Assessing Hydrological Ecosystem Services in a Rubber-Dominated Watershed under Scenarios of Land Use and Climate Change—Supplementary Material

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1) Total water yield and total sediment export at watershed scale

When considering climate change impacts in isolation (INIT land use), the model outputs indicate increases in water yield and sediment export by 2070 for both RCPs (Table S1). Differences in water yield between the land use scenarios are small, whereas the differences in sediment export between land use scenarios are large. The model output indicates increased sediment export in BAU and decreased sediment export in 5YP and BTO. Uncertainties increase from 2030 to 2070. Uncertainties for sediment export were lower (3.8 – 7.9%) as compared to the uncertainties in the results for water yield (9.1 – 17.2%). Because of lower precipitation in RCP 8.5, the model suggests lower values for both water yield and sediment export in RCP 8.5 compared to RCP 4.5. Differences between the land use scenarios within each time slice all revealed significant differences ($p<0.5$). Detailed results of water yield, evapotranspiration, and sediment export for each GCM are provided in Table S1, Table S3 and Table S5.

Table S1. Total water yield and total sediment export in Nabanhe Reserve estimated by InVEST for all climate and land use scenarios as well as percentage comparisons to the baseline climate and land use conditions.

Climate	Land Use	Water Yield (km^3)	Standard Deviation	Difference to Baseline (%)	Sediment Export (10^6 kg)	Standard Deviation	Difference to Baseline (%)
Baseline	INIT[1]	101.42	-	-	53.31	-	-
RCP 4.5 2030	INIT[1]	98.26	9.01	-3.12	53.72	2.08	0.76
	BAU[2]	94.45	8.97	-6.87	60.92	2.39	14.26
	5YP[3]	97.47	9.00	-3.89	23.91	0.98	-55.15
	BTO[4]	97.45	9.00	-3.92	22.93	0.94	-56.98
RCP 4.5 2050	INIT[1]	105.37	11.19	3.89	55.80	2.70	4.66
	BAU[2]	101.53	11.14	0.11	63.35	3.10	18.82
	5YP[3]	104.57	11.18	3.11	24.91	1.27	-53.28
	BTO[4]	104.55	11.18	3.08	23.88	1.22	-55.20
RCP 4.5 2070	INIT[1]	117.20	19.61	15.56	58.35	4.42	9.45
	BAU[2]	113.32	19.53	11.73	66.26	5.06	24.28
	5YP[3]	116.39	19.59	14.76	26.10	2.07	-51.04
	BTO[4]	116.36	19.59	14.73	25.03	1.98	-53.06
	INIT[1]	91.17	13.45	-10.11	52.39	3.43	-1.73

RCP 8.5 2030	BAU[2]	87.40	13.38	-13.82	59.44	3.92	11.50
	5YP[3]	90.39	13.44	-10.87	23.31	1.61	-56.29
	BTO[4]	90.37	13.43	-10.90	22.35	1.53	-58.07
RCP 8.5 2050	INIT[1]	99.47	13.95	-1.92	55.34	3.60	3.79
	BAU[2]	95.66	13.88	-5.68	62.81	4.12	17.82
	5YP[3]	98.68	13.93	-2.70	24.68	1.68	-53.70
	BTO[4]	98.66	13.93	-2.73	23.67	1.61	-55.61
RCP 8.5 2070	INIT[1]	103.51	17.02	2.06	57.44	4.33	7.73
	BAU[2]	99.68	16.94	-1.71	65.22	4.96	22.33
	5YP[3]	102.72	16.99	1.28	25.67	2.03	-51.85
	BTO[4]	102.69	16.99	1.25	24.61	1.94	-53.84

[1] INIT: Initial land use in the year 2015. [2] BAU: Business-As-Usual, further rubber expansion based on past expansion rates in the study area. [3] 5YP: 5-Years-Plan, restricted rubber expansion combined with reforestation of bushland areas, high altitude/steep-slope rubber plantations. [4] BTO: Balanced-Trade-Offs, includes all measures of 5YP and reduced herbicide application for rubber plantations, water source protection areas and riverine buffer zones.

2) Water yield and evapotranspiration

Table S2. Simulation results of the InVEST water yield model for the land use scenarios and each General Circulation Model (GCM) in Nabanhe Reserve.

	Water Yield (mm)											
	2030				**2050**				**2070**			
	INIT	**BAU**	**5YP**	**BTO**	**INIT**	**BAU**	**5YP**	**BTO**	**INIT**	**BAU**	**5YP**	**BTO**
ac 4.5	351	338	348	348	379	366	376	376	388	375	386	386
bc 4.5	348	335	345	345	395	382	393	393	484	471	481	481
cc 4.5	387	374	384	384	391	378	389	388	329	316	326	326
gf 4.5	305	292	302	302	410	397	407	407	518	504	515	515
he 4.5	401	388	398	398	436	423	433	433	454	440	451	451
ip 4.5	336	323	333	333	286	273	283	283	313	301	311	311
mg 4.5	366	353	363	363	387	374	384	384	468	454	465	465
mp 4.5	358	346	356	356	393	380	391	391	423	410	420	420
no 4.5	421	408	418	418	432	418	429	429	524	510	521	521
ac 8.5	310	298	308	308	370	357	367	367	360	347	357	357
bc 8.5	351	339	349	349	441	428	439	438	463	450	460	460
cc 8.5	399	386	396	396	388	375	385	385	425	412	423	422
gf 8.5	355	342	352	352	360	347	357	357	393	380	390	390
he8.5	317	305	315	315	344	332	342	342	340	327	337	337
ip 8.5	233	221	231	231	255	243	253	253	252	240	250	249
mg 8.5	304	291	301	301	336	323	333	333	344	331	341	341
mp 8.5	371	358	368	368	399	386	397	396	421	408	418	418
no 8.5	397	384	394	394	419	406	417	416	450	436	447	447

GCM abbreviations are as follows: ACCESS1.0 (ac), BCC_CSM1.1 (bc), CCSM4 (cc), GFDL CM3 (gf), HadGEM2-ES (he), IPSL-CM5A-LR (ip), MRI-CGCM3 (mg), MPI-ESM-LR (mp), NorESM1-M (no).

Table S3. Results of a two-tailed, paired Student's t-test to determine significant differences between water yield model results. Green values indicate significant differences ($p<0.05$), red values indicate no significant difference ($p>0.05$).

p-values, Scenario comparison

RCP 4.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

p-values, Time slice comparison

INIT 4.5	2050	2070
2030	0.091	0.033
2050		0.042

BAU 4.5	2050	2070
2030	0.091	0.033
2050		0.042

5YP 4.5	2050	2070
2030	0.091	0.033
2050		0.042

BTO 4.5	2050	2070
2030	0.091	0.033
2050		0.042

INIT 8.5	2050	2070
2030	0.014	0.001
2050		0.038

BAU 8.5	2050	2070
2030	0.014	0.001
2050		0.037

5YP 8.5	2050	2070
2030	0.014	0.001
2050		0.038

BTO 8.5	2050	2070
2030	0.014	0.001
2050		0.038

p-values, RCP comparison

INIT 2030	0.158
INIT 2050	0.139
INIT 2070	0.068
BAU 2030	0.158
BAU 2050	0.139
BAU 2070	0.068
5YP 2030	0.158
5YP 2050	0.139
5YP 2070	0.068
BTO 2030	0.158
BTO 2050	0.139
BTO 2070	0.068

Table S4. Simulation results for evapotranspiration for the land use scenarios and each GCM in Nabanhe Reserve.

	Evapotranspiration (mm)											
	2030				2050				2070			
	INIT	BAU	5YP	BTO	INIT	BAU	5YP	BTO	INIT	BAU	5YP	BTO
ac 4.5	1,114	1,116	1,114	1,114	1,144	1,147	1,145	1,145	1,147	1,150	1,148	1,148
bc 4.5	1,109	1,111	1,109	1,109	1,124	1,127	1,125	1,125	1,146	1,149	1,147	1,147
cc 4.5	1,117	1,119	1,117	1,117	1,125	1,127	1,126	1,126	1,125	1,127	1,126	1,126
gf 4.5	1,103	1,104	1,103	1,103	1,153	1,155	1,153	1,153	1,156	1,159	1,157	1,157
he 4.5	1,110	1,113	1,111	1,111	1,125	1,127	1,125	1,125	1,140	1,143	1,141	1,141
ip 4.5	1,102	1,104	1,102	1,102	1,104	1,106	1,105	1,105	1,117	1,119	1,117	1,117
mg 4.5	1,101	1,103	1,101	1,101	1,112	1,114	1,112	1,112	1,135	1,138	1,136	1,136
mp 4.5	1,075	1,077	1,075	1,075	1,094	1,096	1,094	1,094	1,099	1,102	1,100	1,100
no 4.5	1,123	1,126	1,124	1,124	1,143	1,146	1,144	1,144	1,160	1,163	1,161	1,161
ac 8.5	1,104	1,106	1,105	1,105	1,146	1,148	1,146	1,146	1,165	1,167	1,165	1,165
bc 8.5	1,115	1,117	1,115	1,115	1,147	1,150	1,148	1,148	1,176	1,179	1,177	1,177
cc 8.5	1,125	1,127	1,125	1,125	1,142	1,144	1,143	1,143	1,173	1,176	1,174	1,174
gf 8.5	1,114	1,116	1,114	1,114	1,142	1,145	1,143	1,143	1,171	1,173	1,171	1,171
he8.5	1,097	1,099	1,098	1,098	1,119	1,121	1,119	1,119	1,142	1,144	1,142	1,142
ip 8.5	1,075	1,077	1,075	1,075	1,096	1,098	1,097	1,097	1,118	1,120	1,118	1,118
mg 8.5	1,084	1,086	1,084	1,084	1,103	1,105	1,103	1,103	1,124	1,126	1,125	1,125
mp 8.5	1,123	1,125	1,123	1,123	1,150	1,153	1,151	1,151	1,179	1,182	1,180	1,180
no 8.5	1,124	1,127	1,125	1,125	1,148	1,150	1,148	1,148	1,176	1,179	1,177	1,177

GCM abbreviations are as follows: ACCESS1.0 (ac), BCC_CSM1.1 (bc), CCSM4 (cc), GFDL CM3 (gf), HadGEM2-ES (he), IPSL-CM5A-LR (ip), MRI-CGCM3 (mg), MPI-ESM-LR (mp), NorESM1-M (no).

