Climate Warming and Natural Rubber Productivity

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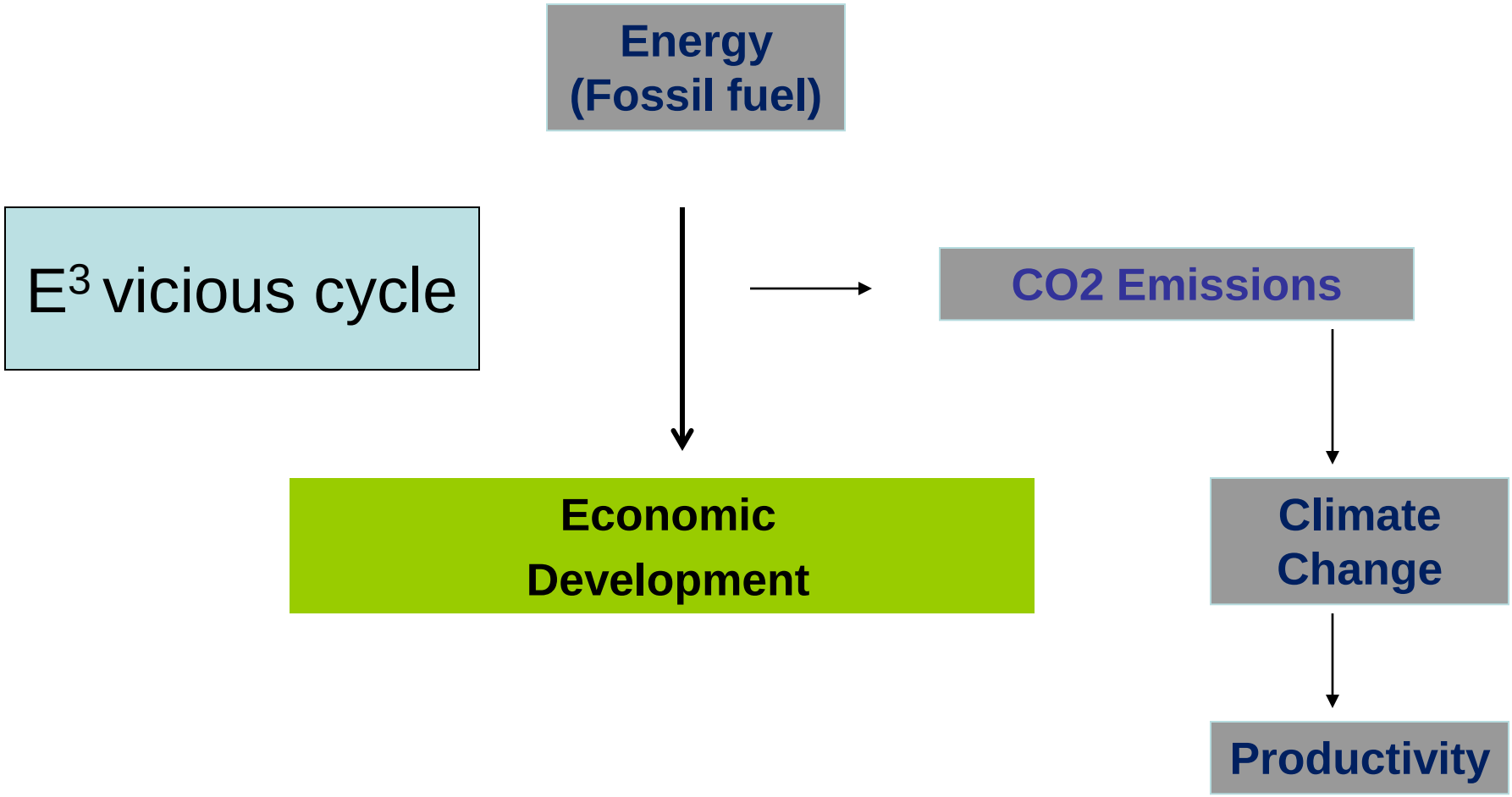
KEC 2012
16-18 August 2012
Trivandrum

Session Outline

1. Introduction
2. Has climate changed in the NR belt in the country?
3. How did these changes impact NR productivity in the past?
4. What is in store for future?
5. Geo-informatics and Ecological Niche Modeling
6. Are trees the answer to global warming?

