**		***VL***	**447**
	IV	Number of Days for Recovery of damages of edge only in width		days		*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days		*NDRh*	0
		Number of Days for Recovery of damage of whole functionality in width		days		*NDRw*	365
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional		*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional		*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle		*AVTTSars*	**5.00**
		Road Traffic Loss due to edge-only damage in width		US$		*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$		*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	0
		Loss for Waiting due to whole-functionality road damage in width		US$		*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	19,102,381,065
		Loss for Detour loss due to whole-functionality road damage in width		US$		*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)*	21,350,454
		Road Traffic loss due to whole-functionality damage in width		US$		*RTLw =*	lesser value between *LWw* and *LDw*	21,350,454
		Road Traffic Loss		US$		***RTL = PTLe + RTLh+ RTLw***	***21,350,454***
	V	**Other Public Property or Infrastructure Direct Loss**		US$		***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		US$		***OIIDL***	***0***
	VII	**Private Property Loss**		US$		***PPL***	***0***
Total Loss				**US$**		***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***25,374,005***

H2.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name　H2: CA6 Sta.63km



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	3,018,342.0	25,374,005.0	25,374,005.0	25,374,005.0
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	3.0	33.0	33.0	33.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	33.3%	3.0%	3.0%	3.0%
	Potential annual loss (US$/year)	*ALp_oIDRR*					5,939,696
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					500.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	3,018,342	25,374,005	25,374,005	25,374,005
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	501.1	503.0	533.0	533.0	533.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	0.2%	0.2%	0.2%	0.2%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					49,206
Decrease in annual loss by IDRR (US$/year)		*DAL*					5,890,490

H2.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	H2: CA6 Sta.63km				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	2,520,320	2,520,320
2	Consultant	LS	1	378,048	378,048
3					0
4					0
5					0
6					0
7					0
Cost total					**2,898,368**
Annual maintenance cost				***AMC***	**25,203**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	5,939,696
Disaster risk reduction range of return period (year)				*DR4P*	500.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	49,206
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	5,890,490
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	40,912,062
Benefit cost ratio				***BCR***	14.25
Internal rate of return (%)				***IRR***	170%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age}=NB/(1+DR)^{age}$
2015	0	12%	2,898,368	0	0	-2,898,368	-2,898,368
2016	1	12%		25,203	5,890,490	5,865,287	5,236,863
2017	2	12%		25,203	5,890,490	5,865,287	4,675,771
2018	3	12%		25,203	5,890,490	5,865,287	4,174,795
2019	4	12%		25,203	5,890,490	5,865,287	3,727,496
2020	5	12%		25,203	5,890,490	5,865,287	3,328,121
2021	6	12%		25,203	5,890,490	5,865,287	2,971,537
2022	7	12%		25,203	5,890,490	5,865,287	2,653,158
2023	8	12%		25,203	5,890,490	5,865,287	2,368,891
2024	9	12%		25,203	5,890,490	5,865,287	2,115,081
2025	10	12%		25,203	5,890,490	5,865,287	1,888,465
2026	11	12%		25,203	5,890,490	5,865,287	1,686,130
2027	12	12%		25,203	5,890,490	5,865,287	1,505,473
2028	13	12%		25,203	5,890,490	5,865,287	1,344,172
2029	14	12%		25,203	5,890,490	5,865,287	1,200,154
2030	15	12%		25,203	5,890,490	5,865,287	1,071,566
2031	16	12%		25,203	5,890,490	5,865,287	956,755
2032	17	12%		25,203	5,890,490	5,865,287	854,246
2033	18	12%		25,203	5,890,490	5,865,287	762,720
2034	19	12%		25,203	5,890,490	5,865,287	681,000
2035	20	12%		25,203	5,890,490	5,865,287	608,035
Net present value		***NPV***	2,898,368	188,254	43,998,684	40,912,062	**40,912,062**
Benefit/Cost ratio		***BCR***	$= DAL_{NPV}/(IDRR_{NPV}+AMC_{NPV})$				**14.25**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20}\frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}}=0$				**170%**

H3: 国道6号線地すべり対策 (Sta.22km)

H3.1 道路谷側斜面 豪雨災害の発災脆弱性点検評価表

DIRECCIÓN DE ADAPTABILIDAD AL CAMBIO CLIMATICO Y GESTION ESTRATÉGICA DEL RIESGO

Risk Assessment Sheet 1:Potential Return Period of A Disaster Event — **For Valley Side Slope**

Location and General Data					
Technician:	Date:	Time:	Site ID: H3		
			Department:	Municipality:	
Village/Neighborhood:		Address/Road Name and Station:			
Observations:					

Position Data		**Information related to the damage**					
Geodetic Coordinates		**Damage type**		**Dimension**	1	2	3
Latitude:		Cárcava	Flujos	Length (m):			
Longitude:		Slope Erosion	Otro	Height (m):			
Elevation:		Scour		Depth (m):			
Lambert Coordinates		Slides		Scarp height (m):			
North:		Detachments		Perimeter (m):			
West:		Belonging basin	Rain gauge station	Department	City	Road name	Station
Elevation:							

Past disaster event	Hazard level	Event type	Date of event			Evaluated return period of the event (year)	Description
			Date	Month	Year		
	edge only loss						
	half function loss						
	whole function loss						

