Climate Impacts and Resilience in Caribbean Agriculture: Assessing the consequences of climate change on cocoa and tomato production in Trinidad & Tobago and Jamaica (CIRCA)

WP2 – Crop-Climate Suitability Modeling

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University of west Indies, January, 2015

WP2 – Crop-Climate Suitability Modeling

- Introduction: CIAT - CCAFS
- Generation of climatological baseline through interpolation of weather station data
- Generation of future climate data
- Impact of climate change in tomato and cocoa crops using crop model Ecocrop
- Conclusions and way forward

Crops

Advancing the fight against cassava diseases in Africa

14 . August 2014 by *afernando*

How to create a "game-changing" vision for cassava disease control in

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Soils

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CIAT led a Rapid Rural Appraisal (RRA), an integrative approach to data

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Decision and Policy Analysis

Wageningen UR & CIAT to Lead Inclusive Agribusiness Course in Addis Ababa

Climate Change

Getting climate-smart talk on the top agenda

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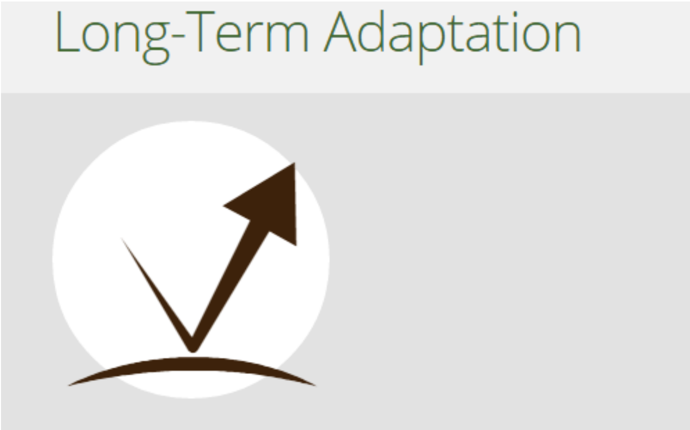
CCAFS: the partnership! The largest global coalition of scientists working on developing-country agriculture and climate change

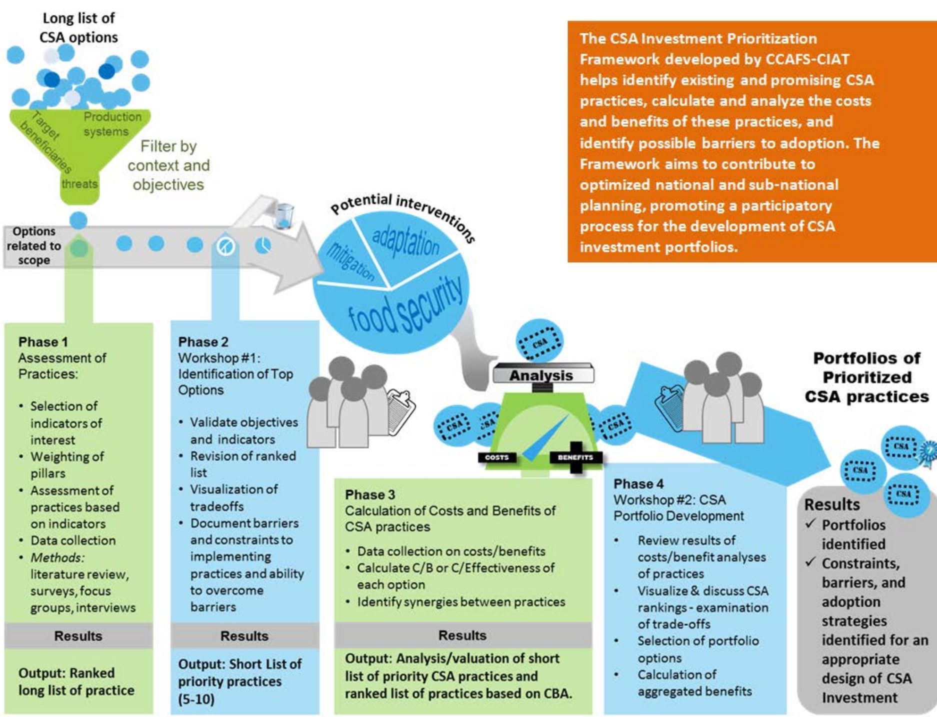
CGIAR

Earth System Science Partnership

http://ccafs.cgiar.org

1. What is Climate Smart Agriculture?

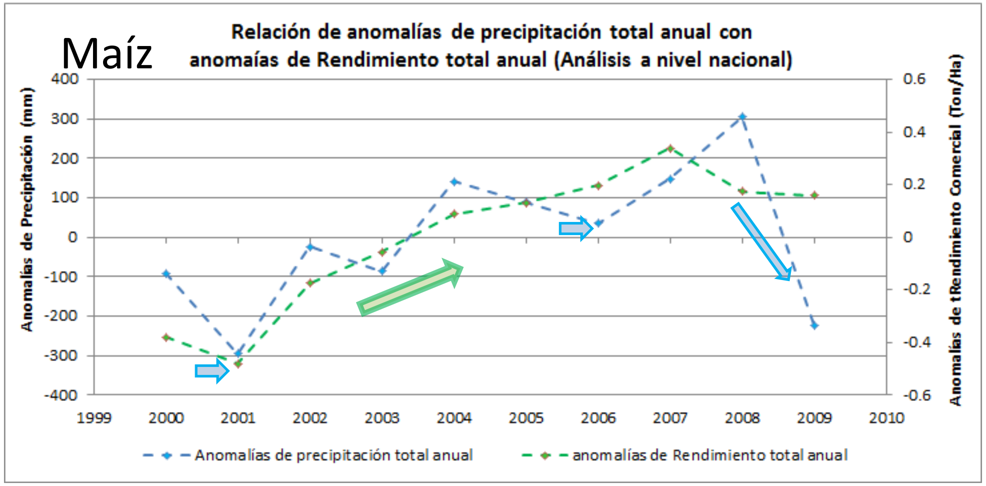


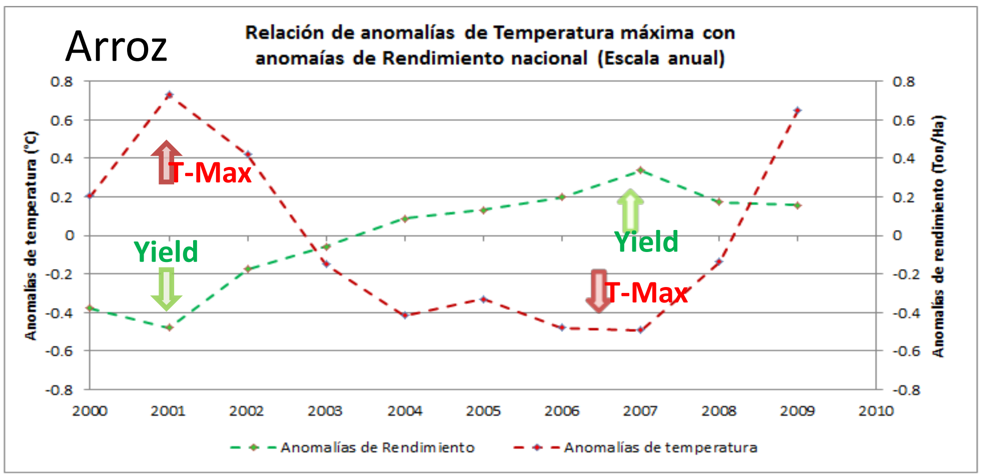


The CSA Investment Prioritization Framework developed by CCAFS-CIAT helps identify existing and promising CSA practices, calculate and analyze the costs and benefits of these practices, and identify possible barriers to adoption. The Framework aims to contribute to optimized national and sub-national planning, promoting a participatory process for the development of CSA investment portfolios.

2013

Why is CSA important? – Food Security





Climate drives yield variation: our systems are **sensitive** to climate, not *resilient* to it

RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

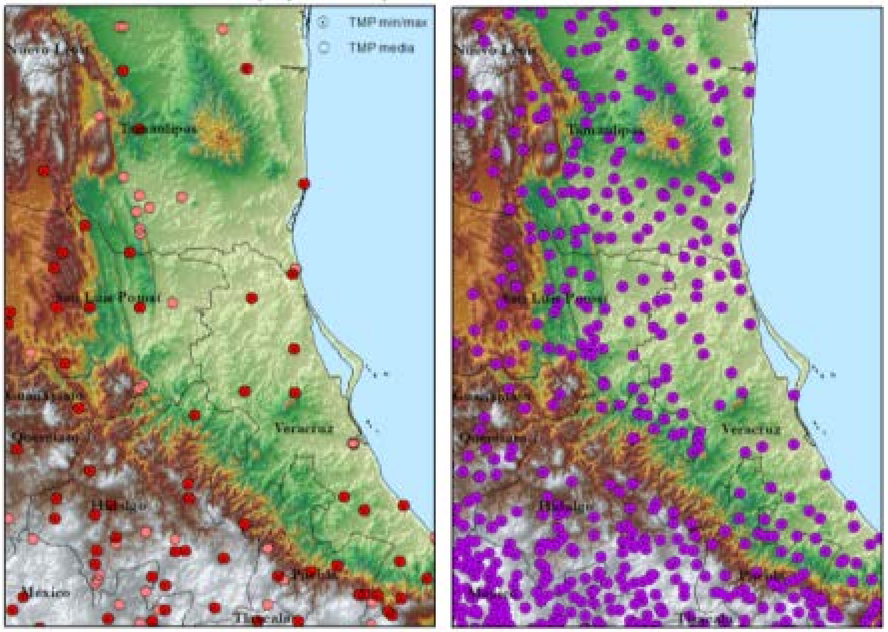
CGIAR CCAFS

CIRCA project: Methods & results

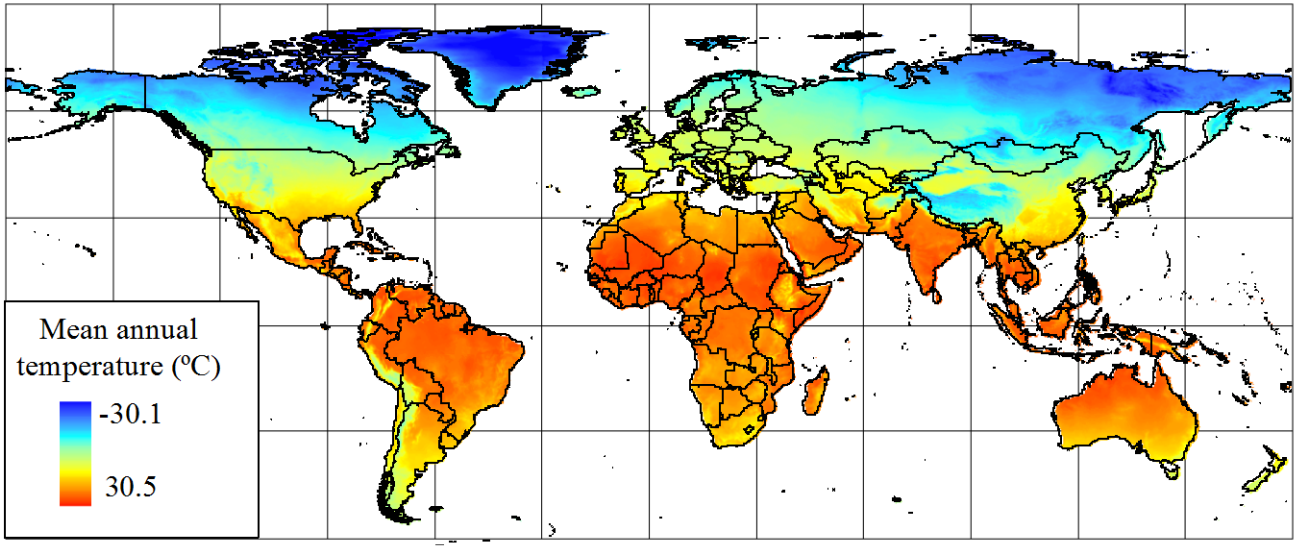
Interpolation of climate baseline

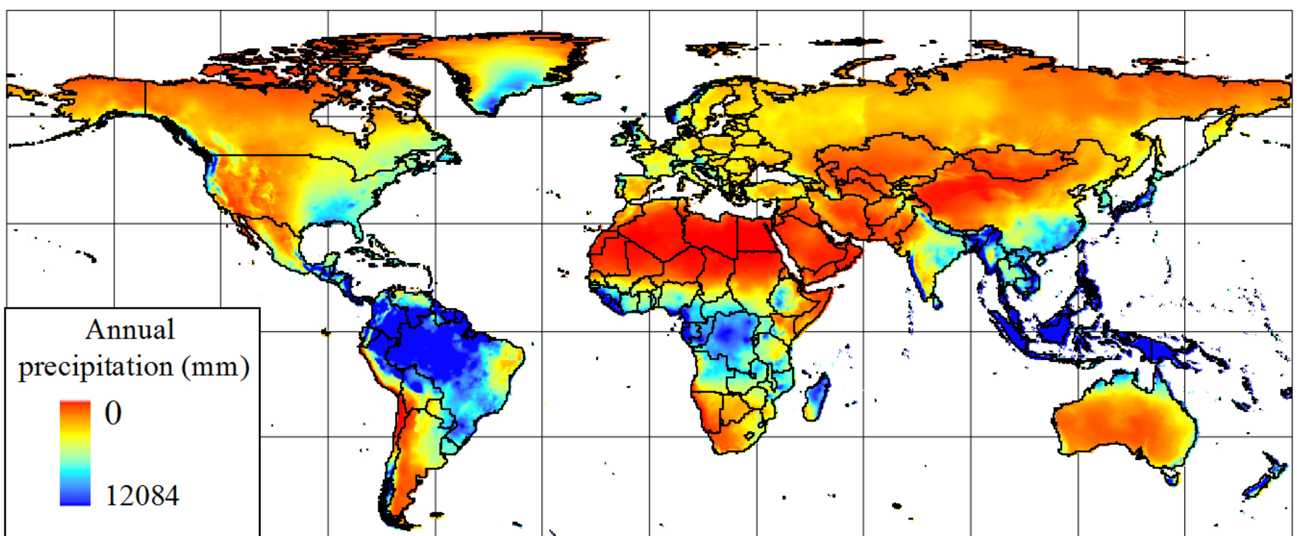
- The database of weather stations provided by the CIRCA project and quality control.
- The database STRM elevation of 30 arc-second resolution.
- Generate interpolated climate surfaces using ANUSPLIN-SPLINA with weather station data

following methodology as described by Hijmans et al (2005)



What is WorldClim?

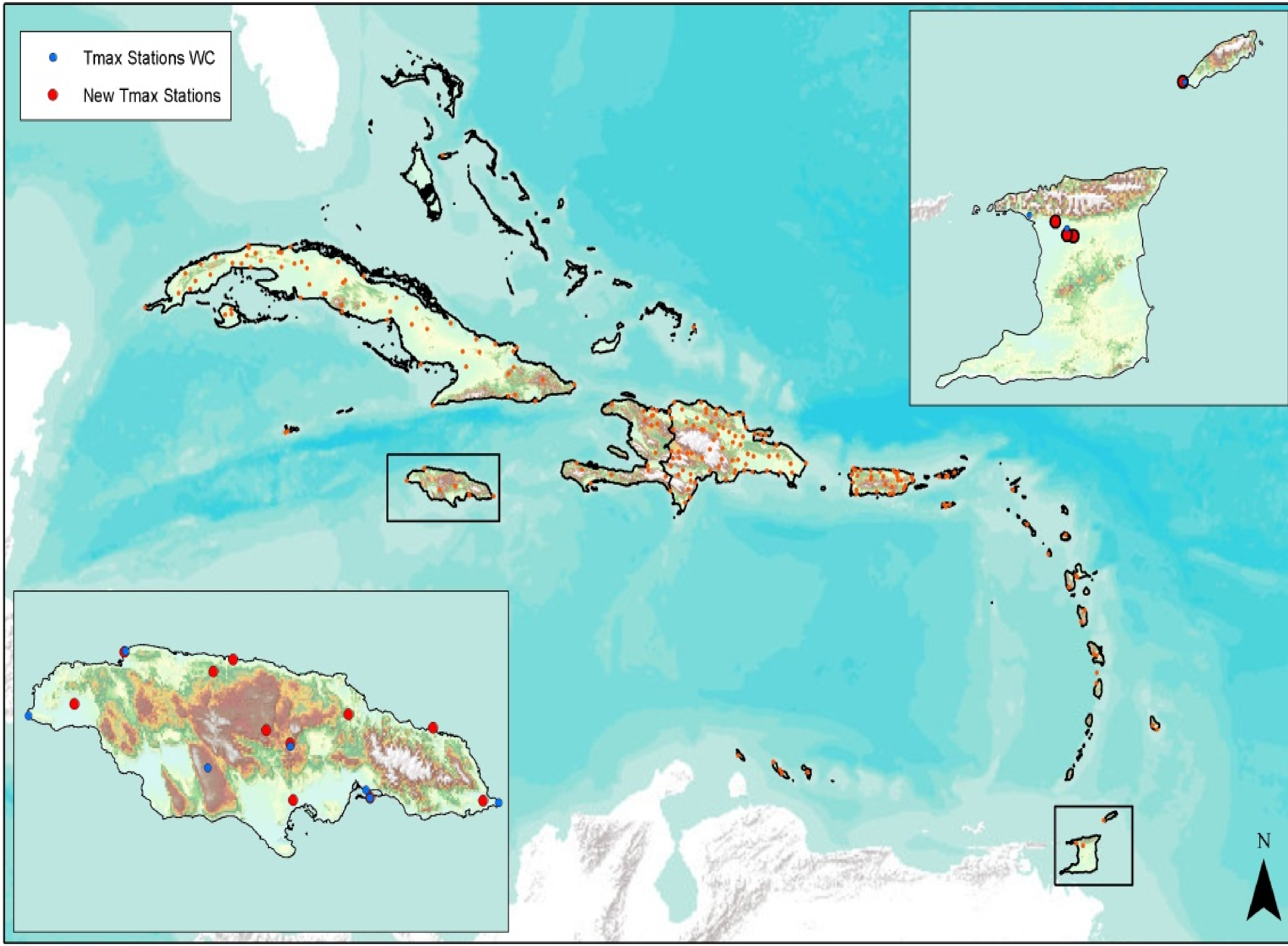




Stations by variable:

- 47,554 precipitation
- 24,542 tmean
- 14,835 tmax y tmin

Sources:
- GHCN
- FAOCLIM
- WMO
- CIAT
- R-Hydronet
- Redes nacionales


Tmax Stations WC
New Tmax Stations
N

Station data received from UWI and cross-validation of interpolated monthly climate surfaces for monthly accumulated rainfall and maximum and minimum temperature.

Table 2. Exploratory analysis of maximum and minimum temperature data respectively for Trinidad and Tobago

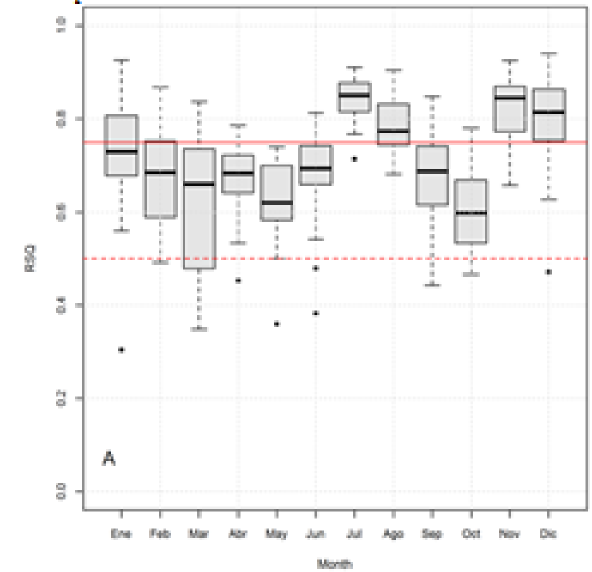
Station	Centeno	Crow_Point	Piarco	St. Aug.
N (Months)	220.00	534.00	627.00	504.00
Min	25.06	28.16	29.07	28.98
Max	33.46	32.89	34.74	34.00
Q1	29.77	30.03	30.66	30.77
Mean	30.41	30.55	31.39	31.38
Q3	30.94	31.05	32.05	31.97
Std. Desv	0.99	0.76	1.01	0.84
Median	30.38	30.56	31.35	31.38

Station	Centeno	Crow_Point	Piarco	St. Aug.
N (Months)	220.00	534.00	627.00	504.00
Min	17.91	21.11	19.61	18.90
Max	23.82	26.01	25.20	24.18
Q1	20.55	23.11	22.01	21.17
Mean	21.40	23.85	22.72	21.88
Q3	22.32	24.59	23.48	22.70
Std. Desv	1.26	1.01	1.12	1.08
Median	21.71	23.94	22.82	21.98

