

Impact-based Forecasting for Maldives

Capacity Building on National and Subnational Planning for Sustainable Disaster Risk Reduction, Climate Change Adaptation, and Mitigation

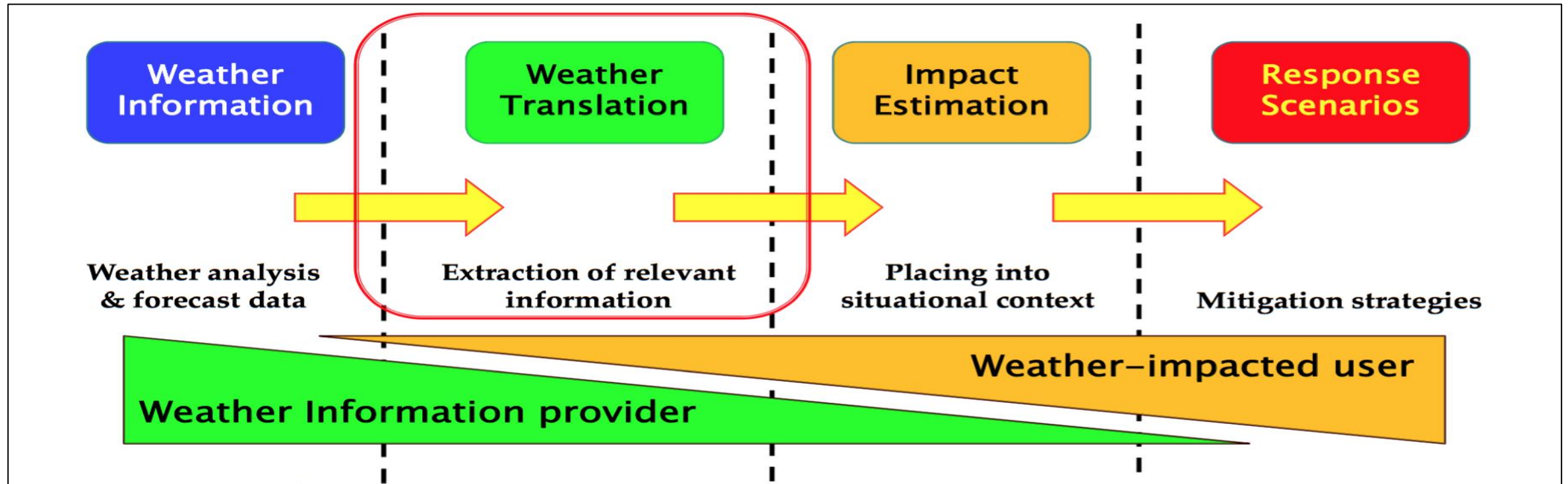
February 1, 2024

Prangya Paramita Gupta

Impact-based Forecasting

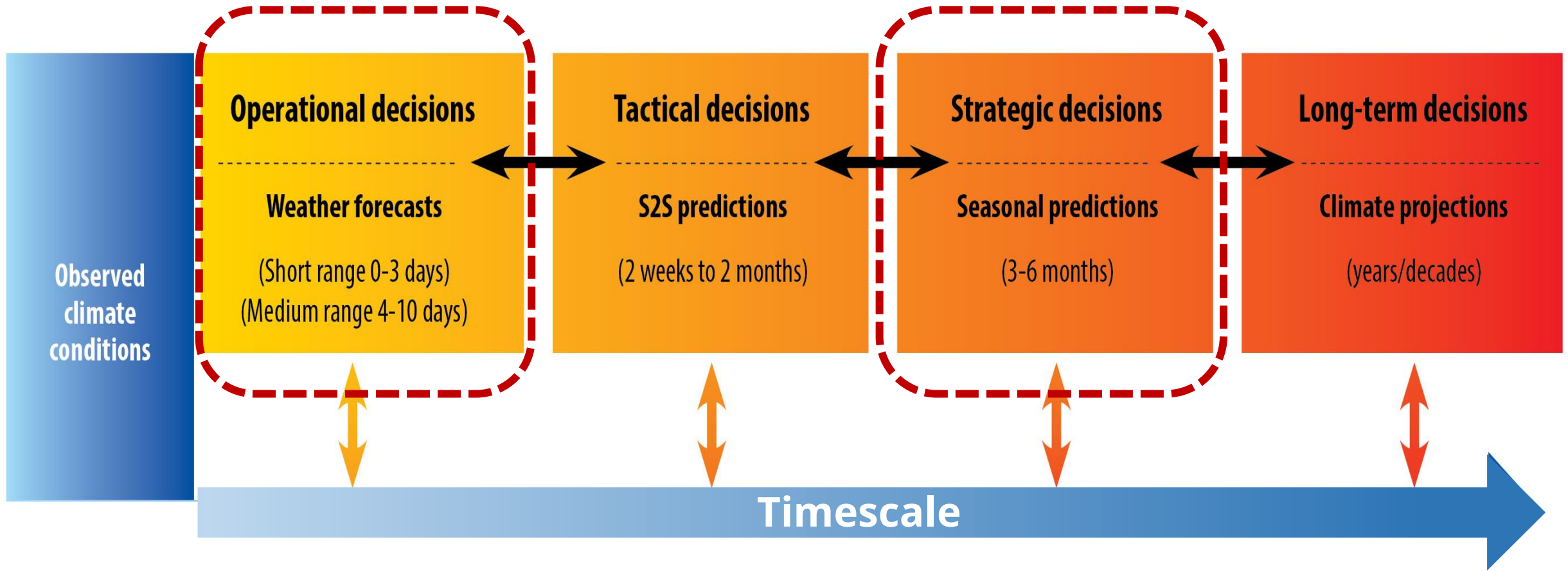
An illustration on how weather information can be translated to response actions

- Relevant information from **weather information** is **extracted** and placed into the **situation context** to produce **impact estimations**.
- With potential impact information available, response scenarios can be set-up.



Source: Baode Chen and Xu Tang (2014) Translating weather forecasts into impact-relevant information; ESCAP presentation in RSMC.

IBF, in different timescale, can help decisions of relevant stakeholders.



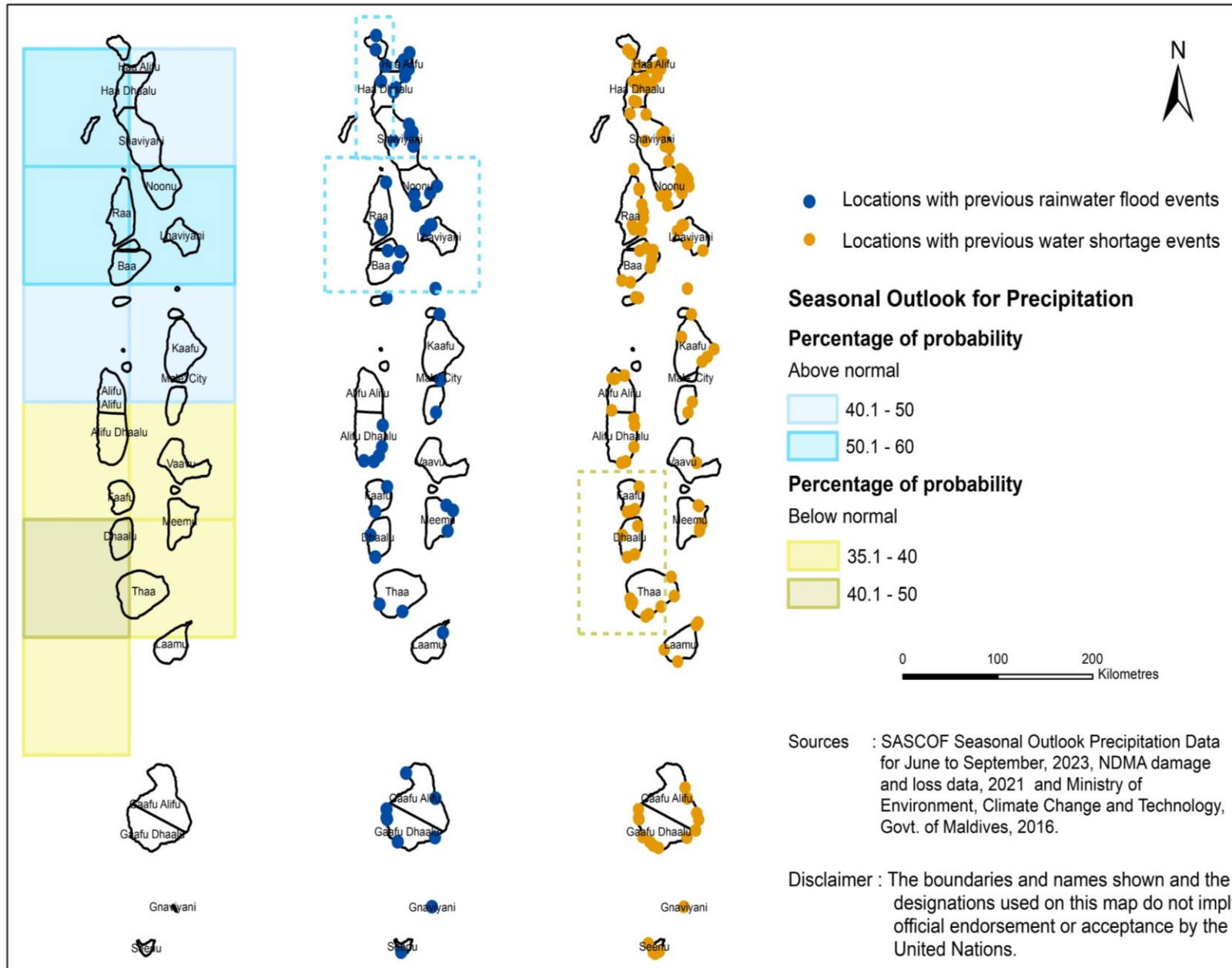
Source: ESCAP(2018) Asia-Pacific Disaster Report 2017; ESCAP presentation in RSMC.