1. Introduction

Emissions ---→ climate change:
Blame it on economic development

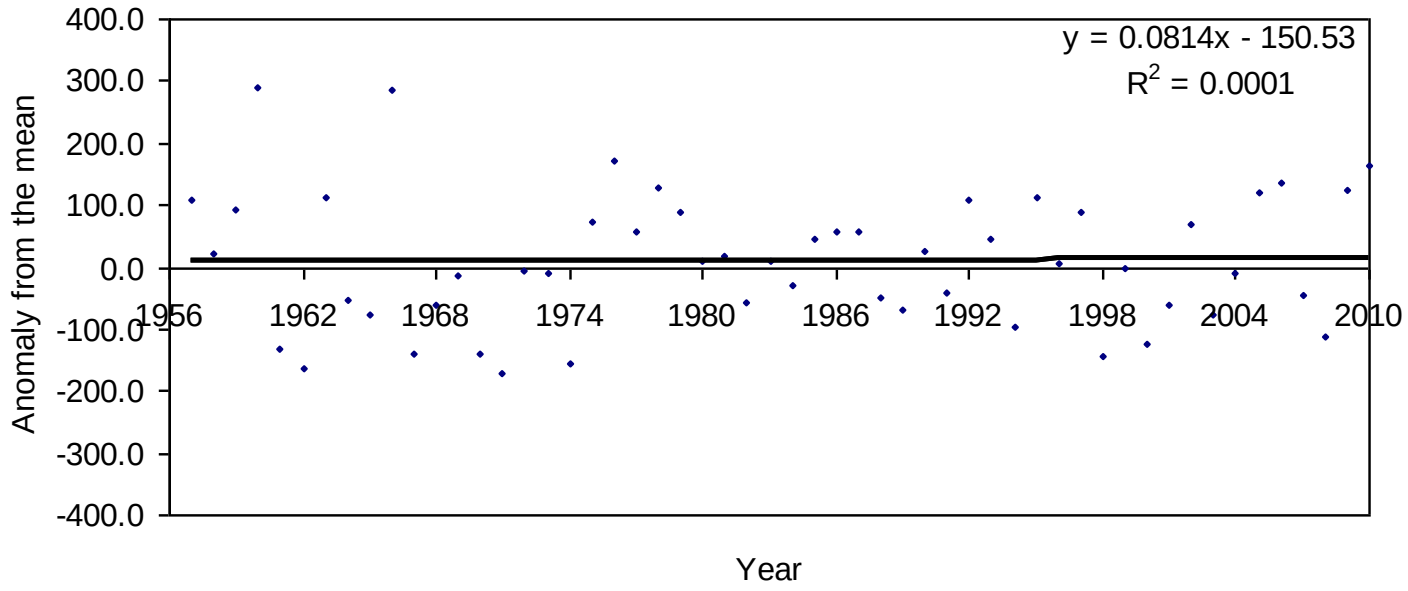


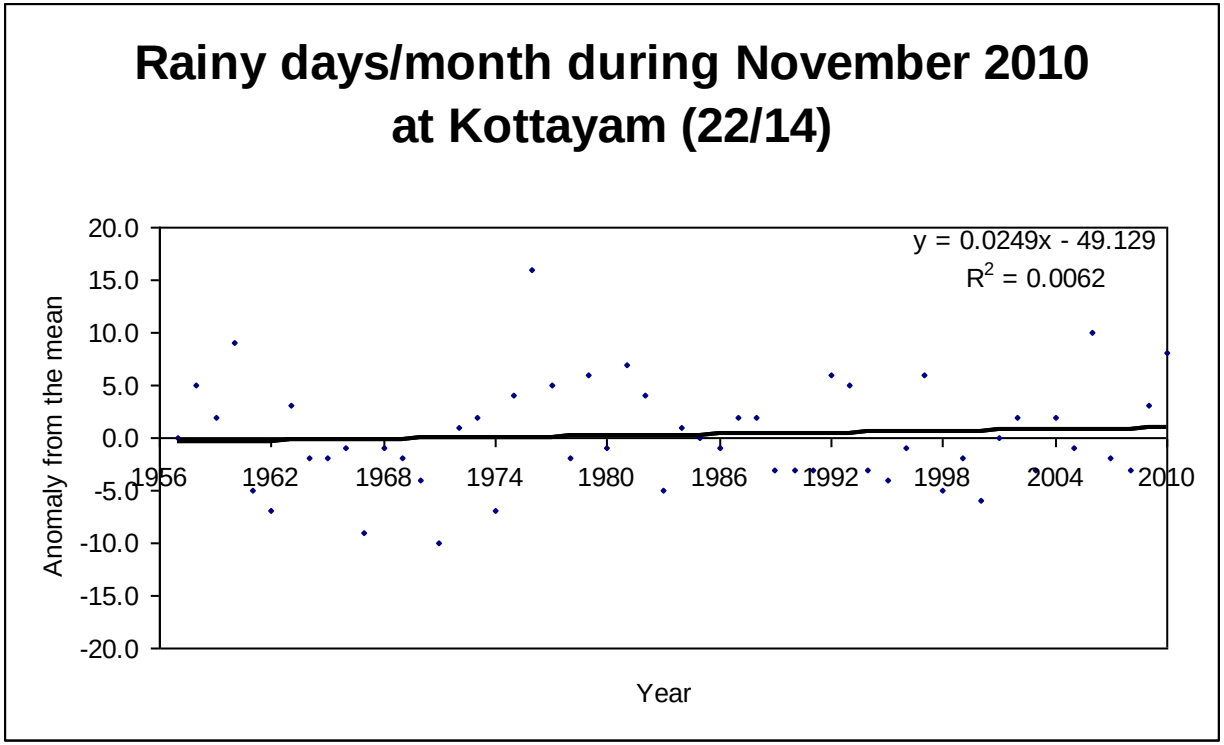
$$\uparrow \text{Profit} = f(\downarrow \text{COP}, \uparrow \text{Market Price})$$

$$\downarrow \text{COP} = \frac{\downarrow \text{Cost}}{\uparrow \text{Productivity}}$$