Table S5. Results of a two-tailed, paired Student's *t*-test to determine significant differences between evapotranspiration model results. Green values indicate significant differences ($p < 0.05$), red values indicate no significant difference ($p > 0.05$).

p-values, Scenario comparison

RCP 4.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

p-values, Time slice comparison

INIT 4.5	2050	2070
2030	0.004	0.000
2050		0.004

BAU 4.5	2050	2070
2030	0.004	0.000
2050		0.004

5YP 4.5	2050	2070
2030	0.004	0.000
2050		0.004

BTO 4.5	2050	2070
2030	0.004	0.000
2050		0.004

INIT 8.5	2050	2070
2030	0.000	0.000
2050		0.000

BAU 8.5	2050	2070
2030	0.000	0.000
2050		0.000

5YP 8.5	2050	2070
2030	0.000	0.000
2050		0.000

BTO 8.5	2050	2070
2030	0.000	0.000
2050		0.000

p-values, RCP comparison

INIT 2030	0.902
INIT 2050	0.317
INIT 2070	0.045
BAU 2030	0.917
BAU 2050	0.326
BAU 2070	0.048
5YP 2030	0.906
5YP 2050	0.320
5YP 2070	0.046
BTO 2030	0.906
BTO 2050	0.320
BTO 2070	0.046

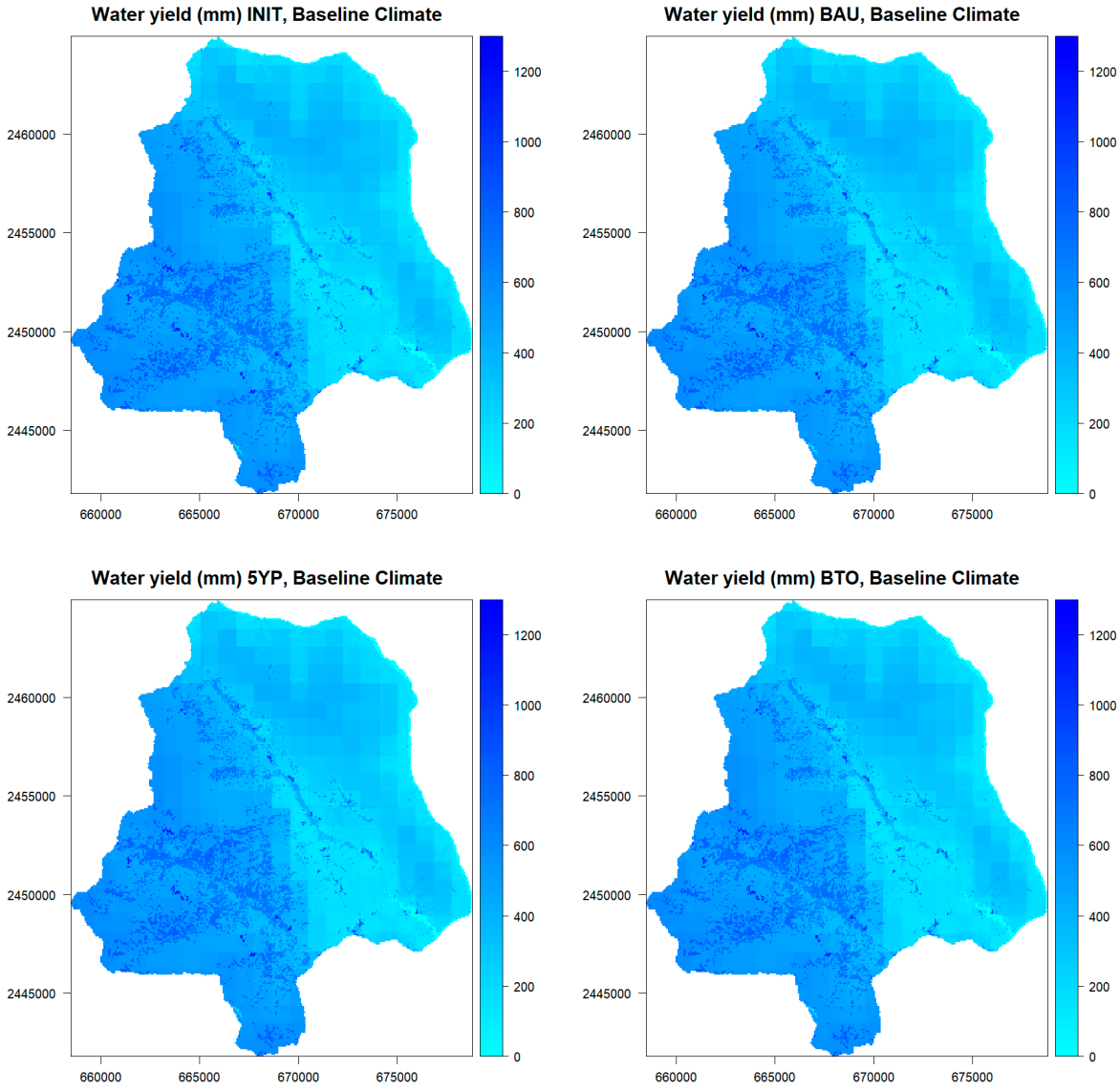

Figure S1. Water yield results for every land use scenario and the baseline climate data. INIT: Initial land use in 2015, BAU: Business-As-Usual, 5YP: 5-Years-Plan, BTO: Balanced-Trade-Offs.

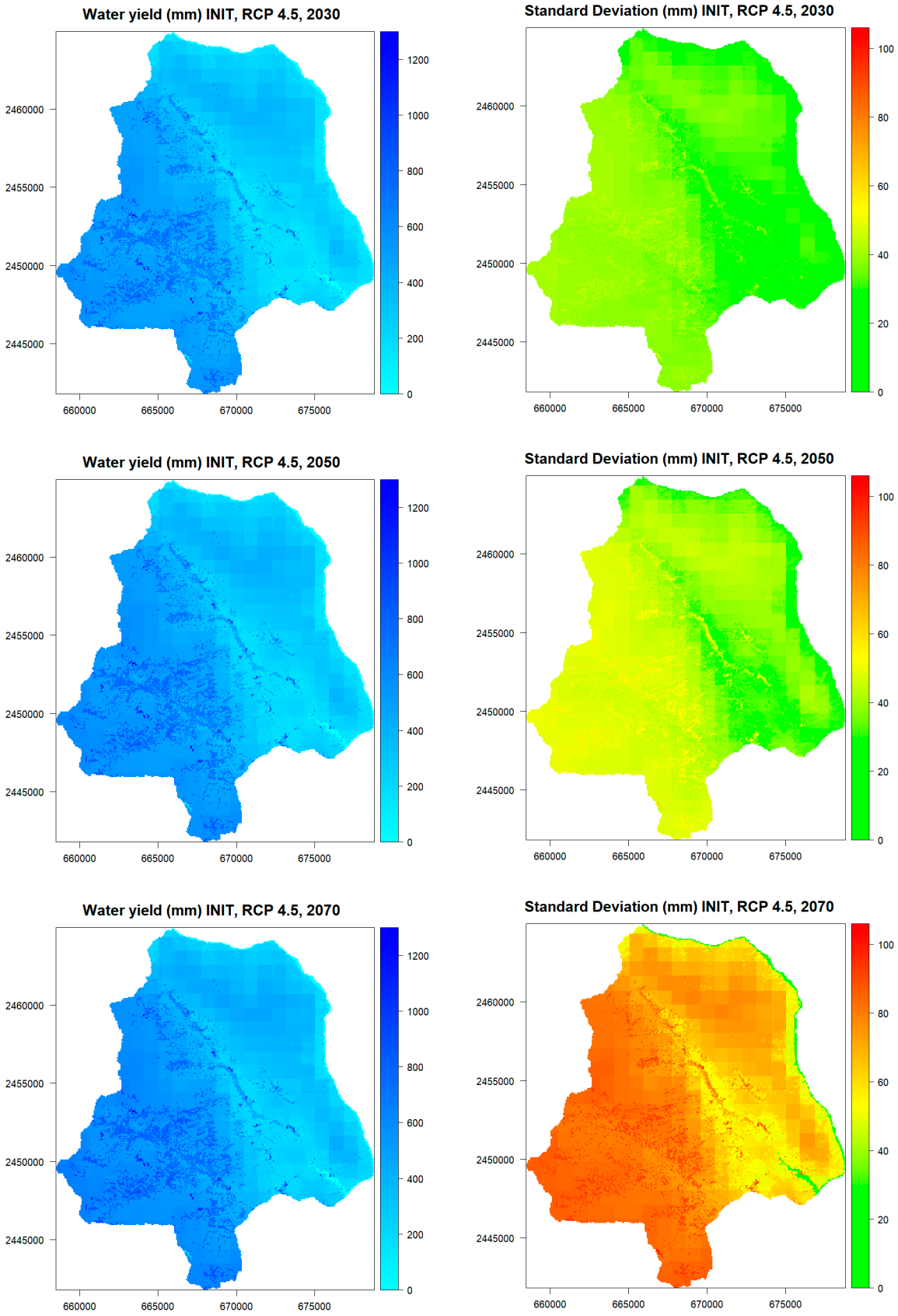

Figure S2. Water yield and standard deviation results in Nabanhe Reserve for the initial land use in 2015 (INIT) under RCP 4.5 climate data.

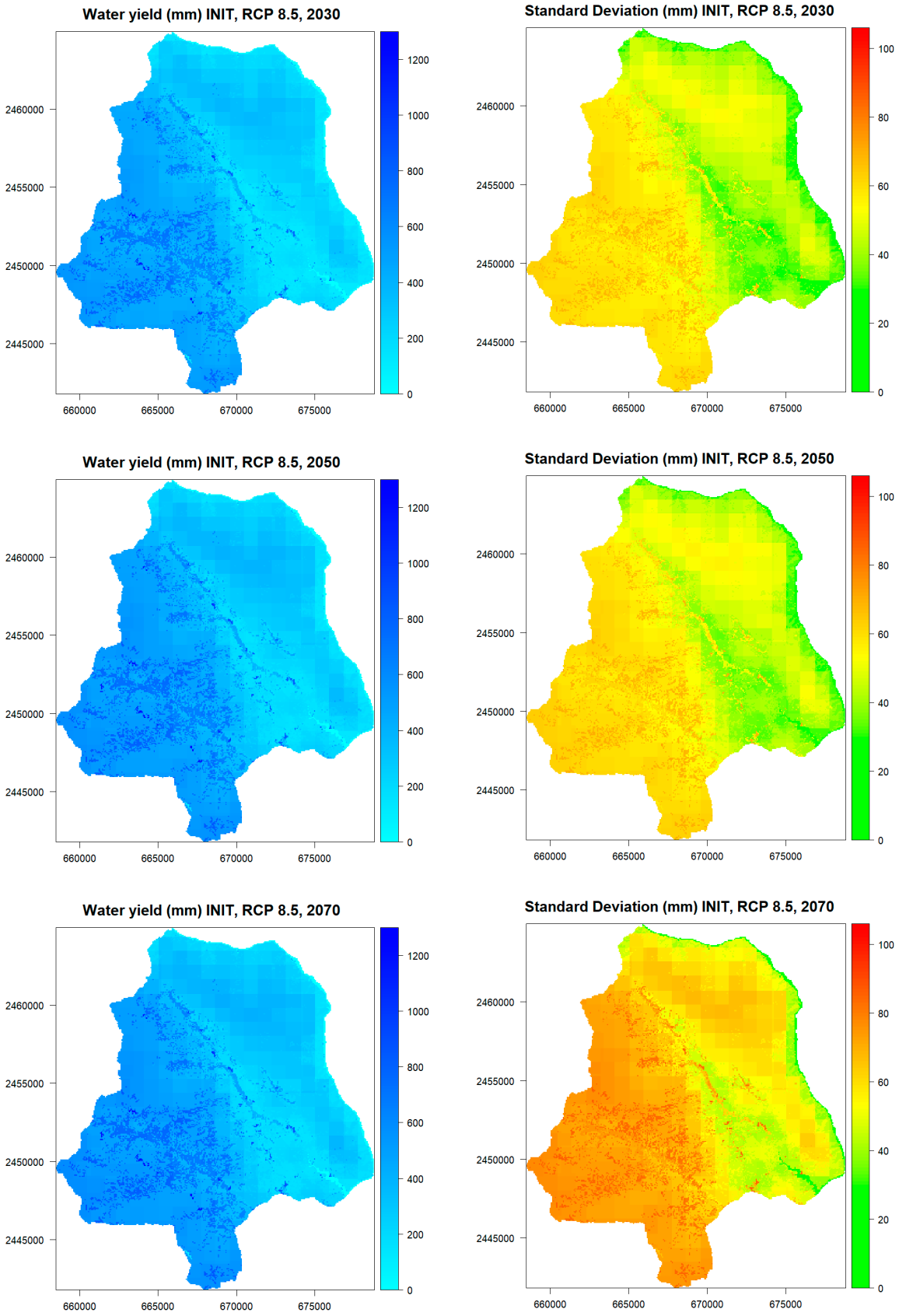

Figure S3. Water yield and standard deviation results in Nabanhe Reserve for the initial land use in 2015 (INIT) under RCP 8.5 climate data.

