PRELIMINARY SUPPLEMENTARY DATA

Future Costs of Climate Change for Humanitarian and Disaster Aid

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1. Descriptive stats

VARIABLE	UNIT	DESCRIPTION
RESPONSE VARIABLE		
ΣEX (people at risk)	million persons	Sum of people analytically exposed per country to average between dengue and malaria, coastal floods, earthquakes with Modified Mercalli Intensity higher than 6, floods, tropical cyclone winds with Saffir-Simpson category higher than 1, tsunamis, drought based on 12-month standardized precipitation and evapotranspiration indices (SPI/SPEI), and conflict. Each subcategory is summed up regardless of possible overlap.
GLOBAL PREDICTORS		
SST_global	°C	Global average temperature of seawater near the surface.
GSATΔ_global	K	Change in global average near-surface air temperatures over land, oceans and sea ice above pre-industrial levels (1850-1900).
SFCWIND_global	m s^{-1}	Global average near-surface wind speed. The magnitude of the two-dimensional horizontal air velocity near the surface.
PR_global	kg m-2 s^{-1}	Global average of the sum of liquid and frozen water, comprising rain and snow, that falls to the Earth's surface. It is the sum of large-scale precipitation and convective precipitation. This parameter does not include fog, dew or the precipitation that evaporates in the atmosphere before it lands at the surface of the Earth. This variable represents the amount of water per unit area and time.

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COUNTRY LEVEL PREDICTORS		
POP	Million persons	Population of a given country.
GDP	Billion USD_{2024}	Gross Domestic Product at Purchasing Power Parity (PPP) with US dollar prices in 2024.
HDI	-	The Human Development Index is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions.
cdd	Days	Maximum number of consecutive dry days. The maximum length of a dry spell, computed sequentially for the entire time series, then taking the maximum value during each month in the data period (a dry day is defined as any day in which the daily accumulated precipitation < 1 mm)
cdw	Days	Max Number of Consecutive Wet Days. This series measures the maximum length of a wet spell, computed sequentially for the entire time series, then taking the maximum value during each month in the data period (a wet day is defined as any day in which the daily accumulated precipitation ≥ 1 mm).
hd40	Days	The number of days with daily maximum temperature >= 40°C that occurred during the aggregation period
pr	mm	Aggregated accumulated precipitation.
r20mm	Days	The number of heavy precipitation days during the aggregation period. A heavy precipitation day for r20mm is defined as any day in which the daily accumulated precipitation is ≥ 20 mm.
rx5day	mm	The average highest precipitation amount over a consecutive 5-day period during each month in the data period.
tas	°C	Average mean temperature over the aggregation period.
Net migration	Thousand persons	The net total of migrants during the period, that is, the number of immigrants minus the number of emigrants, including citizens and noncitizens.
FINAL TARGET VARIABLES		
PIN (people in need)	million persons	The people in need of humanitarian assistance per country according to the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA).
Funding requirement	million $USD_{nominal}$	The funding required to provide humanitarian assistance to the people in need per country according to UN OCHA's analysis.

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variable	count	mean	std	min	25%	50%	75%	max
ΣEX	312	39.60	57.39	2.11	13.46	23.40	37.89	512.85
EX_DENMAL	312	29.03	47.88	0.00	8.79	16.14	28.33	414.56
EX_CFL	312	0.03	0.18	0.00	0.00	0.00	0.01	2.45
EX_EQ_MMI6	312	0.03	0.04	0.00	0.00	0.01	0.04	0.25
EX_FL	312	0.27	0.43	0.00	0.03	0.12	0.27	3.81
EX_TC_SS1	312	0.06	0.17	0.00	0.00	0.00	0.02	0.98
EX_TS	312	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EX_DR	312	3.58	6.36	0.02	0.86	1.66	3.98	74.46
EX_CON	312	6.60	7.36	0.36	1.92	3.87	8.73	46.60
SST_global	2626	14.81	0.47	13.97	14.40	14.83	15.19	15.58
SFCWIND_global	2626	6.26	0.01	6.24	6.25	6.26	6.26	6.29
PR_global	2626	2.51	0.04	2.43	2.47	2.51	2.55	2.59
GSATΔ_global	2626	1.86	0.59	0.77	1.37	1.95	2.38	2.71
POP	2626	62.75	95.70	3.09	15.15	34.90	59.93	696.73
GDP	2626	880.01	2181.07	3.06	92.33	286.90	823.92	23983.47
HDI	2626	0.64	0.15	0.26	0.54	0.66	0.76	0.94
cdd	2626	101.31	75.38	7.63	43.17	71.98	169.11	252.43
cdw	2626	53.79	48.28	3.64	10.14	39.28	83.81	197.51
hd40	2626	24.44	36.69	0.00	0.04	5.03	35.77	156.01
pr	2626	1126.01	838.98	96.35	334.44	1003.32	1810.29	3537.99
r20mm	2626	6.86	8.63	0.16	1.09	3.22	8.97	35.40
rx5day	2626	75.44	38.48	18.12	44.82	74.11	96.44	201.32
tas	2626	25.39	4.54	8.86	24.51	26.42	28.29	31.63
Net migration	2626	-24.02	153.02	-5699.45	-34.34	-17.06	-3.56	1146.01
PIN	168	9.55	8.54	0.61	3.28	5.80	13.65	37.08
Funding requirement	168	1624.94	2128.05	26.03	384.79	778.29	2283.18	11668.37

2. GPR core in the script

```
def build_pipeline():
  kernel = (
    RBF(length_scale=np.ones(len(PREDICTORS)), length_scale_bounds=(1e-2,1e3))
    + WhiteKernel(noise_level_bounds=(1e-2,1e3))
  )
  gpr = GaussianProcessRegressor(
    kernel=kernel,
    normalize_y=True,
    n_restarts_optimizer=5,
    random_state=42
  )
  return Pipeline([('scaler', RobustScaler()), ('gpr', gpr)])
```

3. Diagnostics

=== Global Diagnostics ===

Metric	Value
RMSE	3.23
R^2	0.9968

=== Cross-Validation ===

Fold	RMSE	R^2
1	4.62	0.984
2	4.24	0.9871
3	3.87	0.9905
4	3.3	0.9948
5	2.18	0.9978
6	3.17	0.9955
7	4.51	0.9924
8	3.69	0.995
9	2.64	0.9975
10	2.99	0.9971
11	72.35	0.2171
12	94.84	0.0447

=== Learned Length-Scales ===

Feature	Length-Scale
SST_global	1000
SFCWIND_global	1000
PR_global	1000
GSATΔ_global	6.36
POP	4.83
GDP	1000
HDI	11.97
cdd	1000
cdw	1000
hd40	1000
pr	1.9
r20mm	1000
rx5day	9.95
tas	1.16
Net migration	1000

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=== ∑EX to PIN Coefficients (Theil-Sen) ===

Country	Coefficient
SYR	2.443
SSD	0.9013
YEM	0.8811
PSE	0.7489
UKR	0.5658
AFG	0.4879
VEN	0.4534
CAF	0.3936
SDN	0.365
HTI	0.3194
TCD	0.3133
SOM	0.3024
ETH	0.2571
MLI	0.2523
BDI	0.2473
COD	0.2345
GTM	0.2337
SLV	0.2254
HND	0.2042
COL	0.1559
NER	0.146
BFA	0.1384
CMR	0.1298
MOZ	0.0721
MMR	0.0573
NGA	0.0311