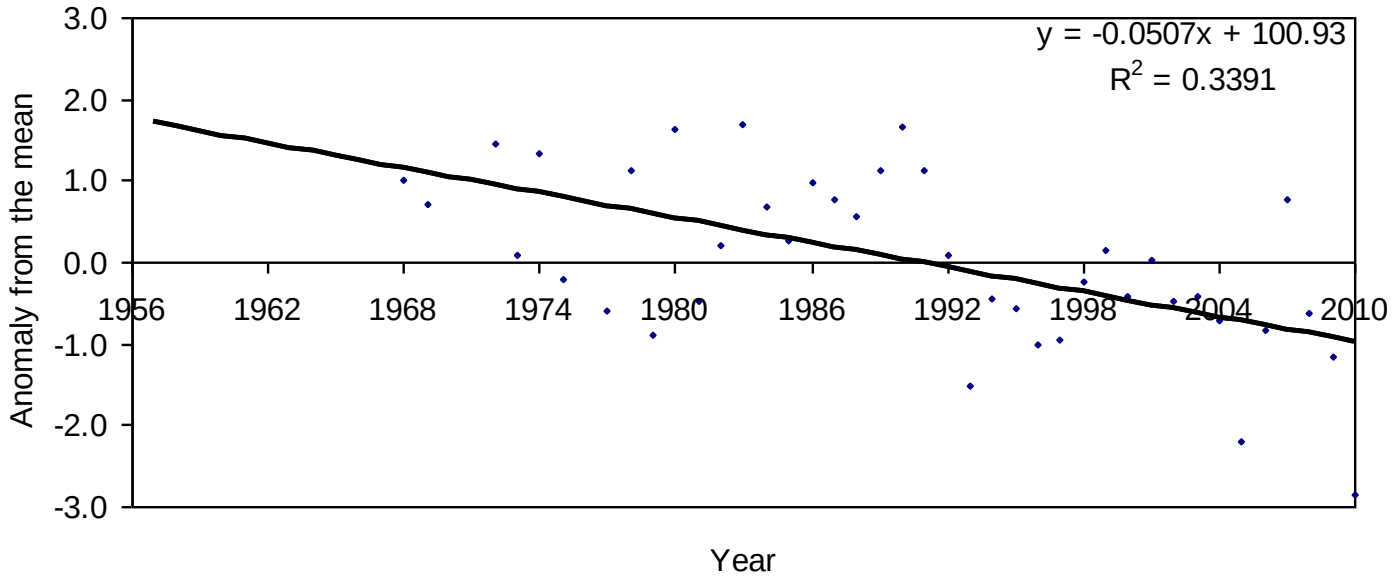
2. Has climate changed in the NR producing regions?

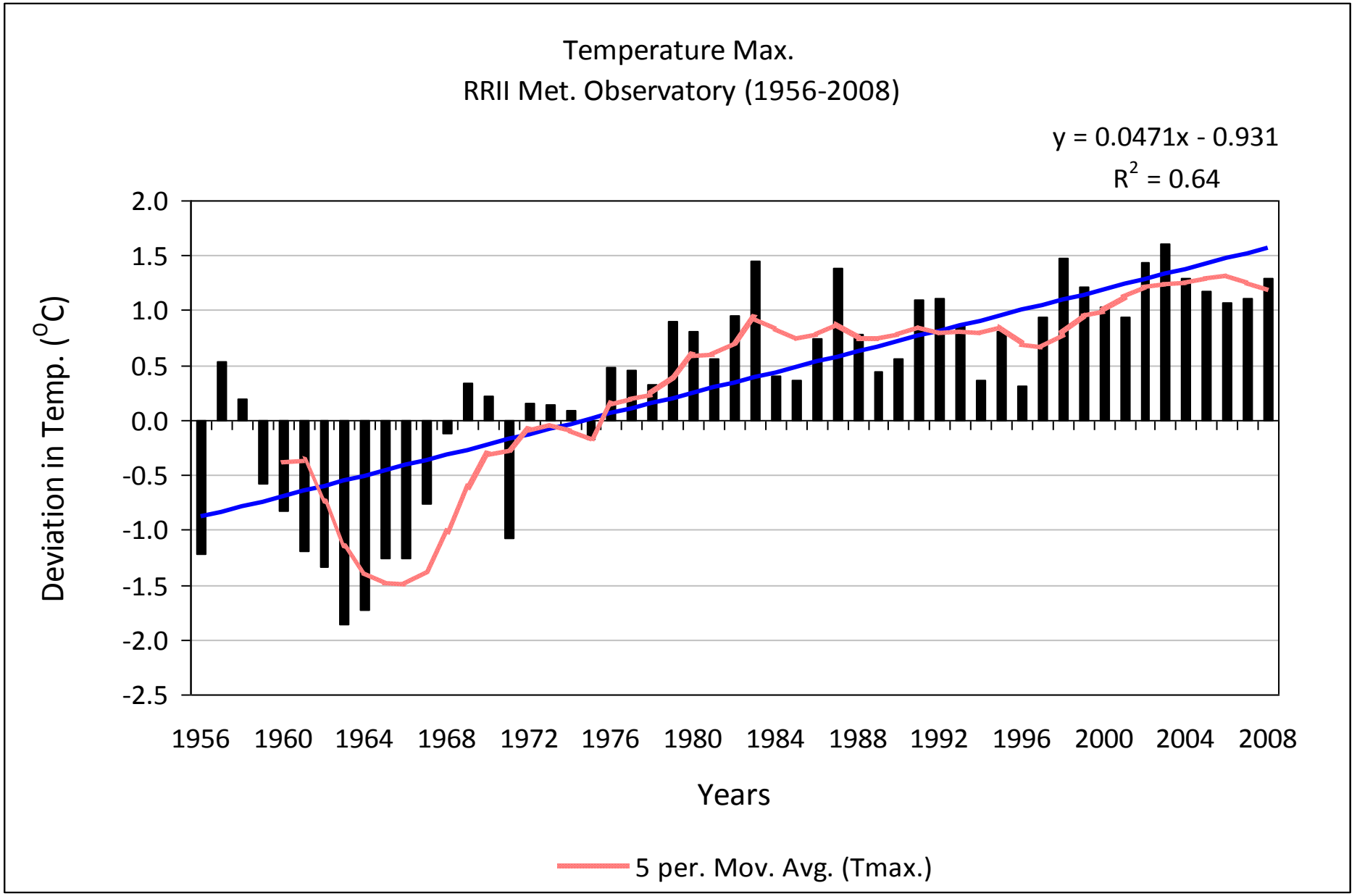
Rainfall during November 2010 at Kottayam (374/212)

