Cities as Systems:

application of vulnerability reduction credits (VRCs™) across heterogenous stressors for dynamic adaptations

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The Higher Ground Foundation

International Conference on

Adaptation Metrics & Techniques for Water, Agriculture & Resilient Cities

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Q 1: What is a city?

A city is a complex social and bio-physical system comprised of multiple sub-systems

'A city is a large human settlement. Cities generally have extensive systems for housing, transportation, sanitation, utilities, land use, and communication. Their density facilitates interaction between people, government organizations and businesses, sometimes benefiting different parties in the process.'

['City': Wikipedia]

Ur, Mesopotamia

[creative commons, Kaufindude]

Singapore

Q 2: How is the city system vulnerable to climate change?

Multiple interlinking systems vulnerable to multiple climate stresses – one “climate stressor”: increasing precipitation intensities/increased flooding

City System	Impacts
Housing	Damage, loss of buildings, impacts on shelter provision, health
Transportation	Damage, loss, of roads, bridges, impacting provision of food, medicine, business activities – and correlating health, social and economic impacts
Utilities	Loss of power/water/clean water/communications throughout city, damage to supply infrastructure, impacting health, wellbeing, economic activity
Health Services	Damage to infrastructure, inability to access services *exactly when most needed resulting in reduced health and wellbeing*
Food	Reduced access to food (see transportation), crop loss - resulting health and economic loss

Q3: The challenge of making cities resilient

More so than many other climatically vulnerable systems, cities possess complexities making adaptation – and their metrics - particularly challenging

Kampala, Uganda (R. Balimwezo, KCCA)

- ❑ Decision making is confounded by complexities and politics
- ❑ Difficult to consider merits of interventions within and between sub-systems
- ❑ Challenging to consider the “whole system”
- ❑ Adaptation planning using “pathways approaches” is tough for cities (see above)

Q4: How are Vulnerability Reduction Credits (VRCs™) relevant?

Sector-specific (sub-system-specific) metrics for climate adaptations are necessary building-blocks but approaches to consider and measure adaptation results for the whole city system are essential

- ❑ Qualitative and multi-criteria approaches may be only option possible in many contexts
- ❑ Universal metrics are not "absolutely" possible

However:

- ❑ Climate Vulnerability Reduction Credits (VRCs™) with a VRC Standard Framework can be an instrument to better integrate systems thinking into urban adaptation planning
- ❑ VRCs are compatible with pathways approaches (e.g. use of real options analysis)

Q4: What is a VRC?

€ 50 worth of income adjusted avoided impact costs

$$VRC = €50(AIC_{IEF})$$

Vulnerability Reduction Credits (VRCs™)

VRCs™ provide a means of exchange enabling their sponsors (e.g. purchasers: governments/ NGOs/ private investors) to support climate adaptation projects with knowledge of the effectiveness that the return on that investment is likely to bring to communities in terms of adapting to climate change effects.

VRCs enable sustained effectiveness of this return (or vulnerability reduction) through continuous monitoring and third-party verification for crediting, and periodic revisiting of the project baseline over the lifetime of the project/investment.

Vulnerability Reduction Credits (VRCs™)

At the heart of the VRC premise:

Human vulnerability is more important than protecting assets	Economic cost/benefits can be a proxy for human vulnerability + supports avoidance of "double counting"	Loss and damage can be equalized for poorer communities by factoring in per capita income
Economic well-being ≠ human well-being	Pathways Approach Compatible: Adaptation may require changes over time of project:	Whole Systems Approach: VRCs can consider multiple climate stresses and adaptations within system

Vulnerability Reduction Credits (VRCs™)