- **Impact-based Forecasting using Seasonal Outlook Data**

- **Impact-based Forecasting using Ocean Wave Model Data**
- **Impact-based Forecasting using cyclone forecast data**



Seasonal precipitation outlook for JJAS, 2023 for Maldives



Need attention -

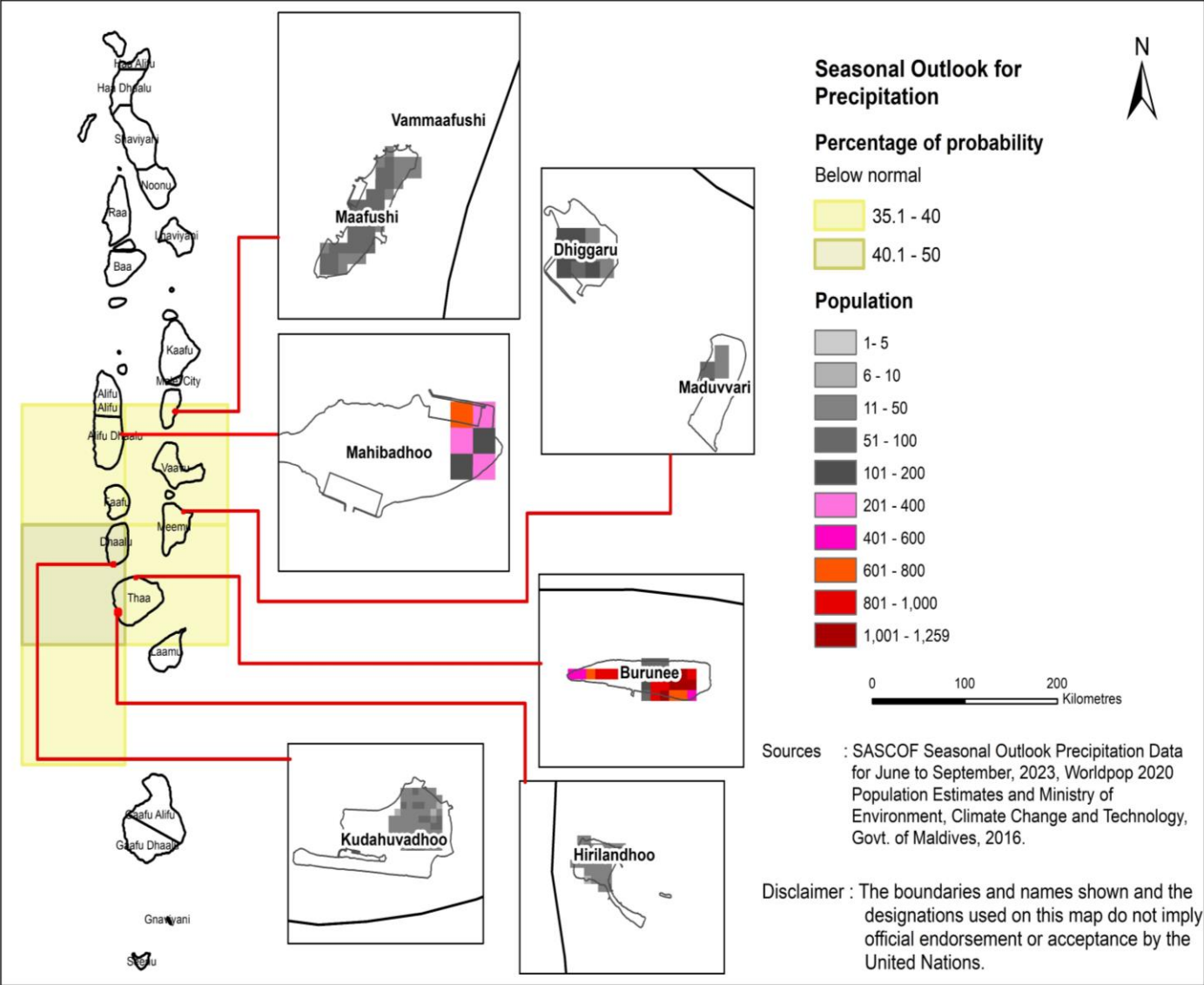
Above normal precipitation

- Haa Alifu atoll
- Raa atoll
- Baa atoll
- Shaviyani
- Lhaviyani atoll

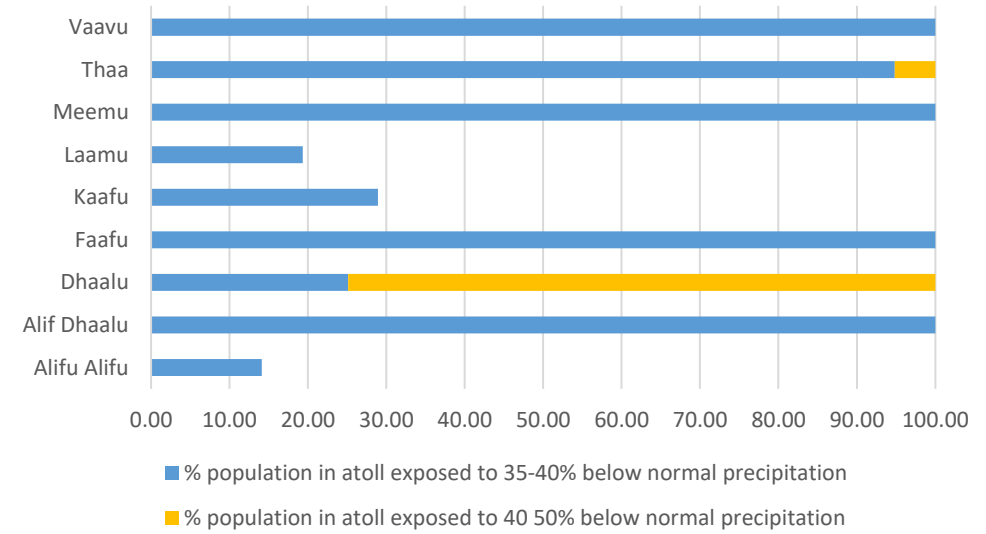
Below normal precipitation

- Faafu atoll
- Dhaalu atoll
- Thaa atoll

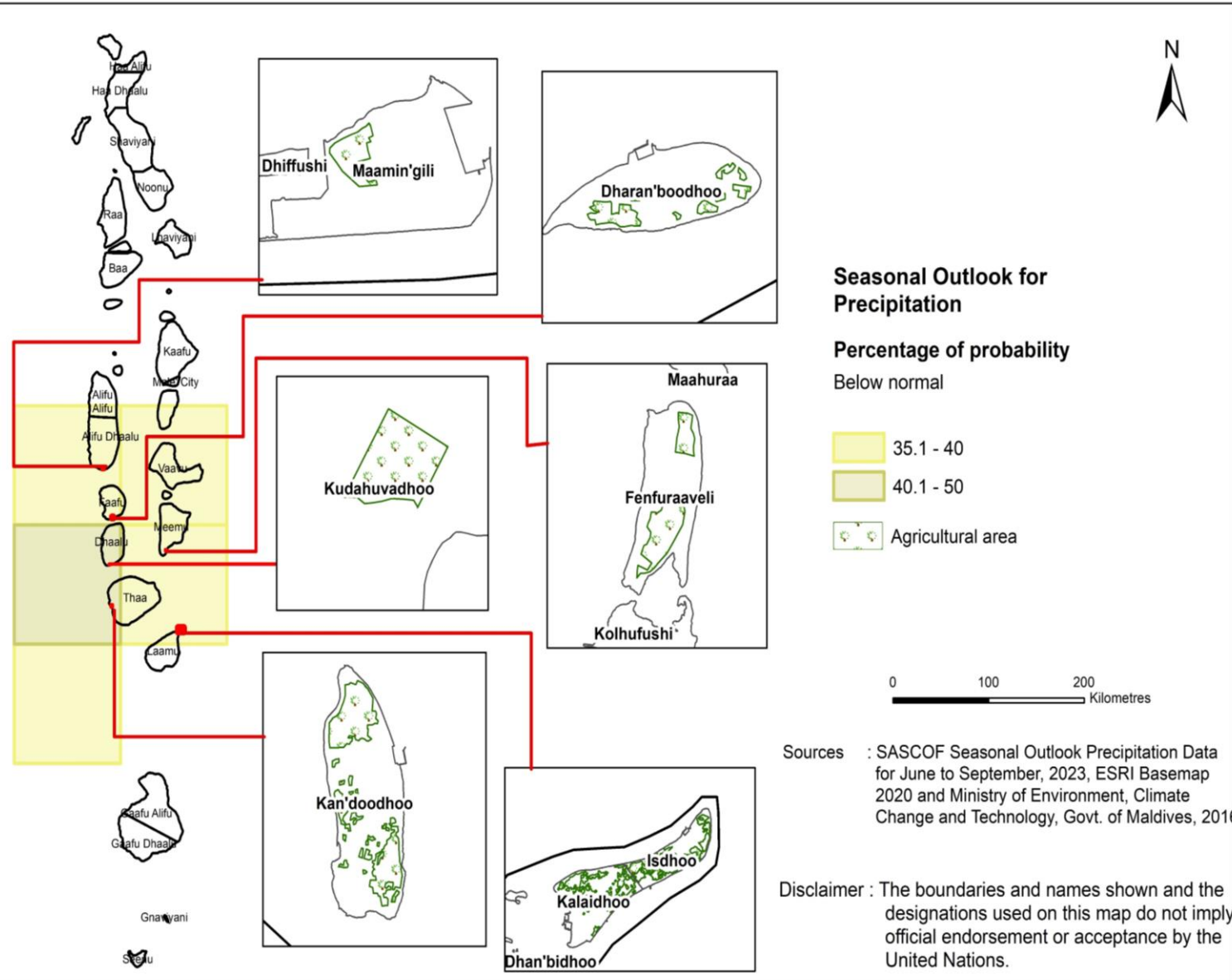
Population exposure to below normal precipitation



Atoll	Total population (Worldpop population count)	% population in atoll exposed to 35-40% probability of below normal precipitation	% population in atoll exposed to 40 50% probability of below normal precipitation