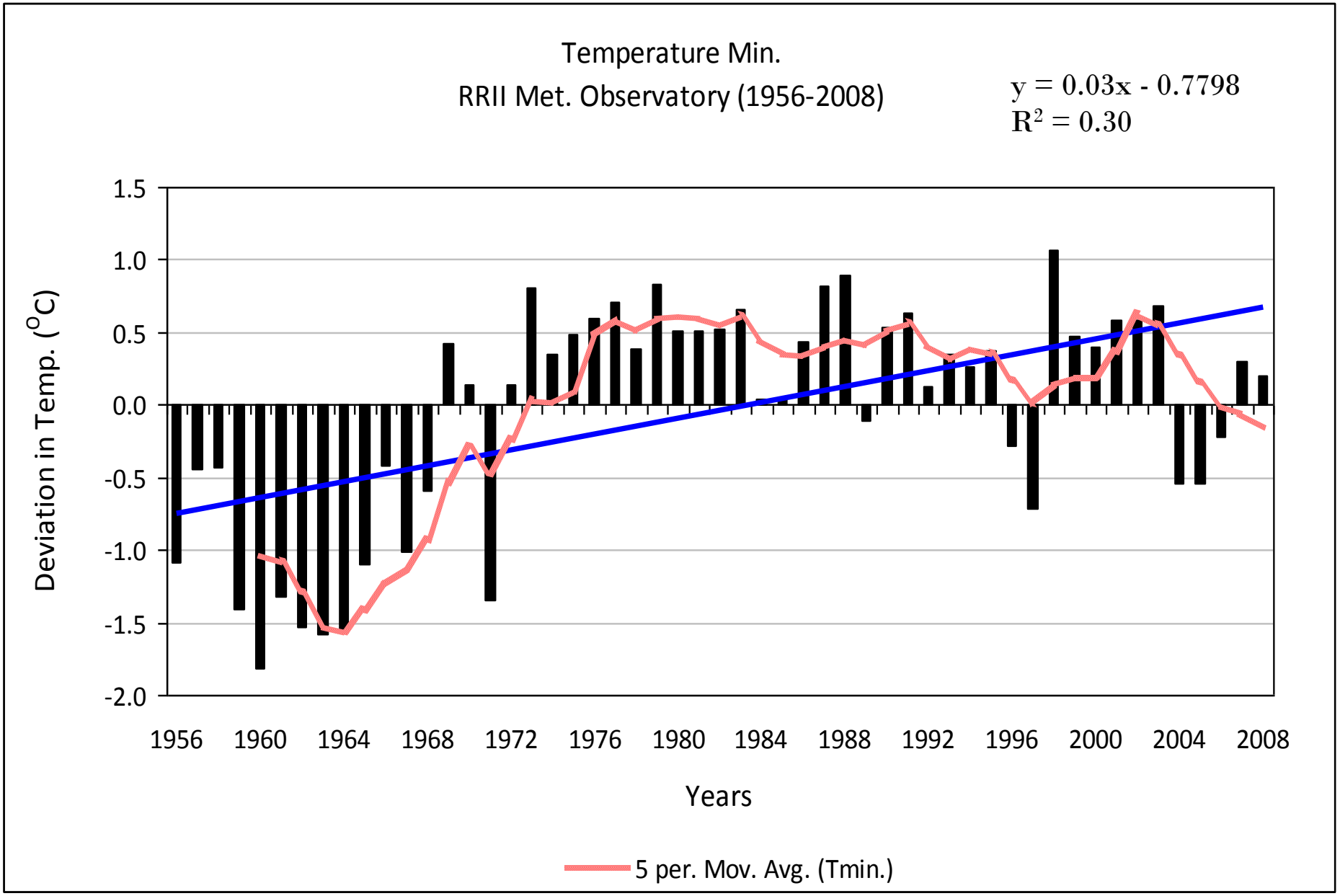


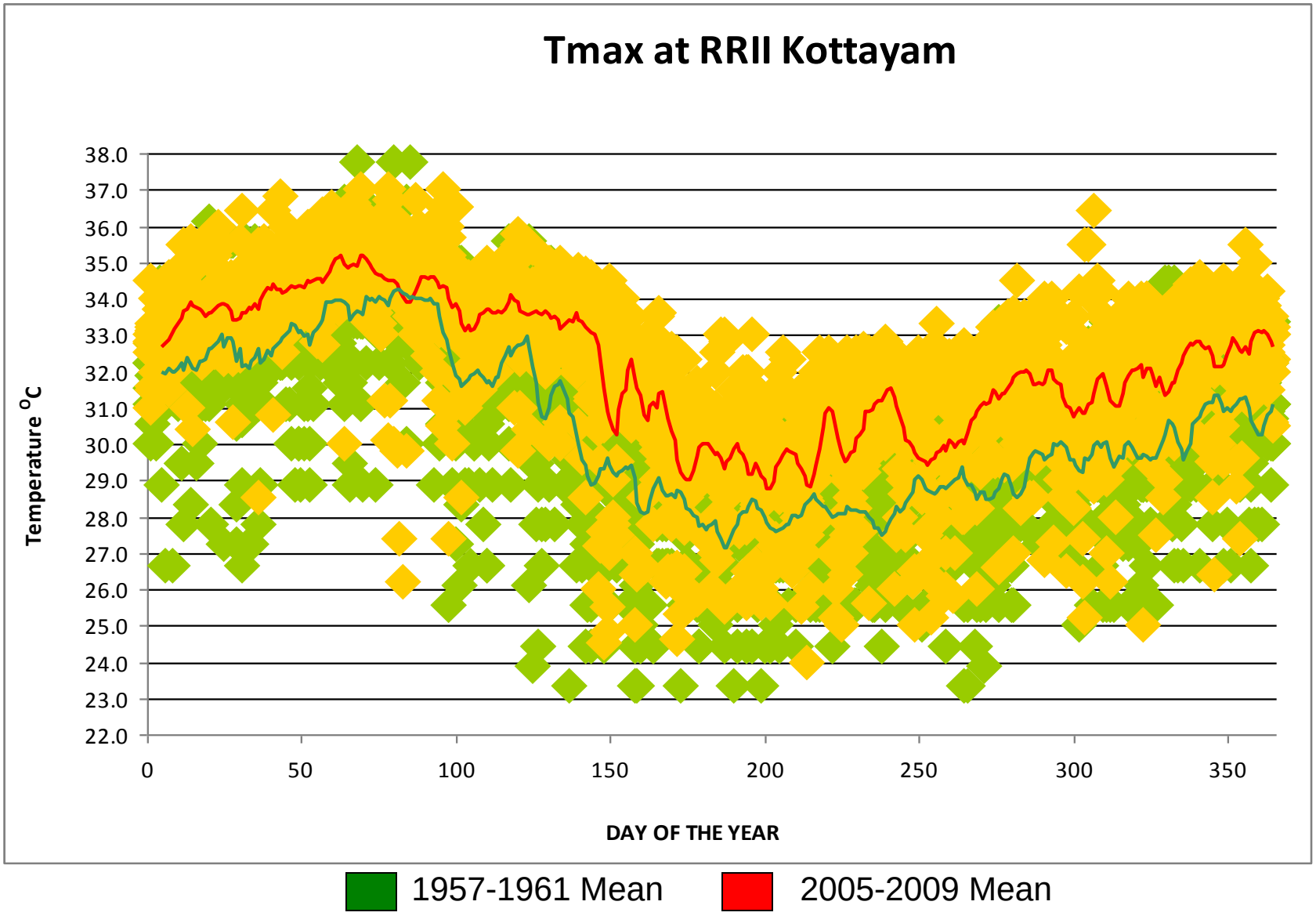

Rainy days/month during November 2010
at Kottayam (22/14)
y = 0.0249x - 49.129
R2 = 0.0062
Anomaly from the mean