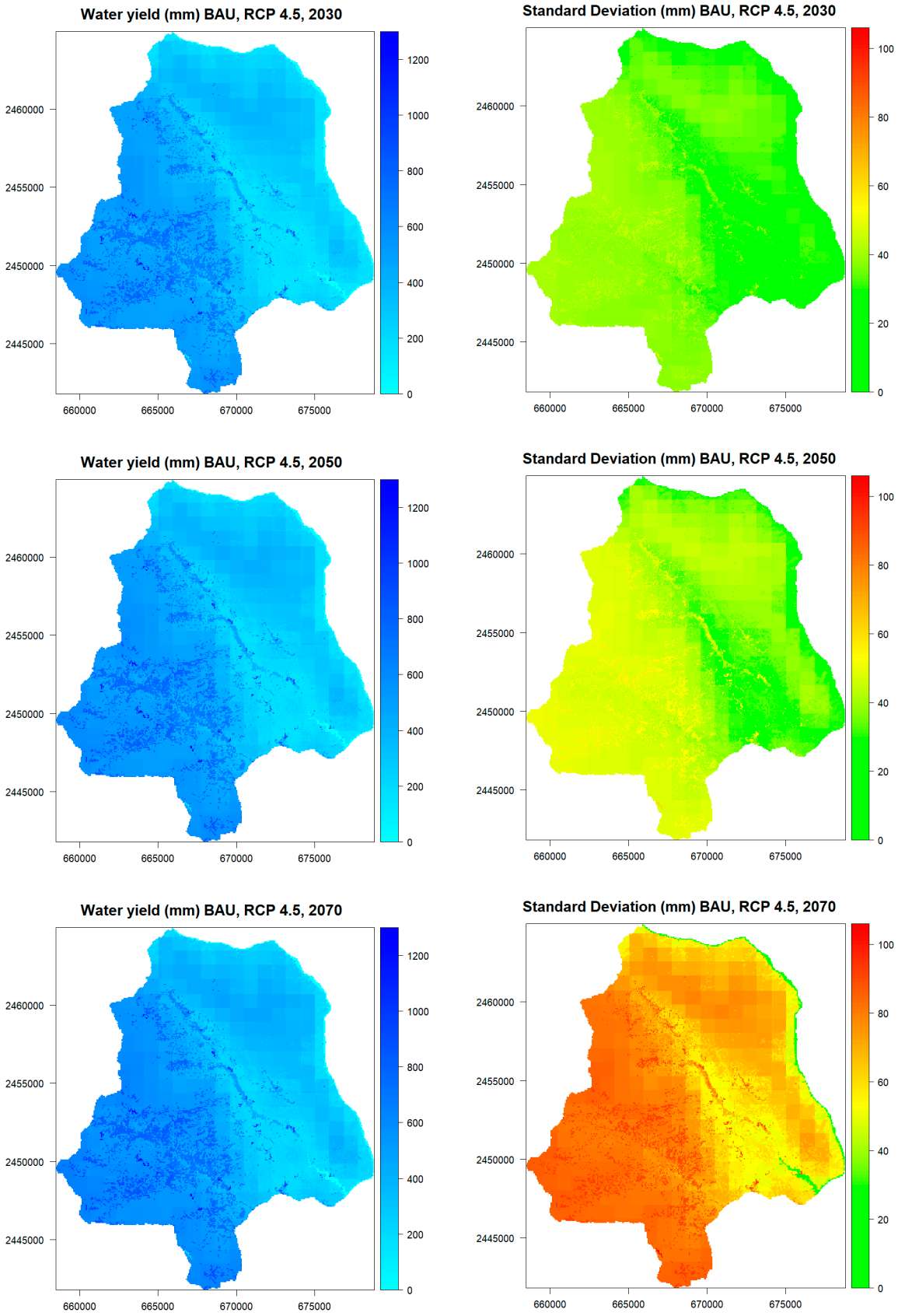

Figure S4. Water yield and standard deviation results in Nabanhe Reserve for the Business-As-Usual scenario (BAU) under RCP 4.5 climate data.

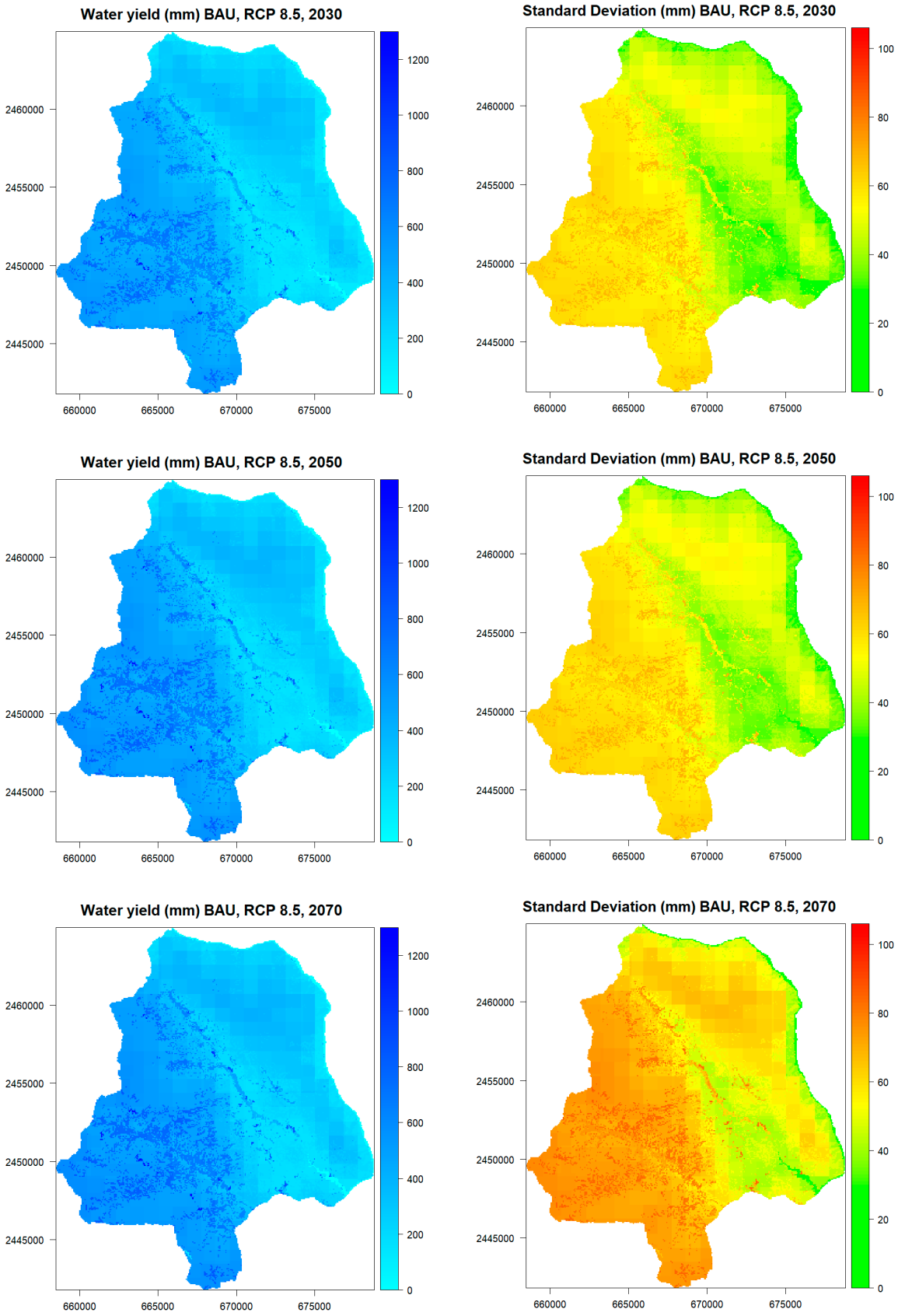

Figure S5. Water yield and standard deviation results in Nabanhe Reserve for the Business-As-Usual scenario (BAU) under RCP 8.5 climate data.