PRELIMINARY SUPPLEMENTARY DATA

=== PIN to Funding Requirement Coefficients (Theil-Sen) ===

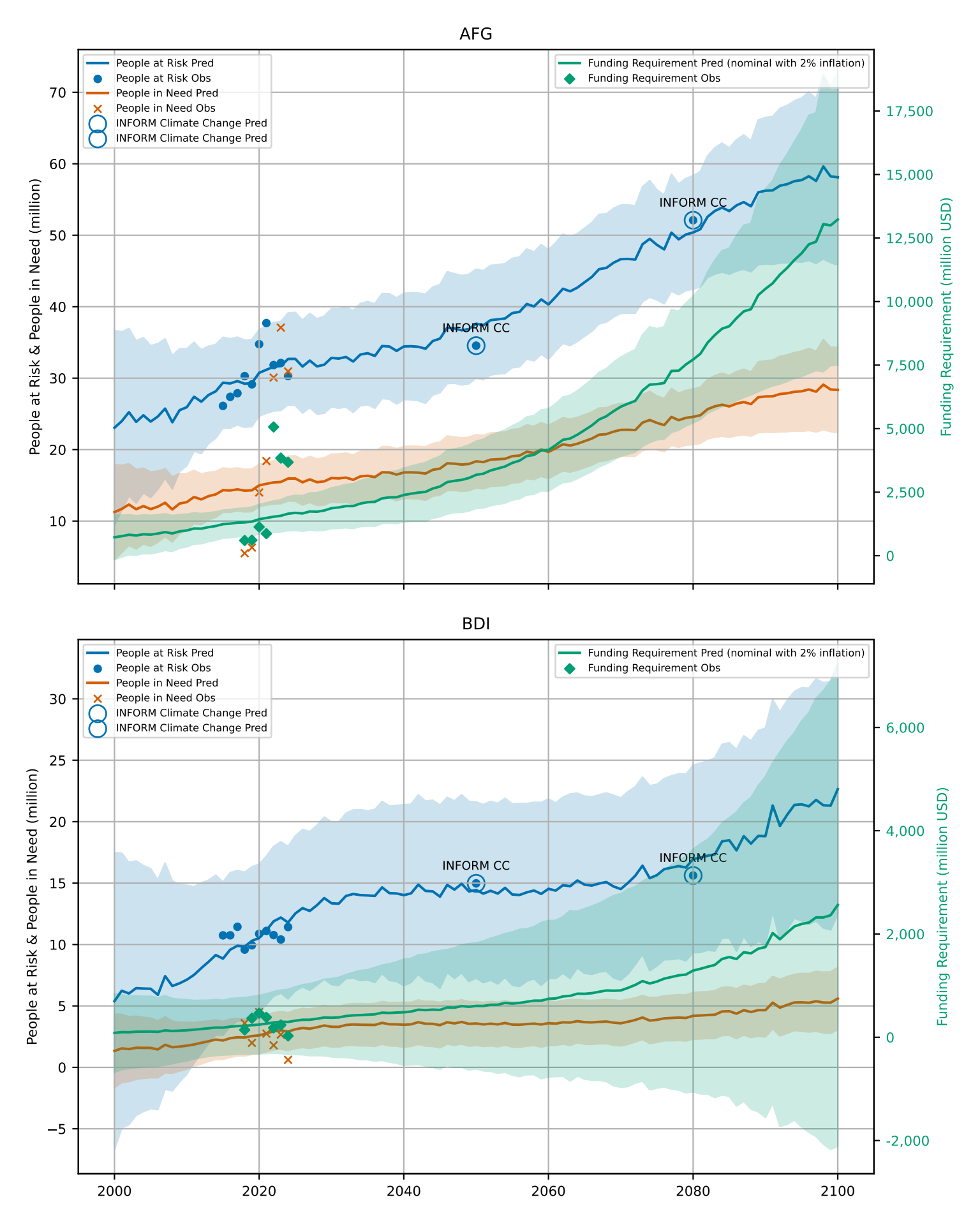
Country	Coefficient
SYR	424.06
MMR	293.97
SOM	256.54
SSD	226.96
PSE	215.89
MOZ	204.65
YEM	173.97
CAF	155.64
VEN	150.83
BFA	148.49
SDN	144.26
NER	140.21
ETH	139.68
NGA	118.98
COD	117.4
TCD	111.9
AFG	103.58
BDI	101.57
HTI	96.22
MLI	91.15
CMR	86.66
SLV	72.3
HND	64.01
UKR	60.19
COL	36.76
GTM	24.44

PRELIMINARY SUPPLEMENTARY DATA

=== Per-Country Diagnostics ===

ISO3	RMSE	R^2	Bias
NGA	7.67	0.9931	-0.49
MMR	5.95	0.6369	-1.16
COD	5.44	0.9715	-0.22
SDN	4.75	0.8443	-0.1
SOM	4.64	-1.8757	1.07
UKR	3.27	0.7662	0.13
CMR	3.03	0.7978	-0.17
GTM	2.95	0.7071	0.8
NER	2.92	0.9774	-1.29
VEN	2.88	0.7528	-1.12
AFG	2.82	0.8198	-0.13
COL	2.59	0.8485	0.61
HTI	2.5	-0.5986	-1.47
YEM	2.18	0.8333	0.26
MOZ	2.09	0.9413	-0.89
CAF	1.98	-2.4002	1.27
ETH	1.94	0.9885	0.68
SLV	1.91	-1.0992	1.29
SSD	1.79	0.6613	-0.88
SYR	1.75	0.8176	-0.29
PSE	1.68	-2.2887	0.39
BFA	1.48	0.9849	-0.42
TCD	1.35	0.9602	0.75
MLI	1.23	0.9878	0.56
BDI	1.09	0.6287	-0.02
HND	1.08	0.8577	0.45