Using Impact Cost Analysis to Create a "Universal" Metric

$$\text{Number of VRCs} = \frac{(\text{AIC} \times \text{IEF})}{€50}$$

Avoided Impact Cost

Nominal Value

Income Equalization Factor

Beyond a Metric: VRC Standard Framework

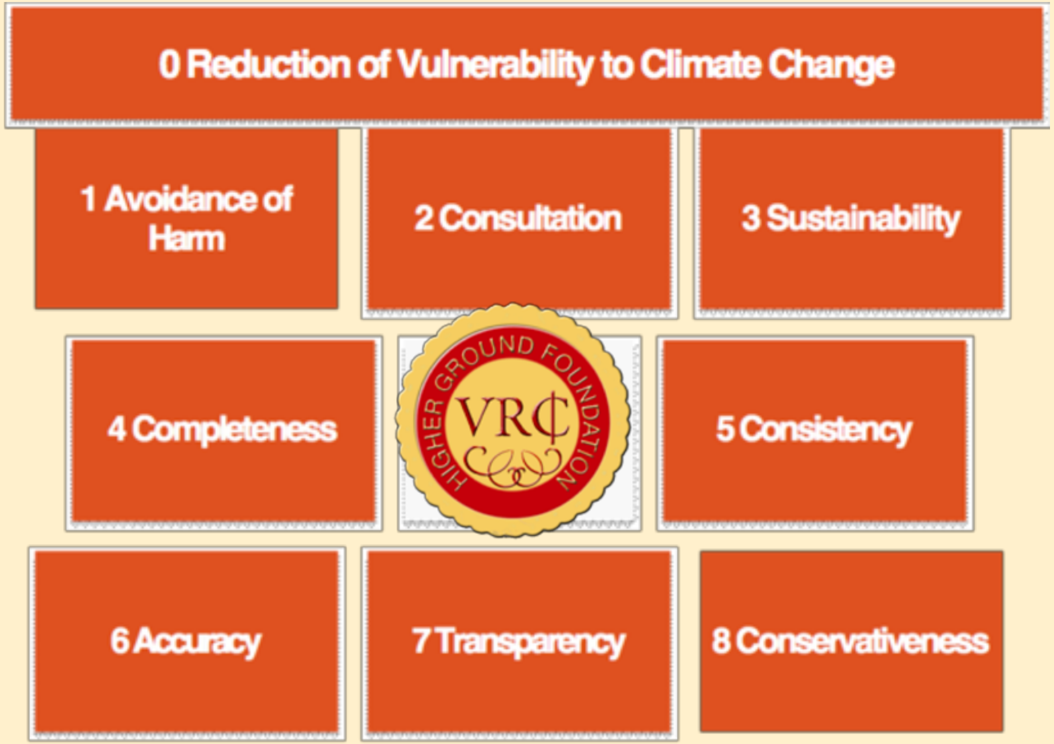
Context is key: VRC Standard Framework creates qualitative and quantitative, social, environmental and confidence standards to be met by all registered projects

VRC Standard Framework Launch

- ❑ Developed over several years by Higher Ground team
- ❑ Validated over nine months in 2017 by 40 transdisciplinary experts
- ❑ Undertook public consultation (early 2018)
- ❑ Published and launched last Autumn at the COP 23
- ❑ Currently: Pilot Implementation and Partnership Phase (PIPP) to test, validate or encourage improvements in standards and creation of sector/stressor methodologies

Beyond a Metric: VRC Standard Framework

Standard Framework Principles



Beyond a Metric: VRC Standard Framework

Published at: https://www.thehighergroundfoundation.org/standard-framework

The Higher Ground Foundation
- stand up to climate change

Vulnerability Reduction Credits (VRCs) Standard Framework

V1.1 (March 2018)

Contents

VRC PROJECT PROCESS

HGF Approved Methodology + System and Project Details

1. Design/Project Development
2. Local Stakeholder Consultation
3. Validation by Auditor
4. HGF Registration
5. Implementation
6. Monitoring
7. Verification by Auditor
8. HGF Credit Issuance
9. 10-Year Revalidation

Q5: How are VRCs relevant for Cities?

While politics and other dynamics and metrics may be a necessary (and useful) means of processing complexity, VRCs demand some (imperfect), "impartial objectivity" ☺

VRCs can help support cities and urban constituents with adaptation target setting, planning, and implementation of robust projects.

- ❑ To assess alternative technical options across different sectors
- ❑ To compare across sectors and bring in systems perspectives
- ❑ Policy and Planning: results based target setting
- ❑ Finance: If priced, creates a sustained revenue stream to secure/service finance

Q6: How do VRCs work with whole systems?