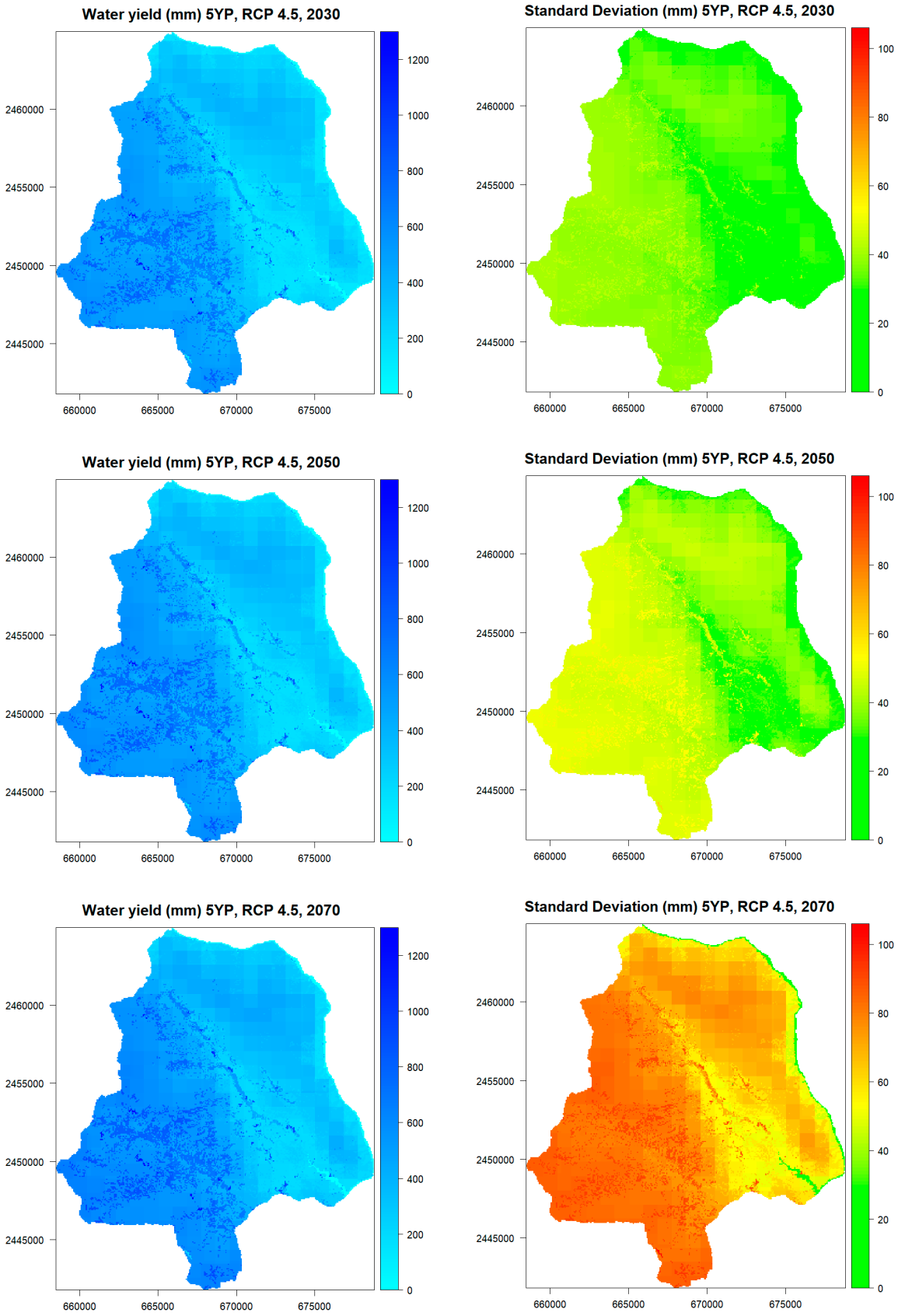

Figure S6. Water yield and standard deviation results in Nabanhe Reserve for the 5-Years-Plan scenario (5YP) under RCP 4.5 climate data.

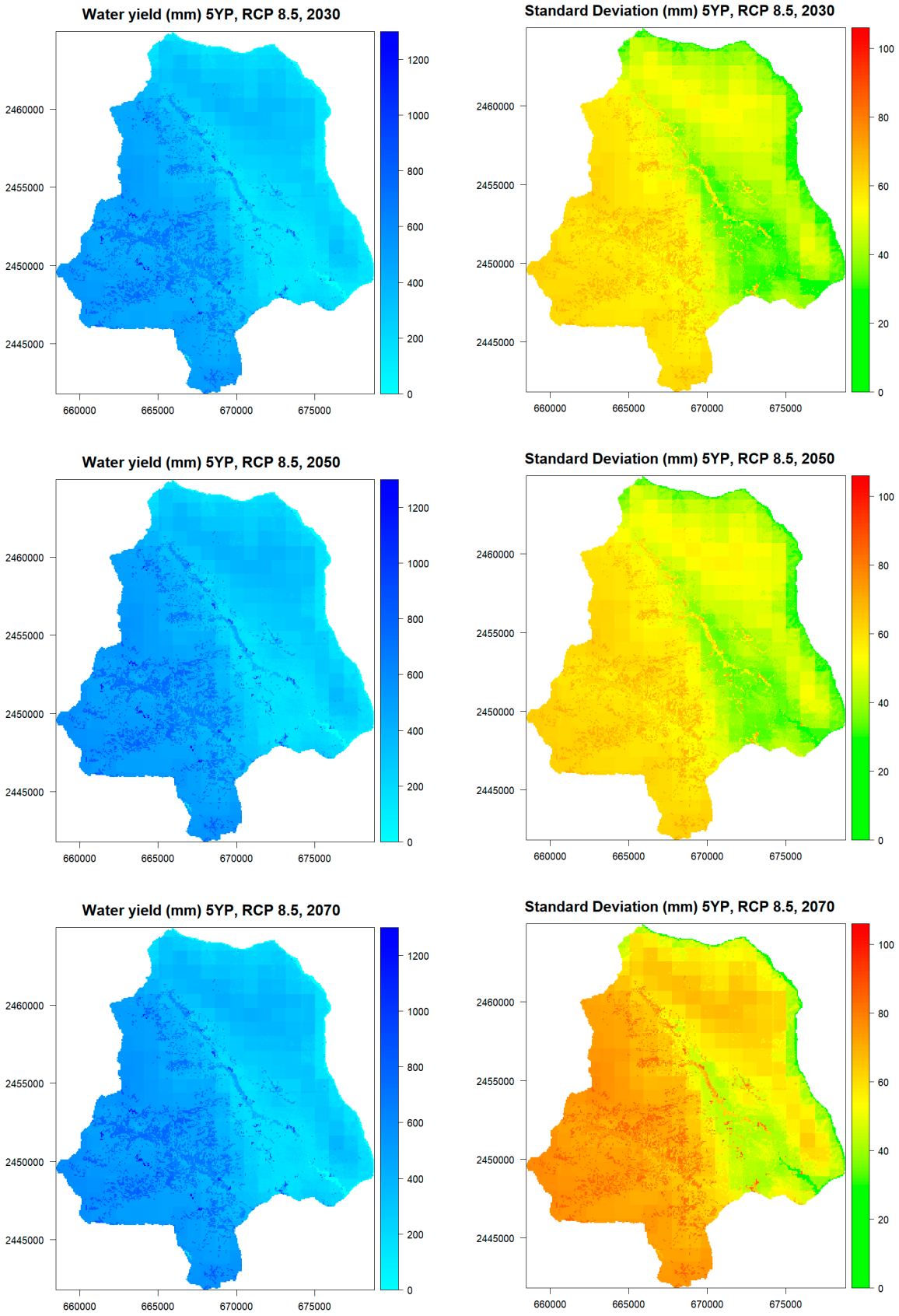

Figure S7. Water yield and standard deviation results in Nabanhe Reserve for the 5-Years-Plan scenario (5YP) under RCP 8.5 climate data.

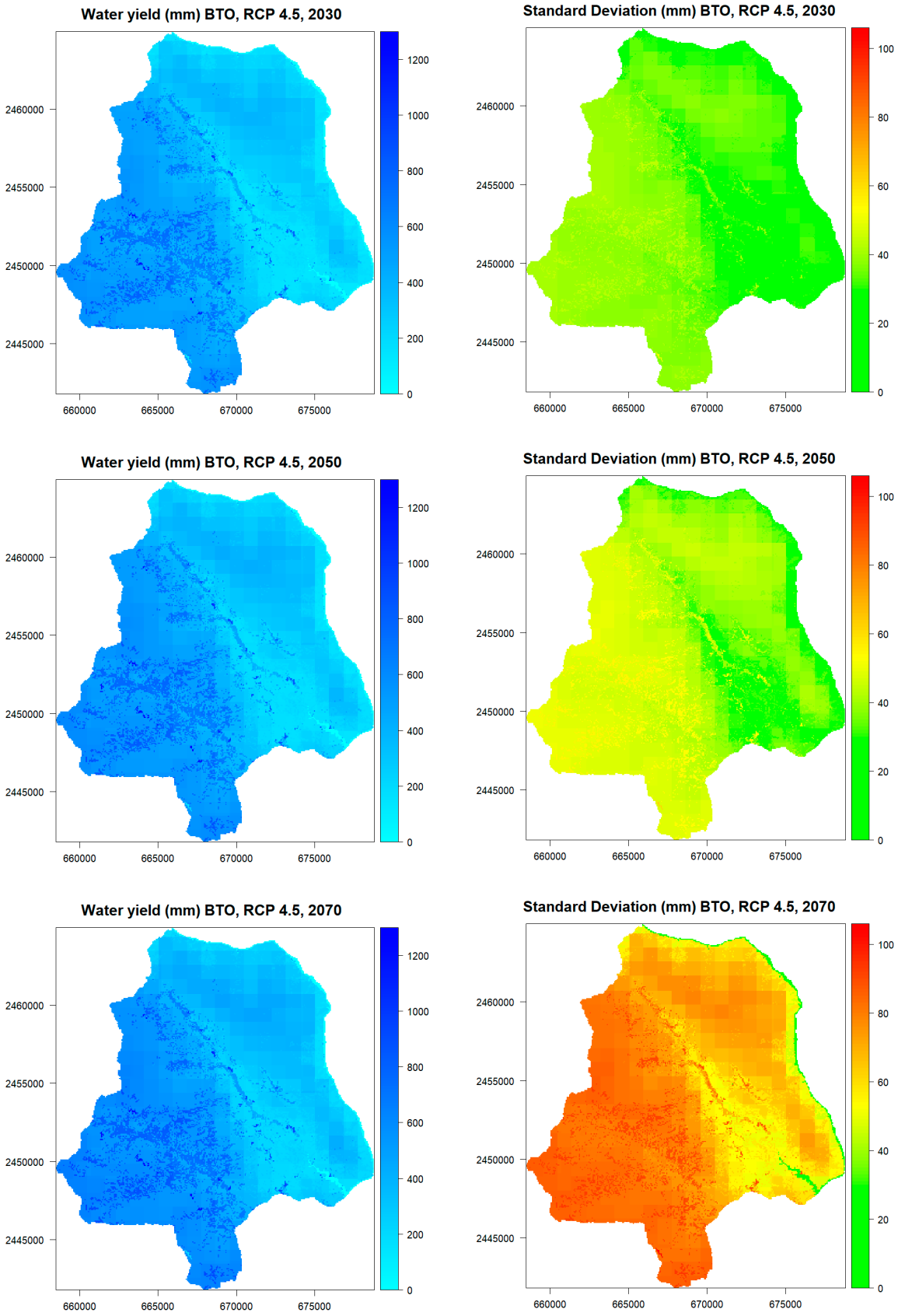

Figure S8. Water yield and standard deviation results in Nabanhe Reserve for the Balanced-Trade-Offs scenario (BTO) under RCP 4.5 climate data.