Alifu Alifu	4674.15	14.11	
Alif Dhaalu	9276.32	100.00	
Dhaalu	6433.42	25.13	74.87
Faafu	3711.77	100.00	
Kaafu	20047.92	28.93	
Laamu	14117.30	19.34	
Meemu	3884.25	100.00	
Thaa	28408.22	94.83	5.17
Vaavu	1163.93	100.00	



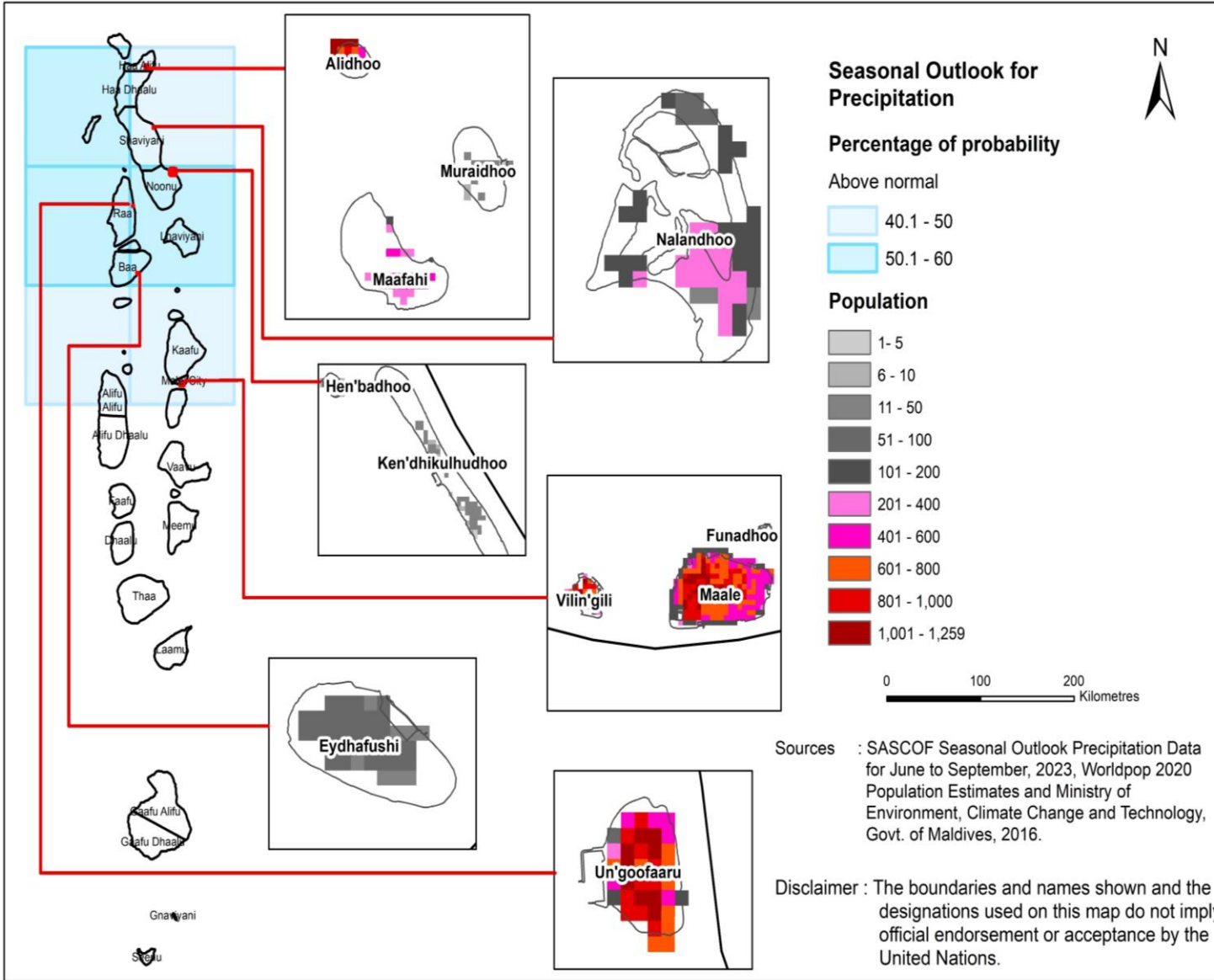
Exposure of agricultural lands to below normal precipitation



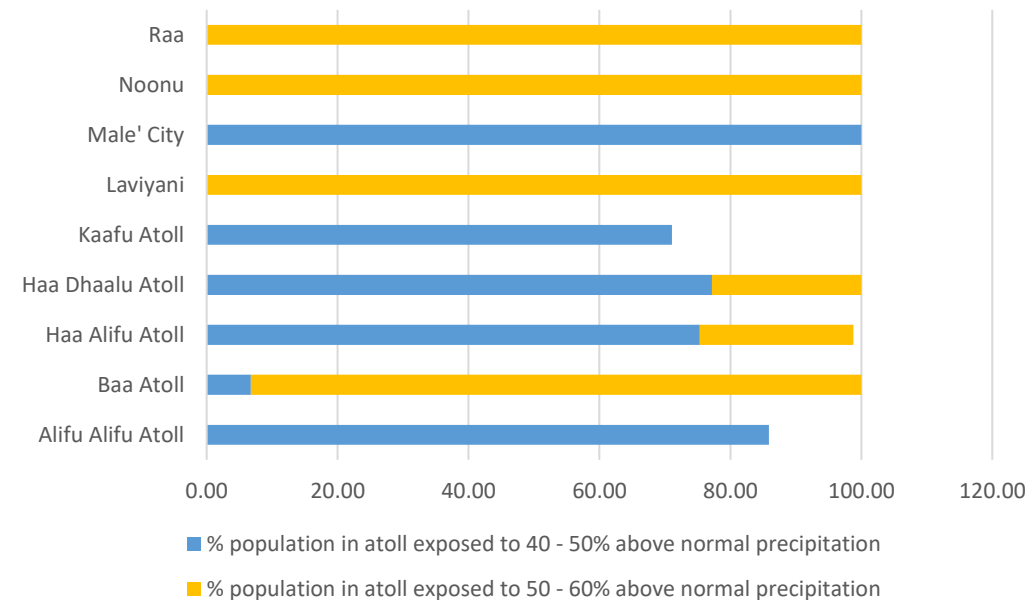
Atoll Name	Exposed Island	Total Agricultural areas in the atoll (ha)	% Area in atoll exposed to 35-40% probability of below normal precipitation
Alifu Alifu atoll	Maalhos	98.86	1.42
	Himendhoo		
Alifu Dhaalu atoll	Dhigurah	15.14	100.00
	Maamin'gili		
Faafu atoll	Dharan'boodhoo	4.97	100.00
Meemu atoll	Gaakurali	9.21	100.00
	Thuvaru		
	Fenfuraaveli		
Laamu atoll	Mundoo	302.81	42.02
	Maabaidhoo		
	Kalaidhoo		
	Isdhoo		
	Dhan'bidhoo		