Use of benefit-cost tools normalizes across sectors

- VRCs are not a cost-benefit analysis – adaptation project costs are not incorporated
- Can use indicators (=impact cost factors) – and translate to net economic value for less tangible benefits

Examples of tangible benefits	Examples of less tangible benefits
Increased revenue	Improved institutional capital
Health improvement	Improved social capital
Educational improvement	Empowerment
Ecosystem improvement	Agency and participation
Infrastructure improvement	Improvements in self-esteem, self-confidence and overall mental health

From: Vardakoulias, O., (2014). Simplified guidelines for Social Cost-Benefit Analysis of Climate Change adaptation projects on a local scale

- Economic value does not have to be monetized: may use externalities, non-financial opportunity costs, etc.

Q6: How do VRCs work with whole systems?

Project Options and Sectoral Difference for Increasing Floods		
Sector	**Project**	**Impact Cost Factors (i.e. indicator) (red=challenge for CBA)**
Housing	Land use planning	Damage, loss of buildings: replacement costs Impacts on shelter provision Health: medical cost or lost income from injuries, disease
Housing	Flood resilient design	Same
Transport	Flood resilient bridges	Damage, loss of bridges: Replacement costs Provision of food, medicine, business activities, correlating health, social and economic impacts

It is possible to translate these – and other - very different projects/sectors into VRCs

Q7: How do VRCs work with pathways approaches to adaptation?

Flexibility is critical for climate adaptation

- Our deep uncertainty on climate impacts and adaptation solution – and the nature of plan execution – demands approaches that don't lock in maladaptation /suboptimal adaptation = need for "pathways" approaches
- "Futures literacy" an important starting point – "better anticipations"
- Optionality in all investment decisions not always possible (e.g. infrastructure decisions) but there are always alternative future pathways
- VRC Registration: need to revisit baseline (10 years max.)

Case Study: Coastal Towns Resilience Options

Based on real data from Bangladesh for Asian Development Bank project preparations

- ❑ Based on assessments of climate changes, impact cost reductions of adaptation measures (mainstreaming) to infrastructure developments
- ❑ Use economic data from surveys, engineering costs, and town real estate assessment data
- ❑ HGF translates these into VRC estimates

ADB

Japan Fund for Poverty Reduction

Case Study: Coastal Towns Resilience Options

Study area climate change projections

Table II.11-A: New Scenarios of Temperature (^{0}C) of Bangladesh for Future at 10-year Intervals with 2000 as the Base Year

GHG Scenario	YEAR	2010	2020	2030	2040	2050	2060	2065
A2	Annual	0.49	0.95	1.42	1.89	2.35	2.82	3.05
	DJF	0.73	1.40	2.07	2.74	3.41	4.08	4.42
	JJA	0.58	1.08	1.50	1.84	2.10	2.28	2.34
B1	Annual	0.51	0.98	1.38	1.71	1.98	2.18	2.26
	DJF	0.92	1.66	2.23	2.64	2.89	2.98	3.00
	JJA	0.59	1.05	1.41	1.67	1.81	1.85	1.83

Reconstructed after Tanner, et al. 2007, using best judgment.

Table II.11-B: Scenarios of Future Rainfall (%) over the Study Area at 10-year Intervals with 2000 as the Base Year

GHG Scenario		2010	2020	2030	2040	2050	2060	2065
A2	Annual	3.54	6.87	9.87	12.53	14.86	16.86	17.74
	Winter	19.34	34.91	47.16	56.09	61.70	63.99	63.89
	JJA (monsoon)	4.63	9.05	13.47	17.89	22.32	26.74	28.95
B1	Annual	1.5	4.2	8.0	12.9	19.0	26.2	30.2
	Winter	29.2	47.2	52.0	43.6	22.0	-12.8	-35.2
	JJA (monsoon)	7.4	13.7	18.7	22.4	24.7	25.7	25.7

Reconstructed after Tanner et al. 2007, using best judgment following the current climate change.

Case Study: Coastal Towns Resilience Options

Study area climate change projections

Table II.12: Bangladesh Sea Level Rise in 2010, 2030 and 2050, with 1990 as the Reference Year Considering IPCC Prediction with Uncertainties

Projection year	Sea level rise (cm) due to warming	Land Subsidence (cm)	Sediment Deposition (cm) in side polders	Sediment Deposition (cm) outside polders	Net sea level rise (cm) relative to lands inside polder	Net sea level rise (cm) relative to lands outside polder
	A	B	C	D	**A+B-C**	A+B-D
2010	3.5	3	1	3	**5.5**	3.5
2020	8.5	6	2	6	**12.5**	8.5
2030	15	9	3	9	**21**	15
2040	21.5	12	4	12	**27.5**	21.5
2050	29.4	15	5	15	**39.4**	29.4
2060	39.6	18	6	18	**51.6**	39.6
2065	44.4	19.5	6.5	19.5	**57.9**	53.