4. Initial country graphs (n=26)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Funding Requirement Obs
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INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
70
60
50
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17,500
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BDI
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People in Need Pred
People in Need Obs
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INFORM Climate Change Pred
Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
INFORM CC
INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
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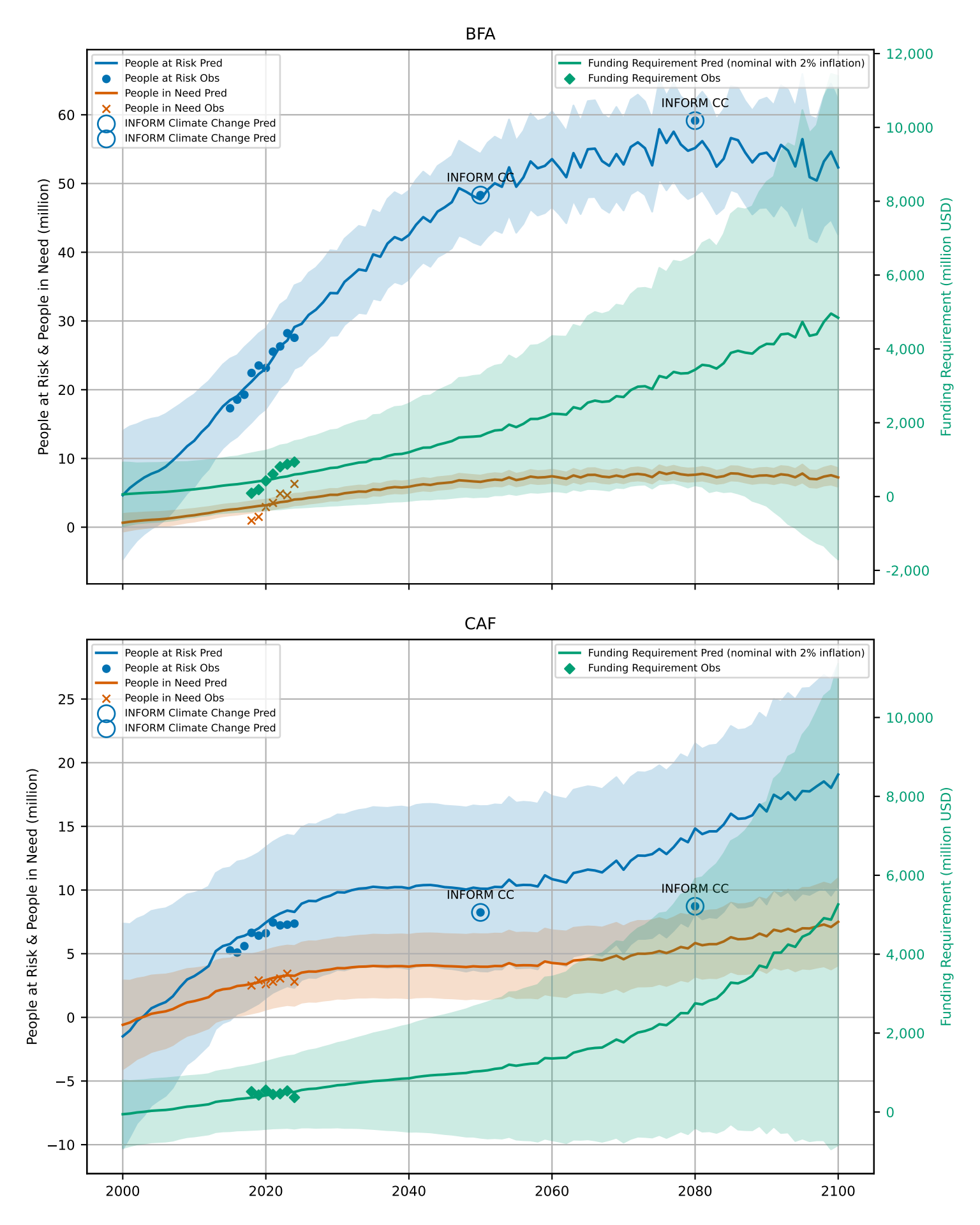
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Funding Requirement Obs