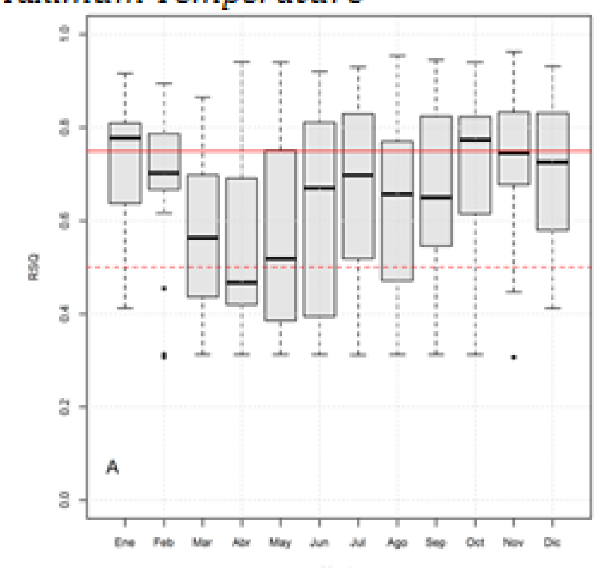
Table 4. *Exploratory analysis of maximum temperature data in Jamaica*

ID_Station	JAM01	JAM02	JAM03	JAM04	JAM05	JAM06	JAM07	JAM08	JAM09	JAM10	JAM11
N (Months)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
Min	29.50	27.40	26.90	27.90	28.20	29.80	26.60	24.30	30.20	25.60	26.10
Max	34.10	32.30	32.20	34.00	32.30	34.20	32.50	29.90	33.90	31.40	32.30
Q1	31.10	29.25	28.80	30.40	29.42	31.30	29.55	26.78	31.20	28.00	28.40
Mean	31.97	30.17	29.93	31.43	30.38	32.07	30.47	27.73	31.97	29.07	29.60
Q3	32.90	31.30	31.10	32.70	31.50	33.10	31.40	28.90	32.70	30.50	30.60
Std. Desv	1.09	1.24	1.32	1.39	1.12	1.10	1.26	1.32	0.92	1.53	1.34
Median	31.90	30.30	30.10	31.40	30.40	32.00	30.80	27.80	32.00	29.00	29.80
% NA	27.92	60.00	23.33	19.58	60.83	44.17	61.33	56.67	20.42	61.33	10.83

- *Precipitation*



Maximum Temperature



Result: monthly climate baseline

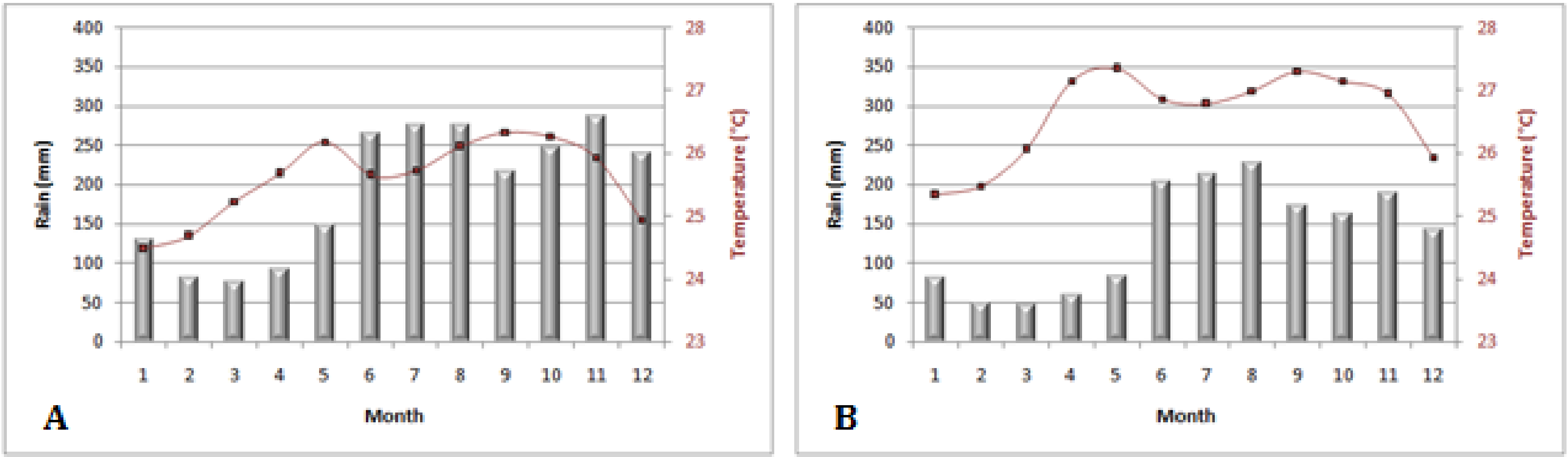


Figure 4. Climatic characteristics for wet (a) and dry (b) areas in Trinidad and Tobago respect to variables of precipitation (mm) and mean temperature (° C)

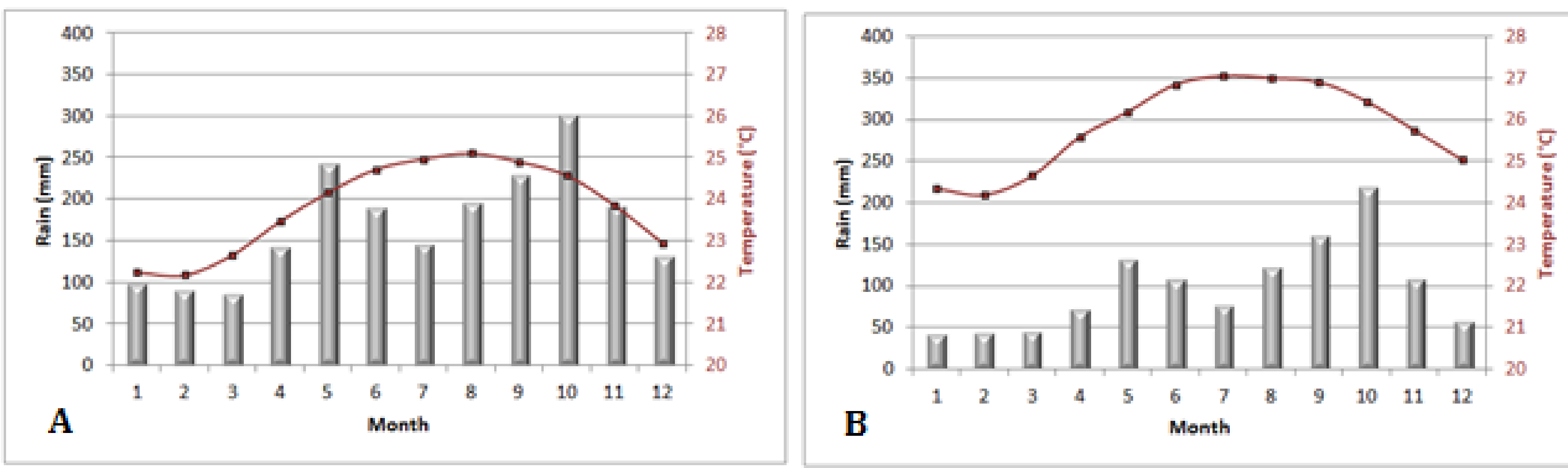
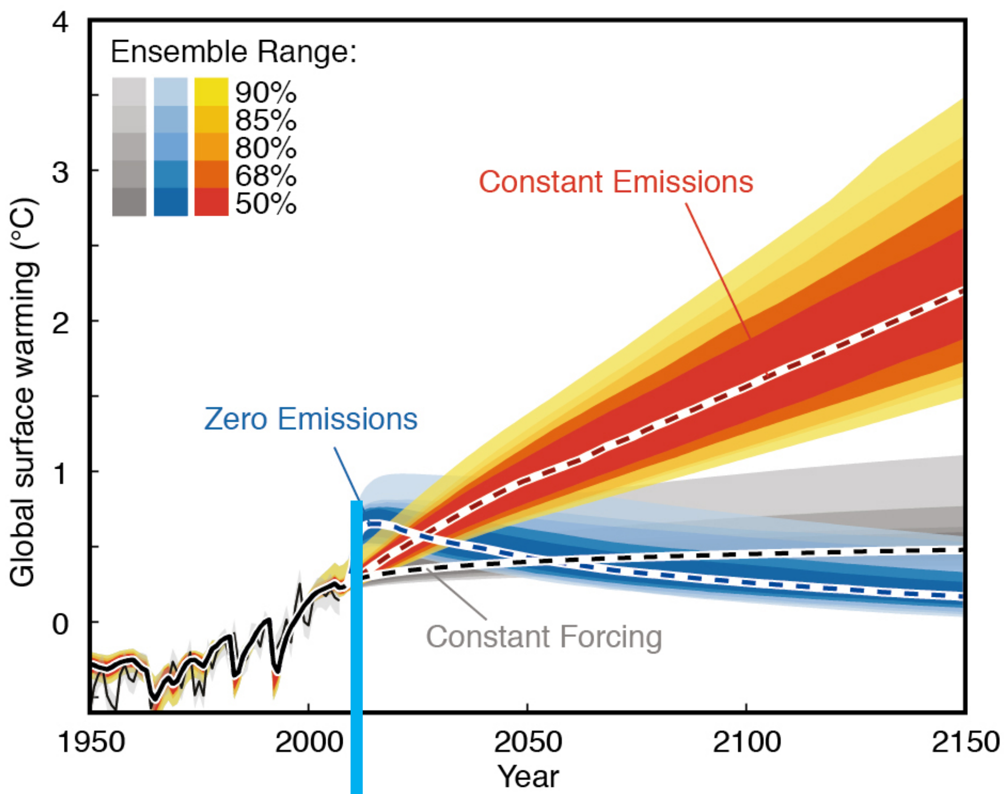
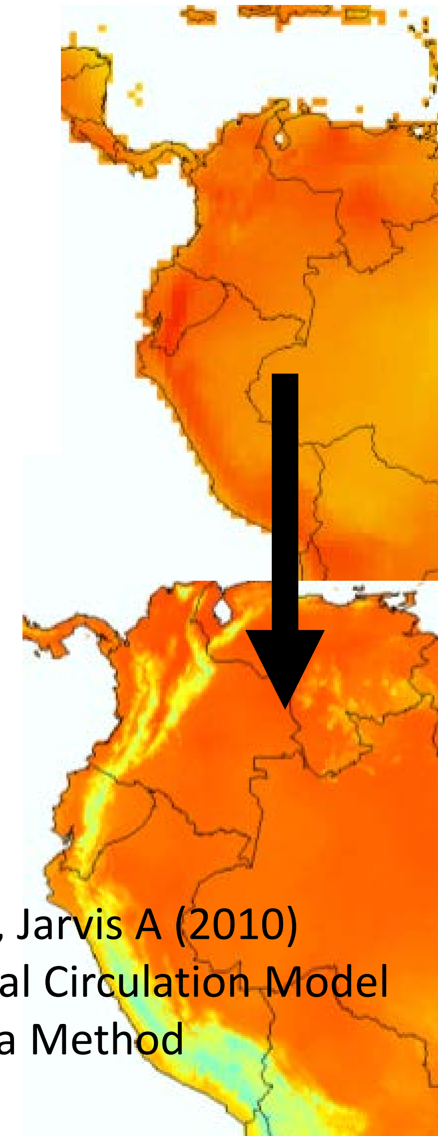


Figure 6. Climatic characteristics for wet (a) and dry (b) areas in Jamaica respect to variables of precipitation (mm) and mean temperature (° C)

Generation of future climate data: Circulation models from IPCC AR5

Delta method to downscale





Observe climate

Model climate

Ramirez-Villegas J, Jarvis A (2010) Downscaling Global Circulation Model Outputs: The Delta Method

Suitability modeling with Ecocrop

EcoCrop, originally by Hijman et al. (2001), was further developed, providing calibration and evaluation procedures (Ramirez-Villegas et al. 2011).