Note: Local factors of land subsidence and deposition are considered.
Source: IPCC.

Case Study: Coastal Towns Resilience Options

Study area climate change projections

Table II.13: The Projection of Storm Surges for Future Sea Level rise at Different Storm Intensity

Vmax (km/year)	2000	2010	2020	2030	2040	2050	2060	2065
85	1.5	1.6	1.6	1.7	1.8	1.9	2.0	2.1
115	2.5	2.6	2.6	2.7	2.8	2.9	3.0	3.1
135	3	3.1	3.1	3.2	3.3	3.4	3.5	3.6
165	3.5	3.6	3.6	3.7	3.8	3.9	4.0	4.1
195	4.8	4.9	4.9	5.0	5.1	5.2	5.3	5.4
235	6.5	6.6	6.6	6.7	6.8	6.9	7.0	7.1
260	7.8	7.9	7.9	8.0	8.1	8.2	8.3	8.4
280	9.0	9.1	9.1	9.2	9.3	9.4	9.5	9.6

Table II.14: Increase of the Intensity of Tropical Cyclones Hitting Bangladesh Coast based on the Relation between SST and Maximum Wind of Tropical Cyclones

Climate parameters	2020	2030	2040	2050	2050
Increase of SST (^{0}C)	0.12	0.24	0.36	0.48	0.48
Increase of Vmax (km/hr)	9.8	19.8	29.4	39.6	39.6

Note: RMS value of the regression equation is 41.3 and R^2-value is 0.267 reference to 2010.

Case Study: Coastal Towns Resilience Options

Study area climate change projections

Table II.15: Projection of Annual Probability of Tropical Cyclone for the Future for Different Intensity Levels for Specified Decades

Categories	2011-2020	2021-2030	2031-2040	2041-2050	2051-2060
Tropical Cyclonic storms Cat-0 (62-117 km/hr)	0.5	0.5	0.3	0.1	0
Cat-1 (118-153 km/hr)	0.1	0.1	0.2	0.4	0.5
cat-2 (154-177 km/hr)	0.2	0.1	0.1	0.1	0.1
Cat-3 (178-207 km/hr)	0.1	0.1	0.2	0.2	0.1
Cat-4 (208-251 km/hr)	0.3	0.4	0.3	0.2	0.3
Cat-5 km/hr (speed>250 km/hr)	0.1	0.1	0.2	0.3	0.3

Source: PPTA Consultant.

Case Study: Coastal Towns Resilience Options

Study area climate change impact projections

Table III.2: Relating the Elevation with Five Inundation Classes

Ser. No.	Inundation Classes (Depth in cm)	Range of elevation (m)
1	No flood	1.9 m and above
2	0-40	1.75-1.9
3	40-50	1.7-1.75
4	50-100	1.5-1.7
5	Above 100 cm	-.75-1.5

Source: PPTA Consultant.

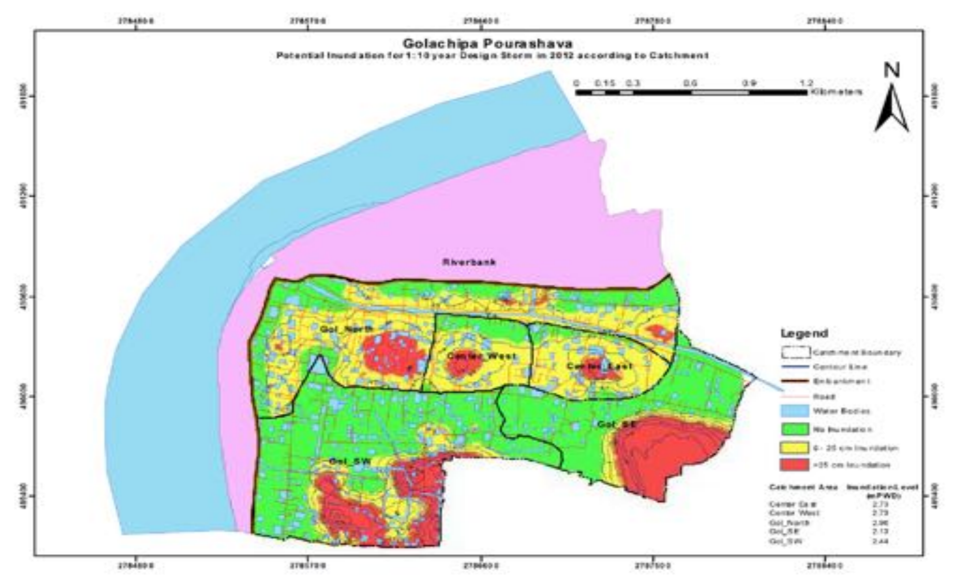
Case Study: Coastal Towns Resilience Options