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INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
CAF
People at Risk Pred
People at Risk Obs
People in Need Pred
People in Need Obs
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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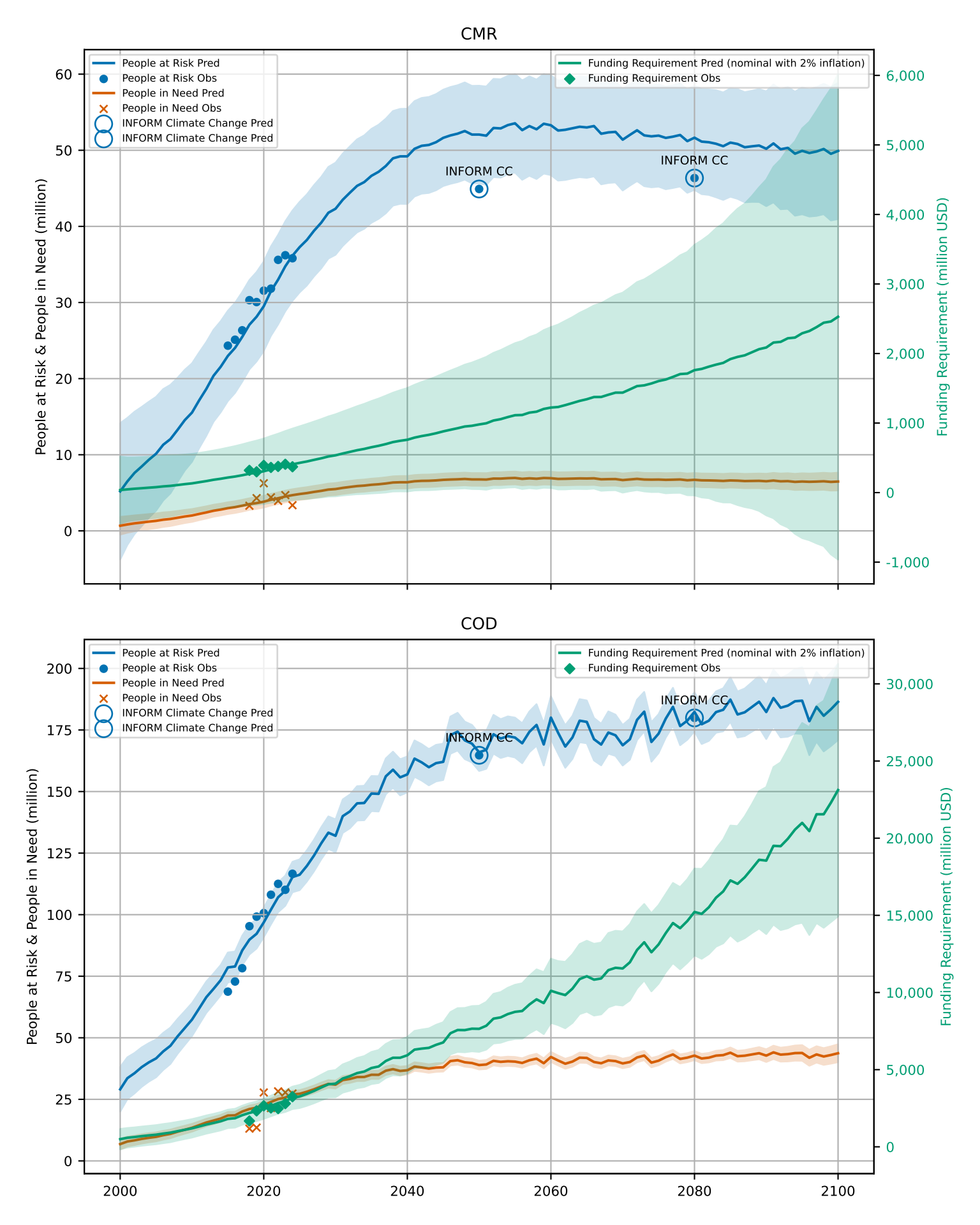
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INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
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COD
People at Risk Pred
People at Risk Obs
People in Need Pred
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Funding Requirement Obs
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People at Risk & People in Need (million)