How does it work?

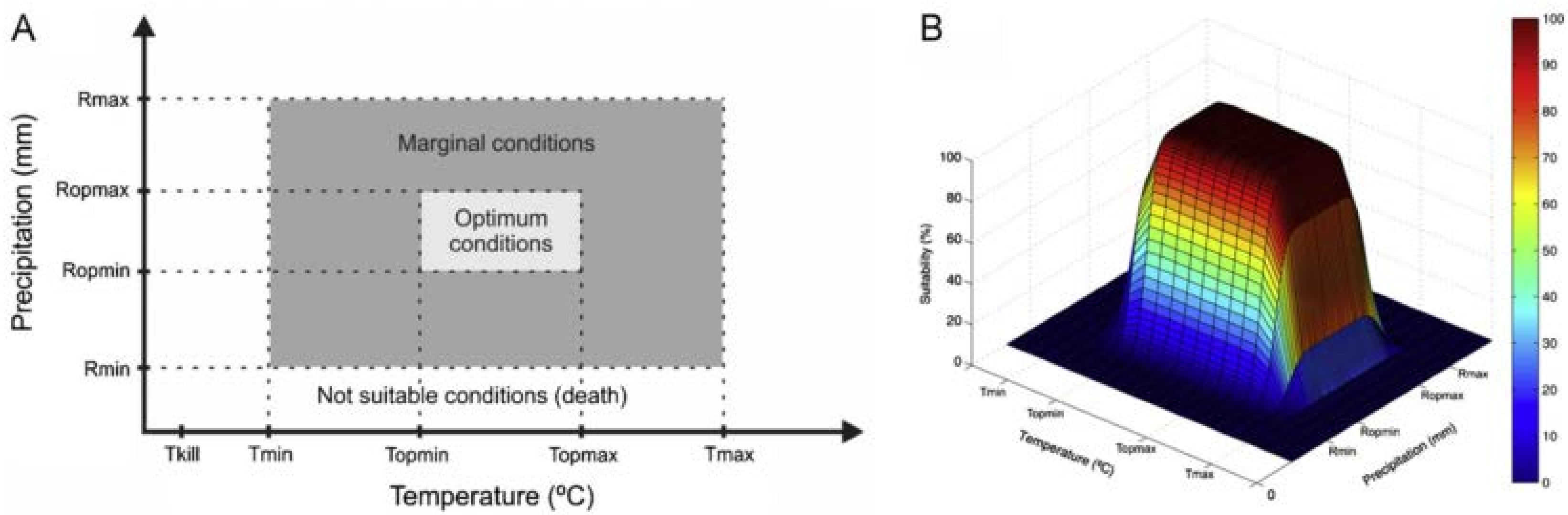


Fig. 1. Two- (A) and three-dimensional (B) diagram of the mechanistic model used in the analysis.

It evaluates on monthly basis if there are adequate climatic conditions within a growing season for temperature and precipitation…

…and calculates the climatic suitability of the resulting interaction between rainfall and temperature…

For temperature suitability

Ktmp: absolute temperature that will kill the plant

Tmin: minimum average temperature at which the plant will grow

Topmin: minimum average temperature at which the plant will grow optimally

Topmax: maximum average temperature at which the plant will grow optimally

Tmax: maximum average temperature at which the plant will cease to grow

For rainfall suitability

Rmin: minimum rainfall (mm) during the growing season

Ropmin: optimal minimum rainfall (mm) during the growing season

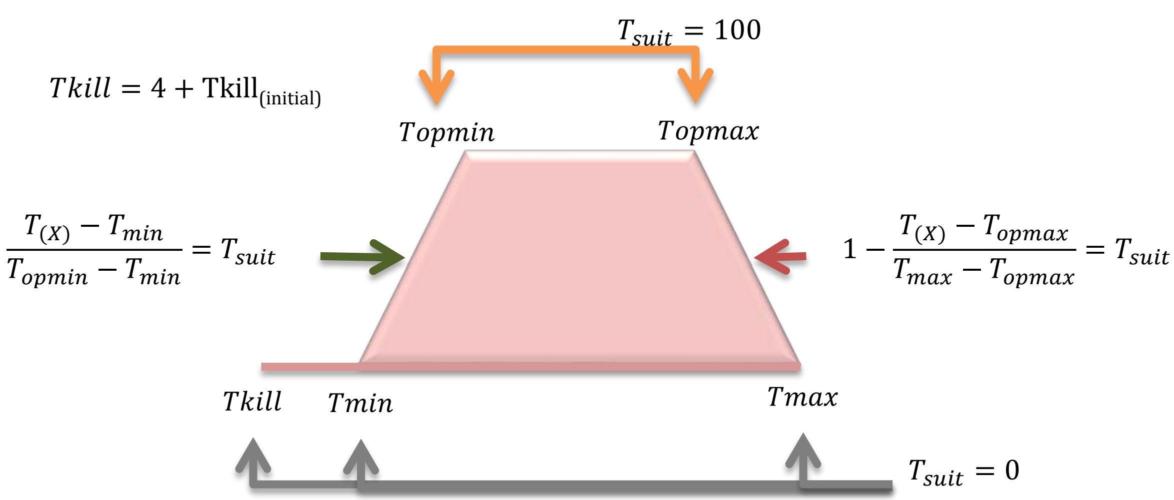
Ropmax: optimal maximum rainfall (mm) during the growing season

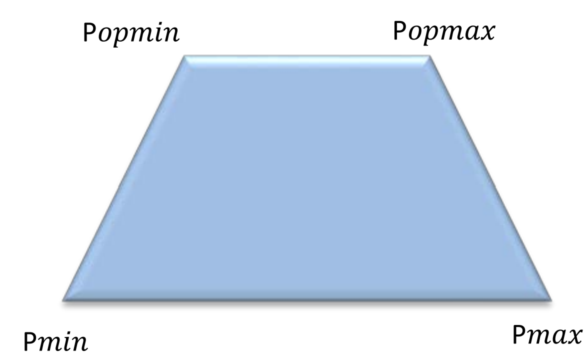
Rmax: maximum rainfall (mm) during the growing season

Length of the growing season

Gmin: minimun days of growing season

Gmax: maximum days of growing season





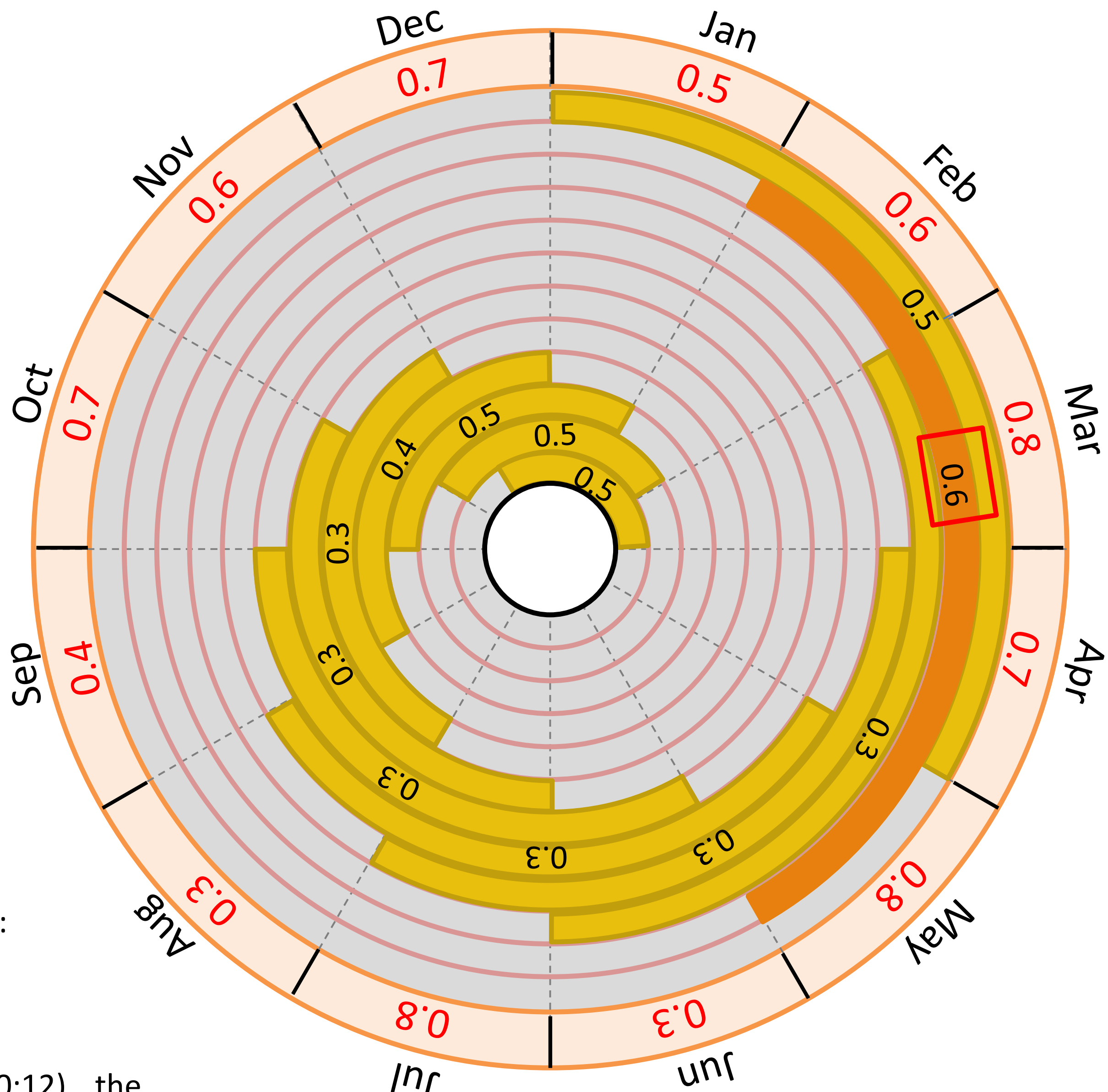
How it works??