Study area climate impact projections

Figure III.2: Storm Surge Inundation Map due to Cyclone Sidr for Galachipa Pourashava

Source: PPTA Consultant.

Figure III.6: 1:10 Year Design Storm Inundation due to Drainage Congestion in Galachipa, in 2012 (a) and 2050 (b)



Case Study: Coastal Towns Resilience Options

Study area climate impact projections

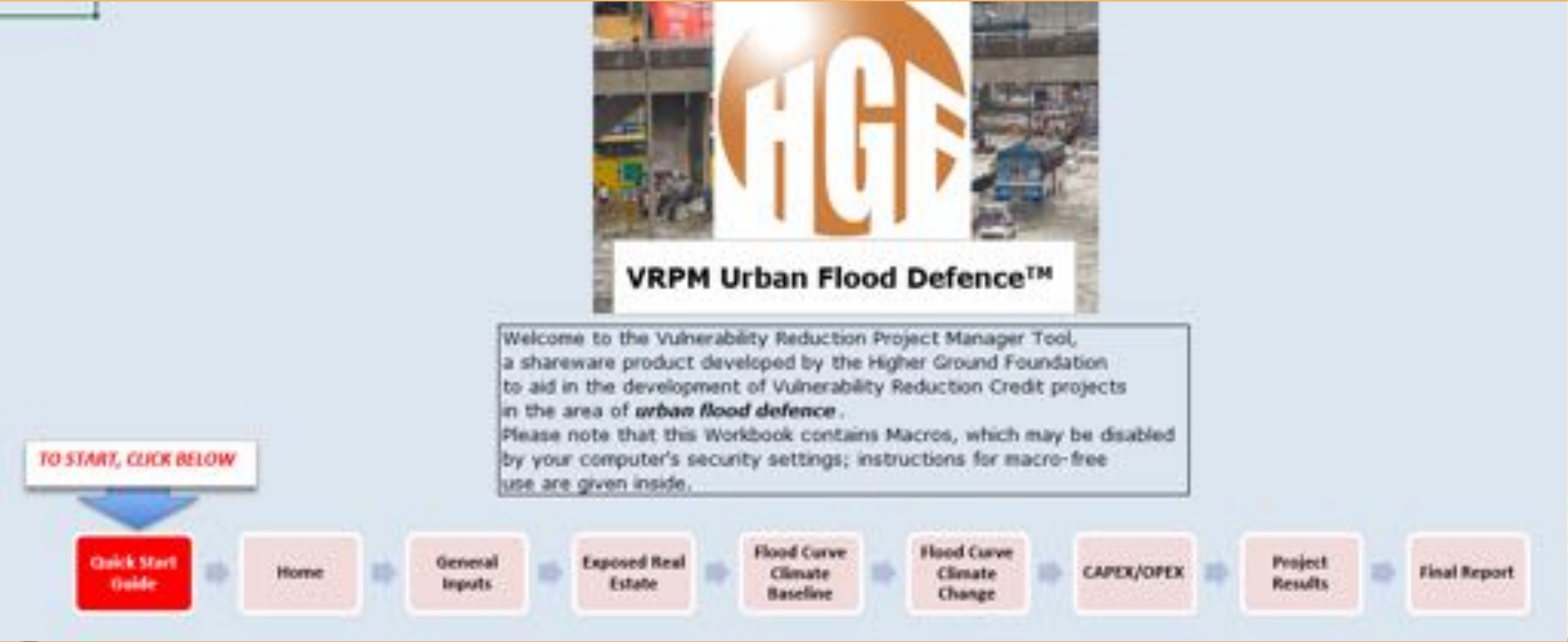
Table III.6: Estimated Future Projection of Damages Caused by Tropical Cyclones