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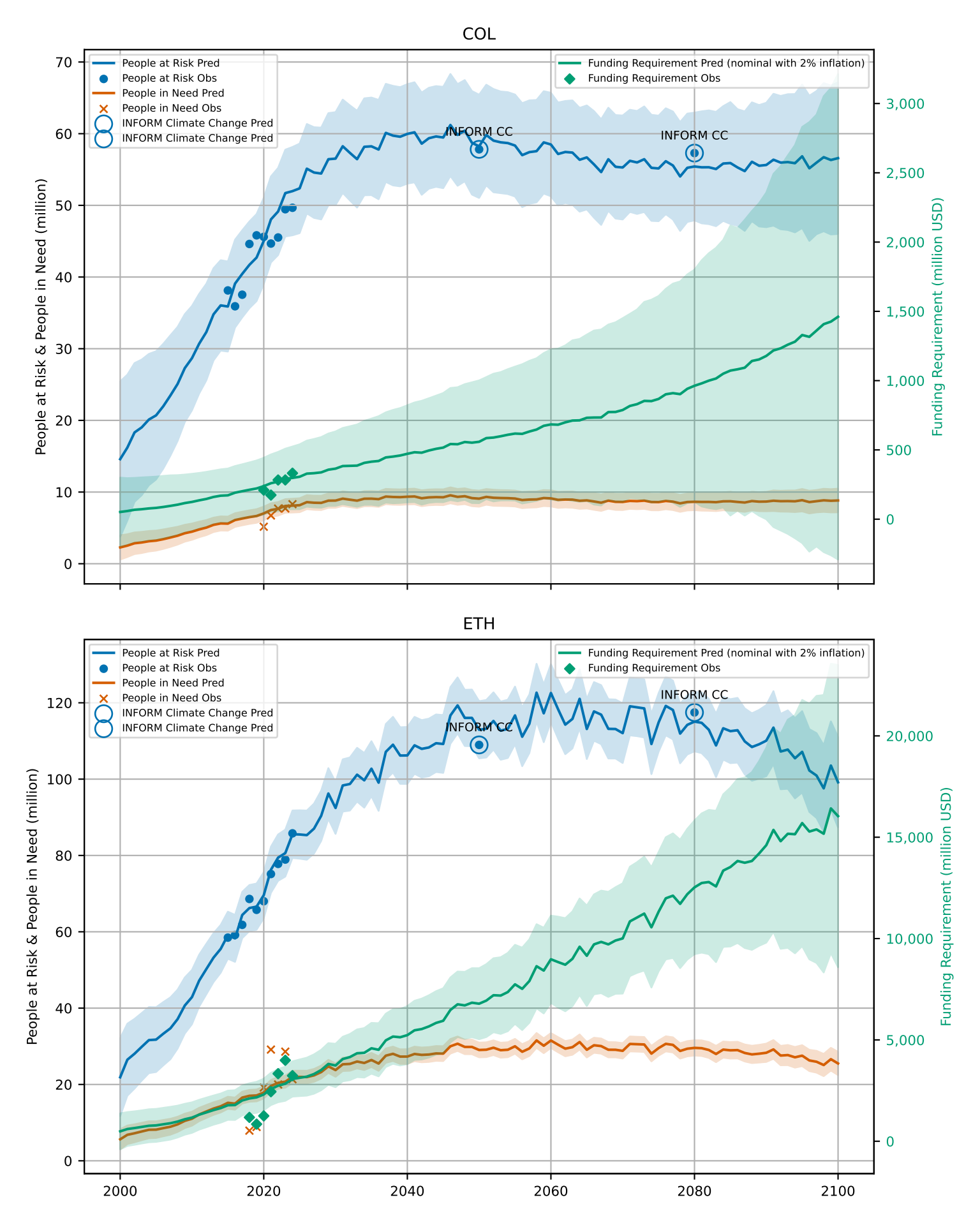
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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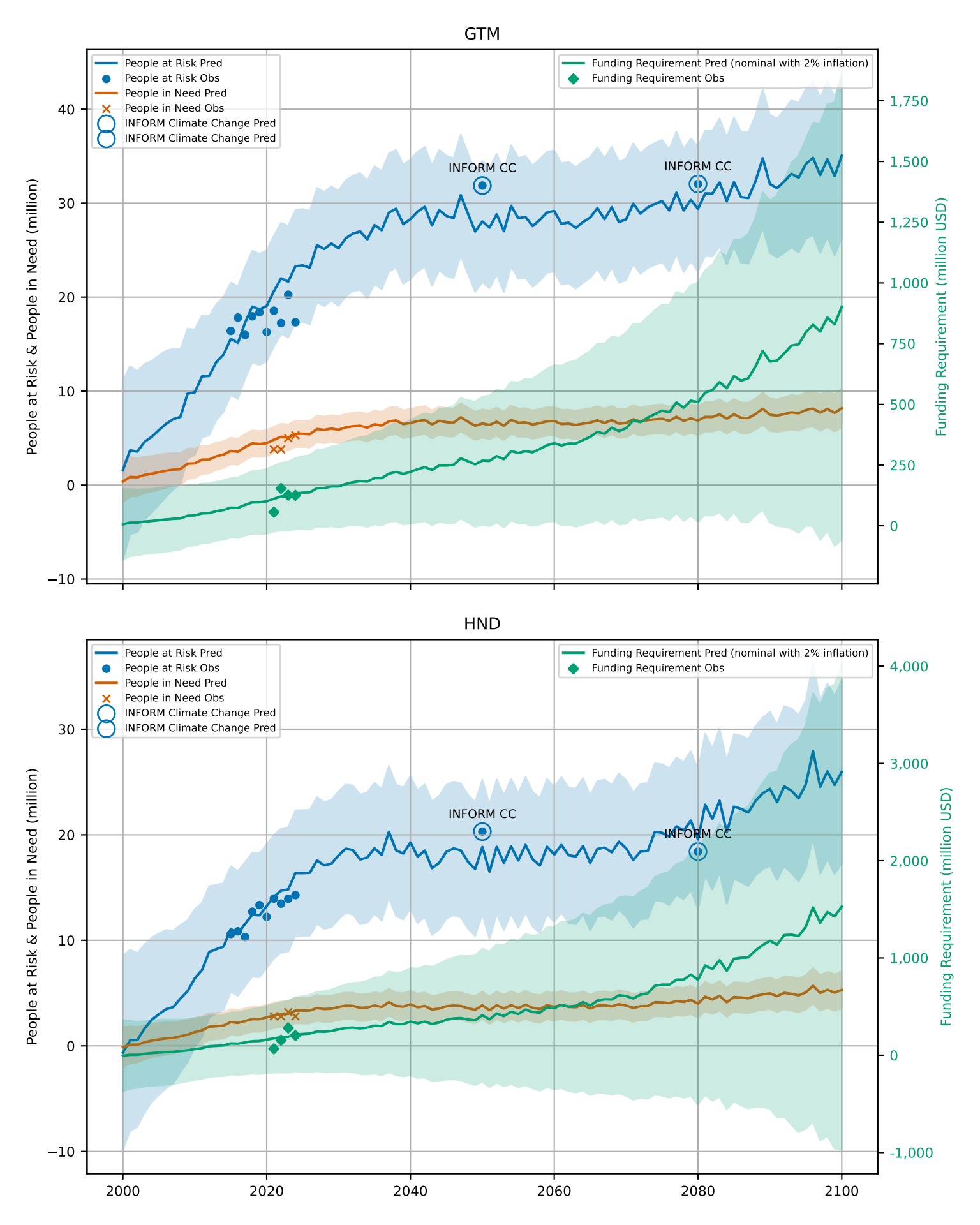
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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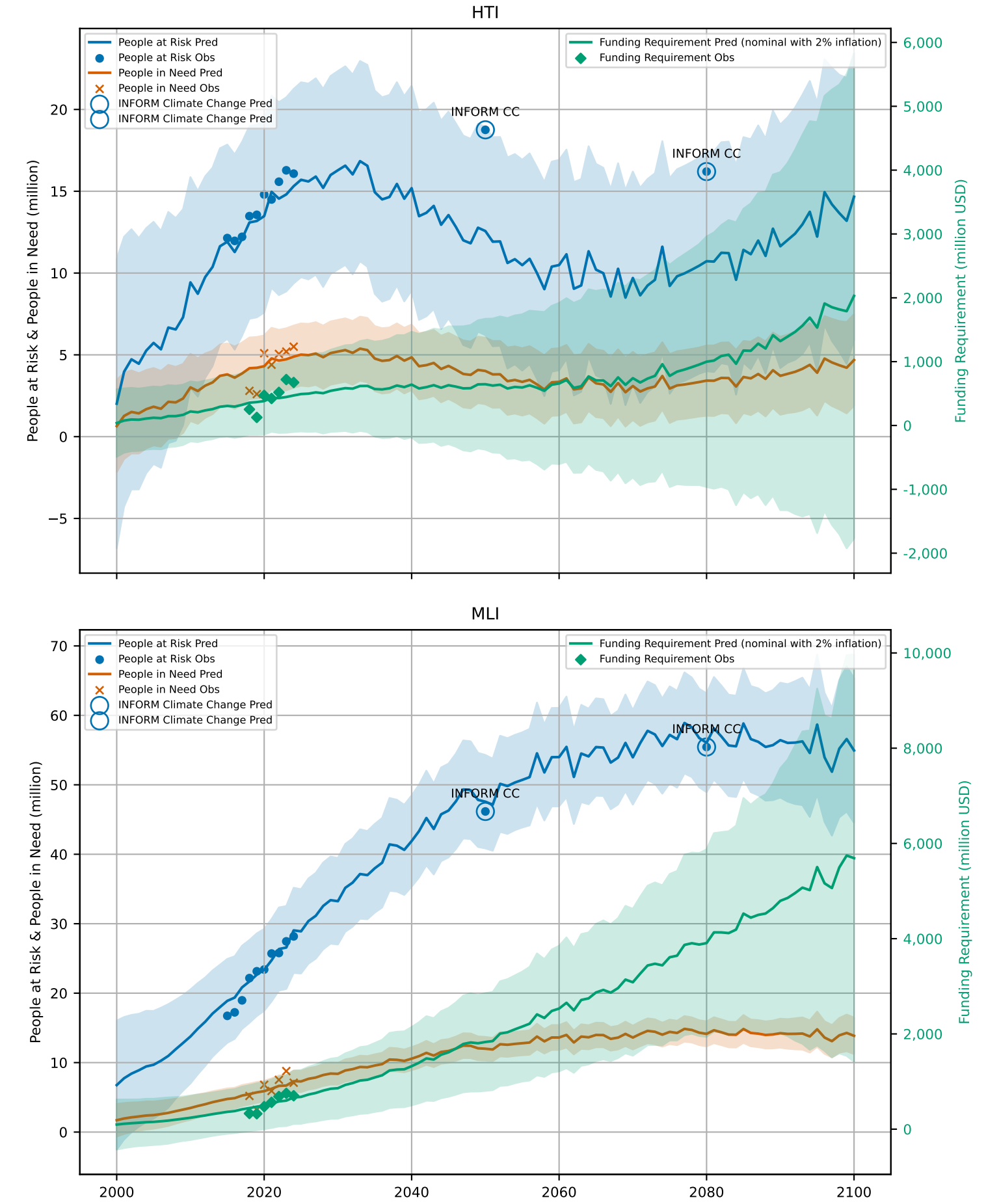
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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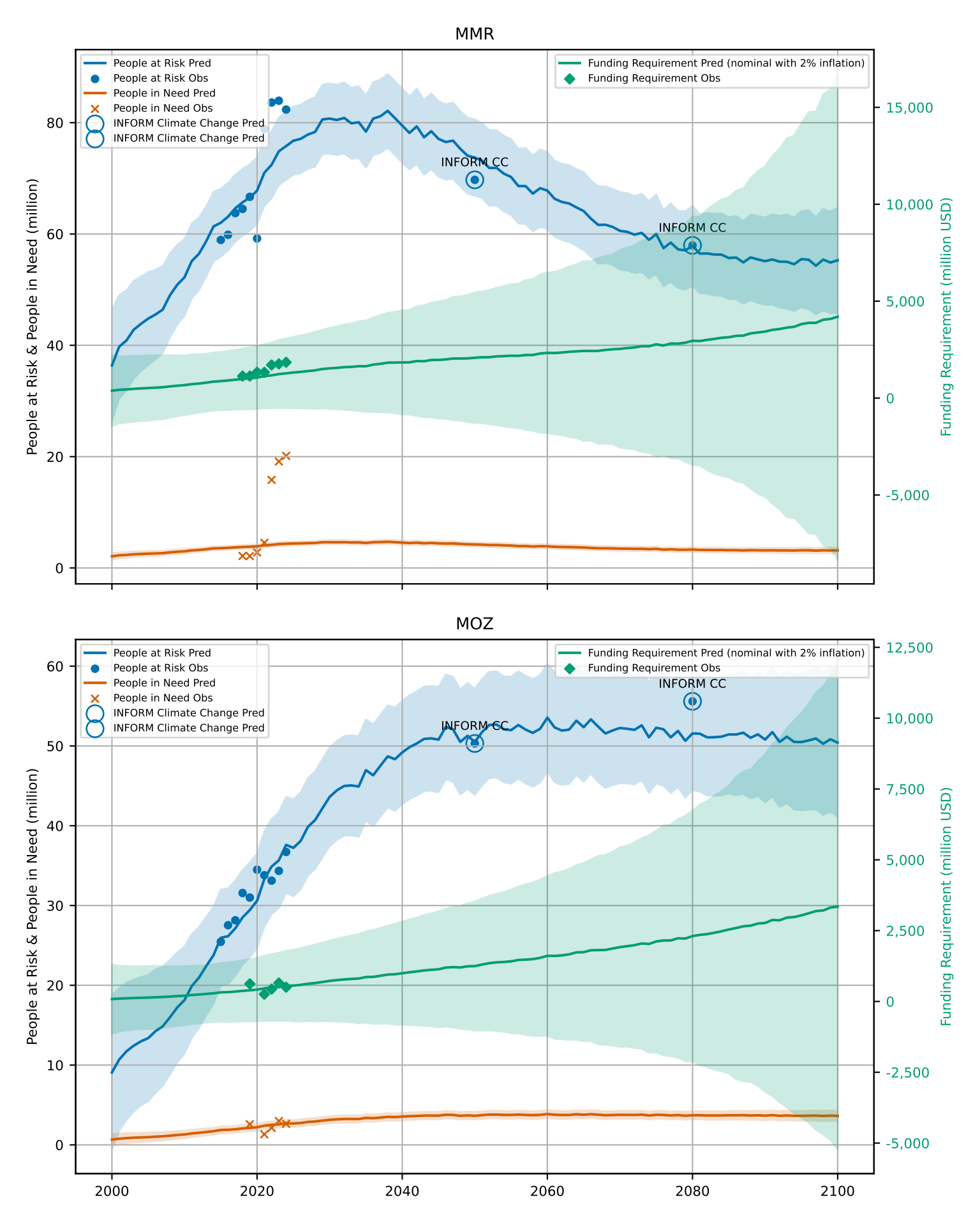
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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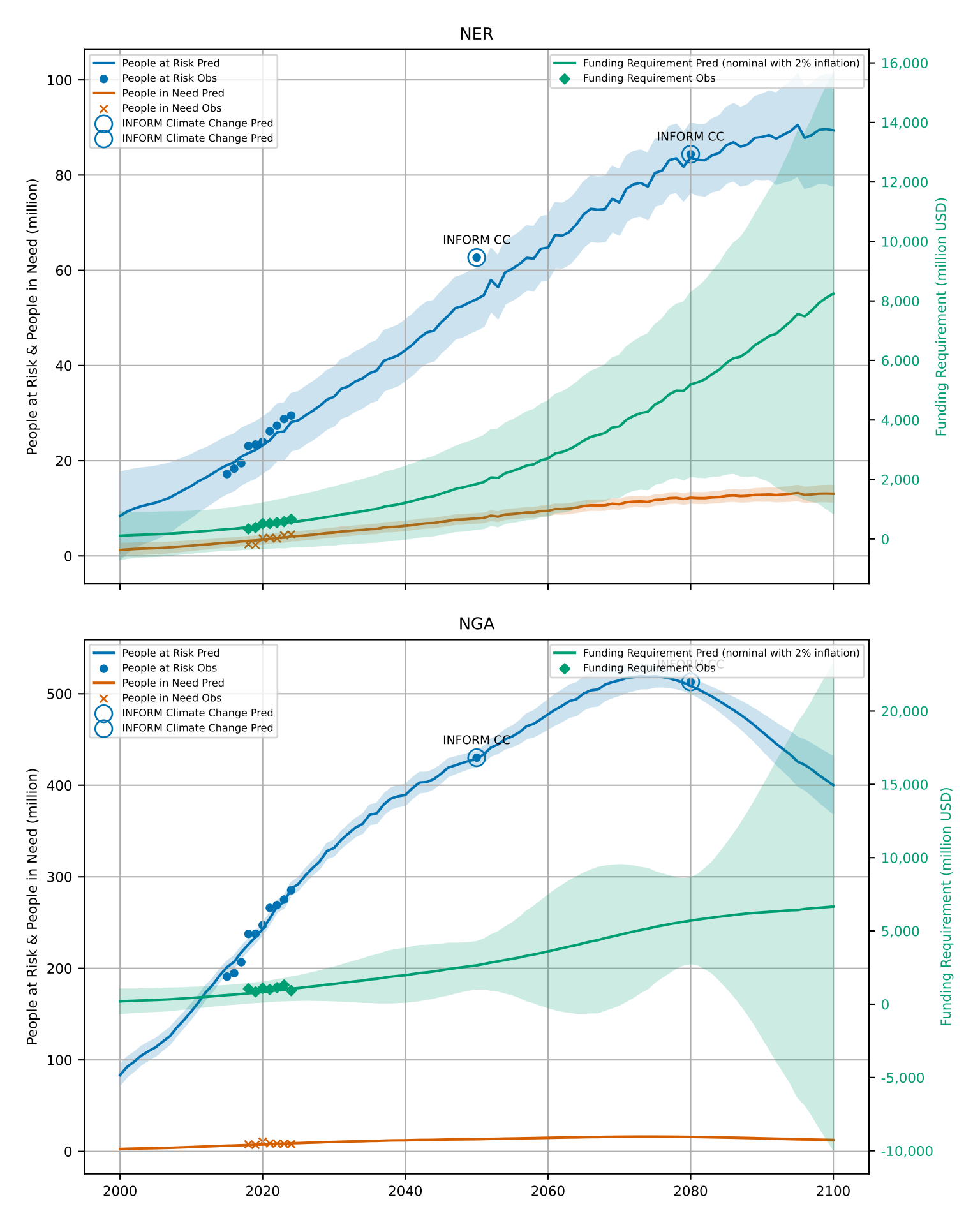
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Funding Requirement (million USD)
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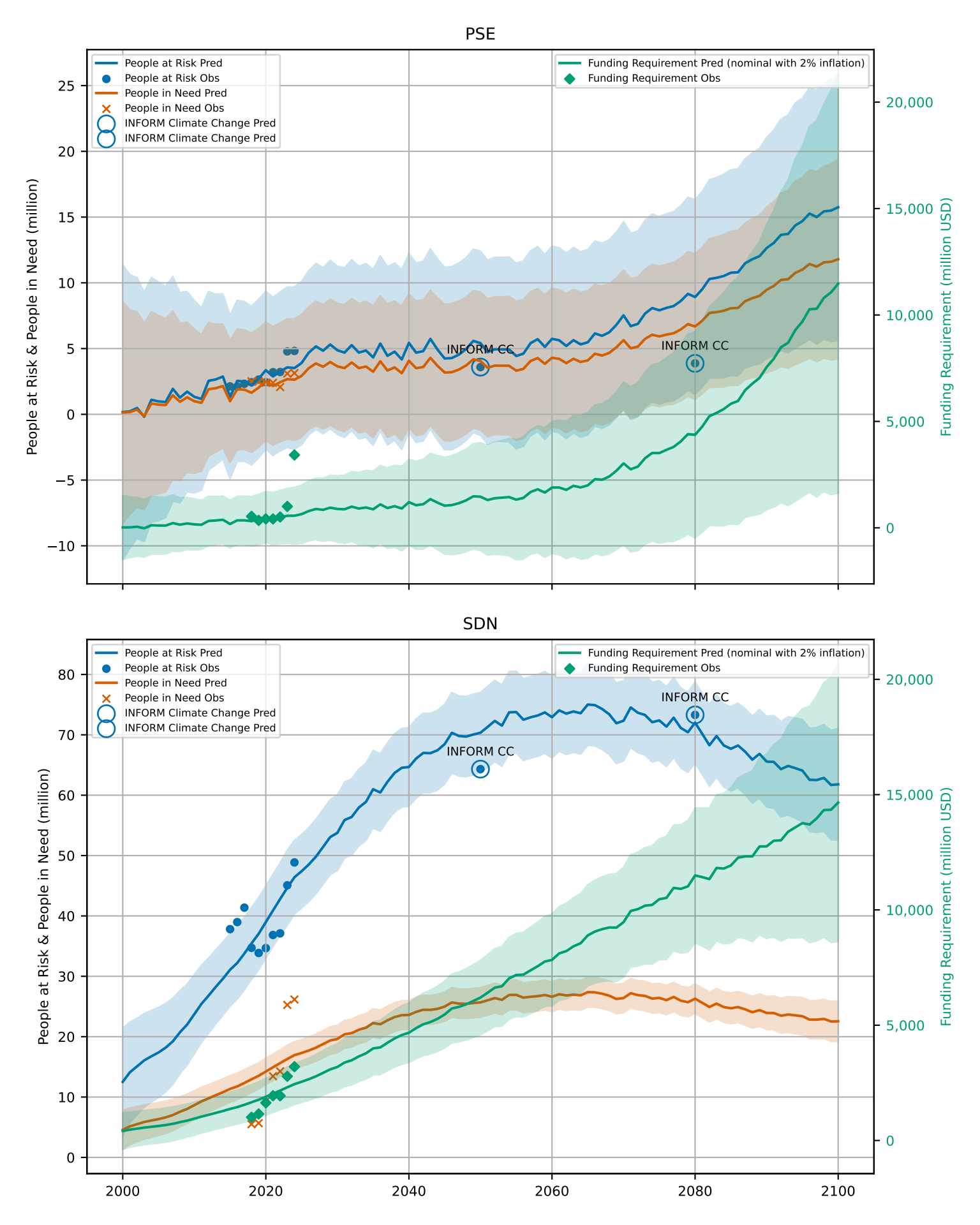