❖ **Temperature:**

The suitability for each month is calculated according to the mean temperature value of the pixel

Select the lowest suitability for each of the 12 potential growing seasons, according to the length of the growing season of the crop (months)

The final temperature suitability is the maximum value of all growing seasons



The results can be seen through the maps:

TSUIT = suitability by temperature (0-100)

GSTMEAN = Better growing season (0:12), the number indicating that the start of growing season in that month provides the best conditions respect to temperature

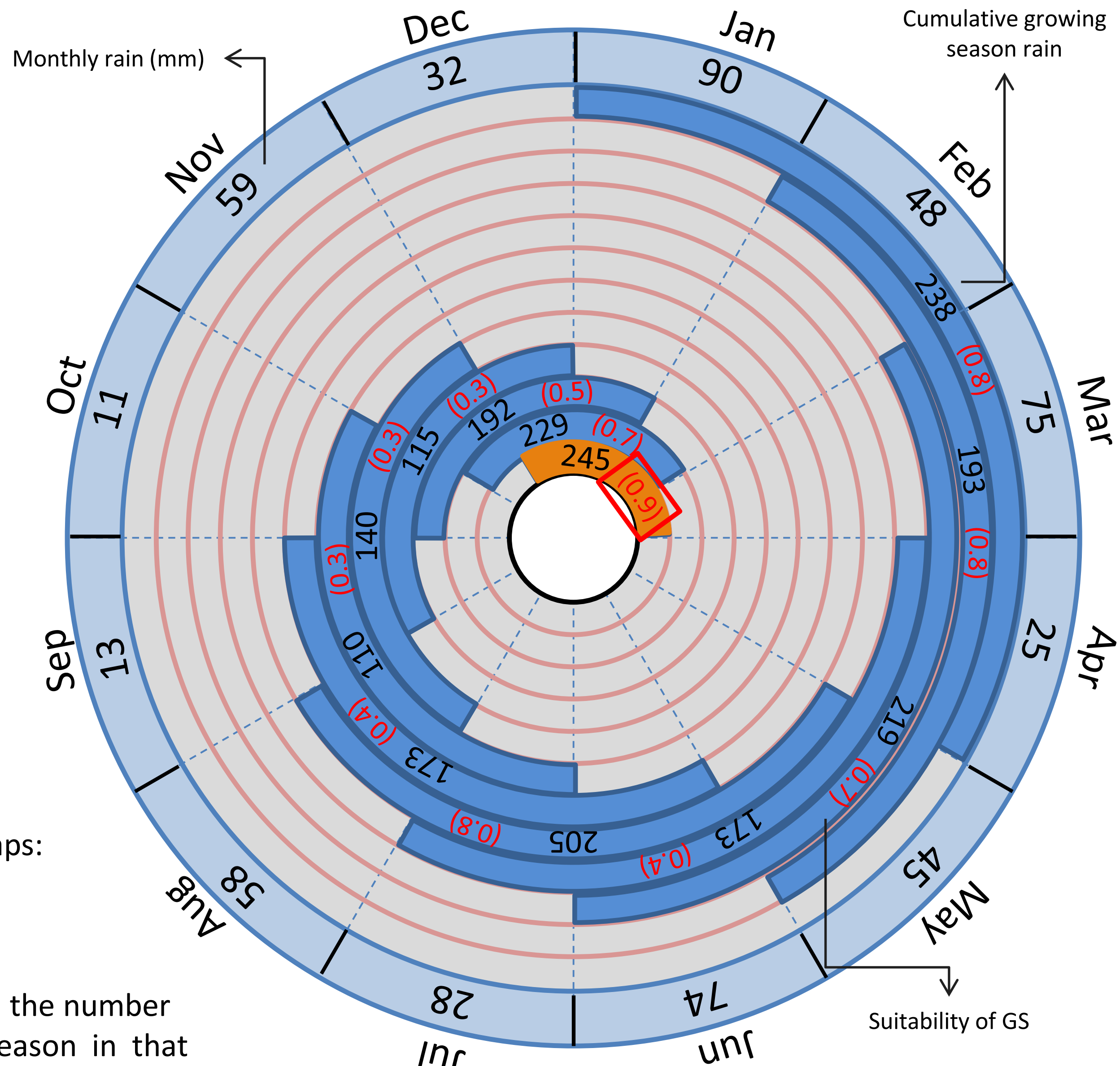
In the example:
TSUIT = 0.6 (60%) and GSTMEAN = 2

How it works??

❖ Precipitation:

The evaluation for rainfall is similar as for temperature, except that there is one evaluation for the total growing season through the total cumulative rain of the growing season of the crop (months)
and not for each month.

The final rainfall suitability is the maximum value of all growing seasons



The results can be seen through the maps:

RSUIT = suitability by rainfall (0-100) %

GSRAIN = Better growing season (0:12), the number indicating that the start of growing season in that month provides the best conditions respect to rainfall

In the example:
RSUIT = 0.9 (90%) and GSRAIN = 12

Finally the interaction (product) is calculated between the suitability of temperature and precipitation for each growing season

$$T1_{SUIT}{}^{*}R1_{SUIT}; T2_{SUIT}{}^{*}R2_{SUIT}; T3_{SUIT}{*}R3_{SUIT}; \ldots; T12_{SUIT}{*}R12_{SUIT}$$

The final suitability will be the best result of the 12 products calculated

	GS1	GS2	GS3	GS4	GS5	GS6	GS7	GS8	GS9	GS10	GS11	GS12
TSUIT	0.5	**0.6**	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5
RSUIT	0.8	0.5	0.7	0.4	0.8	0.4	0.3	0.3	0.3	0.5	0.7	**0.9**
SUIT (TSUIT*RSUIT)	0.40	0.30	0.21	0.12	0.24	0.12	0.09	0.09	0.12	0.25	0.35	0.45
SUIT (%)	40	30	21	12	24	12	9	9	12	25	35	45

In the example, GS2 is the best season for temperature (60%) and GS12 for precipitation (90%). For interaction of two variables the better suitability (45%) is obtained also in the growing season 12 (GSSUIT = 12)

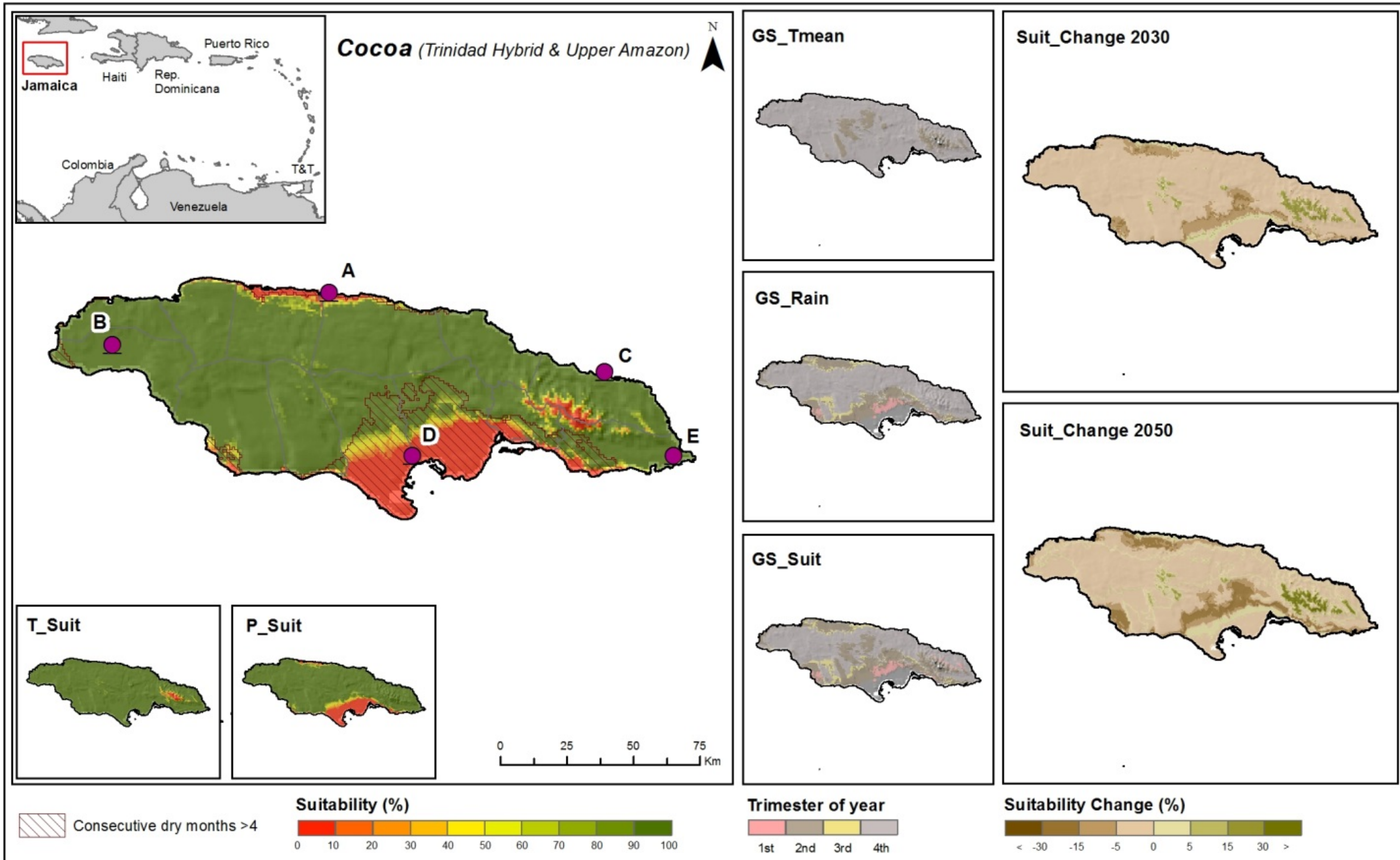
Modeling of potential future impacts on crop suitability: Results