Atoll Name	Exposed Islands	Total Agricultural areas in the atoll (ha)	% Area in atoll exposed to 40-50% probability of below normal precipitation
Dhaalu atoll	Kudahuvadhoo	7.555	100.00
	Uhdhoo		
	Lhohi		
Thaa atoll	Vandhoo	23.9	97.74
	Kan'doodhoo		
	Kakolhas		

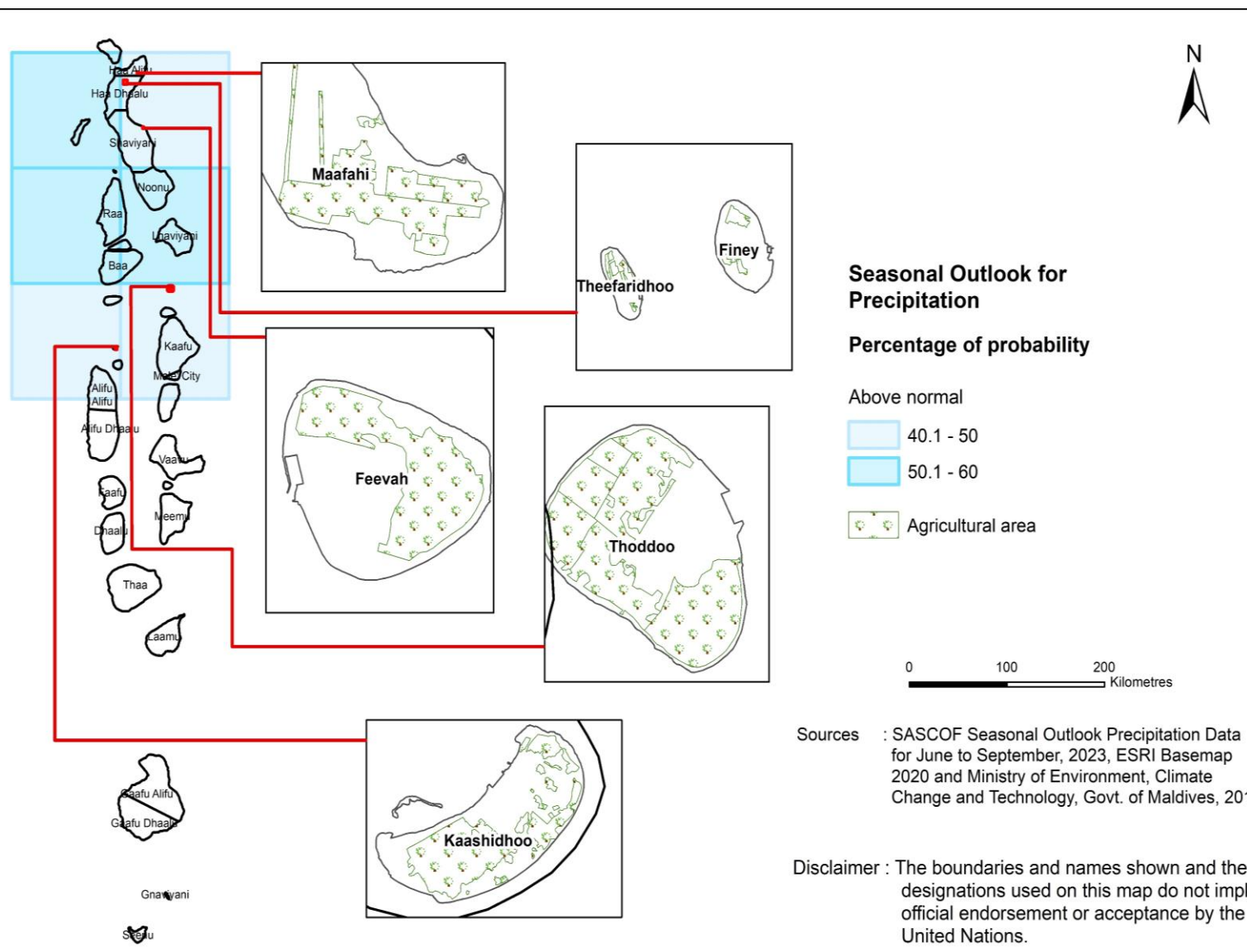
Population exposure to above normal precipitation



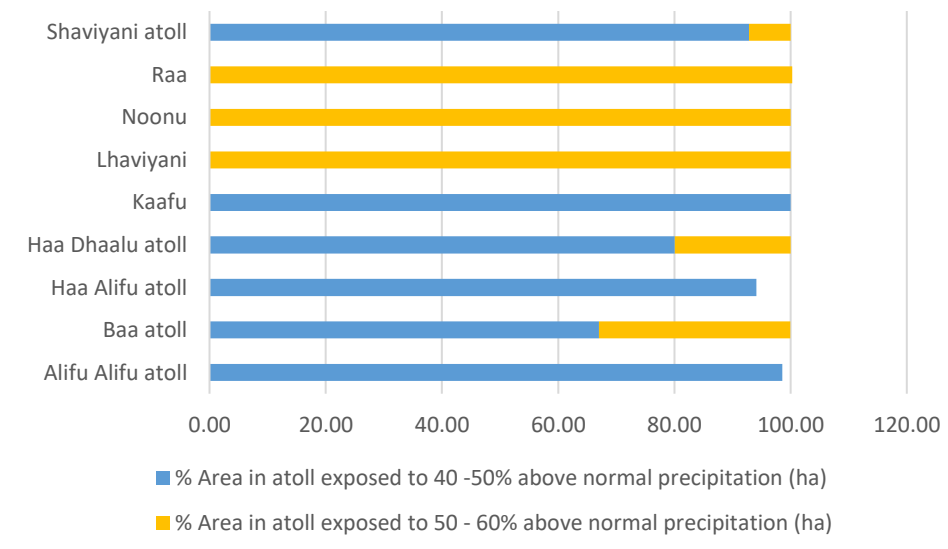
Atoll	Total population (Worldpop population count)	% population in atoll exposed to 40 - 50% probability of above normal precipitation	% population in atoll exposed to 50 - 60% probability of above normal precipitation
Alifu Alifu Atoll	4674.15	85.89	
Baa Atoll	9163.93	6.76	93.24
Haa Alifu Atoll	38030.78	75.34	23.45
Haa Dhaalu Atoll	15118.58	77.18	22.82
Kaafu Atoll	20047.92	71.07	
Laviyani	8176.12		100.00
Male' City	200805.52	100.00	
Noonu	7195.00		100.00
Raa	41594.17		100.00
Shaviyani Atoll	18378.91	90.11	9.89