Hazard Evaluation

	Factor items/categories for return period of a disaster event	Input '1' to only one applicable category	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event		Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
Topographical situations (Choose one for the most appropriate category)	**Length of survey slope along infrastructure: L**					**Slope inclination of infrastructure side slope up to inclination change point: SI**					
	L ≥ 300 m		0.5	1.0	2.0	SI ≥45°			0.5	1.0	2.0
	300 m > L ≥ 200 m		1.0	2.0	4.0	45° > SI ≥ 30°			1.0	2.0	4.0
	200 m > L ≥ 100 m		2.0	4.0	8.0	30° > SI ≥ 15°		1	2.0	4.0	8.0
	100 m > L	1	3.0	6.0	9.0	15° > SI			3.0	6.0	9.0
	Score of a selected category:S1		**3**	**6**	**8**	**Score of a selected category:S2**			**2**	**4**	**8**
	Whole Height of valley side slope: WH					**Height of infrastructure side slope up to inclination change point: H**					
	WH ≥ 90 m	1	0.5	1.0	2.0	HS ≥ 90 m		1	0.5	1.0	2.0
	90 m > WH ≥ 60 m		1.0	2.0	4.0	90 m > HS ≥ 60 m			1.0	2.0	4.0
	60 m > WH ≥ 30 m		2.0	4.0	8.0	60 m > HS ≥ 30 m			2.0	4.0	8.0
	30 m > WH		3.0	6.0	9.0	30 m > HS			3.0	6.0	9.0
	Score of a selected category:S3		**0.5**	**1**	**2**	**Score of a selected category:S4**			**0.5**	**1**	**2**
	Distance from infrastructure to shoulder of valley side slope					**Height from high water to infrastructure (such as road surface)**					
	D ≥ 2.0 m		3.0	6.0	12.0	HW ≥ 2.0 m		1	0.5	1.0	2.0
	2.0 m > D ≥ 1.0 m		2.0	4.0	8.0	2.0 m > HW ≥ 1.0 m			1.0	2.0	4.0
	1.0 m > D ≥ 0.5 m		1.0	2.0	4.0	1.0 m > HW ≥ 0.0 m			2.0	4.0	8.0
	0.5 m > D	1	0.5	1.0	2.0	0.0 m > HW			3.0	6.0	9.0
	Score of a selected category:S5		**0.5**	**1**	**2**	**Score of a selected category:S6**			**0.5**	**1**	**2**
	Slope shape					**Rain water flow infrastructure to valley side slope**					
	Valley type	1	0.5	1.0	2.0	Yes		1	0.00	0.00	0.00
	Straight type		1.0	2.0	4.0	No			2.00	4.00	6.00
	Ridge type		2.0	4.0	8.0						
	Combined type		3.0	6.0	9.0						
	Score of a selected category:S7		**0.5**	**1**	**2**	**Score of a selected category:S8**			**0**	**0**	**0**
Surface & subsurface situations (Choose one for the most appropriate category)	**Dominant materials of slope surface**					**Dominant geology**					
	Silt, clay	1	0.5	1.0	2.0	Recent	Alluvium		1.0	2.0	4.0
	Sand		0.8	1.6	3.2		Lava		2.0	4.0	8.0
	Gravels		1.0	2.0	4.0	Pleistocene to Holocene	Volcanic material in (White)		0.5	1.0	2.0
	Cobbles, or Boulders		1.0	2.0	4.0		tectonic depressions (Other)	1	0.5	1.0	2.0
	Fractured rocks		2.0	4.0	8.0		Volcanic massifs		3.0	6.0	12.0
	Weathered rock		2.0	4.0	8.0		Lava domes		3.0	6.0	12.0
	Soft fresh rock		4.0	8.0	16.0		Welded tuff		3.0	6.0	12.0
	Hard fresh rock		10.0	20.0	30.0	Pliocene	Volcanic material (Tuff)		2.0	4.0	8.0
	Score of a selected category:S0		**0.5**	**1**	**2**		Volcanic material (Other)		3.0	6.0	12.0
	Apparent inclination of dominant discontinuity against slope surface: AI					Miocene to Early	Granit		4.0	8.0	16.0
	AI ≥60°		1.0	2.0	4.0	Cretaceous	Sedimentary Rocks		3.0	6.0	12.0
	60° > AI ≥ 20°		0.5	1.0	2.0	**Score of a selected category:S10**			**0.5**	**1**	**2**
	20° > AI ≥ 10°		1.0	2.0	4.0	**True angle of dominant discontinuity of rocky slope: D**					
	10° > AI ≥ 0°		2.0	4.0	8.0	D ≥45°			0.5	1.0	2.0
	0° > AI ≥ -10°		3.0	6.0	9.0	45° > D ≥ 15°			1.0	2.0	4.0
	-10° > AI ≥ -20°		4.0	8.0	10.0	15° > D			2.0	4.0	8.0
	-20° > AI		5.0	10.0	20.0	Not existing			10.0	20.0	40.0
	No discontinuity	1	6.0	12.0	24.0	Not rocky slope		1	10.0	20.0	40.0
	Score of a selected category:S11		**6**	**12**	**24**	**Score of a selected category:S12**			**10**	**20**	**40**
	Spring (groundwater) condition					**Surface water**					
	Spring water is recognized in all seasons		0.0	0.0	0.0	Surface water is recognized in all seasons			0.5	1.0	2.0
	Spring water is recognized during rainy season only		1.0	2.0	4.0	Surface water is recognized during rainy season only			1.0	2.0	4.0
	Spring water is recognized during heavy rain only	1	2.0	4.0	8.0	Surface water is recognized during heavy rain only			2.0	4.0	8.0
	Not seen		3.0	6.0	9.0	Not seen		1	3.0	6.0	9.0
	Score of a selected category:S13		**2**	**4**	**8**	**Score of a selected category:S14**			**3**	**6**	**9**
	Dominate vegetation					**Slope type of infrastructure side slope up to inclination change point**					
	Urban area		0.5	1.0	2.0	Natural slope		1	0.0	1.0	2.0
	Deforested area		0.5	1.0	2.0	Artificial slope of cutting			1.0	2.0	4.0
	Annual crops		0.5	1.0	2.0	Artificial slope of embankment			2.5	5.0	10.0
	Moderate vegetation	1	2.0	4.0	8.0	Combined or unknown			0.5	1.0	2.0
	Intense vegetation		4.0	8.0	16.0						
	Score of a selected category:S15		**2**	**4**	**8**	**Score of a selected category:S16**			**0**	**1**	**2**
	Soil covering impervious bedrock					**The rock is hard at upper part and soft at foot part**					
	Yes		0	0	0	Yes			0	0	0
	No	1	5	10	20	No		1	4	8	16
	Score of a selected category:S17		**5**	**10**	**20**	**Score of a selected category:S18**			**4**	**8**	**16**
Predictor	Factor items/categories for return period of a disaster event	If applicable, Input '1'	Score of return period of disaster event of edge only	half function	whole function	Factor items/categories for return period of a disaster event		If applicable, Input '1'	Score of return period of disaster event edge only	half	whole
	Miner collapse/fall	1	-3.0	-6.0	-9.0	Continuous cracks (more than 3 meters) on slope		1	-3.0	-6.0	-9.0
	Fallen/inclined trees	1	-4.0	-8.0	-12.0	Apparent deformation by land-sliding		1	-10.0	-20.0	-30.0
	Open cracks below an over hang		-3.0	-6.0	-9.0	Open cracks by toppling			-3.0	-6.0	-9.0
	Cross open cracks to cause wedge shape slide		-4.0	-8.0	-12.0	Open cracks by sliding			-3.0	-6.0	-9.0
	Continuous cracks (more than 3m) on infrastructure		-5.0	-10.0	-15.0	Depression on infrastructure		1	-5.0	-10.0	-20.0
	Upheaval on infrastructure		-5.0	-10.0	-15.0	Erosion laminar		1	-1.0	-2.0	-4.0
	Erosion en surcos	1	-2.0	-4.0	-6.0	Erosion interna o tubificacion (piping)		1	-3.0	-6.0	-9.0
	Erosion en zanjas o cárcava	1	-5.0	-10.0	-15.0	**Score of summing up of applicable predictors:S19**			**-36**	**-72**	**-114**
Existing countermeasure (Choose one for the most appropriate category)	**Factor items/categories for return period of a disaster event**	**Input '1' to only one applicable**	**Score of return period of disaster edge only**	**half function**	**whole**	**Factor items/categories for return period of a disaster event**		Input '1' to only one applicable	Score of return period of disaster event edge only	half	whole
	Superficie principal (Main Surface)					**Principal obras de retención (Main retaining works)**					
	Reja de concreto (Grating crib works or similar		20.0	40.0	80.0	Anclajes Activos (anchored wall)			30.0	60.0	120.0
	Shotcrete or Pitching works		10.0	20.0	40.0	Tierra Armada (Reinforced Earth)			20.0	40.0	80.0
	Zacate (Grass)		1.0	2.0	4.0	Muro Flexible (Flexible Wall)			20.0	40.0	80.0
	Arbustos (Bushes)		2.0	4.0	8.0	Muro de Gravedad (Gravity Wall)			15.0	30.0	60.0
	Grand Arboles (Threes)		2.0	4.0	8.0	Muro de Gavión (Gabion Wall)			10.0	20.0	40.0
	No slope protection works and planting works	1	0.0	0.0	0.0	Soil Nailing, Rock bolts			2.0	4.0	8.0
	Score of selected category :S20		**0**	**0**	**0**	No retaining works		1	0.0	0.0	0.0
	Principal obras de drenaje superficial (Main surface drainage)					**Score of selected category :S21**			**0**	**0**	**0**
	Drenaje superficial natural (natural drainage)		0.1	0.2	0.4	**Principal Obras de Sub Surface Drainage (Main Sub surface drainage)**					
	Drenaje superficial forjado (dug drainage)		2.0	4.0	8.0	En buen estado (fair state)			10.0	20.0	40.0
	Drenaje forjado con recubrimiento (dug drainag		5.0	10.0	20.0	Not En buen estado (Not fair state)			0.2	0.4	0.8
	Drenaje Completo, canaletas, bajantes, etc., con daños o historial de sobreflujo (full		10.0	20.0	40.0	Necesario / No hay suficiente(Needed/not enough)			0.1	0.2	0.4
	Drenaje Completo, canaletas, bajantes, etc. (full drainage system, gutters, pipe drainage		15.0	30.0	60.0	Necesario / Ausente (Needed/not present)		1	0.0	0.0	0.0
	No surface drainage.	1	0.0	0.0	0.0						
	Score of selected category :S22		**0**	**0**	**0**	**Score of applicable measuers:S23**			**0**	**0**	**0**