(Million US$)

Pourashava	1991-2000	2001-2010	2011-2020	2021-2030	2031-2040	2041-2050	2050-2060
Galchipa	1.54	3.26	3.67	4.00	4.63	4.88	5.19
Amtoli	**2.39**	3.10	3.47	3.80	4.22	4.46	4.71
Mathbaria	2.39	3.10	3.47	3.80	4.22	4.46	4.71
Pirojpur	3.41	3.65	4.26	4.66	5.85	6.06	6.51
Total	9.73	13.10	14.86	16.26	18.92	19.86	21.13
Damage with no climate change	9.73	9.73	9.73	9.73	9.73	9.73	9.73
Additional damage due to climate change	0	3.37	5.13	6.53	9.19	10.13	11.4

Source: PPTA Consultant.

Use of HGF Tool: the Vulnerability Reduction Project Manager: Flood Defence



Use of HGF Tool, the Vulnerability Reduction Project Manager: Flood Defence

MENU

Quick Start Guide → Home → General Inputs → Exposed Real Estate → Flood Curve Climate Baseline → Flood Curve Climate Change → CAPEX/OPEX → Project Results → Final Report

FILL IN THE *BLUE* CELLS ONLY

LOCATION OF THE PROJECT

Approximate Centre of Project

Latitude (DD MM SS):	22° 09' 45" N
Longitude (DDD MM SS):	090° 25 13" E

Approximate Extent of Project

NW Corner Lat (DD MM SS):	22°10'33.57"N
NW Corner Lon (DDD MM SS):	90°24'17.05"E
NE Corner Lat (DD MM SS):	22°10'35.14"N
NE Corner Lon (DDD MM SS):	90°25'29.93"E
SE Corner Lat (DD MM SS):	22° 9'15.90"N
SE Corner Lon (DDD MM SS):	90°25'29.09"E
SW Corner Lat (DD MM SS):	22° 9'12.16"N
SW Corner Lon (DDD MM SS):	90°24'18.14"E

or

Approximate Radius of Project area (km):

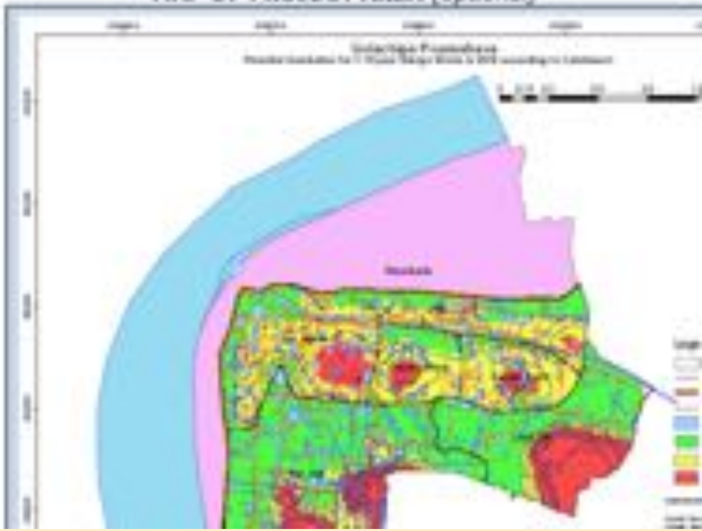
INPUT METHODOLOGIES

Input Specific Properties

or

Input Digital Elevation areal data

MAP OF PROJECT AREA *(optional)*



Use of HGF Tool, the Vulnerability Reduction Project Manager: Flood Defence

MENU

Quick Start Guide → Home → General Inputs → Exposed Real Estate → Flo… C… B…

FILL IN TI

HISTORICAL FLOOD STAGE DATA SERIES

Enter (or paste) historic flood stages (highest annual flood levels)
in descending order in the blue cells below.