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Funding Requirement Pred (nominal with 2% inflation)
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Funding Requirement (million USD)
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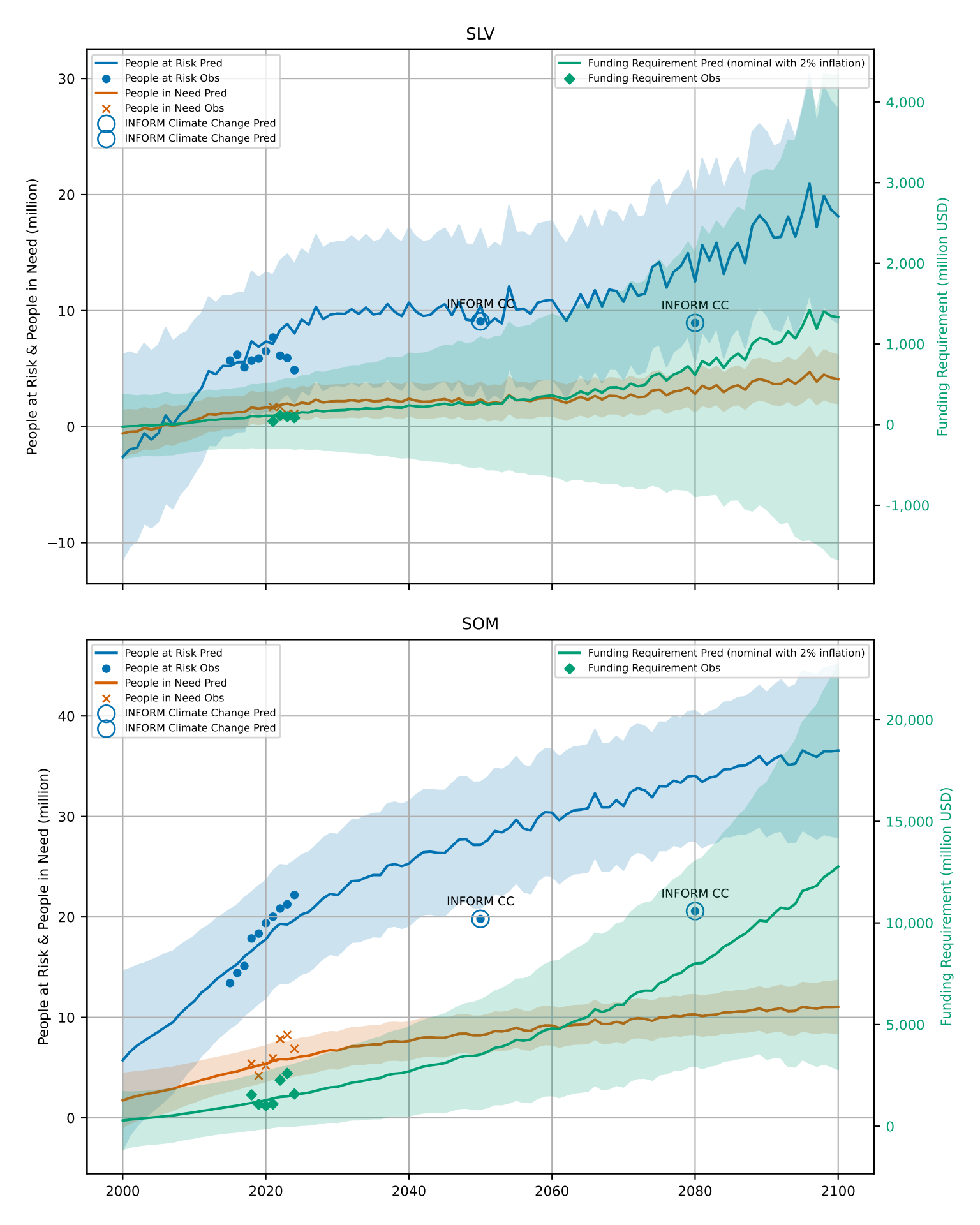
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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SOM
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Funding Requirement Obs
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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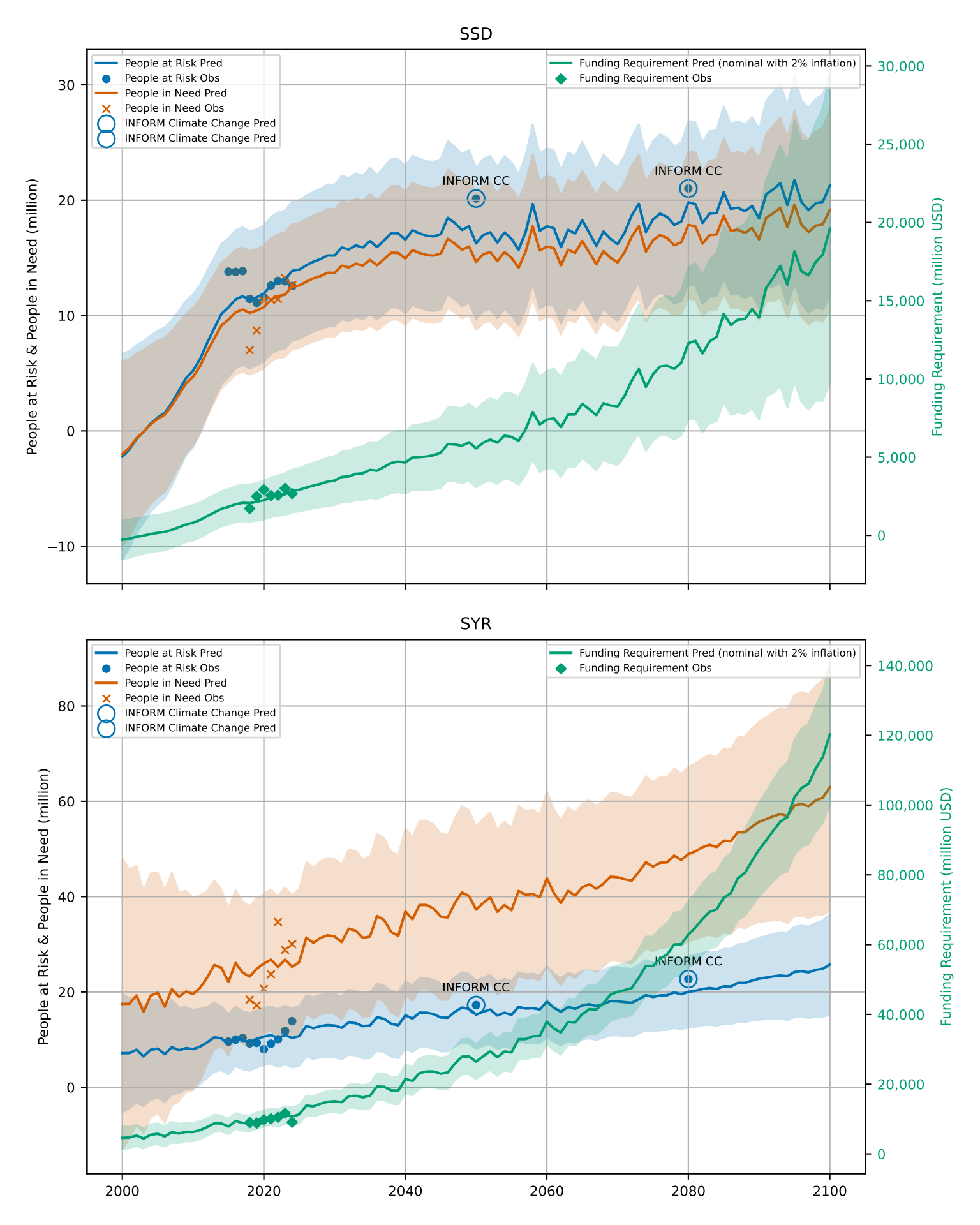
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People at Risk & People in Need (million)
Funding Requirement (million USD)