Probable return period of a disaster event = Σ(S1:S23) summing up of score of return period > 1	**Score of return period for disaster of edge only loss (year)**	**4.5**
	Score of return period for disaster of half function loss (year)	**10**
	Score of return period for disaster of whole function loss (year)	**43**

H3.2.1　被害算定表　10年確率

Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H3-12year					
Department:			Municipality			
Address/ Street name and station						
Item					**Symbol or calculated formula**	**Quantity**
Traffic Economics Data Input	(1)	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	0.0
			of half functionality	**m**	***LRDh***	50.0
			of whole functionality	**m**	***LRDw***	0.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	742
			Pickup automobile	vehicles/day	*AADT_ap*	2,086
			Microbus	vehicles/day	*AADT_mb*	0
			Autobus	vehicles/day	*AADT_ab*	344
			Autotruck two axis	vehicles/day	*AADT_at2*	578
			Autotruck three axis	vehicles/day	*AADT_at3*	63
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	157
		Annual Average Daily Traffic		vehicles/day	***AADT***	**3,970**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCars_mb*	0.37
			Autobus	USD/km/vehicles	*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.42**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles	*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.42**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	73.84
			Pickup automobile	km/hour	*VSars_pa*	73.54
			Microbus	km/hour	*VSars_mb*	57.35
			Autobus	km/hour	*VSars_ab*	57.50
			Autotruck two axis	km/hour	*VSars_at2*	65.60
			Autotruck three axis	km/hour	*VSars_at3*	60.06
			Trailer Truck	km/hour	*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**70.26**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	73.84
			Pickup automobile	km/hour	*VSas_pa*	73.54
			Microbus	km/hour	*VSas_mb*	57.35
			Autobus	km/hour	*VSas_ab*	57.50
			Autotruck two axis	km/hour	*VSas_at2*	65.60
			Autotruck three axis	km/hour	*VSas_at3*	60.06
			Trailer Truck	km/hour	*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**70.26**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	73.84
			Pickup automobile	km/hour	*VSdrs_ap*	73.54
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	57.50
			Autotruck two axis	km/hour	*VSdrs_c2*	65.60
			Autotruck three axis	km/hour	*VSdrs_c3*	60.06
			Trailer Truck	km/hour	*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**70.26**
Loss Estimation	I	Cost of Emergency Response		US$	*CER*	**0**
		Cost of Rehabilitation		US$	*Crehab*	**1,000,000**
		Cost of Reconstruction		US$	*Crecon*	**0**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon***	***1,000,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***13,659***
	III	**Vehicles Loss**		**US$**	***VL***	**214**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	150
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	0
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	**5.24**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars*	0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars*	35,504
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars*	0
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs/AVSdrs -Dars/AVSars) x AVTTSars)*	0
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw*	0
		Road Traffic Loss		**US$**	***RTL =***	***PTLe + RTLh+ RTLw***	***35,504***
	V	**Other Public Property or Infrastructure Direct Loss**		**US$**	***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		**US$**	***OIIDL***	***0***
	VII	**Private Property Loss**		**US$**	***PPL***	***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL***	***1,049,377***

H3.2.2　被害算定表　43年確率

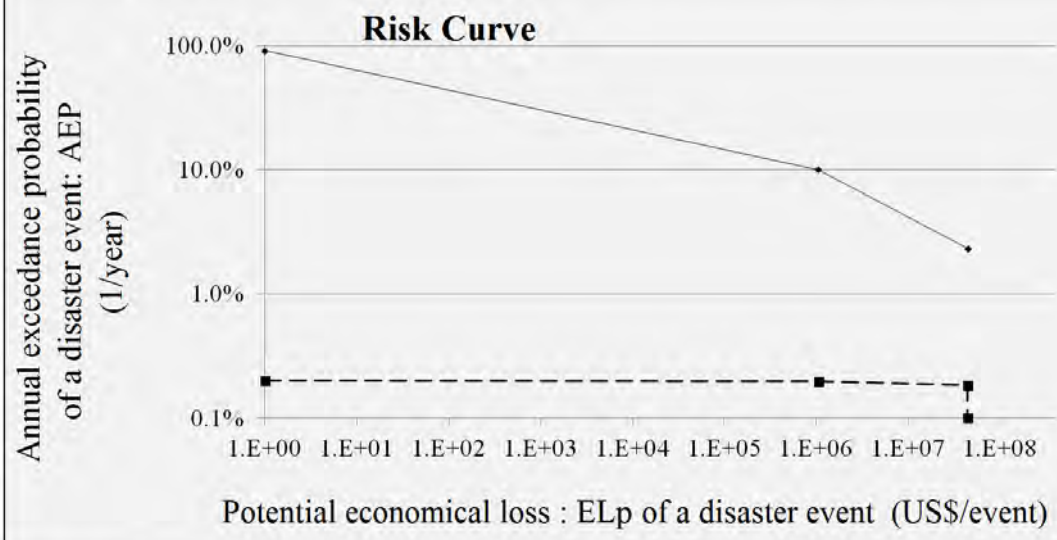
Loss Estimation Spreadsheet Pertaining to Disasters of Road and Bridge