If entered unsorted, click button ------------>

NOTE: more data points provide more r
we recommend using at least 30 years
For more information, refer to the Home

Bank Height (m above Sea Level)	15.00	Stage (m above Sea Level)	Rank		Recurrence Interval (years)	Annual Probability*
		21.00	1	1.00	54.00	0.0185185
		20.00	2	2.00	27.00	0.037037
		19.00	3	3.00	18.00	0.0555556
		18.14	4	4.00	13.50	0.0740741

Case Study: Coastal Towns Resilience Options

Analysis of Avoided Impact Costs of Climate Adaptations

Water Supply
Summary of Benefits - (Tk Million) with CCR

	Amtali	Galachipa	Pirojpur	Mathbaria
Savings in income - collection time	67.6	56	No Project	160.0
Cost of Storage tank saved	1.7	4		9.4
Saved purchase cost	44.2	47		174.5
Saved purification Cost	55.0	0		0
Total	**168.6**	**107.3**		**343.9**

Cyclone Shelters
Summary of Benefits - (Tk Million) with CCR

	Amtali	Galachipa	Pirojpur	Mathbaria
Loss of Income	84.0	86.6	128.2	66.7
Saved Medical Cost	6.7	7.4	13.4	3.3
Total	**90.7**	**94.0**	**141.6**	**69.9**

Case Study: Coastal Towns Resilience Options

Analysis of Avoided Impact Costs of Climate Adaptations

Bridges
Summary of Benefits - (Tk Million) with CCR

	Amtali	Galachipa	Pirojpur	Mathbaria
Vehicle Operating Cost Savings	No Project	No Project	0.1	0.2
Time Savings			31.6	41.0
Total	0	0	**31.7**	**41.2**

Sanitation
Summary of Benefits - (Tk Million) with CCR

	Amtali	Galachipa	Pirojpur	Mathbaria
Saved Income Loss	4.1	5.7	No Project	11.2
Saved Medical Cost	12.1	21.9		28.3
Total	**16.2**	**27.6**	**0.0**	**39.5**

Solid Waste
Summary of Benefits - (Tk Million) with CCR

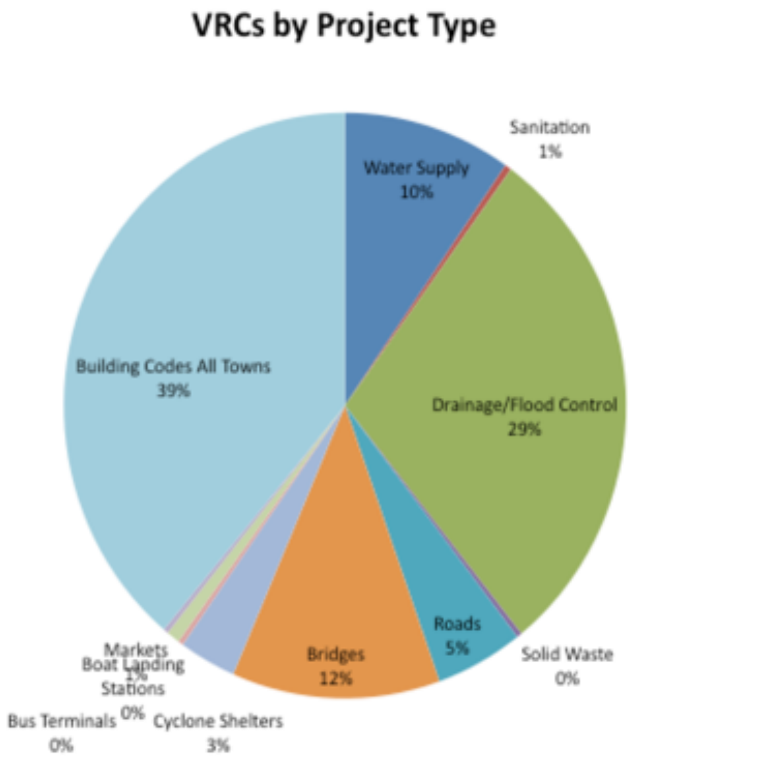
	Amtali	Galachipa	Pirojpur	Mathbaria
Saved Income Loss	1.1	1.3	2.0	1.8
Saved Medical Cost	0.3	0.4	0.7	0.3
Total	**1.4**	**1.7**	**2.7**	**2.1**