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SYR
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People in Need Pred
People in Need Obs
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Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
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INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
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60
40
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140,000
120,000
100,000
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60,000
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2000
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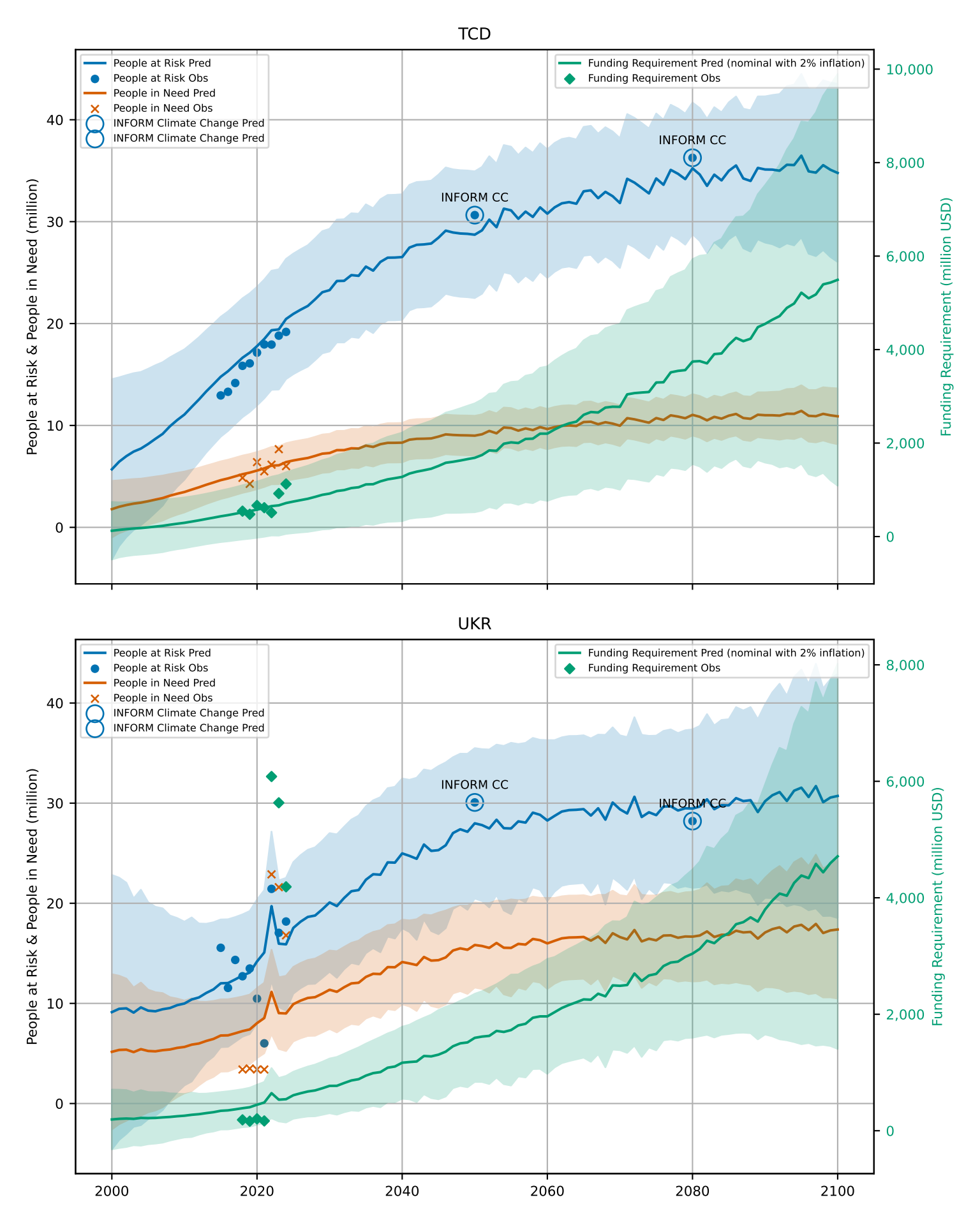
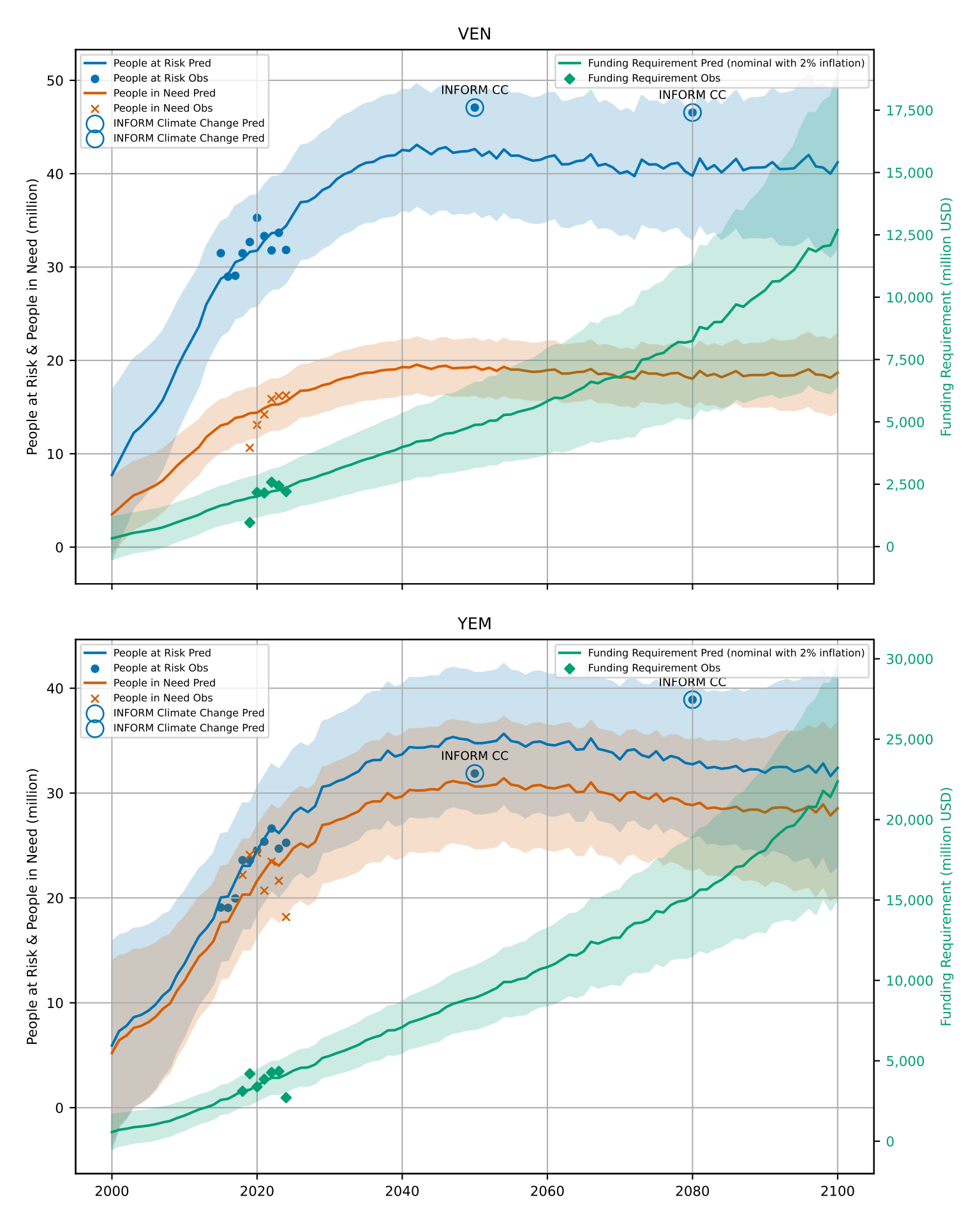
2040
2060
2080
2100