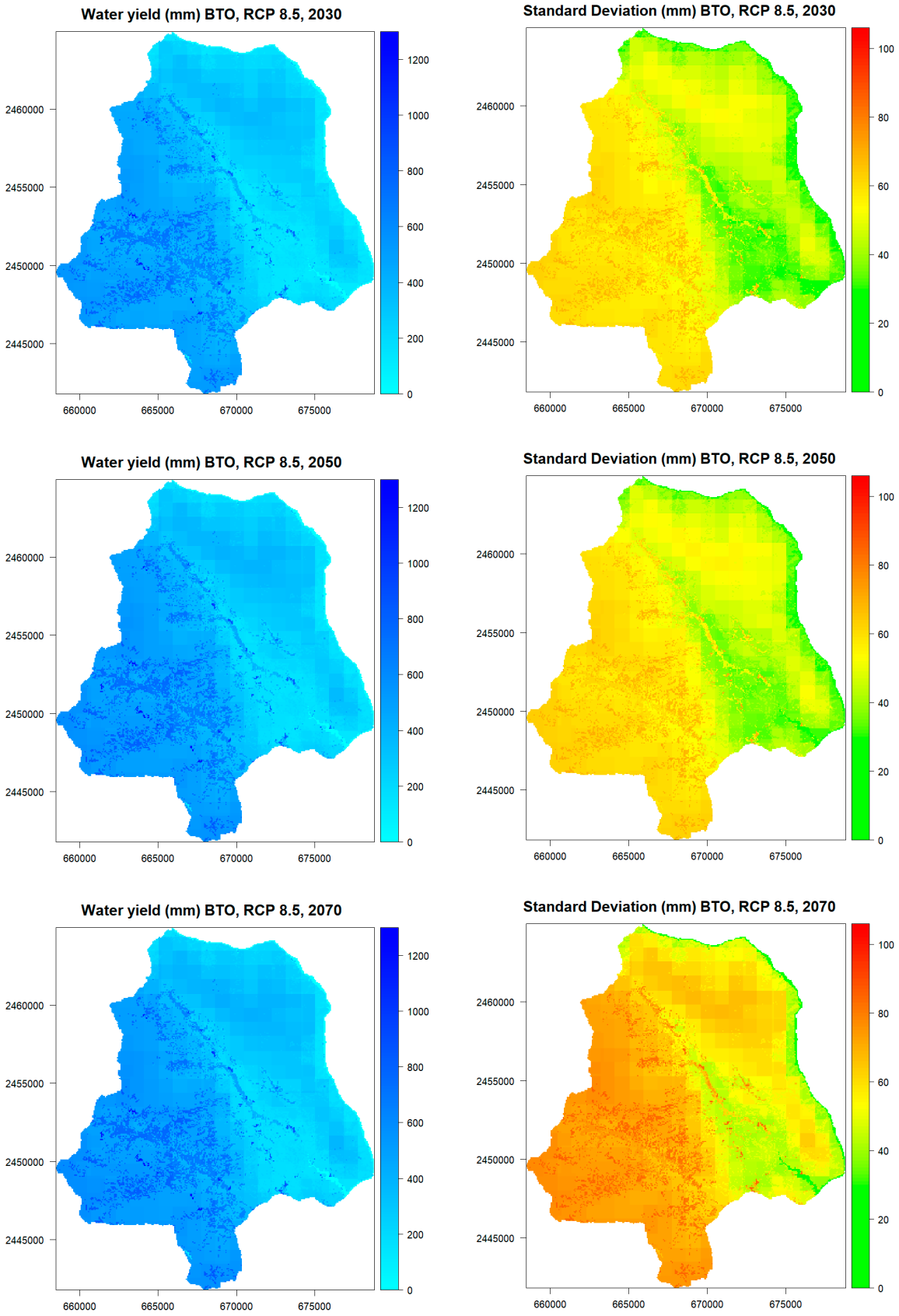

Figure S9. Water yield and standard deviation results in Nabanhe Reserve for the Balanced-Trade-Offs scenario (BTO) under RCP 8.5 climate data.

3) Sediment export

Table S6. Simulation results for sediment export for the land use scenarios and each GCM in Nabanhe Reserve.

	Sediment Export (10^3 t)											
	2030				**2050**				**2070**			
	INIT	**BAU**	**5YP**	**BTO**	**INIT**	**BAU**	**5YP**	**BTO**	**INIT**	**BAU**	**5YP**	**BTO**
ac 4.5	53.31	60.50	23.81	22.87	53.31	60.50	23.81	22.87	53.31	60.50	23.81	22.87
bc 4.5	53.43	60.64	23.79	22.82	56.51	64.16	25.23	24.19	57.21	64.96	25.55	24.50
cc 4.5	53.06	60.22	23.62	22.65	56.27	63.89	25.14	24.10	62.00	70.35	27.75	26.61
gf 4.5	55.44	62.94	24.74	23.72	56.17	63.77	25.07	24.04	52.91	60.03	23.54	22.58
he 4.5	50.50	57.28	22.41	21.50	58.55	66.50	26.20	25.11	64.33	73.12	28.91	27.70
ip 4.5	55.84	63.39	24.92	23.90	58.47	66.40	26.15	25.07	60.19	68.37	26.96	25.84
mg 4.5	52.11	59.11	23.16	22.21	49.64	56.29	21.99	21.10	51.62	58.58	22.98	22.04
mp 4.5	53.63	60.86	23.87	22.89	55.26	62.72	24.64	23.62	60.73	68.98	27.19	26.06
no 4.5	51.89	58.86	23.05	22.11	54.67	62.05	24.36	23.36	56.46	64.11	25.21	24.17
ac 8.5	50.91	57.74	22.60	21.68	56.20	63.79	25.06	24.03	56.63	64.29	25.27	24.23
bc 8.5	53.55	60.76	23.84	22.86	59.86	68.00	26.81	25.70	62.47	70.98	28.04	26.88
cc 8.5	56.43	64.07	25.22	24.18	56.85	64.54	25.39	24.35	60.38	68.59	27.05	25.93
gf 8.5	53.70	60.94	23.92	22.94	55.43	62.92	24.72	23.71	58.63	66.59	26.23	25.14
he8.5	50.89	57.72	22.58	21.66	53.41	60.60	23.77	22.80	54.23	61.54	24.18	23.18
ip 8.5	45.30	51.33	20.00	19.19	47.53	53.89	21.05	20.20	48.49	54.99	21.50	20.63
mg 8.5	49.40	56.01	21.91	21.02	52.13	59.14	23.17	22.23	53.74	60.98	23.91	22.93
mp 8.5	54.97	62.40	24.51	23.50	57.90	65.75	25.88	24.81	60.55	68.78	27.12	26.00
no 8.5	56.38	64.01	25.18	24.14	58.71	66.68	26.28	25.19	61.81	70.24	27.73	26.58

GCM abbreviations are as follows: ACCESS1.0 (ac), BCC_CSM1.1 (bc), CCSM4 (cc), GFDL CM3 (gf), HadGEM2-ES (he), IPSL-CM5A-LR (ip), MRI-CGCM3 (mg), MPI-ESM-LR (mp), NorESM1-M (no).

Table S7. Results of a two-tailed, paired Student's t-test to determine significant differences between sediment export model results. Green values indicate significant differences ($p<0.05$), red values indicate no significant difference ($p>0.05$).

p-values, Scenario comparison

RCP 4.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 4.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2030	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2050	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

RCP 8.5, 2070	BAU	5YP	BTO
INIT	0.000	0.000	0.000
BAU		0.000	0.000
5YP			0.000

p-values, Time slice comparison

INIT 4.5	2050	2070
2030	0.052	0.032
2050		0.060

BAU 4.5	2050	2070
2030	0.052	0.032
2050		0.060

5YP 4.5	2050	2070
2030	0.053	0.032
2050		0.059

BTO 4.5	2050	2070
2030	0.052	0.032
2050		0.059

INIT 8.5	2050	2070
2030	0.001	0.000
2050		0.001

BAU 8.5	2050	2070
2030	0.001	0.000
2050		0.001

5YP 8.5	2050	2070
2030	0.001	0.000
2050		0.001

BTO 8.5	2050	2070
2030	0.001	0.000
2050		0.001

p-values, RCP comparison

INIT 2030	0.575
INIT 2050	0.957
INIT 2070	0.927
BAU 2030	0.575
BAU 2050	0.957
BAU 2070	0.931
5YP 2030	0.573
5YP 2050	0.951
5YP 2070	0.928
BTO 2030	0.570
BTO 2050	0.948
BTO 2070	0.924

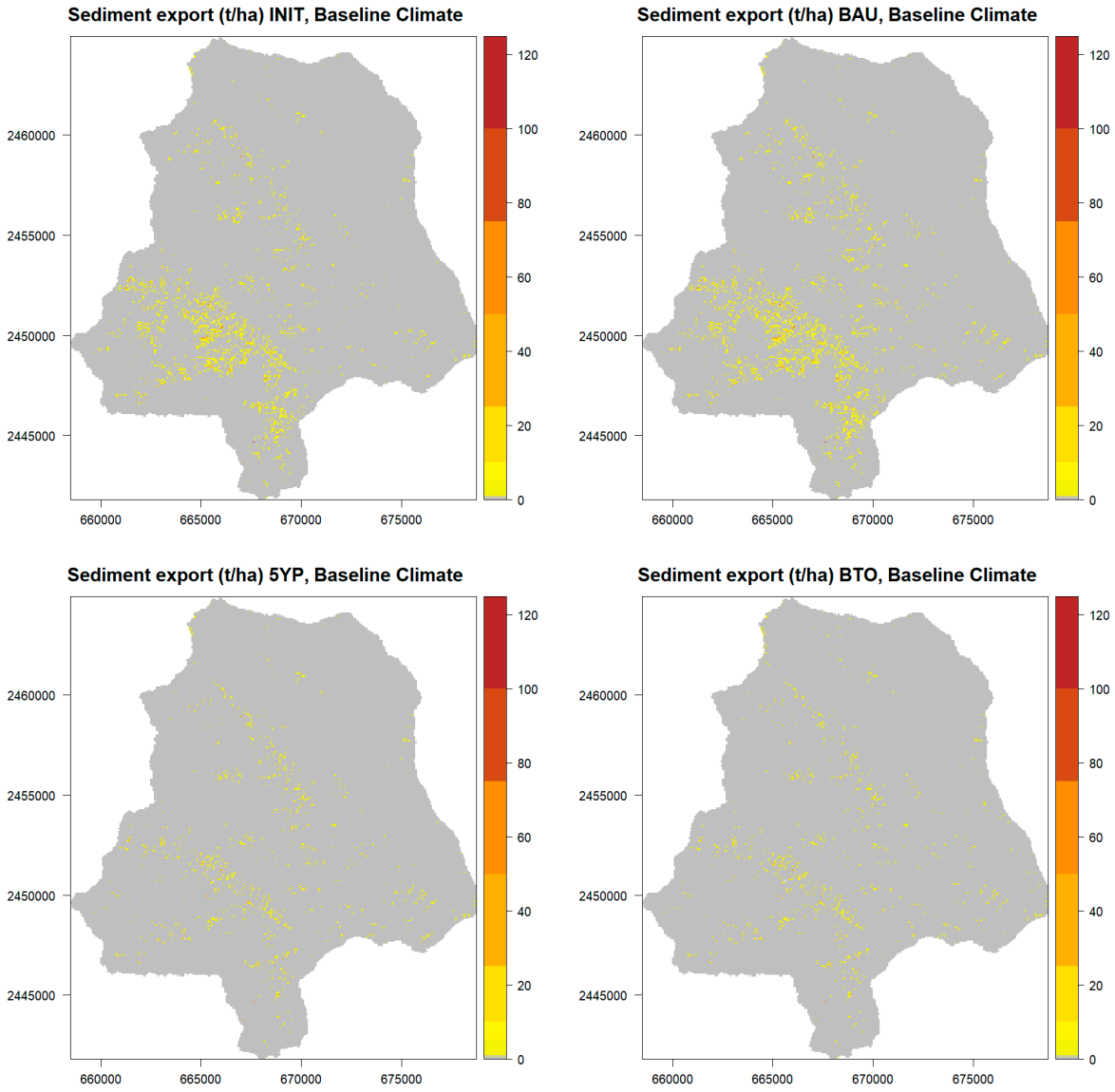

Figure S10. Sediment export results for every land use scenario and the baseline climate data. INIT: Initial land use in 2015, BAU: Business-As-Usual, 5YP: 5-Years-Plan, BTO: Balanced-Trade-Offs.