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
1956
1962
1968
1974
1980
1986
1992
1998
2004
2010
Year

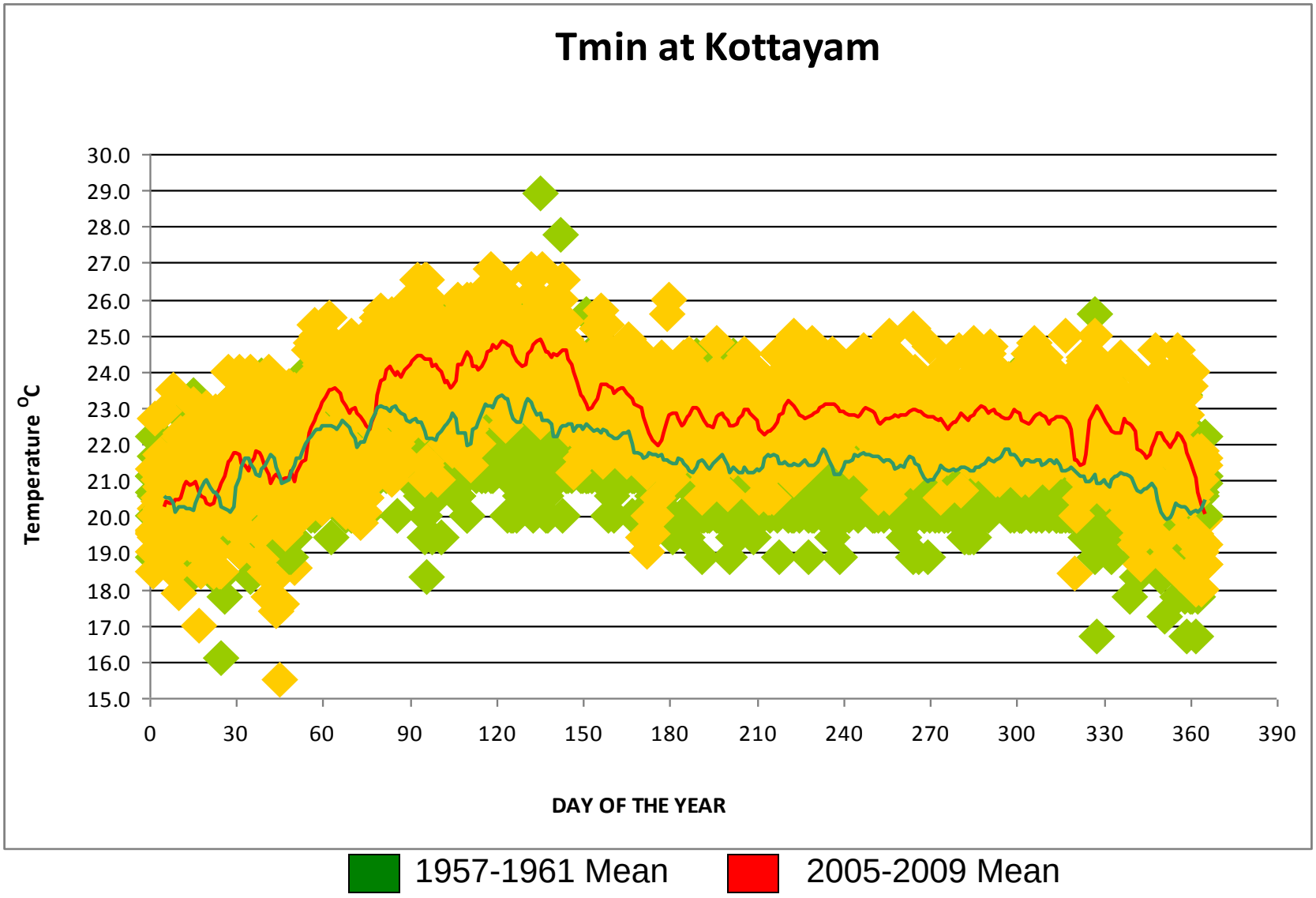
Sunshine hours per day during November 2010 at Kottayam (3.3/6.2)