- Climate data from UWI climate data group
- Climate parameters from WP 1

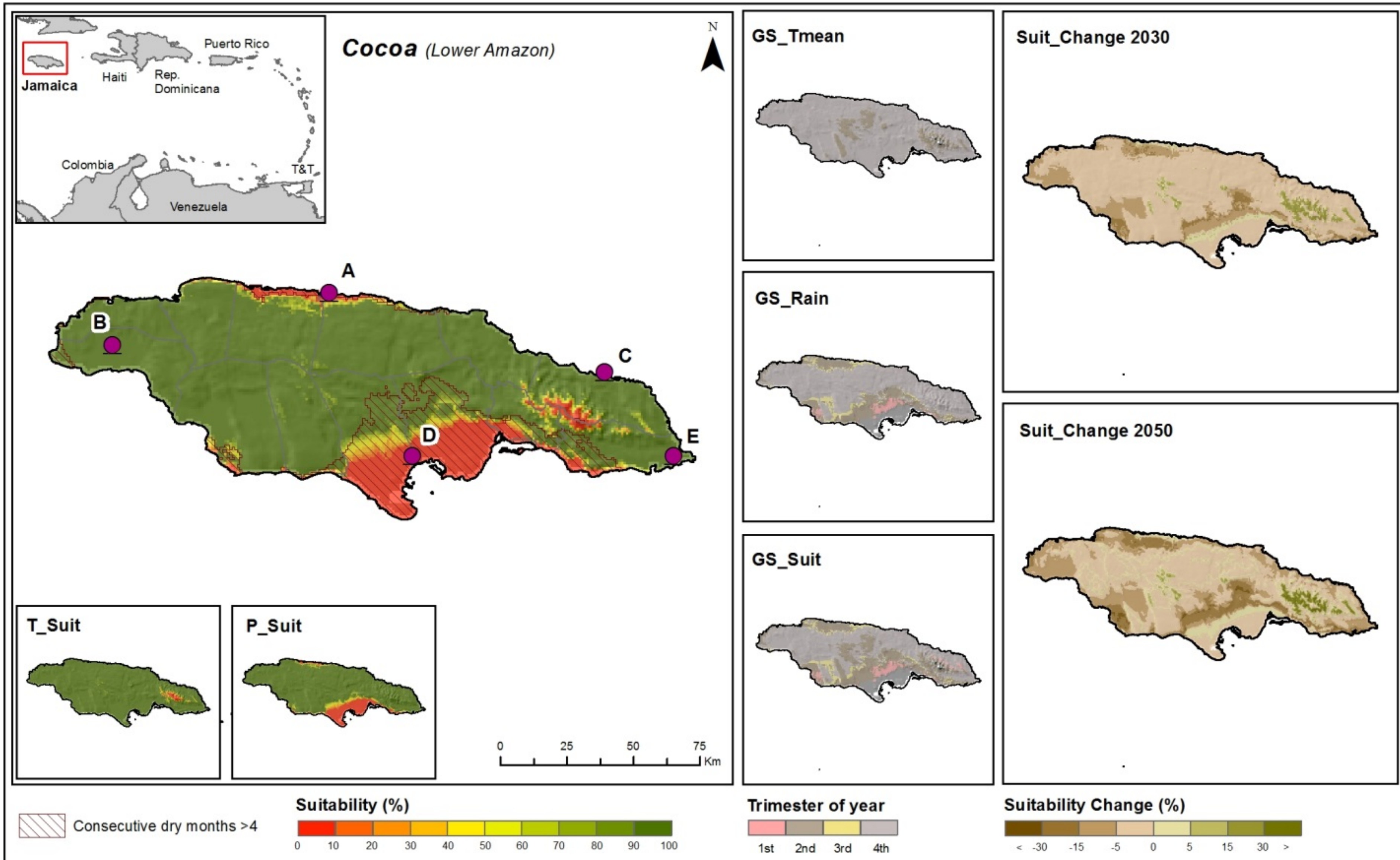
Table 6. Crop parameters to Ecocrop Model

SPECIE	GMIN	GMAX	TKILL	TMIN	TOPMIN	TOPMAX	TMAX	RMIN	ROPMIN	ROPMAX	RMAX
Cocoa Lower Amazon	180	365	10	15	20	27.7	46	1000	1250	2500	2800
Cocoa Trinidad hybrid	180	365	10	15	20	30	43.5	1000	1250	2500	2800
Cocoa Upper Amazon	180	365	10	15	20	34.3	46	1000	1250	2500	2800
Tomato	90	140	10	15	21	24	30	400	600	1300	1800

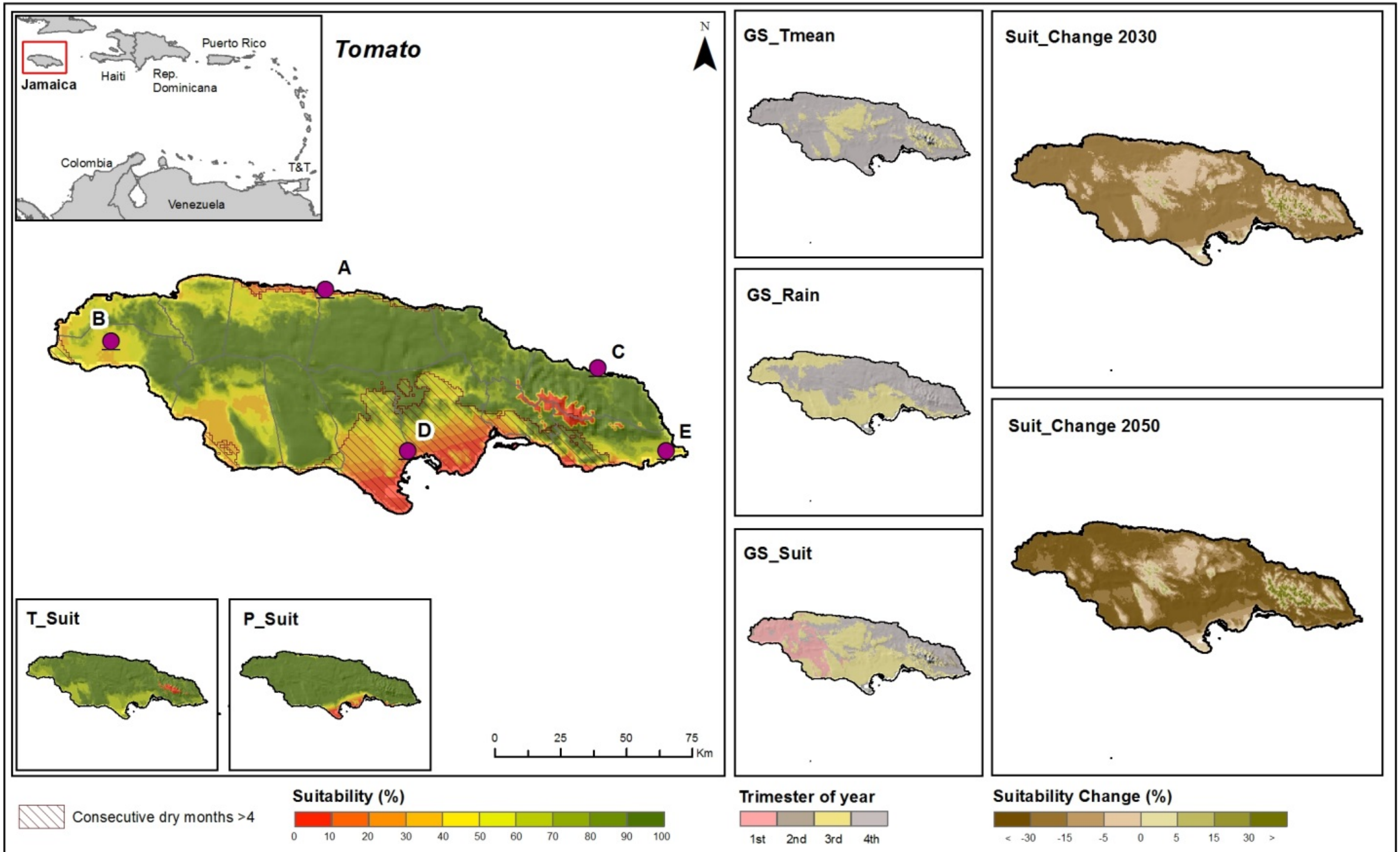
Cocoa: Trinidad Hybrid & Upper Amazon



Cocoa: Lower Amazon



Tomato



Tomato
Puerto Rico
Haiti
Rep. Dominicana
Jamaica
Colombia
T&T
Venezuela
N
A
B
C
D
E
T_Suit
P_Suit
0 25 50 75 Km
GS_Tmean
GS_Rain
GS_Suit
Suit_Change 2030
Suit_Change 2050
Consecutive dry months >4
Suitability (%)
0 10 20 30 40 50 60 70 80 90 100
Trimester of year
1st 2nd 3rd 4th
Suitability Change (%)
< -30 -15 -5 0 5 15 30 >