Place ID	H3-43year					
Department:			Municipality			
Address/ Street name and station						
	Item			**Symbol or calculated formula**		**Quantity**
Traffic Economics Data Input	**(1)**	**Length of Road Damaged for each magnitude of disaster in total width of all traffic lanes**	**of edge only**	**m**	***LRDe***	0.0
			of half functionality	**m**	***LRDh***	0.0
			of whole functionality	**m**	***LRDw***	120.0
	(2)	**Distance (*D*) of assessed road sections measured along the assessed road sections between sides of the origin/destination intersections with detour roads**		**km**	***Dars***	**133**
	(3)	**Distance (D) of Detour Road Sections measured along the detour road sections between sides of the origin/destination intersections with assessed roads.**		**km**	***Ddrs***	**180**
	(4)	Annual Average Daily Traffic	Normal Automobile	vehicles/day	*AADT_na*	742
			Pickup automobile	vehicles/day	*AADT_ap*	2,086
			Microbus	vehicles/day	*AADT_mb*	0
			Autobus	vehicles/day	*AADT_ab*	344
			Autotruck two axis	vehicles/day	*AADT_at2*	578
			Autotruck three axis	vehicles/day	*AADT_at3*	63
			Trailer Truck, head 2-3 axis, trailer 2-3 axis	vehicles/day	*AADT_tt*	157
		Annual Average Daily Traffic		vehicles/day	***AADT***	**3,970**
	(5)	Vehicle Operation Cost (*VOC*) of assessed road sections	Normal Automobile	USD/km/vehicles	*VOCars_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCars_mb*	0.37
			Autobus	USD/km/vehicles	*VOCars_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCars_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCars_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCars_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of assessed road sections		USD/km/vehicles	***AVOCarc***	**0.42**
	(6)	Vehicle Operation Cost (VOC) of detour road sections	Normal Automobile	USD/km/vehicles	*VOCdrs_na*	0.20
			Pickup automobile	USD/km/vehicles	*VOCars_pa*	0.30
			Microbus	USD/km/vehicles	*VOCdrs_mb*	0.37
			Autobus	USD/km/vehicles	*VOCdrs_ab*	0.73
			Autotruck two axis	USD/km/vehicles	*VOCdrs_ar2*	0.63
			Autotruck three axis	USD/km/vehicles	*VOCdrs_ar3*	0.89
			Trailer Truck	USD/km/vehicles	*VOCdrs_tt*	1.29
		Average Vehicle Operation Cost (*AVOC*) of detour road sections		USD/km/vehicles	*AVOCdrs*	**0.42**
	(7)	Vehicle Speed of assessed road sections	Normal Automobile	km/hour	*VSars_na*	73.84
			Pickup automobile	km/hour	*VSars_pa*	73.54
			Microbus	km/hour	*VSars_mb*	57.35
			Autobus	km/hour	*VSars_ab*	57.50
			Autotruck two axis	km/hour	*VSars_at2*	65.60
			Autotruck three axis	km/hour	*VSars_at3*	60.06
			Trailer Truck	km/hour	*VSars_tt*	58.95
		Average Vehicle Speed (AVS) of assessed road sections		**km/hour**	***AVSars***	**70.26**
	(8)	Vehicle Speed at the assessed site	Normal Automobile	km/hour	*VSas_na*	73.84
			Pickup automobile	km/hour	*VSas_pa*	73.54
			Microbus	km/hour	*VSas_mb*	57.35
			Autobus	km/hour	*VSas_ab*	57.50
			Autotruck two axis	km/hour	*VSas_at2*	65.60
			Autotruck three axis	km/hour	*VSas_at3*	60.06
			Trailer Truck	km/hour	*VSas_tt*	58.95
		Average Vehicle Speed (AVS) at the risk site		**km/hour**	***AVSas***	**70.26**
	(9)	Vehicle Speed of detour road section	Normal Automobile	km/hour	*VSdrs_na*	73.84
			Pickup automobile	km/hour	*VSdrs_ap*	73.54
			Microbus	km/hour	*VSdrs_mb*	57.35
			Autobus	km/hour	*VSdrs_ab*	57.50
			Autotruck two axis	km/hour	*VSdrs_c2*	65.60
			Autotruck three axis	km/hour	*VSdrs_c3*	60.06
			Trailer Truck	km/hour	*VSdrs_cr*	58.95
		Average Vehicle Speed of detour road section		**km/hour**	***AVSdrs***	**70.26**
Loss Estimation	**I**	Cost of Emergency Response		US$	*CER*	**0**
		Cost of Rehabilitation		US$	*Crehab*	**3,100,000**
		Cost of Reconstruction		US$	*Crecon*	**0**
		Cost of Recovery		**US$**	***Crecov =***	***CER + CReh ab+ CRecon*** ***3,100,000***
	II	**Human Lives Lost (US$)**		Persons	***HLL***	***5,697***
	III	**Vehicles Loss**		**US$**	***VL***	**1,029**
	IV	Number of Days for Recovery of damages of edge only in width		days	*NDRe*	0
		Number of Days for Recovery of damages of half-functionality in width		days	*NDRh*	0
		Number of Days for Recovery of damage of whole functionality in width		days	*NDRw*	450
		Coefficient of Travel Time Loss due to the edge-only damage in width		non-dimensional	*CTTLe*	8
		Coefficient of Travel Time Loss due to the half-functionality damage in width		non-dimensional	*CTTLh*	16
		Average Value of Travel Time Savings per vehicle of assessed road sections		US$/hour/vehicle	*AVTTSars*	**5.24**
		Road Traffic Loss due to edge-only damage in width		US$	*RTLe =*	*AADT x NDRe x LRDe/1000/ASVars x CTTLe x AVTTSars* 0
		Road Traffic Loss due to half-functionality damage in width		US$	*RTLh =*	*AADT x NDRh x LRDh/1000/ASVars x CTTLh x AVTTSars* 0
		Loss for Waiting due to whole-functionality road damage in width		US$	*LWw =*	*AADT x NDRw x 24/2 x AVTTSars* 50,512,685,382
		Loss for Detour loss due to whole-functionality road damage in width		US$	*LDw =*	*AADT x NDRw x ((AVOCdrs x Ddrs - AVOCars x Dars) + (Ddrs /AVSdrs -Dars /AVSars) x AVTTSars)* 41,113,967
		Road Traffic loss due to whole-functionality damage in width		US$	*RTLw =*	lesser value between *LWw* and *LDw* 41,113,967
		Road Traffic Loss		US$	***RTL =***	***PTLe + RTLh+ RTLw*** ***41,113,967***
	V	**Other Public Property or Infrastructure Direct Loss**		US$	***OPPIDL***	***0***
	VI	**Other Infrastructures Indirect Loss**		US$	***OIIDL***	***0***
	VII	**Private Property Loss**		US$	***PPL***	***0***
Total Loss				**US$**	***TL =***	***CRecov+ HLL + VehL + RTL+ OPPIDL+ OIIDL+PPL*** ***44,220,693***

H3.3　リスクおよび災害対策事業によるリスク軽減の算定

Assessment Sheet 1: Disaster Risk of a Site or Area

Project Name　H3



Investment for disaster risk reduction (IDRR)	Disaster level	Symbol of variables	Potential disaster events of different magnitude				
			magnitude level 1	magnitude level 2	magnitude level 3	magnitude level 4	magnitude level 5
Without IDRR	Potential economic loss of a disaster magnitude (US$/event)	*ELp_oIDRR*	1	1,049,377.0	44,220,693.0	44,220,693.0	44,220,693.0
	Potential return period of a disaster magnitude of a disaster event (year)	*RRp_oIDRR*	1.1	10.0	43.0	43.0	43.0
	Annual exceedance probability of a disaster event (%/year)	*AEP_oIDRR*	90.9%	10.0%	2.3%	2.3%	2.3%
	Potential annual loss (US$/year)	*ALp_oIDRR*					3,190,016
With IDRR	Disaster risk reduction effect of return period (year)	*DRRERD*					500.0
	Potential economic loss of a disaster magnitude (US$/event)	*ELp_wIDRR*	1	1,049,377	44,220,693	44,220,693	44,220,693
	Potential return period of a disaster magnitude of a disaster event (year)	*RPp_wIDRR*	501.1	510.0	543.0	543.0	543.0
	Annual exceedance probability of a disaster event (1/year)	*AEP_wIDRR*	0.2%	0.2%	0.2%	0.2%	0.1%
	Potential annual loss (US$/year)	*ALp_wIDRR*					84,153
Decrease in annual loss by IDRR (US$/year)		*DAL*					3,105,862