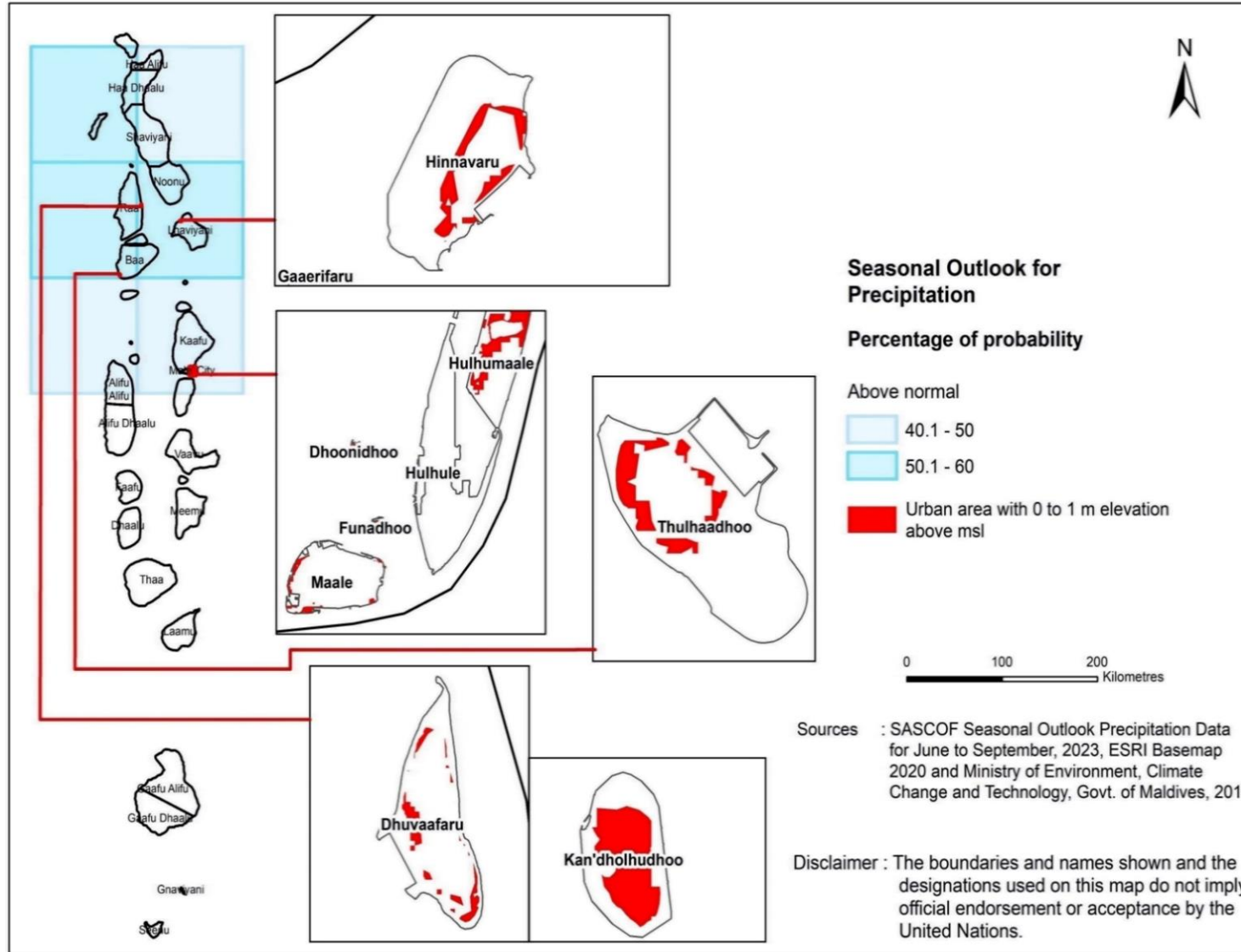
Exposure of agricultural lands to above normal precipitation



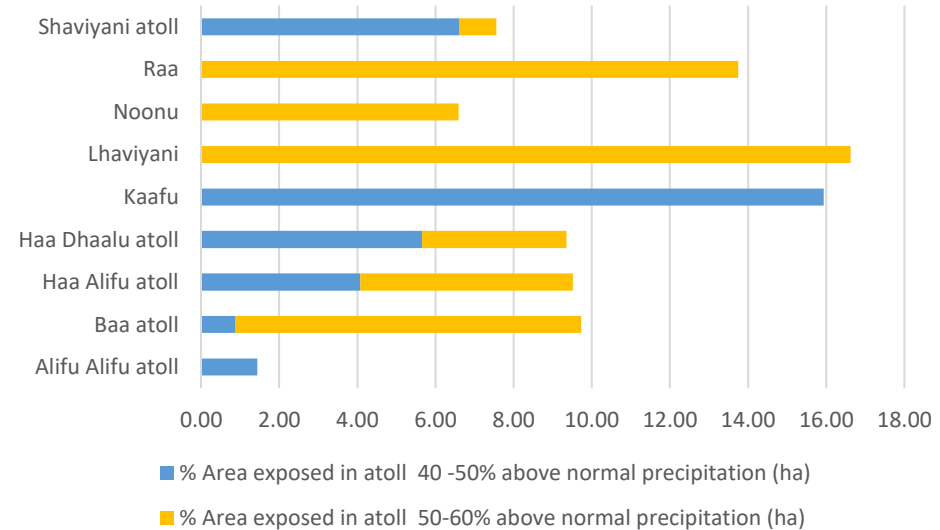
Atoll	Total Agricultural areas in the atoll (Ha)	% Area in atoll exposed to 40 - 50% probability of above normal precipitation (ha)	% Area in atoll exposed to 50 - 60% probability of above normal precipitation (ha)
Alifu Alifu atoll	98.866	98.57	
Baa atoll	39.677	67.04	32.94
Haa Alifu atoll	65.894	94.11	
Haa Dhaalu atoll	95.921	80.05	19.94
Kaafu	112.447	99.99	
Lhaviyani	14.42		100.00
Noonu	46.23		100.00
Raa	20.01		100.30
Shaviyani atoll	138.833	92.82	7.17



Exposure of urban areas with 0 – 1 m elevation above msl to above normal precipitation



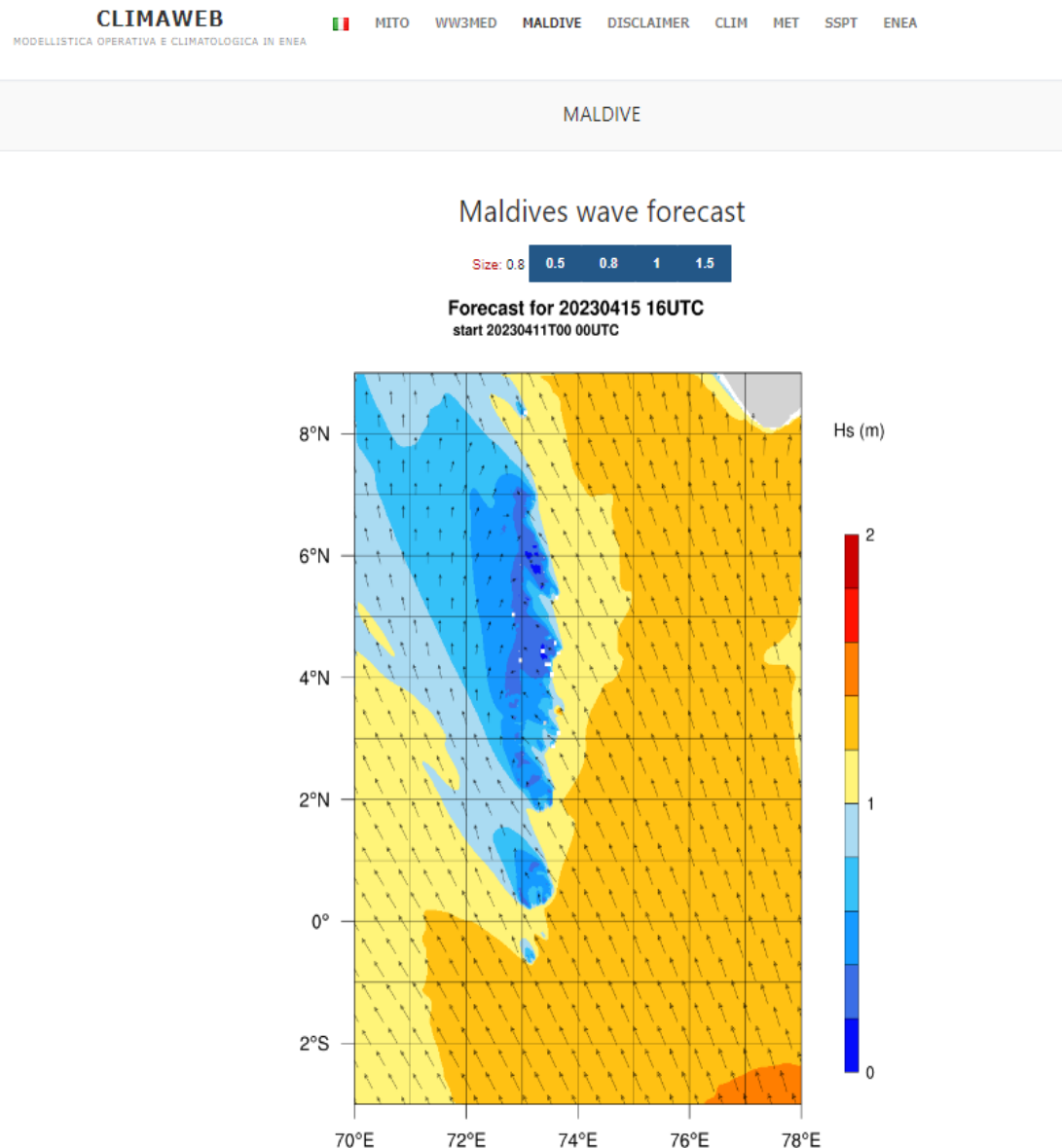
Atoll	Urban areas in atoll (ha)	% Area exposed in atoll 40 -50% probability of above normal precipitation (ha)	% Area exposed in atoll 50-60% probability of above normal precipitation (ha)
Alifu Alifu atoll	106.900	1.44	
Baa atoll	174.000	0.88	8.85
Haa Alifu atoll	359.500	4.08	5.43
Haa Dhaalu atoll	433.400	5.66	3.69
Kaafu	733.200	15.93	
Lhaviyani	112.500		16.62
Noonu	255.700		6.59
Raa	312.300		13.75
Shaviyani atoll	294.400	6.61	0.94