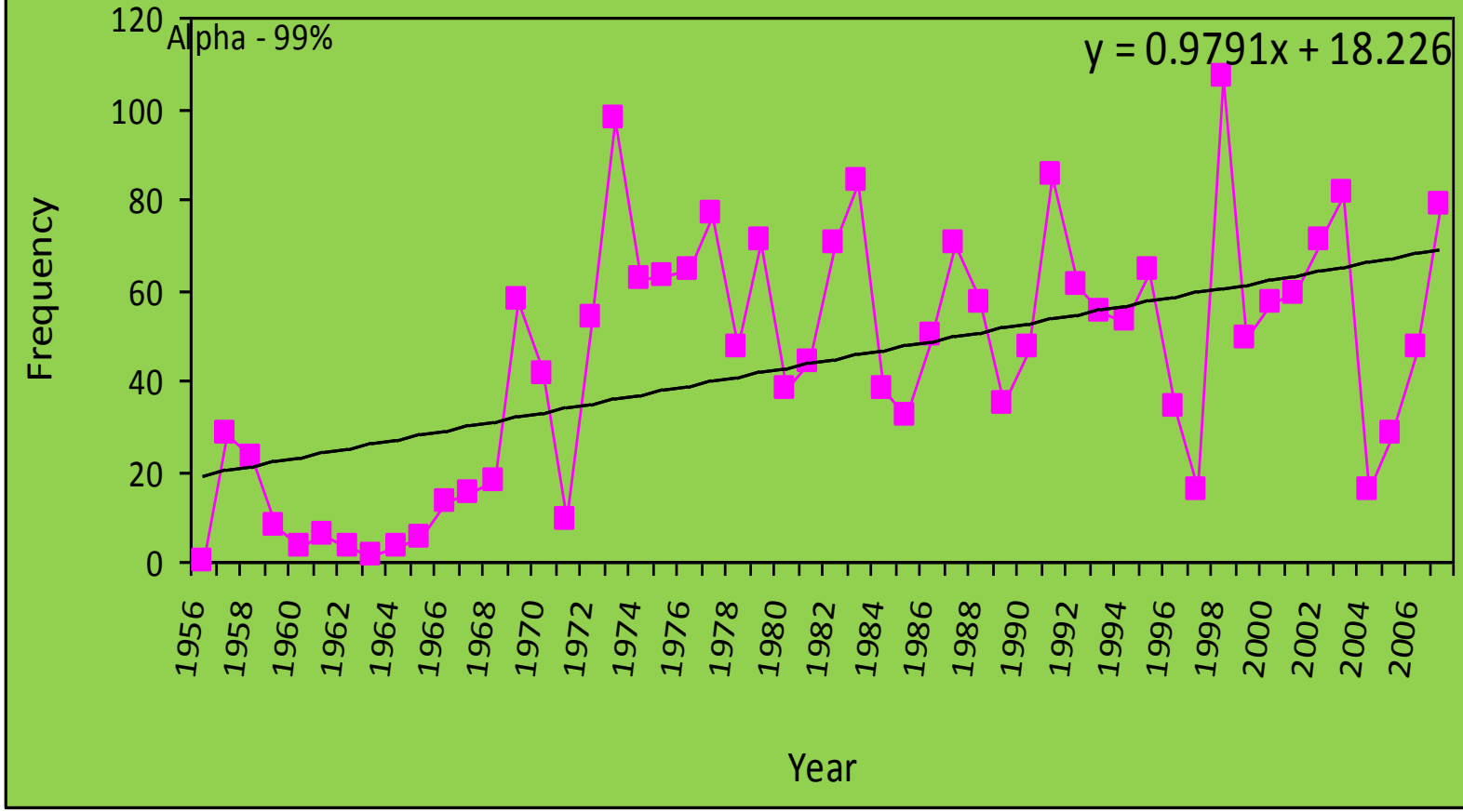

Temperature Max.
RRII Met. Observatory (1956-2008)
y = 0.0471x - 0.931
R2 = 0.64
Deviation in Temp. (OC)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
Years
5 per. Mov. Avg. (Tmax.)


Temperature Min.
RRII Met. Observatory (1956-2008)
y = 0.03x - 0.7798
R2 = 0.30
Deviation in Temp. (OC)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
Years
5 per. Mov. Avg. (Tmin.)