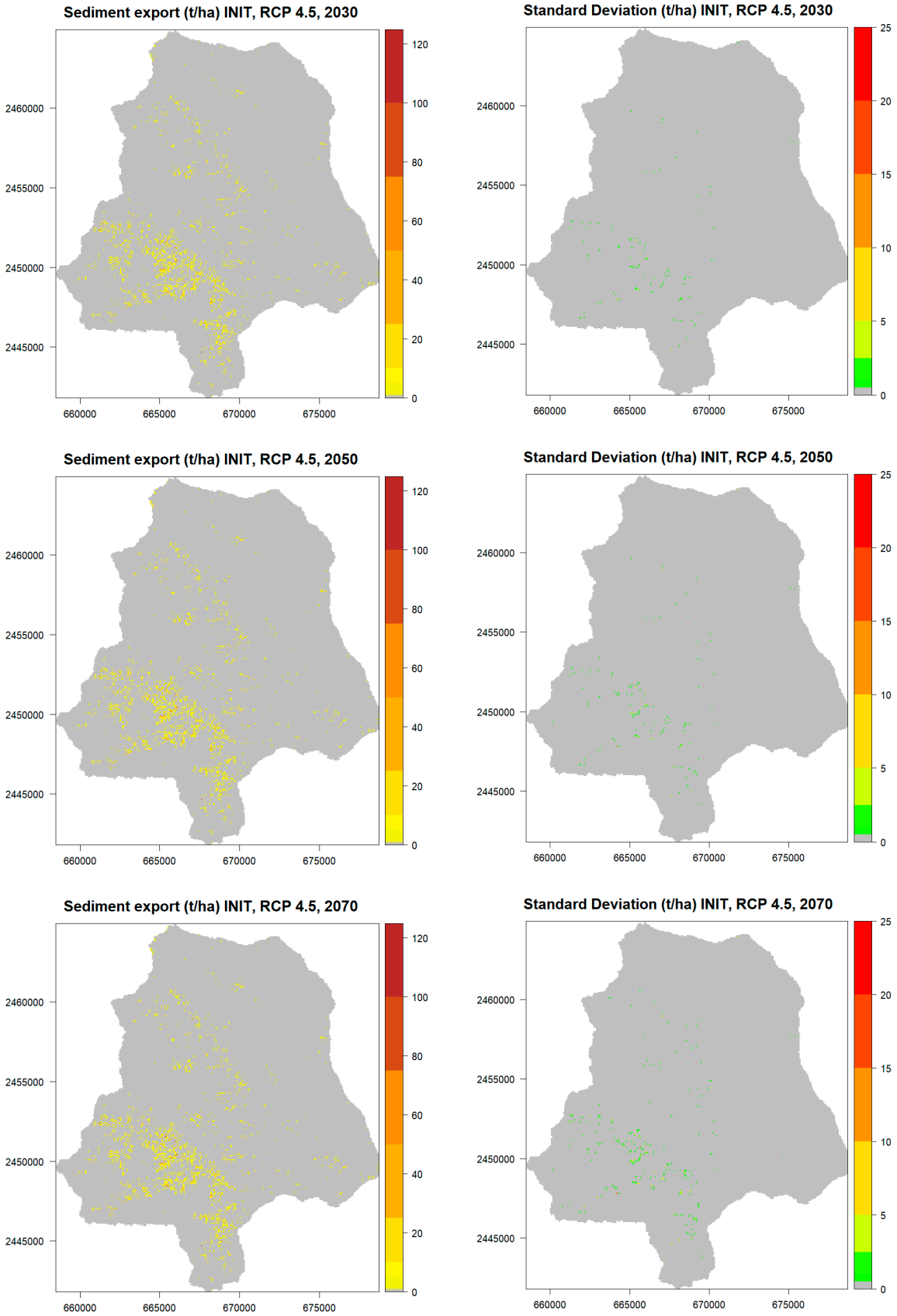

Figure S11. Sediment export and standard deviation results in Nabanhe Reserve for the initial land use (INIT) under RCP 4.5 climate data.

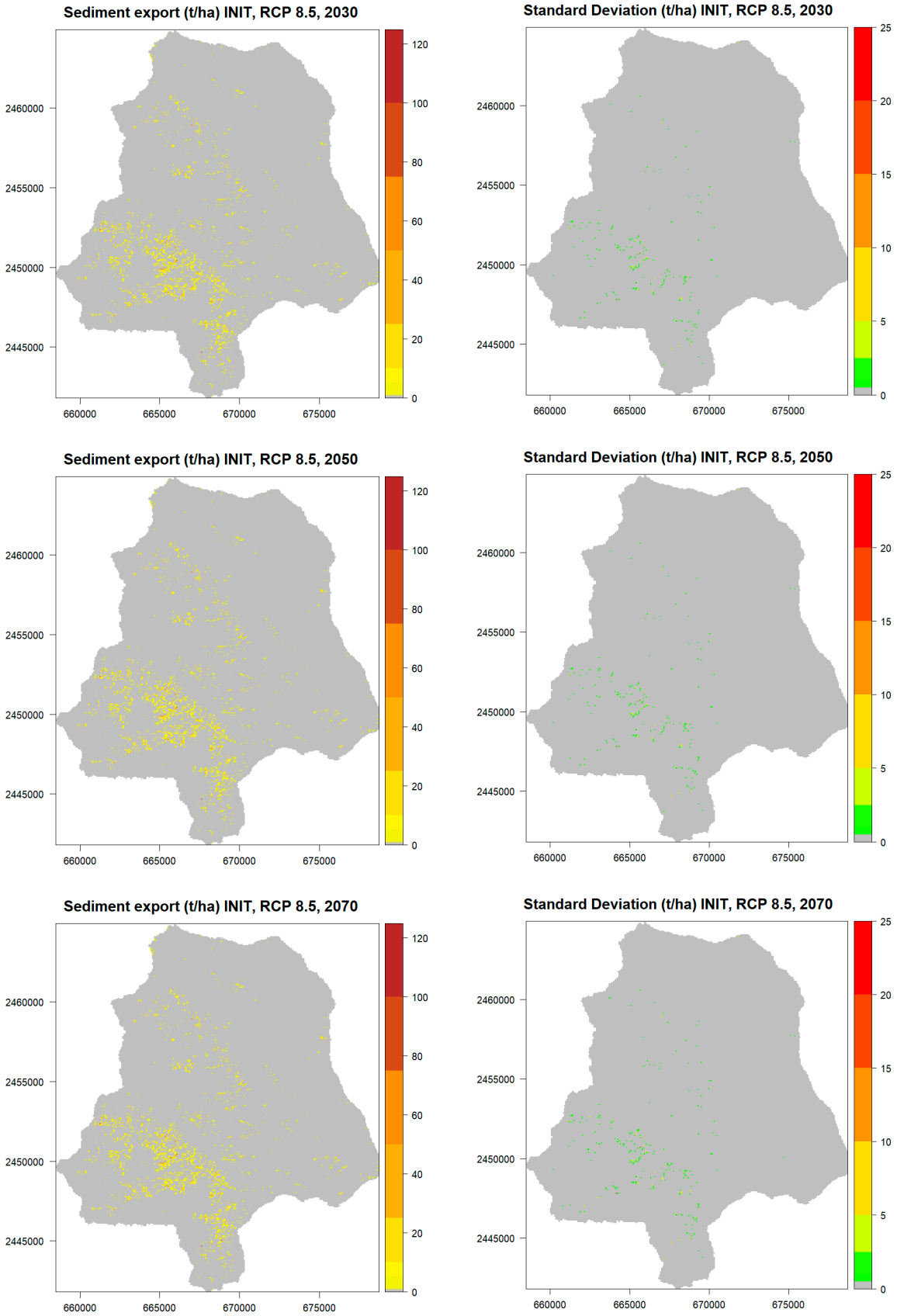

Figure S12. Sediment export and standard deviation results in Nabanhe Reserve for the initial land use (INIT) under RCP 8.5 climate data.

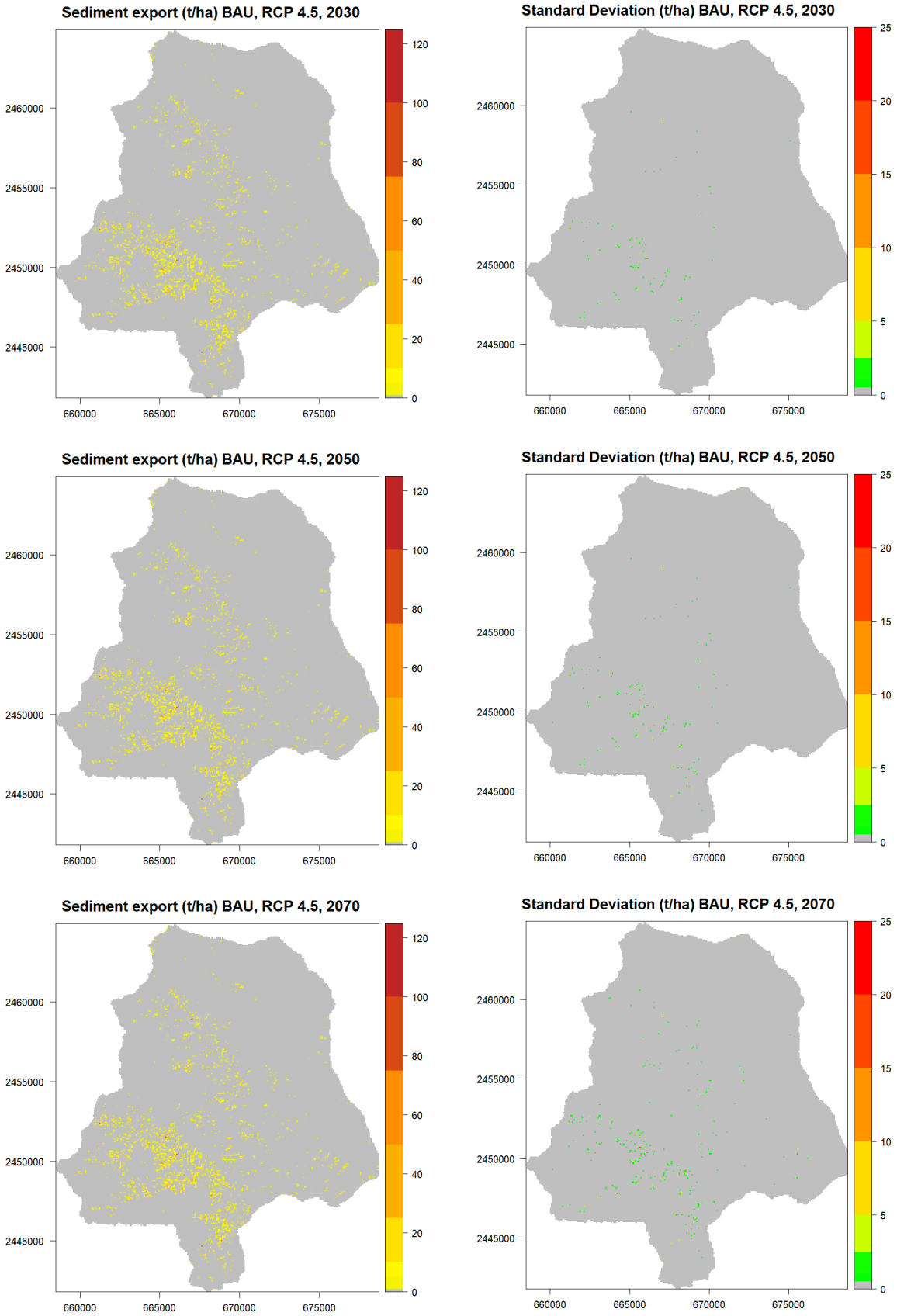

Figure S13. Sediment export and standard deviation results in Nabanhe Reserve for the Business-As-Usual scenario (BAU) under RCP 4.5 climate data.