H3.4　災害対策事業の投資評価指標の算定

Assessment Sheet 2: Economic Feasibility of Investment for Disaster Risk Reduction

Project Name	H3				
Investment for disaster risk reduction (*IDDR*)					
No.	Work	Unit	Quantity	Unit Price (US$)	Amount (US$)
1	Construction	LS	1	2,368,352	2,368,352
2	Consulting	LS	1	355,253	355,253
3					0
4					0
5					0
6					0
7					0
Cost total					**2,723,605**
Annual maintenance cost				***AMC***	**23,684**
Result					
Item				Symbol of variables	Quantity (US$)
Potential annual loss without investment for disaster risk reduction (US$/year)				*ALp_oIDDR*	3,190,016
Disaster risk reduction range of return period (year)				*DR4P*	500.0
Potential annual loss with investment for disaster risk reduction (US$/year)				*ALp_wIDDR*	84,153
Decrease in annual loss by investment for disaster risk reduction (US$/year)				*DAL*	3,105,862
Economic feasibility indicator (evaluation term is 20 year)					
Discount rate					12%
Net present value (US$)				***NPV***	20,298,557
Benefit cost ratio				***BCR***	8.00
Internal rate of return (%)				***IRR***	90%

Calculation table of economical feasibility

Year	Age of investment for disaster risk reduction	Discount rate	Investment of disaster risk reduction in a year (US$)	Annual maintenance cost in a year (US$)	Decrease in annual loss (US$ / year)	Net benefit of a year	Net present value of a year
	age	*DR*	*IDRRage*	AMC_{age}	DAL_{age}	$NB=(DAL-IDRR-AMC)_{age}$	$NPV_{age}=NB/(1+DR)^{age}$
2015	0	12%	2,723,605	0	0	-2,723,605	-2,723,605
2016	1	12%		23,684	3,105,862	3,082,179	2,751,945
2017	2	12%		23,684	3,105,862	3,082,179	2,457,094
2018	3	12%		23,684	3,105,862	3,082,179	2,193,834
2019	4	12%		23,684	3,105,862	3,082,179	1,958,780
2020	5	12%		23,684	3,105,862	3,082,179	1,748,911
2021	6	12%		23,684	3,105,862	3,082,179	1,561,528
2022	7	12%		23,684	3,105,862	3,082,179	1,394,221
2023	8	12%		23,684	3,105,862	3,082,179	1,244,840
2024	9	12%		23,684	3,105,862	3,082,179	1,111,465
2025	10	12%		23,684	3,105,862	3,082,179	992,379
2026	11	12%		23,684	3,105,862	3,082,179	886,053
2027	12	12%		23,684	3,105,862	3,082,179	791,119
2028	13	12%		23,684	3,105,862	3,082,179	706,356
2029	14	12%		23,684	3,105,862	3,082,179	630,675
2030	15	12%		23,684	3,105,862	3,082,179	563,103
2031	16	12%		23,684	3,105,862	3,082,179	502,770
2032	17	12%		23,684	3,105,862	3,082,179	448,902
2033	18	12%		23,684	3,105,862	3,082,179	400,805
2034	19	12%		23,684	3,105,862	3,082,179	357,862
2035	20	12%		23,684	3,105,862	3,082,179	319,520
Net present value		***NPV***	2,723,605	176,903	23,199,064	20,298,557	**20,298,557**
Benefit/Cost ratio		***BCR***	$= DAL_{\_NPV}/(IDRR_{\_NPV}+AMC_{\_NPV})$				**8.00**
Internal rate of return		***IRR***	$\sum_{age=0}^{age=20}\frac{(DAL-IDRR-AMC)_{age}}{(1+IRR)^{age}}=0$				**90%**

付録－5　サンサルバドル火山全体
土石流リスク評価

サンサルバドル火山全体のリスク評価

(1)リスク評価の目的と概要

優先事業案である、「E1) サンサルバドル火山 ラス・ラハス川土石流対策事業」の妥当性の確認のひとつとして、サンサルバドル火山全体の渓流の主要道路および市街地への被災リスクを評価した。

本評価は、エルサルバドル国 DACGER_MOPTVDU と本調査団の共同作業として 2015 年 5 月～6 月に実施した。

(2)リスク評価の手順

リスク評価の手順は下記のとおりとした。

1) 主要道路（国道および市街地の地方自治体道路）および市街地が被災する可能性がある渓流の選定
2) 各渓流の評価基準点（CP）の設定
3) 評価基準点(CP)における降雨量に基づく 100 年超過確率の土石流ピーク流量(Qsp)の算定
4) 各渓流の評価基準点（CP）における水路の土石流ピーク流量に対する流下能力の確認
5) 100 年超過確率豪雨による流出土砂量の算出（対策計画資料）

(3)リスク評価結果

1) 主要道路（国道および市街地の地方自治体道路）および市街地が被災する可能性がある渓流の選定

米国地質調査所（USGS）2001 年のサンサルバドル火山土石流ハザードマップ（Zonificasion de Peligros por Lahares para el Volcan de San Salvador）を元に主要道路および市街地が土石流で被災する可能性がある渓流を抽出した。