Inter annual variability in Trinidad & Tobago

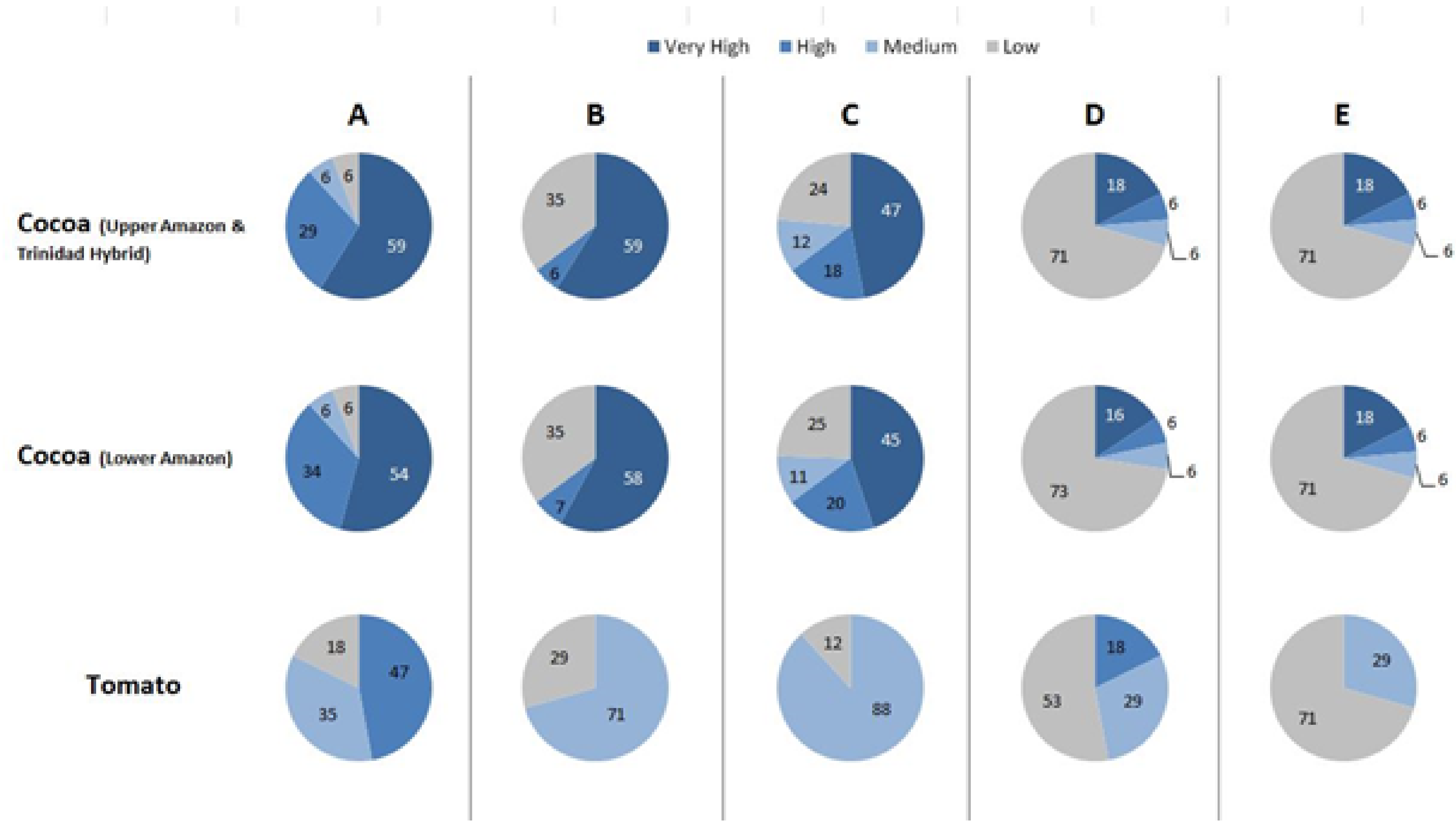
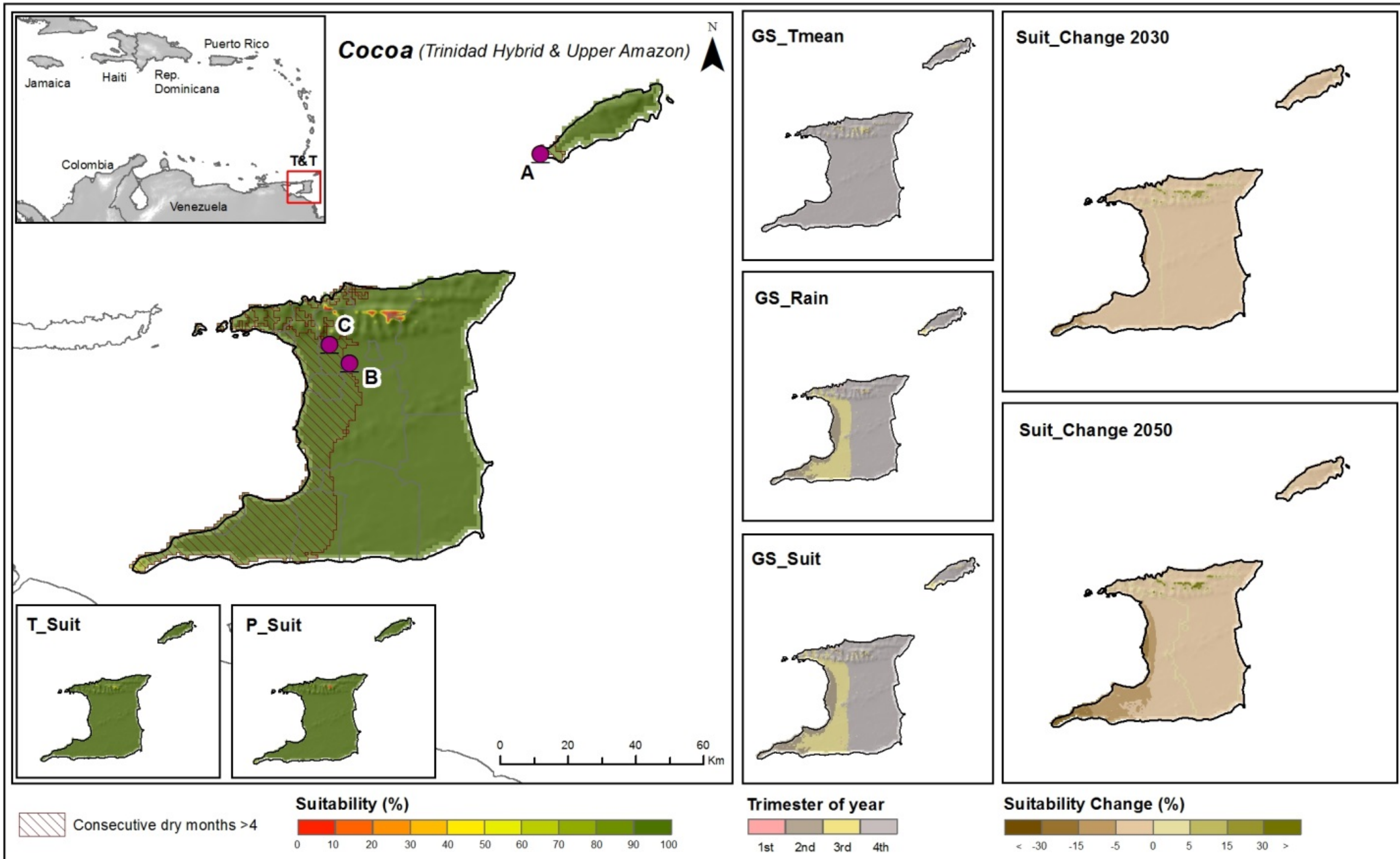
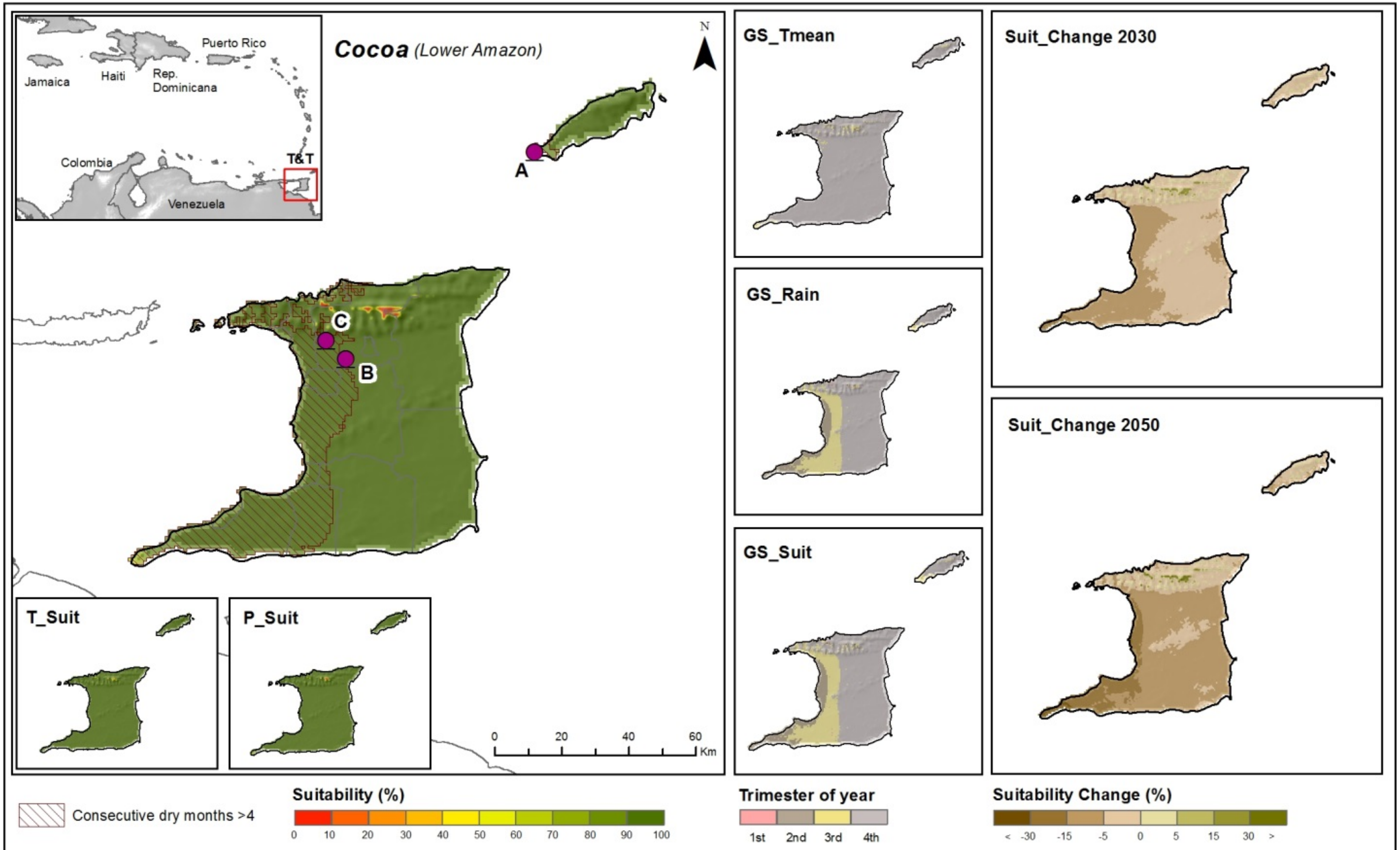


Figure 16. Behavior of suitability crops during the 1997-2013 *time series for* five localities in Jamaica. *The categories refer to aptitude levels: Very High (VH)>75%, High (H) >50%, Medium (M) >30%, Low (L) <30%.*