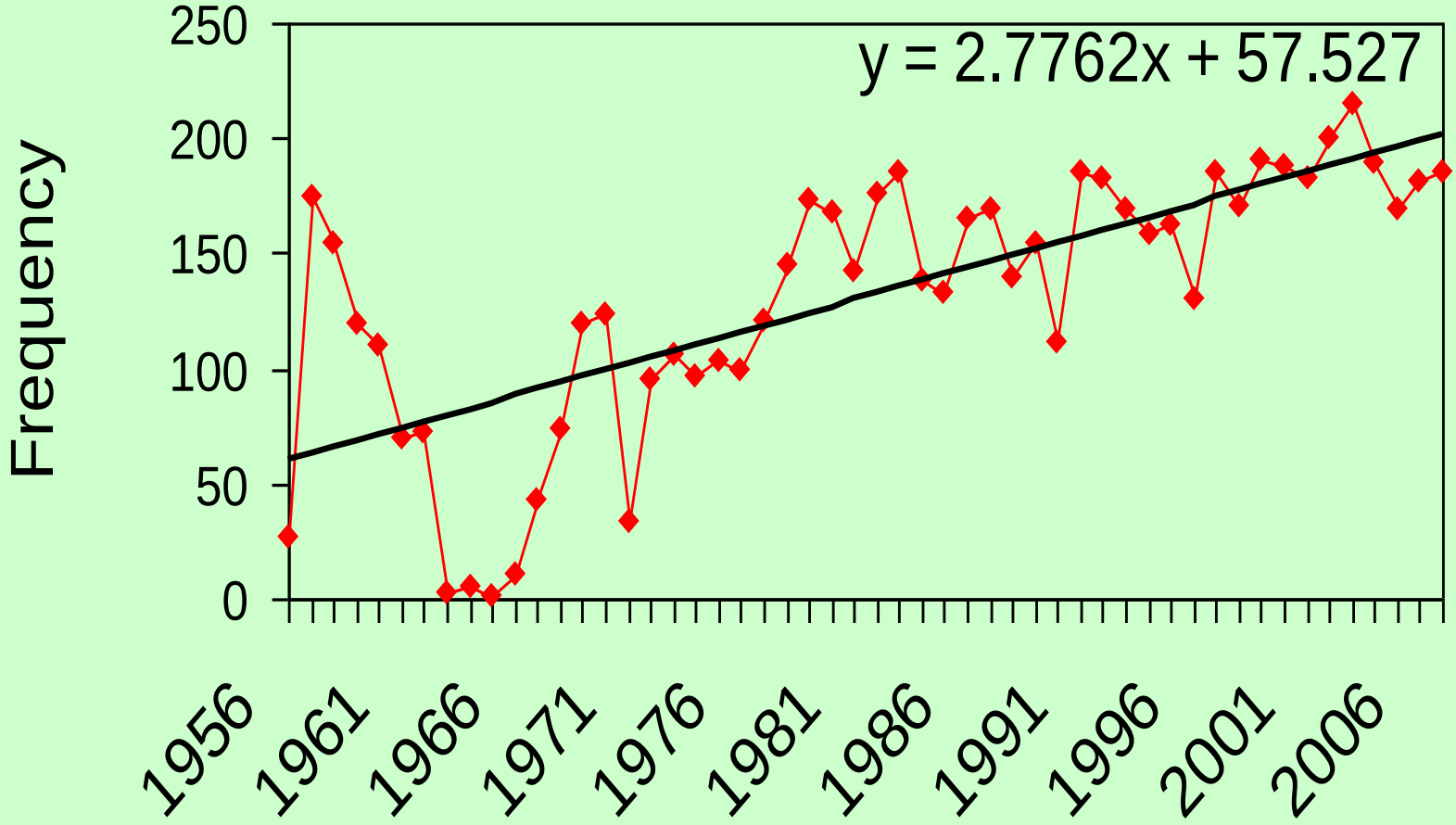

Tmax at RRII Kottayam
Temperature °C
38.0
37.0
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
0
50
100
150
200
250
300
350
DAY OF THE YEAR
1957-1961 Mean
2005-2009 Mean

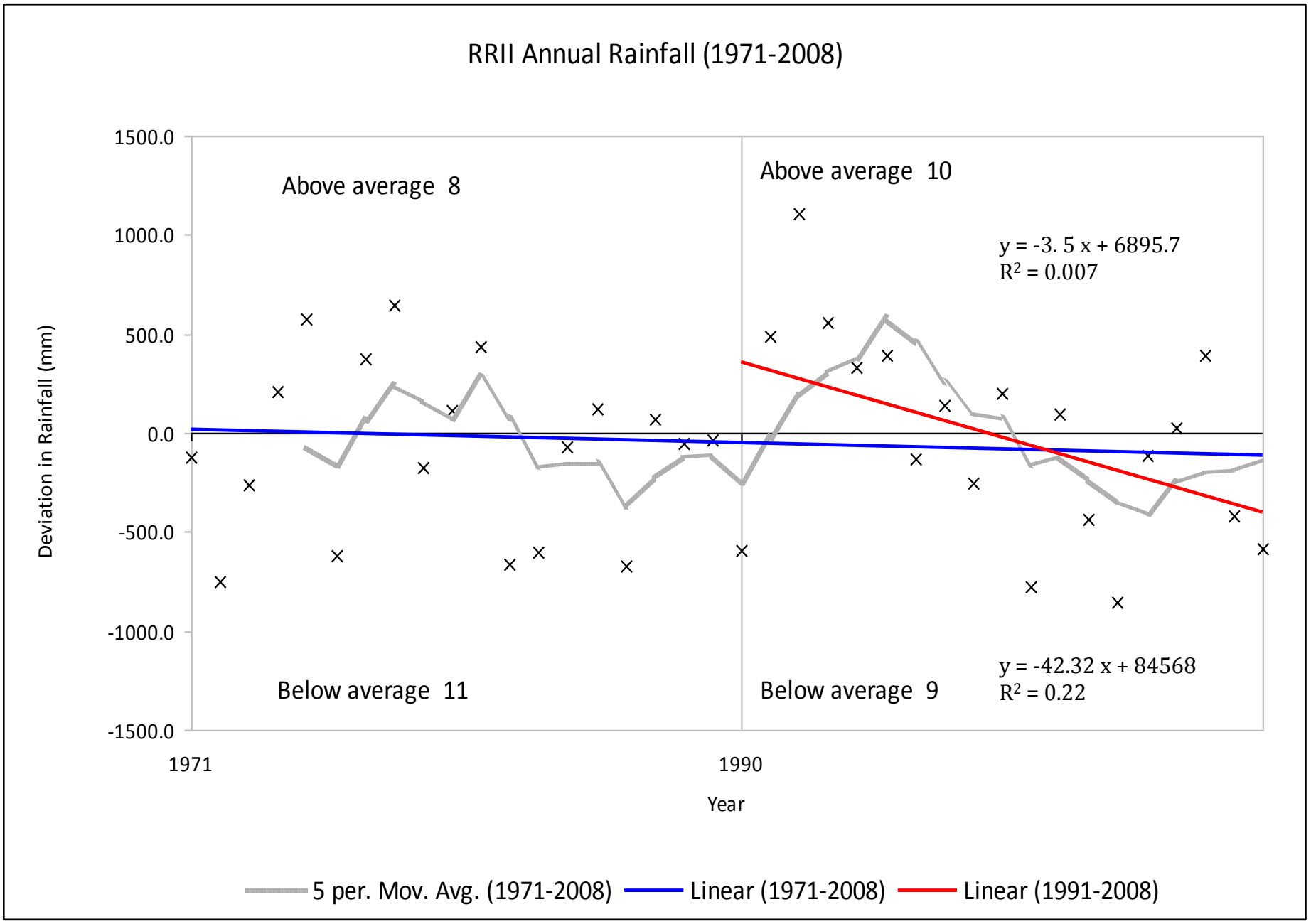

Tmin at Kottayam
Temperature °C
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
0
30
60
90
120
150
180
210
240
270
300
330
360
390
DAY OF THE YEAR
1957-1961 Mean
2005-2009 Mean