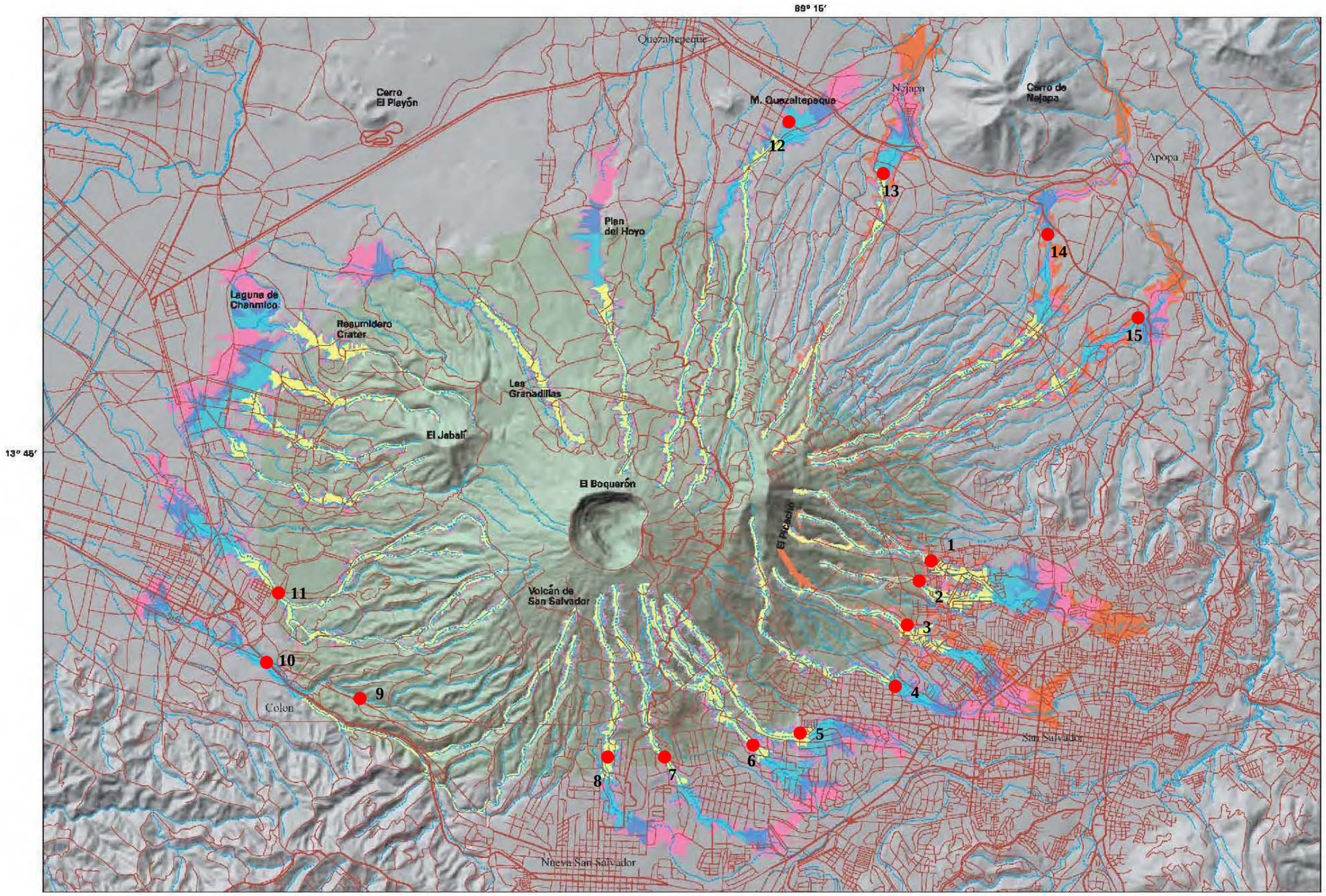
同ハザードマップで土石流が市街地あるいは主要道路を広く覆うと表現されている渓流を被災可能性のある渓流として抽出した。土石流の分布が線状で表現されている場合は渓流から溢流しないと判断されることから対象渓流から除外した。結果として表 A5-1 に示す 15 の渓流が抽出された。

2) 各渓流の評価基点の設定

各渓流において、渓流と市街地の山体縁部との交差点を評価基準点（CP）とした。

表 A5-1　サンサルバドル火山麓において主要道路および市街地が被災する可能性がある渓流

渓流番号	渓流名	被災対象主要道路（代表１道路のみ）	緯度・経度	
			緯度	経度
1	Qda. Mejicanos Las Lajas	75 Ave. Norte	13° 43'51.55"N	89° 13'30.32"W
2	Qda. Arenal Mejicanos	75 Ave. Norte	13° 43'41.95"N	89° 13'42.46"W
3	Qda. El Chilismuyo	Prolongation of Masferrer Ave.	13° 43'19.95"N	89° 14'5.90"W
4	Qda. Escalon Las Lajas	Prolongation of Masferrer Ave.	13° 42'47.46"N	89° 14'50.48"W
5	Qda. Mascota	Jerusalen Ave.	13° 41'56.75"N	89° 14'59.29"W
6	Qda. Triunfo	Jerusalen Ave.	13° 41'29.00"N	89° 15'2.83"W
7	Qda. Buenos Aires	La Sabana Prolong. Hipodromo Bvd.	13° 41'23.35"N	89° 16'19.30"W
8	Qda. El Limón	Road #5 of Buenavista Colony	13° 41'33.38"N	89° 17'10.31"W
9	Qda. Zanjón la Huesera	CA-1 パンアメリカン・ハイウエー	13° 41'41.94"N	89° 19'15.85"W
10	Qda. Belen	CA-1 パンアメリカン・ハイウエー	13° 42'24.47"N	89° 20'39.82"W
11	Qda. Cangrejera	CA-1 パンアメリカン・ハイウエー	13 44´ 05.03"N	89 21´ 36.71"W
12	Qda. La Chacalapa	Quezaltepeque	13° 48'52.19"N	89° 14'38.80"W
13	Qda. Terraplen	Quezaltepeque	13° 48'11.05"N	89° 14'7.17"W
14	Qda. La Chacalapa	Nejapa	13° 47'42.22"N	89° 12'14.76"W
15	Qda. El Velorio	Mariona	13° 46'36.71"N	89° 11'5.11"W