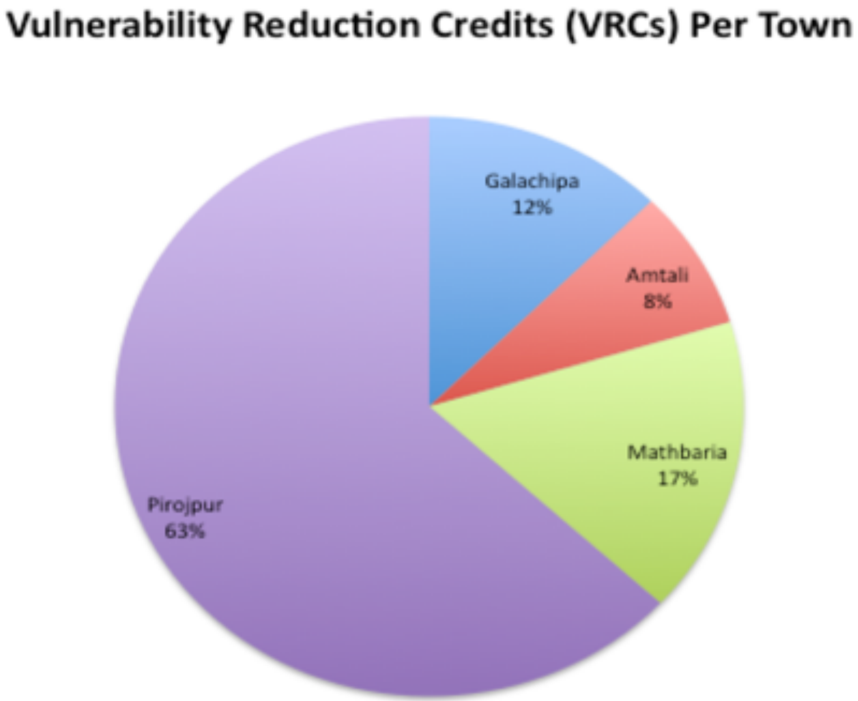
Case Study: Coastal Towns Resilience Options

Income Equalization Factor (IEF)

VRC Income Data				
	Galachipa	Amtali	Mathbaria	Pirojipur
Average Household IncomeTk./Month	13167.00	13841.00	21744.00	14620.00
Average Household Size	4.80	4.60	4.60	5.30
Per Capita Income Tk./Year	32917.50	36106.96	56723.48	33101.89
Fx Tk.: USD	77.83	77.83	77.83	77.83
Per Capita Income USD	422.94	463.92	728.81	425.31
Lower Middle GNI upper bound (2013, USD)	4085.00	4085.00	4085.00	4085.00
Income Equalization Factor	9.66	8.81	5.61	9.60

VRCs for evaluating project alternatives: examples





VRCs for evaluating project costs in different cities

Town	VRCs Generated	Incremental Costs for Climate Resilience (Million $US)	$US/VRC
Galachipa	1,016,362	2.155	$2.12
Amtali	635,674	2.260	$3.56
Mathbaria	1,349,320	3.594	$2.66
Pirojpur	5,140,360	3.860	$0.75
TOTAL	8,141,717	11.870	$1.46
TOTAL (WITH BUILDING CODES)	12,559,000	34.371	$2.74

VRCs for evaluating project alternatives: examples

Project	USD/VRC
Water Supply	$2.97
Sanitation	$1.23
Drainage/Flood Control	$0.91
Solid Waste	$5.22
Roads	$4.10
Bridges	$0.27
Cyclone Shelters	$2.31
Boat Landing Stations	$1.55
Markets	$1.13
Bus Terminals	$1.53
Building Codes All Towns	$4.41
TOTAL	$2.74

Vulnerability Reduction Credits (VRCs™)

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- VRCs enable sustained effectiveness of this return (or vulnerability reduction) through continuous monitoring and verification for crediting, and periodic revisiting of the project baseline over the lifetime of the project/investment.

What's Next For Higher Ground

Next Steps for The Higher Ground Foundation

We have launched our VRC Standard Framework and Pilot Implementation and Partnerships Phase (PIPP) at COP-23 in November 2017

- ❑ We are focused on partnering with relevant institutions and experts
- ❑ We are piloting VRC approaches in different sectors with different adaptation projects

Let's create a future where the best responses to climate change are the choices the world wants to make

Let's discuss!

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