TCD
People at Risk Pred
People at Risk Obs
People in Need Pred
People in Need Obs
INFORM Climate Change Pred
INFORM Climate Change Pred
Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
INFORM CC
INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
0
10
20
30
40
0
2,000
4,000
6,000
8,000
10,000
UKR
People at Risk Pred
People at Risk Obs
People in Need Pred
People in Need Obs
INFORM Climate Change Pred
INFORM Climate Change Pred
Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
INFORM CC
INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
0
10
20
30
40
0
2,000
4,000
6,000
8,000
2000
2020
2040
2060
2080
2100


VEN
People at Risk Pred
People at Risk Obs
People in Need Pred
People in Need Obs
INFORM Climate Change Pred
INFORM Climate Change Pred
Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
INFORM CC
INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
0
10
20
30
40
50
0
2,500
5,000
7,500
10,000
12,500
15,000
17,500
YEM
People at Risk Pred
People at Risk Obs
People in Need Pred
People in Need Obs
INFORM Climate Change Pred
INFORM Climate Change Pred
Funding Requirement Pred (nominal with 2% inflation)
Funding Requirement Obs
INFORM CC
INFORM CC
People at Risk & People in Need (million)
Funding Requirement (million USD)
0
10
20
30
40
0
5,000
10,000
15,000
20,000
25,000
30,000
2000
2020
2040
2060
2080
2100