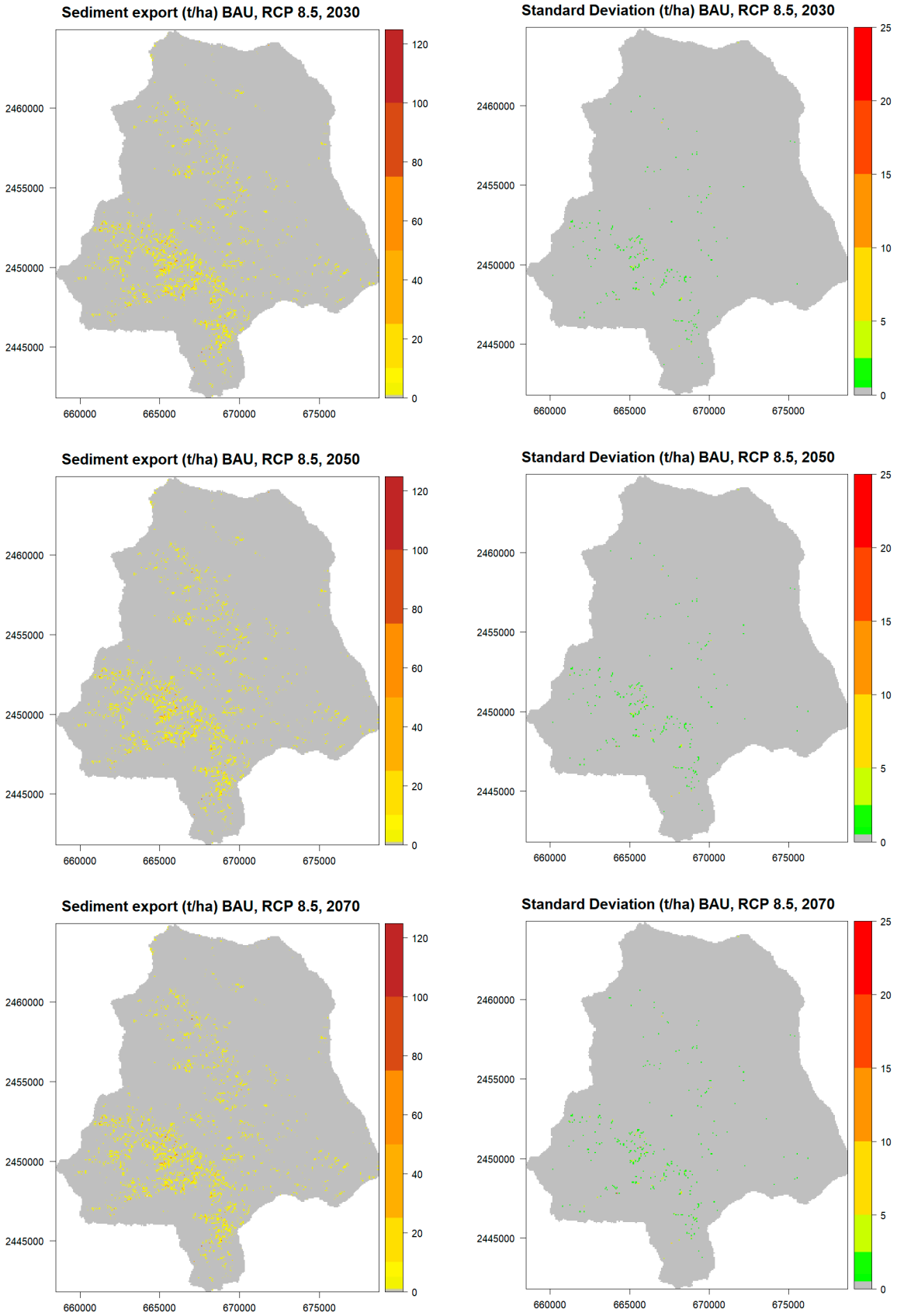

Figure S14. Sediment export and standard deviation results in Nabanhe Reserve for the Business-As-Usual scenario (BAU) under RCP 8.5 climate data.

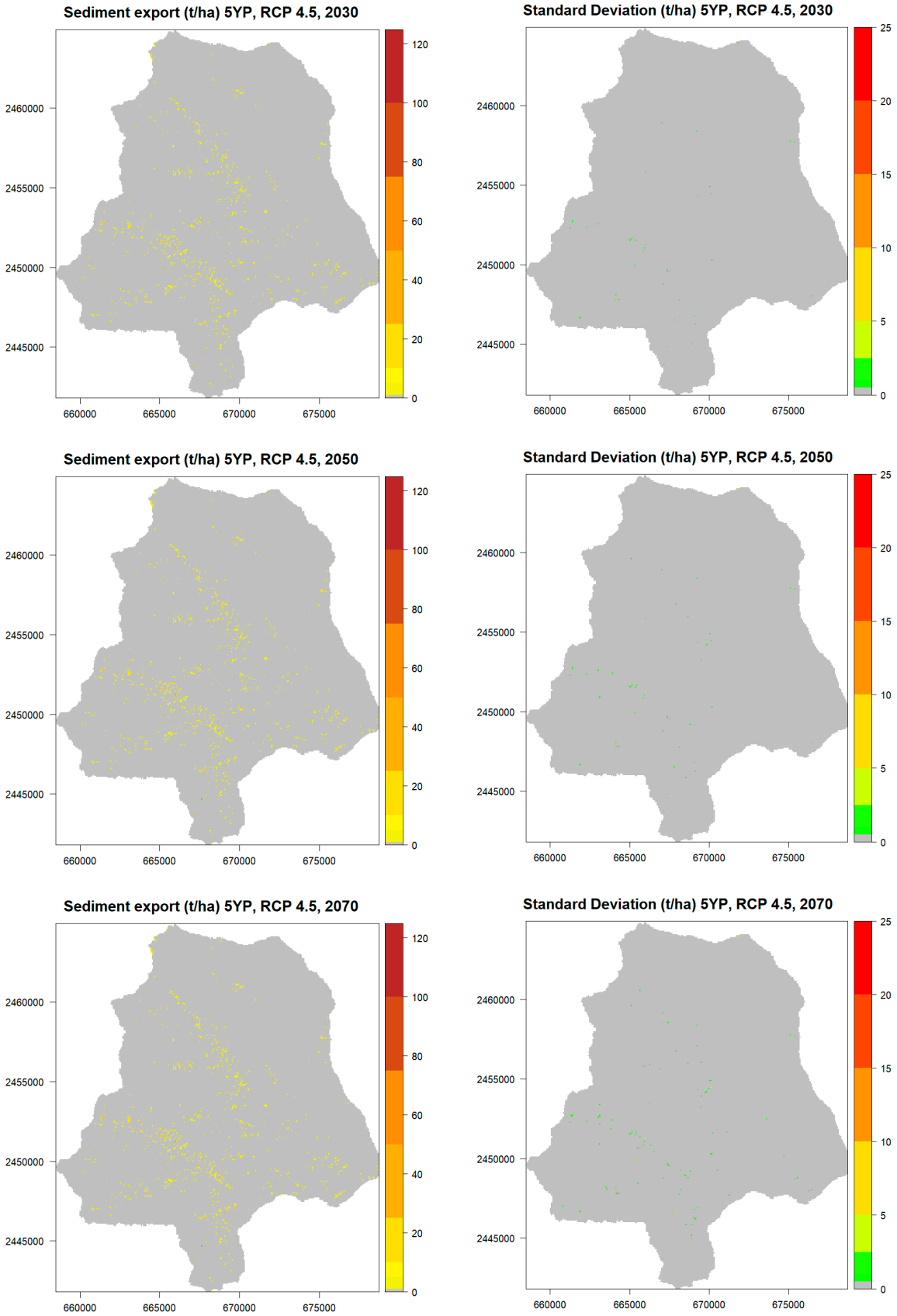

Figure S15. Sediment export and standard deviation results in Nabanhe Reserve for the 5-Years-Plan scenario (5YP) under RCP 4.5 climate data.

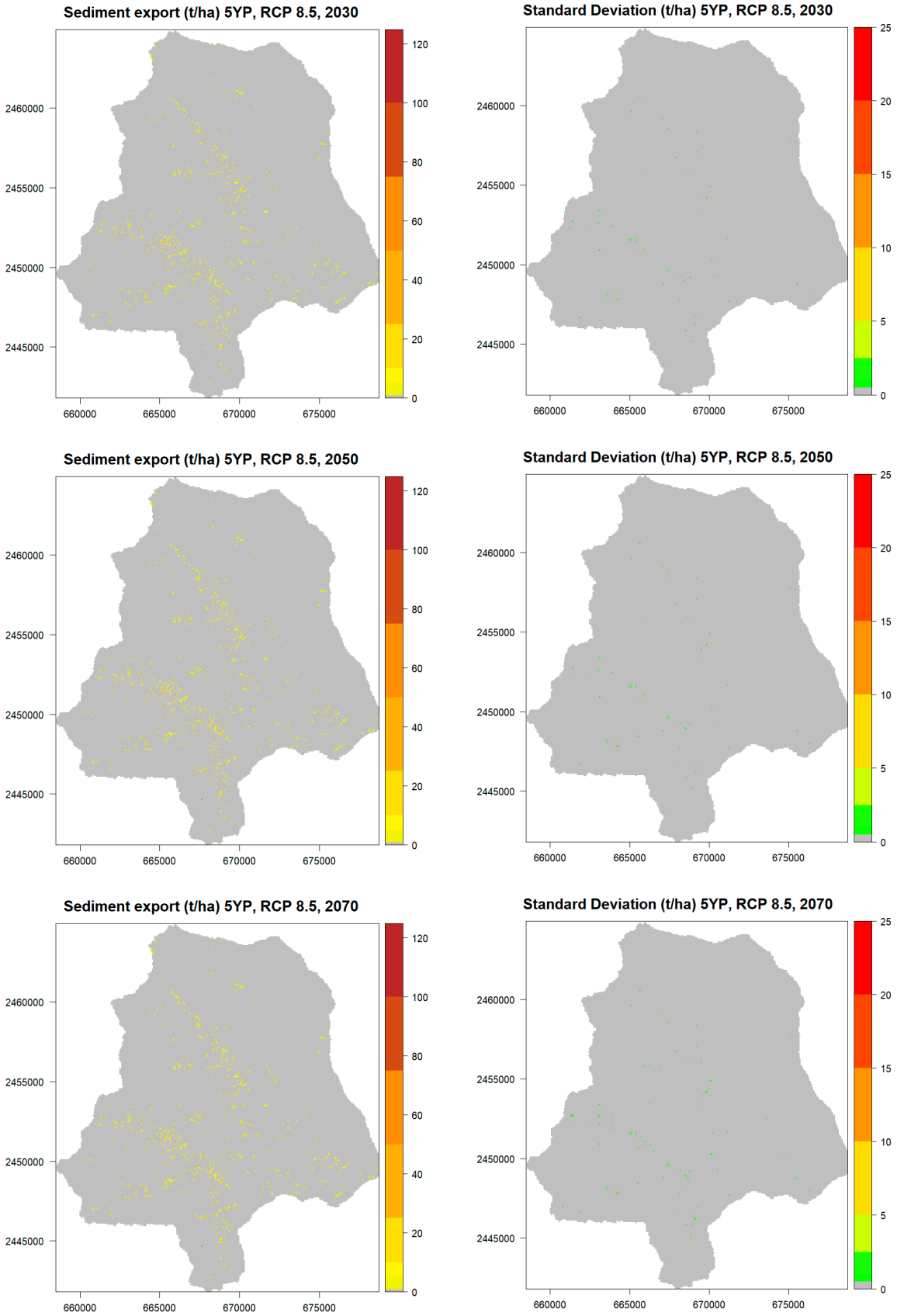

Figure S16. Sediment export and standard deviation results in Nabanhe Reserve for the 5-Years-Plan scenario (5YP) under RCP 8.5 climate data.