- **Impact-based Forecasting using Seasonal Outlook Data**
 - **Impact-based Forecasting using Ocean Wave Model Data**
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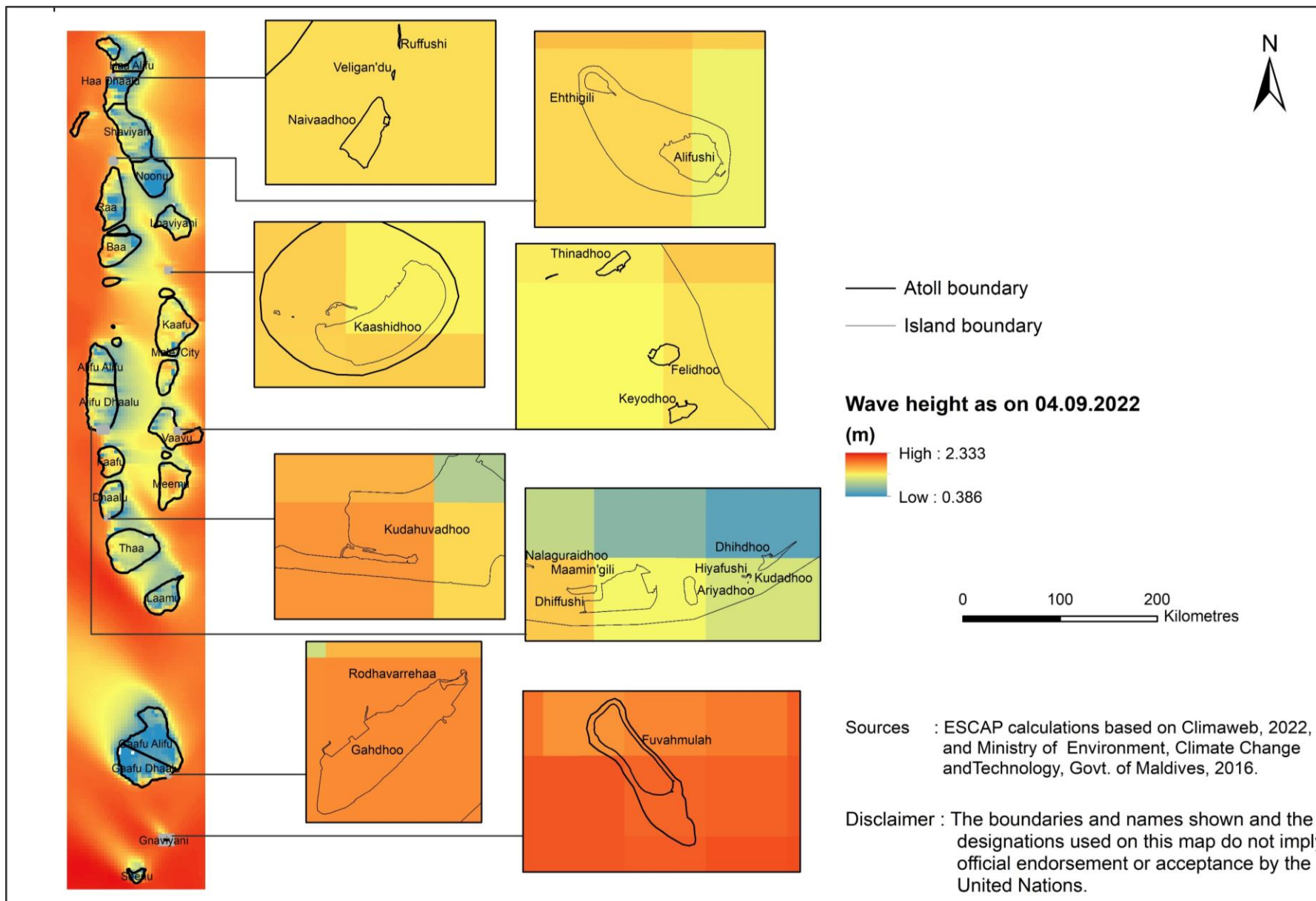
Ocean Wave Model (WAVE4M) Data for Maldives



Layer ID	Layer name
0	[1089x257] status map (16-bit integer)
1	[121x1089x257] depth (32-bit floating-point)
2	[121x1089x257] eastward_wind (32-bit floating-point)
3	[121x1089x257] northward_wind (32-bit floating-point)
7	[121x1089x257] sea_surface_wave_from_direction (32-bit floating-point)
12	[121x1089x257] sea_surface_wave_from_direction_partition_0 (32-bit floating-point)
13	[121x1089x257] sea_surface_wave_from_direction_partition_1 (32-bit floating-point)
6	[121x1089x257] sea_surface_wave_peak_frequency (32-bit floating-point)
10	[121x1089x257] sea_surface_wave_period_at_variance_spectral_density_maximum_partition_0 (32-bit floating-point)
11	[121x1089x257] sea_surface_wave_period_at_variance_spectral_density_maximum_partition_1 (32-bit floating-point)
4	[121x1089x257] sea_surface_wave_significant_height (32-bit floating-point)
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- Italian National Agency for New Technologies, Energy and Sustainable Economic Development (<https://climaweb.casaccia.enea.it/MALDIVE/>)
- Produced from ECMWF NWP model data
- Resolution < 1 km (0.865 km)
- Medium range forecast (4 days)
- Useful for operational decisions

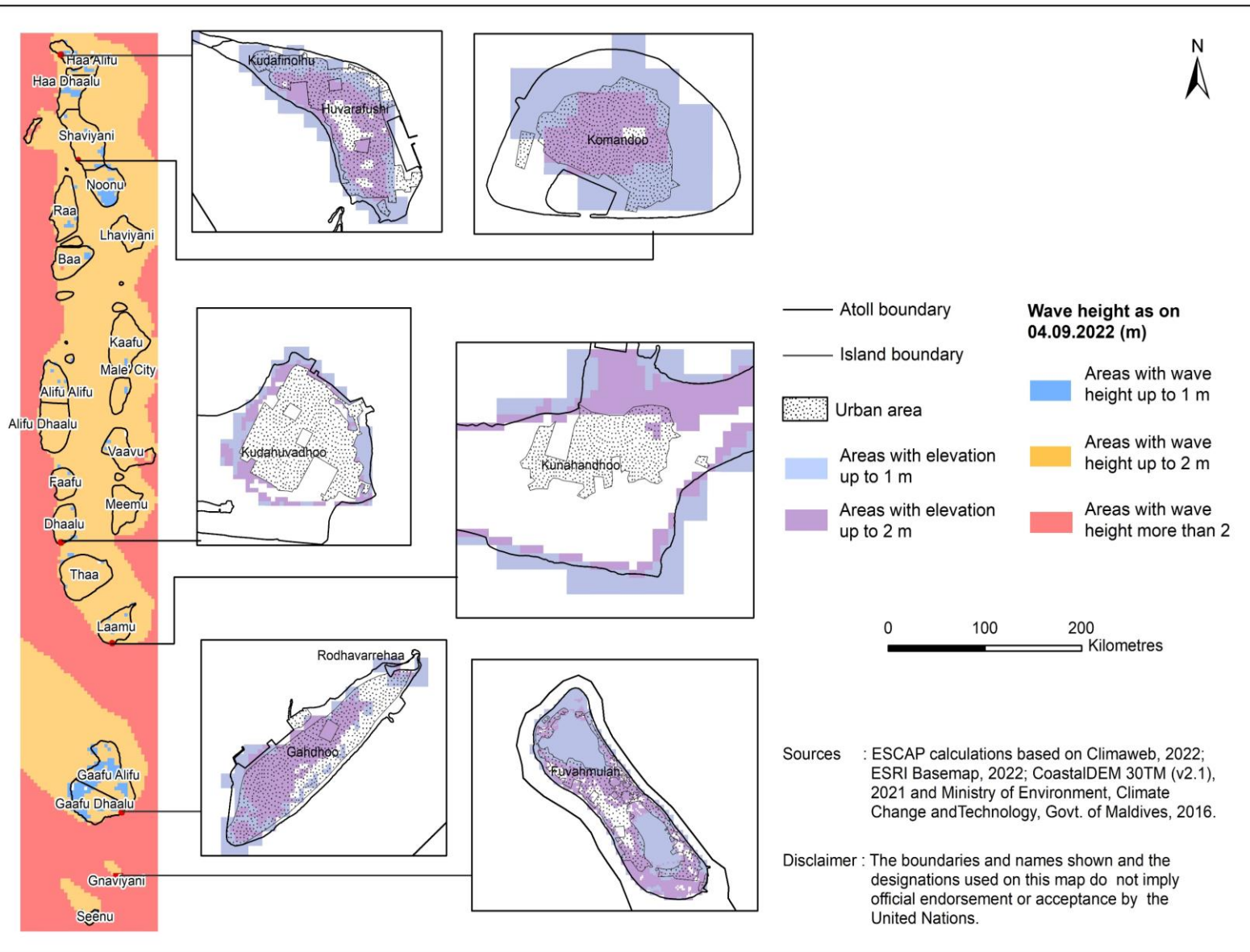
Ocean Wave Model (WAVE4M) Data for Maldives