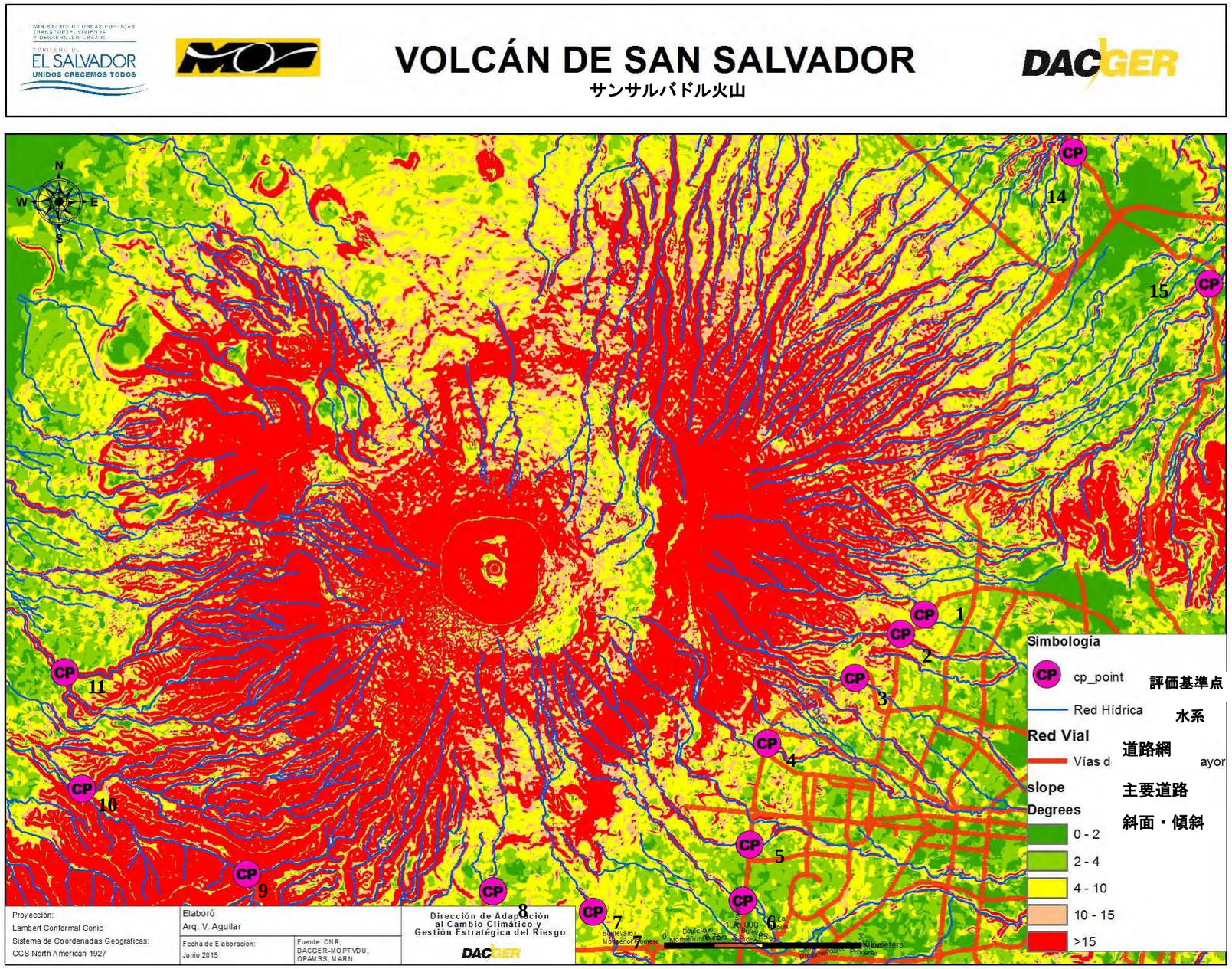
将来の火山噴火に伴う、火砕流、溶岩流および火山弾の被災可能性範囲

土石流リスク区分

- 10万m^3 規模の土石流堆積範囲
- 30万m^3 規模の土石流堆積範囲
- 50万m^3 規模の土石流堆積範囲
- 100万m^3 規模の土石流堆積範囲
- 200万m^3 規模の土石流堆積範囲

基礎ハザードマップ出典：USGS U.S. Geological Survey 2001

図 A5-1　サンサルバドル火山の USGS2001 土石流ハザードマップとリスク評価基準点



出典：エルサルバドル国　DACGER MOPTVDU

図 A5-2　サンサルバドル火山の斜面勾配区分図と土石流リスク評価基準点

3) 評価基準点（CP）における降雨量に基づく 100 年超過確率の土石流ピーク流量(Qsp)の算定

国土交通省河川砂防局砂防部：「砂防基本計画策定指針（土石流・流木対策編）及び同解説」2007 を参照し、100 年超過確率降雨に伴う土石流ピーク流量を算定した。

算定に必要な清水のピーク流量は下記より求めた。算定結果を表A5-2に示す。

$$Qp = \frac{1}{3.6} * Rf * Pa * A$$

ここで、

Qp： 清水のピーク流量 （m^3）
Rf： 流出係数（急峻山地を主体とするこから0.8を適用）
Pa： 洪水流達時間内の平均降雨強度 （洪水流達時間は、洪水流速を1/100勾配より急な斜面の一般値である3.5m/sに設定した。降雨強度は、エルサルバドル国DACGER MOPTVDUが整備したサンサルバドル火山中心部El Boqueron観測地点の降雨強度-連続時間曲線を用いて算定した。
A： 流域面積（km^2）

算定に必要な土石流濃度は下記の平衡濃度式で求めた。算定結果を表A5-3に示す。

$$C_d = \frac{\rho \tan\theta a}{(\sigma - \rho)(\tan\phi - \tan\theta a)} \quad \text{ただし} \quad 0.9 \geq Cd \geq 0.3$$

ここで、

C_d： 土石流濃度
ρ： 水の密度 （kN/m^3） （一般値11.8 kN/m^3を採用）
θ_a： 渓流源頭と評価基準点（CP）間の平均渓床勾配（°）
σ： 礫の密度 （kN/m^3） （一般値25.5 kN/m^3を採用）
ϕ： 渓床堆積土砂の内部摩擦角（°）（一般値35°を採用）

土石流ピーク流量は下記より求めた。算定結果を表 A5-3 に示す。

$$Q_{df} = \frac{C_{vds}}{C_{vds} - Cd} * Qp$$

ここで、

Q_{df}： 土石流ピーク流量 （m^3/s）
C_{vsd}： 渓流対象土砂の容積濃度（一般値 0.6を適用）
Cd： 土石流濃度
Qp： 清水のピーク流量（m^3/s）

V_{dqp}： １波の土石流により流出すると想定される土砂量（空隙込み）
Cd: 土石流濃度
C_{vsd}: 渓流対象土砂の容積濃度（一般値 0.6を適用）

A5-2　サンサルバドル火山評価算定基点（CP）における清水のピーク流量(100年超過確率豪雨)

CP番号	渓流名	流域面積 (km^2) A	渓流長 (m) Lt	渓流源頭とCP間の標高差 (m) ED	渓流源頭とCP間の平均渓床勾配 (°) θa	洪水流達時間 (分) T_f	洪水流達時間内の平均降雨強度 (mm/h) Pa	流出係数 Rr	清水の洪水ピーク流量 (m^3/s) Qp
1	Qda. Mejicanos Las Lajas	2.80	3,900	822	12.1	19	165	0.8	103
2	Qda. Arenal Mejicanos	1.66	1,660	274	9.5	8	246	0.8	91
3	Qda. El Chilismuyo	1.29	3,040	597	11.3	14	193	0.8	55
4	Qda. Escalon Las Lajas	3.41	4,910	861	10.1	23	147	0.8	111
5	Qda. Mascota	2.93	5,160	878	9.8	25	139	0.8	91
6	Qda. Triunfo	2.94	5,970	901	8.6	28	129	0.8	84
7	Qda. Buenos Aires	2.55	5,070	775	8.8	24	143	0.8	81
8	Qda. El Limón	1.06	4,310	767	10.2	21	155	0.8	37
9	Qda. Zanjón Periquera	1.90	5,720	1,000	10.0	27	132	0.8	56
10	Qda. Zanjón la Huesera	6.50	7,010	827	6.8	33	113	0.8	163
11	Qda. Belen	12.45	9,400	907	5.5	45	91	0.8	252
12	Qda. Cangrejera	11.24	11,240	1,165	5.9	54	67	0.8	167
13	Qda. Terraplen	3.44	6,310	856	7.8	30	121	0.8	92
14	Qda. La Chacalapa	5.43	8,710	986	6.5	41	93	0.8	112
15	Qda. El Velorio	13.35	11,110	798	4.1	53	69	0.8	205

表A5-3　サンサルバドル火山評価算定基点（CP）における土石流ピーク流量
（100年超過確率豪雨）

CP番号.	渓流名	土石流濃度 *Cd* *0.9≥ Cd≥ 0.3*	土石流ピーク流量 (m^3/s) *Qdf*	CPから100m上流区間の渓床勾配 (°) *θucp*
1	Qda. Mejicanos Las Lajas	0.380	280	3.3
2	Qda. Arenal Mejicanos	0.300	181	1.4
3	Qda. El Chilismuyo	0.340	128	4.9
4	Qda. Escalon Las Lajas	0.300	223	4.2
5	Qda. Mascota	0.300	181	1.7
6	Qda. Triunfo	0.300	169	0.9
7	Qda. Buenos Aires	0.300	162	3.5
8	Qda. El Limón	0.300	73	3.9
9	Qda. Zanjón Periquera	0.300	111	3.3
10	Qda. Zanjón la Huesera	0.300	326	1.3
11	Qda. Belen	0.300	504	1.3
12	Qda. Cangrejera	0.300	335	1.9
13	Qda. Terraplen	0.300	185	1.2
14	Qda. La Chacalapa	0.300	224	1.6
15	Qda. El Velorio	0.300	409	0.7