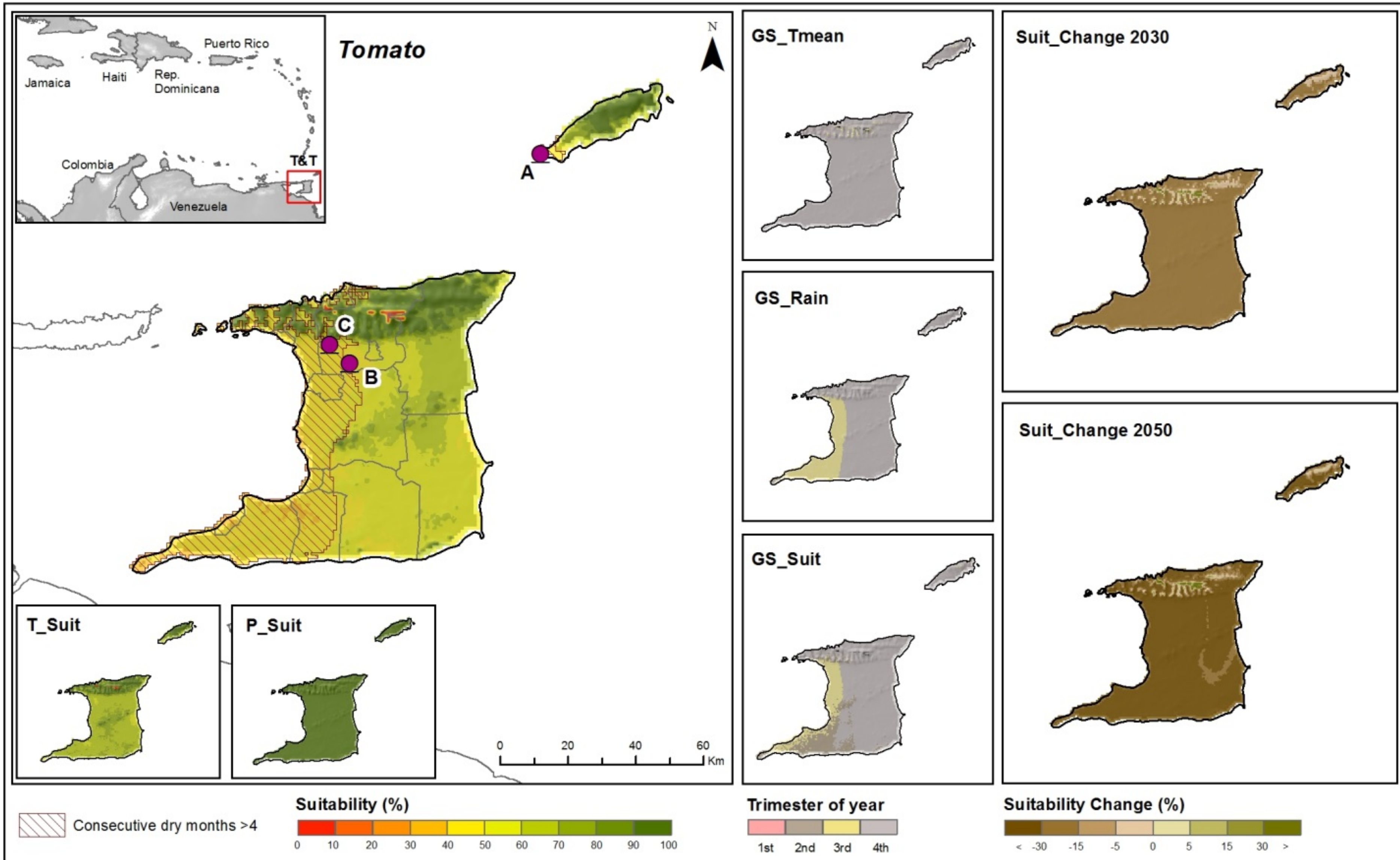
Cocoa: Trinidad Hybrid & Upper Amazon



Cocoa: Lower Amazon



Tomato



Tomato
Puerto Rico
Jamaica
Haiti
Rep. Dominicana
Colombia
T&T
Venezuela
N
A
B
C
T_Suit
P_Suit
0 20 40 60 Km
GS_Tmean
GS_Rain
GS_Suit
Suit_Change 2030
Suit_Change 2050
Consecutive dry months >4
Suitability (%)
0 10 20 30 40 50 60 70 80 90 100
Trimester of year
1st 2nd 3rd 4th
Suitability Change (%)
< -30 -15 -5 0 5 15 30 >

Inter annual variability in Trinidad & Tobago

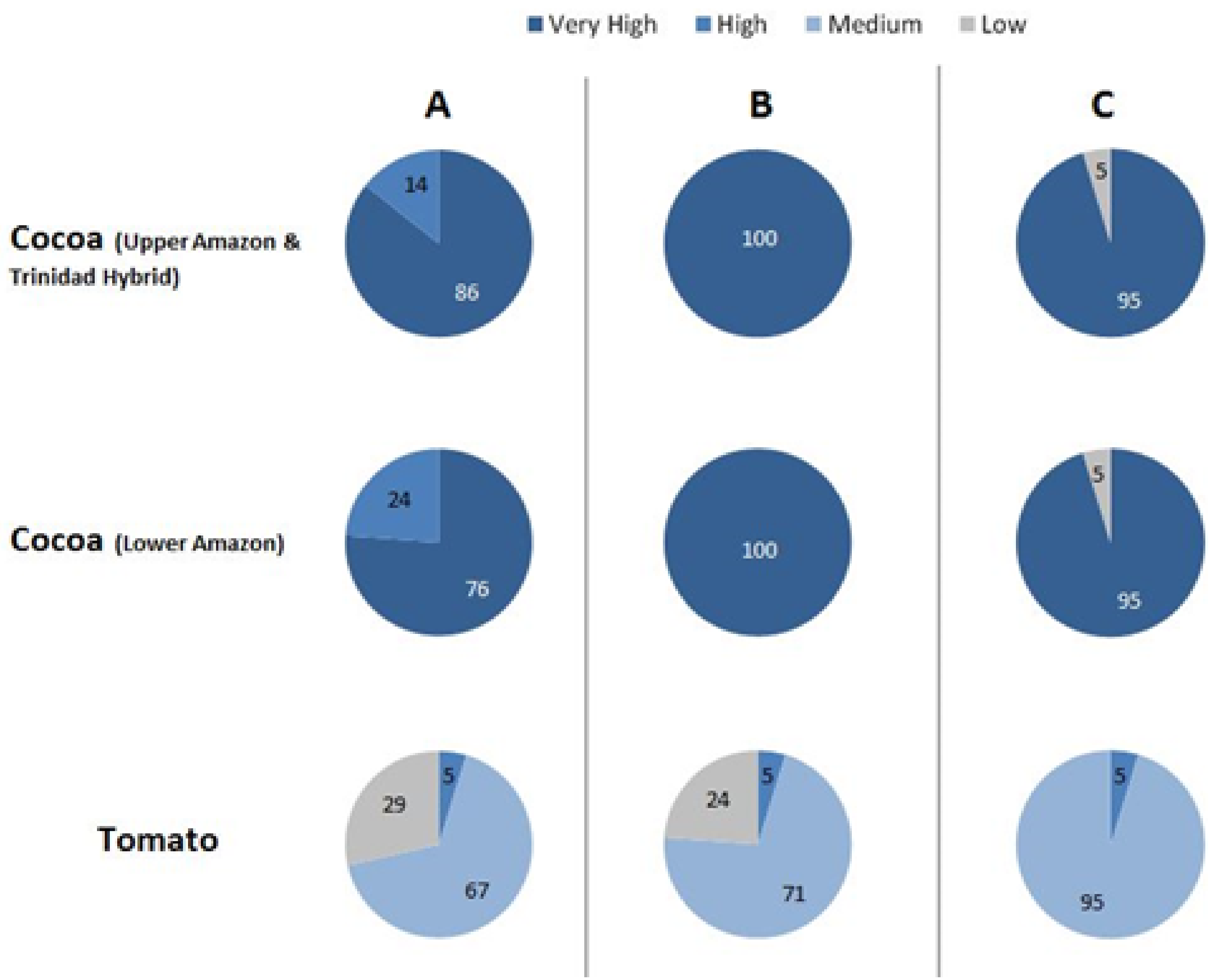


Figure 12. *Behavior* of suitability *crops during the 1990-2010 time series for three* climatic stations *in Trinidad and Tobago. The categories refer to* aptitude *levels:* Very High (VH)>75%, High (H) >50%, Medium (M) >30%, Low (L) <30%.

Impact of climate change in T&T and Jamaica (Conclusions)

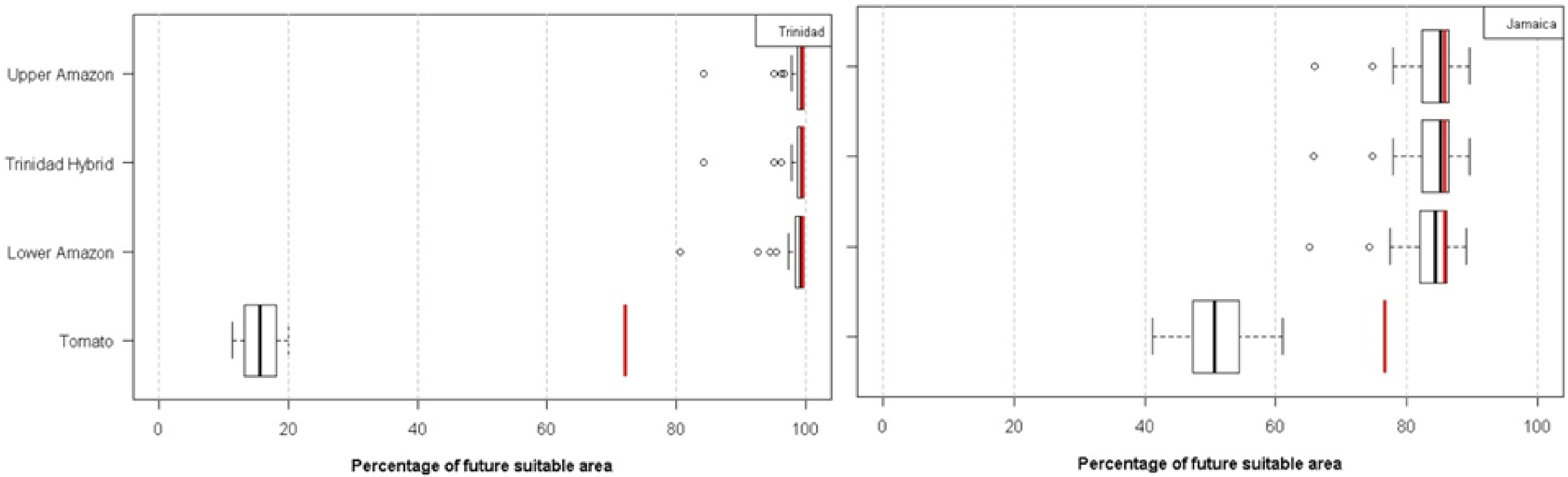


Figure 17.*Percentage of loss currently suitable areas in Trinidad & Tobago and Jamaica, respectively. The red line determines the average of suitable areas for current crops and boxes detailing the media, the first and third quartile of the future suitable areas.*

Participatory local adaptation plans

Outscaling a citizen science approach to test climate adaptation technologies on farms :
Jacob Van Etten, Bioversity International
wimoto
Farmers as Scientists!
23
47
89
1. A broad set of varieties is evaluated
2. Each farmer gets a different combination of varieties
3. Environmental data (GPS, sensors) to assess adaptation
wimoto
4. Farmers test and report back by mobile phone
5. Farmers receive tailored variety recommendations and can order seeds
6. Detect demand for new varieties and traits

Use ICT tools for crow sourcing and M&E

- Registering farmer in the system
- Managing data collection of farmers experiments (surveys, spatial information, …)
- Monitoring CSA implementation projects (activity reports, feedback loops with experts)