Initial observation –

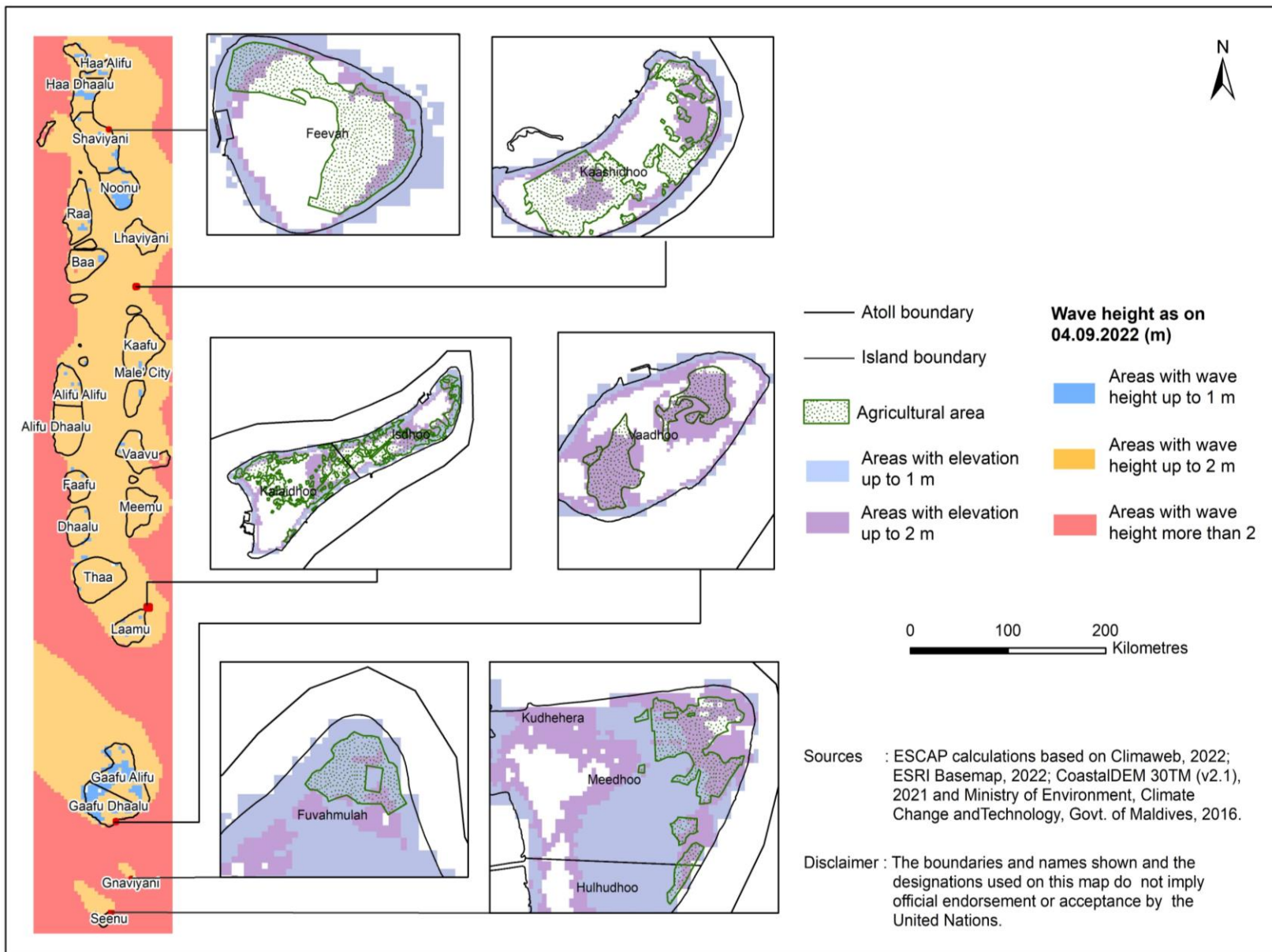
- Many inhabited islands of Haa Dhaalu, Raa, Alifu Dhaalu, Alifu Alifu, Kaafu, Faafu, Dhaalu, Vaavu, Meemu, Laamu and Addu facing open ocean are likely to experience 1.5 to 2m high waves
- Some inhabited islands of Laamu, Gaafu Dhaalu and Gnaviyani atoll are likely to experience more than 2m high wave.

Exposure of Urban areas



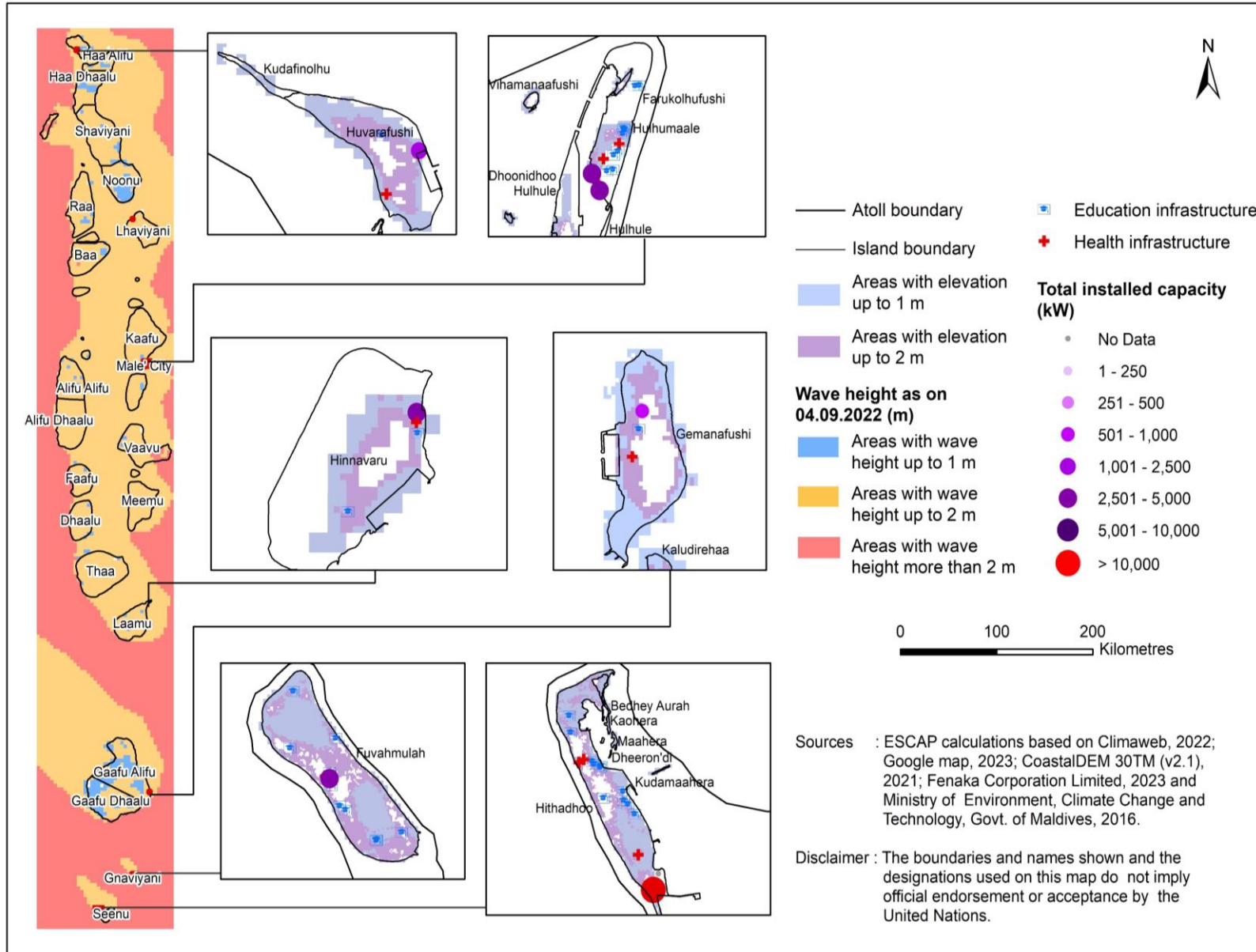
Atoll	Urban Area exposed to 1-2m wave height (ha)	Population exposed to 1-2m wave height
Alifu Alifu atoll	8.76	10653
Addu	297	328657
Alifu Dhaalu	43.66	25295
Baa	45.18	26689
Dhaalu	25.09	12354
Faafu	20.56	8709
Gaafu Dhaalu	23.98	4466
Gaafu Alifu	89.15	30393
Gnaviyani	53.33	17275
Haa Alifu	67.02	21819
Haa dhaalu	53.83	13866
Lhaviyani atoll	43.8	30353
Meemu atoll	37.75	16315
Noonu atoll	21.42	3768
Kaafu	188.21	85220
Raa atoll	89.7	96117
Shaviyani atoll	21.14	39008
Thaa atoll	73.9	55262
Vaavu atoll	11.09	3502
Laamu atoll	57.99	25967
Male city	0.1326	178802