4) 各渓流の評価基準点（CP）における水路の土石流ピーク流量の流下能力の確認

水路の土石流の流下能力の算定に必要な土石流速度を下記より求めた。

$$V_{df} = 1/n * Rh^{2/3} * (\sin\theta_{ucp})^{1/2}$$

ここで、

V_{df}： 土石流の流速（m/s）
Rh： 水路の径深（m）
θ_{ucp}: 評価基準点（CP）からL m区間の渓床勾配

水路の土石流の流下能力を下記より求めた。

$$C_{df} = Ac * V_{df}$$

ここで、

C_{df}： 水路の土石流の流下能力（m^3/s）
A_c： 評価基準点（CP）における水路断面積（m^2）
V_{df}： 土石流の流速（m/s）

評価基準点下流域における土石流による被災危険性を評価する指標として、「土石流ピーク流量/水路の土石流の流下能力比（Q_{df}/C_{df}）を算定した。$Q_{df}/C_{df} > 1$ となるのは唯一評価基準点（CP）番号１Qda. Mejicanos Las Lajas である。当該渓流を 100 年超過確率降雨における土石流による被災の危険性がある渓流と評価した。

以上の算定結果を表A5-4に示す。

表A5-4　サンサルバドル火山評価算定基点（CP）における100年超過確率降雨による土石流による被災危険性

CP番号.	渓流名	粗度係数	CPにおける水路断面積 (m^2)	水路の径深 (m)	CPにおける土石流の速度 (m/s)	CPにおける土石流の速度 (km/h)	CPにおける水路の土石流の流下能力 (m^3/s)	土石流ピーク流量/水路の土石流の流下能力比	100年超過確率降雨における 土石流による被災可能性
		n	*Ac*	*Rh*	*Vdf*	*Vdf*	*Cdf*	*Qdf/Cdf*	*危険: Qdf/Cdf >1*
1	Qda. Mejicanos Las Lajas	0.04	14	1.4	7.6	27	106	2.65	**危険**
2	Qda. Arenal Mejicanos	0.04	212	7.8	15.5	56	3,286	0.06	
3	Qda. El Chilismuyo	0.04	102	4.2	19.0	68	1,942	0.07	
4	Qda. Escalon Las Lajas	0.04	24	3.0	14.0	50	334	0.67	
5	Qda. Mascota	0.04	34	2.8	8.5	31	289	0.63	
6	Qda. Triunfo	0.04	73	3.2	6.7	24	487	0.35	
7	Qda. Buenos Aires	0.04	17	2.5	11.4	41	193	0.84	
8	Qda. El Limón	0.04	121	5.0	19.0	68	2,289	0.03	
9	Qda. Zanjón Periquera	0.04	244	7.9	23.9	86	5,830	0.02	
10	Qda. Zanjón la Huesera	0.04	48	3.1	7.9	29	378	0.86	
11	Qda. Belen	0.04	59	3.8	9.0	32	533	0.95	
12	Qda. Cangrejera	0.04	188	6.2	15.5	56	2,918	0.11	
13	Qda. Terraplen	0.04	26	3.2	7.9	28	204	0.91	
14	Qda. La Chacalapa	0.04	27	3.0	8.8	32	240	0.94	
15	Qda. El Velorio	0.04	168	6.8	10.1	36	1,690	0.24	

5)　100 年超過確率降雨による流出土砂量の算定（対策計画資料）

国土交通省河川砂防局砂防部：「砂防基本計画策定指針（土石流・流木対策編）及び同解説」2007　を参照し、100 年超過確率降雨による流出土砂量を算定した。

計画流出土砂量は、流域内の移動可能土砂量と、計画規模の土石流によって運搬できる土砂量を比較して小さい方の値とすることが一般的である。本検討では、流域内の移動可能土砂量を評価する現地踏査を実施できなかったことから、計画規模（100 年超過確率降雨）の土石流によって運搬できる土砂量の算定のみ実施した。

100 年超過確率降雨）の土石流によって運搬できる土砂量は、100 年超過確率の降雨量（Pp_{100}（mm））に流域面積（A（km^2））と流出補正率（Rrc）を掛けて総水量を求め、これに流動中の土石流濃度（Cd）を乗じて算定した。

総水量は下記より求めた

$V_{tw} = 10^3 * Pp_{100} * A * Rrc$

ここで、

V_{tw}　：総水量（m^3）

Pp_{100}：100年超過確率降雨（mm）MARN　S12 Apopa 観測所　日雨量　206mm

Rrc：　流出補正係数、　$Rrc = 0.05(\log A - 2.0)^2 + 0.05$,　$0.1 \leq Rrc \leq 0.5$

土石流によって運搬できる土砂量（空ゲキ込み）は下記より求めた。

$V_{dyt} = V_{tw} / (1-nv) * Cd/(1-Cd)$

ここで、

V_{dyt}：　土石流によって運搬できる土砂量（空ゲキ込み）　（m^3）

V_{tw}：　総水量（m^3/s）

nv：　堆積土石の空ゲキ率、一般値0.4を適用

Cd：　土石流濃度

土石流総量は下記より求めた。

$\Sigma Q = (1-nv) * V_{dyt} / Cd$

ここで、

ΣQ：　土石流総流量

nv：　堆積土石の空ゲキ率、一般値0.4を適用

V_{dyt}：　土石流によって運搬できる土砂量　（m^3）

Cd：　土石流濃度

以上の算定結果を表A5-5に示す。

表A5-5　サンサルバドル火山評価算定基点（CP）における100年超過確率降雨による流出土砂量

CP番号	渓流名	土石流濃度 Cd $0.9 \geq Cd \geq 0.3$	流域面積 (km^2) A	流出補正率 R_{rc}	総水量 m^3 V_{tw}	100年超過確率降雨によって運搬できる土量(空隙込み) m^3 $Vdyt$	土石流総流量（水込み） m^3 ΣQ
1	Qda. Mejicanos Las Lajas	0.380	2.80	0.17	96,382	100,498	158,681
2	Qda. Arenal Mejicanos	0.300	1.66	0.21	71,265	50,903	101,807
3	Qda. El Chilismuyo	0.340	1.29	0.23	60,720	52,133	92,000
4	Qda. Escalon Las Lajas	0.300	3.41	0.16	110,736	79,097	158,194
5	Qda. Mascota	0.300	2.93	0.17	101,115	72,225	144,449
6	Qda. Triunfo	0.300	2.94	0.17	101,322	72,373	144,746
7	Qda. Buenos Aires	0.300	2.55	0.18	92,955	66,396	132,793
8	Qda. El Limón	0.300	1.06	0.24	53,492	38,208	76,417
9	Qda. Zanjón Periquera	0.300	1.90	0.20	77,550	55,393	110,785
10	Qda. Zanjón la Huesera	0.300	6.50	0.12	161,294	115,210	230,420
11	Qda. Belen	0.300	12.45	0.09	233,223	166,588	333,176
12	Qda. Cangrejera	0.300	11.24	0.10	220,088	157,206	314,411
13	Qda. Terraplen	0.300	3.44	0.16	111,315	79,511	159,022
14	Qda. La Chacalapa	0.300	5.43	0.13	145,456	103,897	207,795
15	Qda. El Velorio	0.300	13.35	0.09	242,666	173,333	346,666