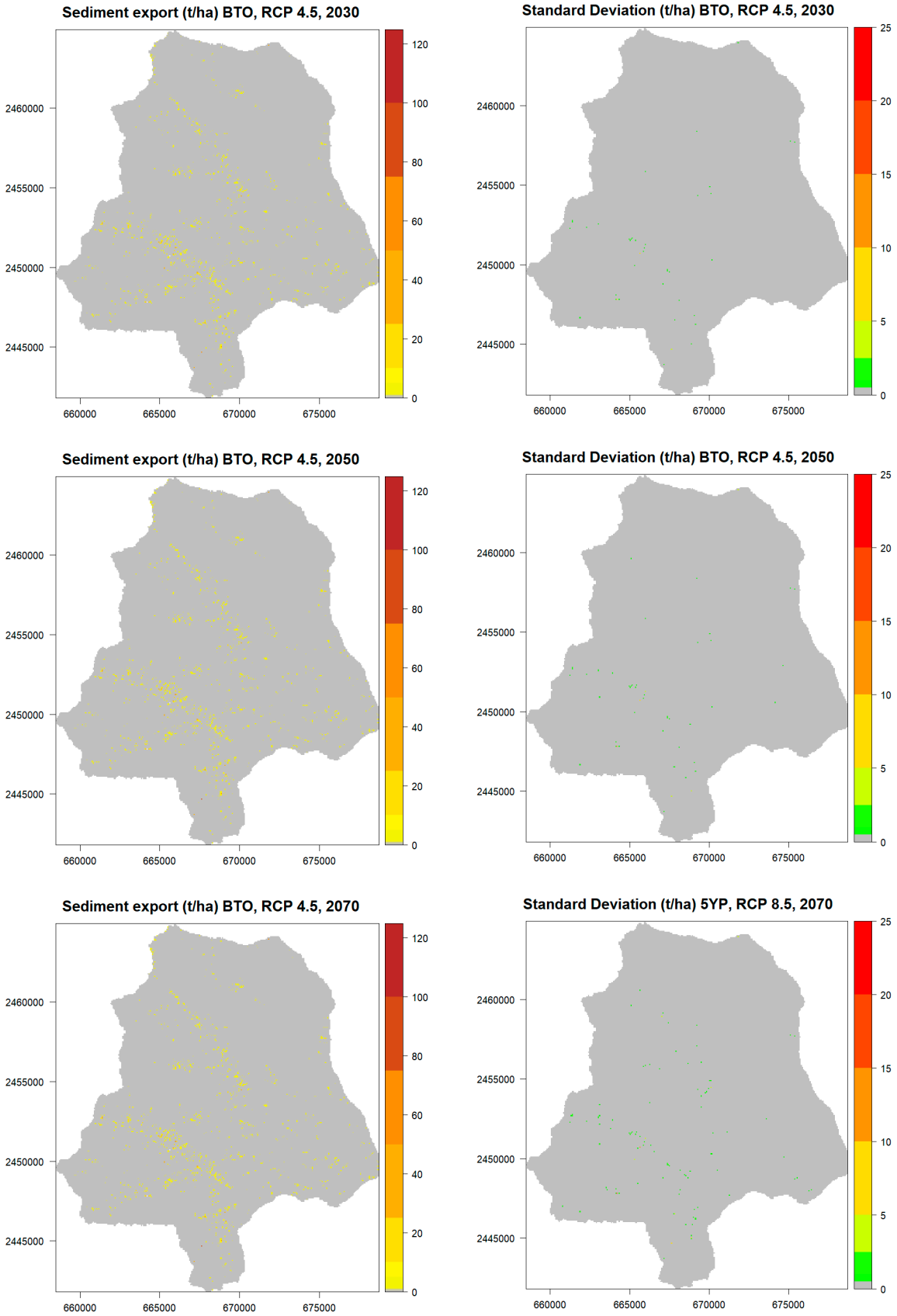

Figure S17. Sediment export and standard deviation results in Nabanhe Reserve for the Balanced-Trade-Offs scenario (BTO) under RCP 4.5 climate data.

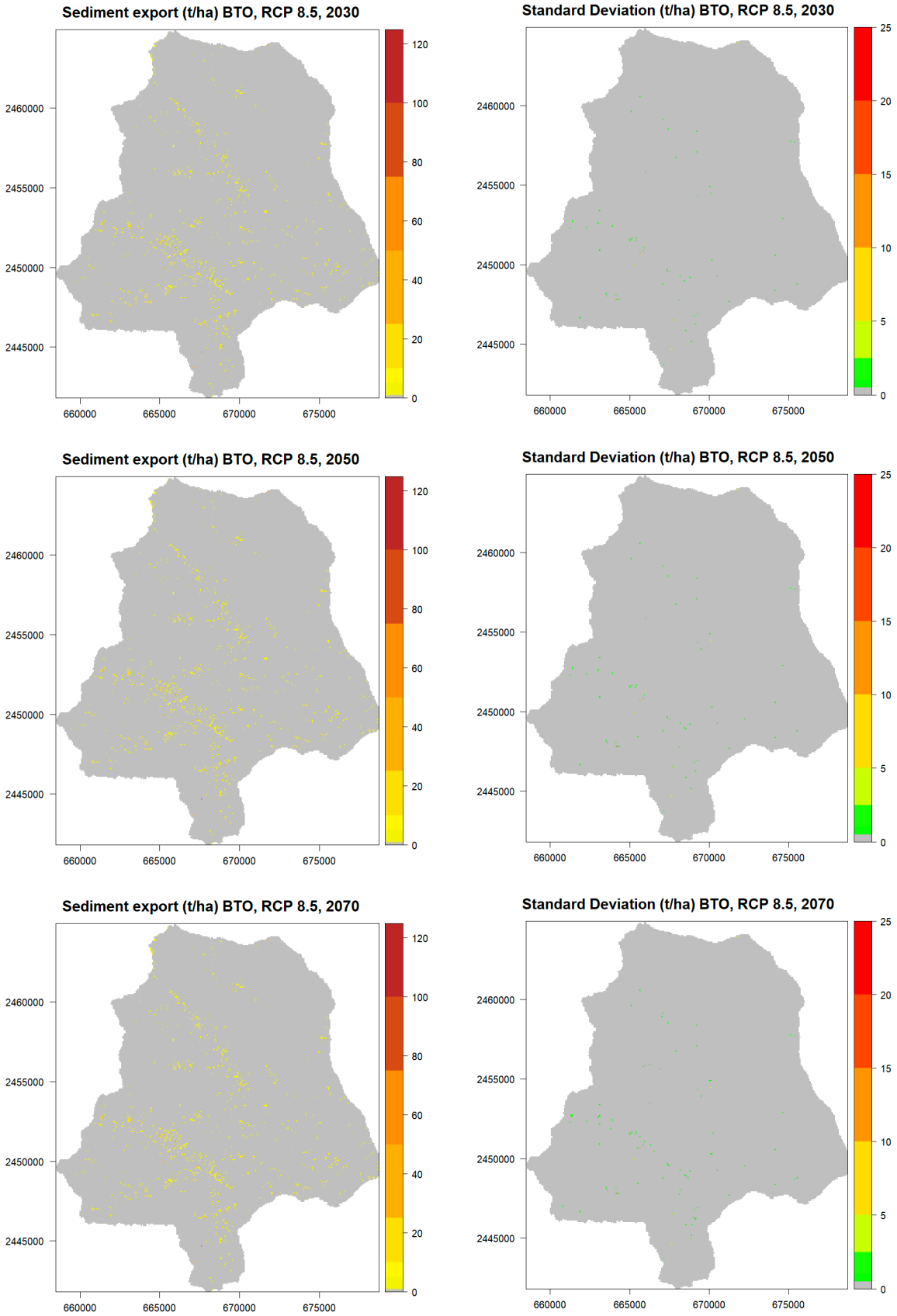

Figure S18. Sediment export and standard deviation results in Nabanhe Reserve for the Balanced-Trade-Offs scenario (BTO) under RCP 8.5 climate data.

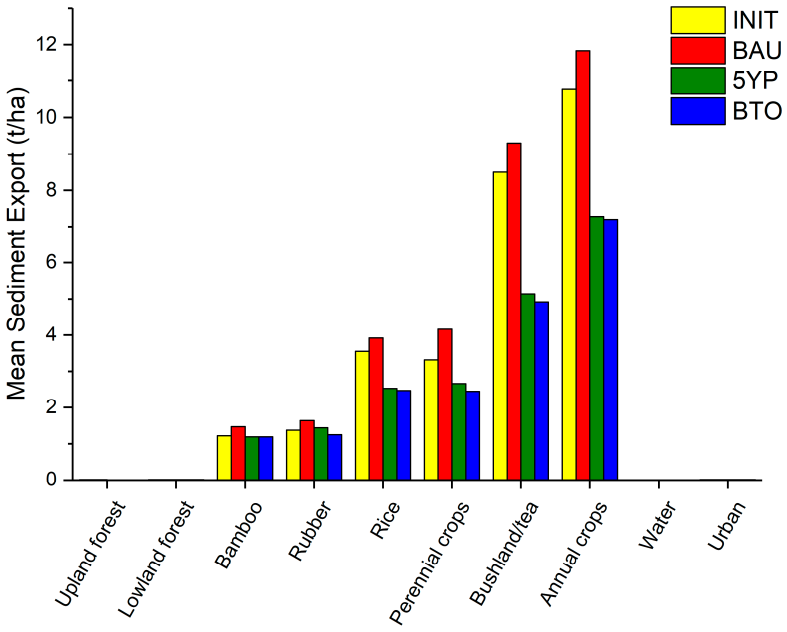

Figure S19. Sediment export averaged over every land use category in Nabanhe Reserve for the initial land use (INIT) and baseline climate. We calculated these values by summing the sediment export amounts from each land use category and divided them by the areal extent of the respective land use category in Nabanhe Reserve.