Exposure of agricultural areas



Atoll name	Area (ha)	Area exposed (ha)	%
Alifu Alifu atoll	98.866	98.866	100.00
Addu atoll	53.9001	53.30	98.89
Alifu Dhaalu atoll	15.142	15.14	99.99
Baa atoll	39.677	29.90	75.36
Dhaalu atoll	7.5524	0.30	3.97
Faafu atoll	4.9775	4.40	88.40
Gaafu Dhaalu atoll	70.1323	59.20	84.41
Gaafu Alifu atoll	28.0659	12.90	45.96
Gnaviyani atoll	10.70	10.70	100.00
Haa Alifu atoll	65.8943	62.80	95.30
Haa Dhaalu atoll	95.9205	74.20	77.36
Lhaviyani atoll	14.4275	13.19	91.42
Meemu atoll	9.2145	9.13	99.08
Noonu atoll	46.2314	6.82	14.75
North Male atoll	112.4466	86.00	76.48
Raa atoll	20.0779	20.00	99.61
Shaviyani atoll	138.8329	92.00	66.27
Thaa atoll	23.9071	19.00	79.47
Laamu atoll	302.8188	172.00	56.80

Exposure of Critical Infrastructure



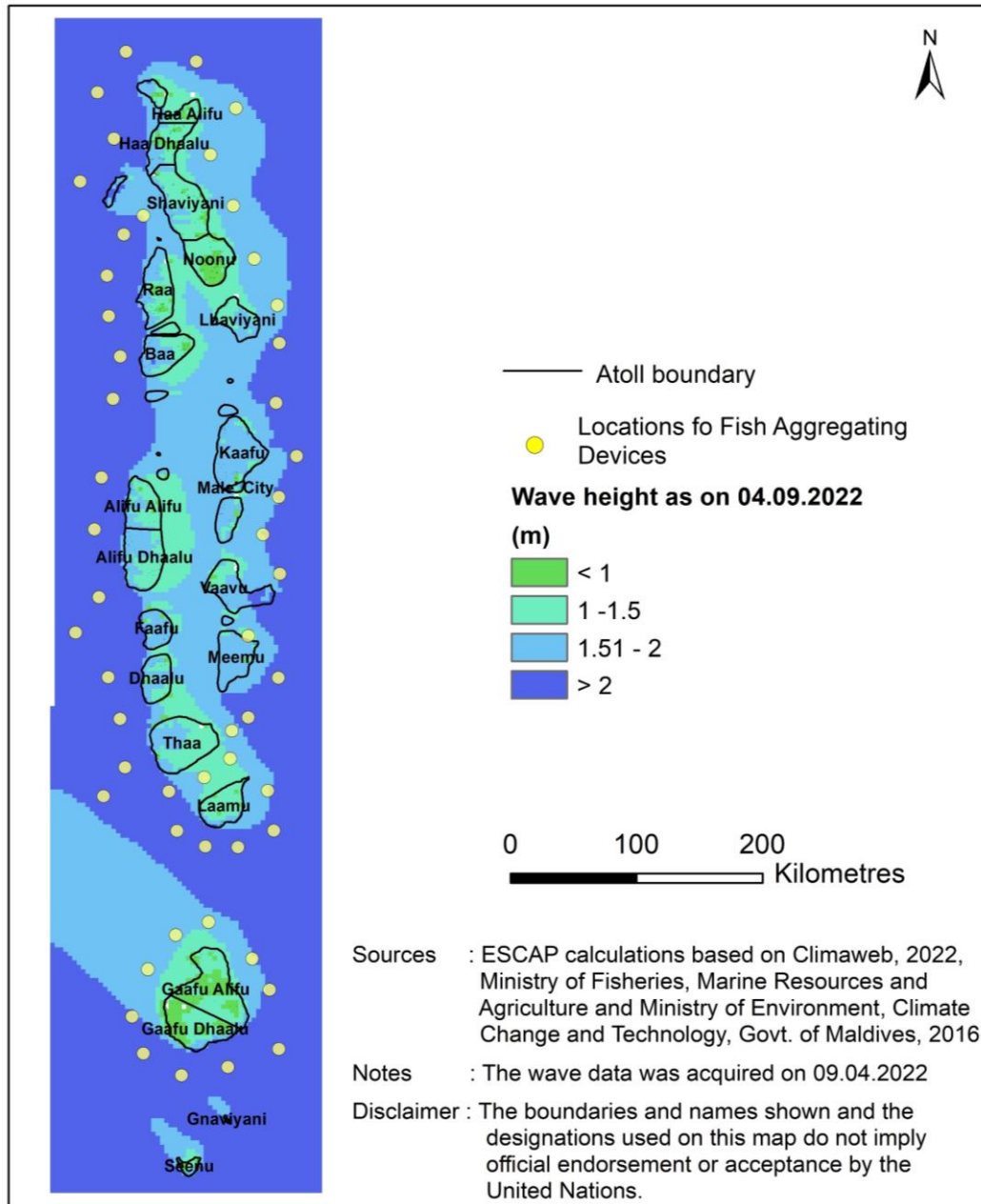
Atoll	Critical infrastructure exposed to 1-2m wave height	Critical infrastructure exposed to more than 2m wave height
Alifu Alifu	3	
Addu	25	
Alifu Dhaalu	11	
Baa	13	
Dhaalu	7	
Faafu	6	
Gaafu Alifu	15	
Gaafu Dhaalu	3	7
Gnaviyani	5	27
Haa Alifu	9	
Haa Dhaalu	6	
Lhaviyani	11	
Meemu	2	
Noonu	7	
Kaafu	7	
Raa	18	
Shaviyani	1	
Thaa	9	
Vaavu	11.09	
Laamu	3	
Male city	3	

Exposure of Critical infrastructure

Atoll	Critical infrastructure exposed to 1-2m wave height	Critical infrastructure exposed to more than 2m wave height
Alifu Alifu	3	
Addu	25	
Alifu Dhaalu	11	
Baa	13	
Dhaalu	7	
Faafu	6	
Gaafu Alifu	15	
Gaafu Dhaalu	3	7
Gnaviyani	5	27
Haa Alifu	9	
Haa Dhaalu	6	
Lhaviyani	11	
Meemu	2	
Noonu	7	
Kaafu	7	
Raa	18	
Shaviyani	1	
Thaa	9	
Vaavu	11.09	
Laamu	3	
Male city	3	

Island name	Type	Name
Fuvahmulah	Mosque	Masjidul Manhajulhudha
Fuvahmulah	Mosque	Masjidul Awwab
Fuvahmulah	School	Fuvahmulaku School
Fuvahmulah	Mosque	Masjidul Siddheeq
Fuvahmulah	Mosque	
Fuvahmulah	Mosque	Heenaadi Miskiyy
Fuvahmulah	Mosque	Kanburaa Miskiy
Fuvahmulah	Mosque	Masjidul Halhaara
Fuvahmulah	School	Zikura school
Fuvahmulah	Mosque	
Fuvahmulah	Mosque	Masjidhul Jihaadh
Fuvahmulah	Mosque	Kedeyre Miskiy
Fuvahmulah	Mosque	Unakede miskiyy
Fuvahmulah	CI	Old fuel reserve
Fuvahmulah	Mosque	Masjid Al-Jihaadh
Fuvahmulah	School	Hoadhadu school
Fuvahmulah	School	Ula pre-school
Fuvahmulah	Mosque	
Fuvahmulah	Council office	DZJ Idhaara
Fuvahmulah	Mosque	
Fuvahmulah	Mosque	
Fuvahmulah	CI	Water treatment plant
Fuvahmulah	CI	Powerhouse
Fuvahmulah	School	
Fuvahmulah	School	Brightway international school
Fuvahmulah	CI	Sewer treatment plant

Exposure of Fishing location



Atoll	Number of fishing locations	Number of fishing locations exposed to more than 2 m wave height	Number of fishing locations exposed to 1.5 - 2 m wave height	Number of fishing locations exposed to less than 1.5m wave height
Ha.Alifu	4	3	1	
Ha. Dhaalu	3	2	1	
Shaviyani	3	1	2	
Noonu	1		1	
Raa	2	2		
Baa	3	2	1	
Lhaviyani	2	1	1	
Kaafu	4	4		
Alifu Alifu	2	2		
Alifu Dhaalu	1	1		
Vaavu	1	1		
Meemu	3	2	1	
Faafu	1	1		
Dhaalu	2	2		
Thaa	6	3	2	1
Laamu	5	4	1	
Ga.Alifu	5	2	3	
Ga.Dhaalu	4	4		
Gnaviyani	2		2	
Seenu	4		4	