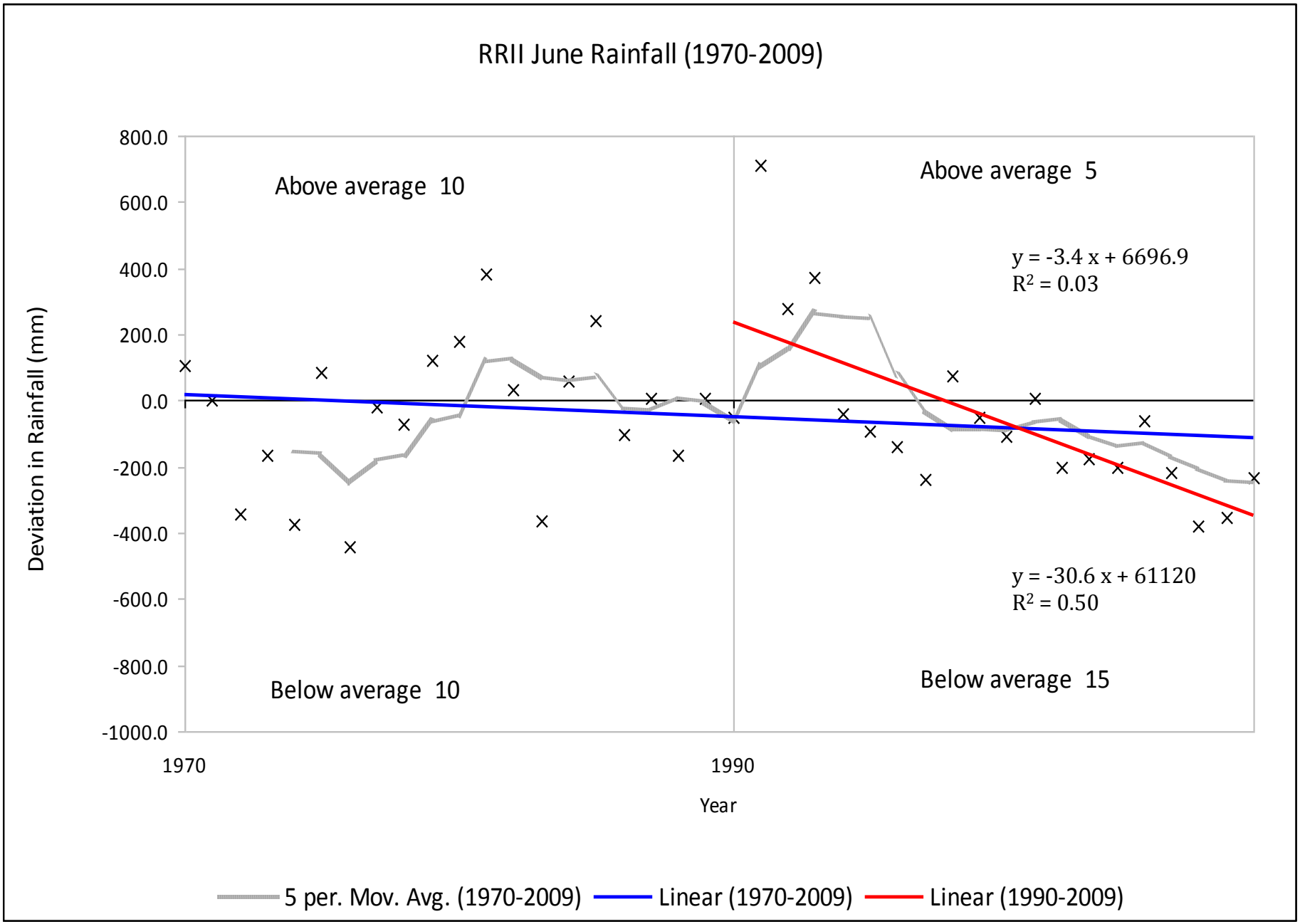
Frequency of warm nights (>24.3 °C) has increased in Kottayam between 1956 and 2007



Frequency of hot days (>32°C) has increased in Kottyam between 1956-2007




RRII Annual Rainfall (1971-2008)
1500.0
1000.0
500.0
0.0
-500.0
-1000.0
-1500.0
Deviation in Rainfall (mm)
Above average 8
Above average 10
y = -3. 5 x + 6895.7
R² = 0.007
Below average 11
Below average 9
y = -42.32 x + 84568
R² = 0.22
1971
1990
Year
5 per. Mov. Avg. (1971-2008)
Linear (1971-2008)
Linear (1991-2008)


RRII June Rainfall (1970-2009)
Above average 10
Above average 5
y = -3.4 x + 6696.9
R² = 0.03
y = -30.6 x + 61120
R² = 0.50
Below average 10
Below average 15
800.0
600.0
400.0
200.0
0.0
-200.0
-400.0
-600.0
-800.0
-1000.0
1970
1990
Year
Deviation in Rainfall (mm)
5 per. Mov. Avg. (1970-2009)
Linear (1970-2009)
Linear (1990-2009)

In RRII campus at Kottayam, during the last 50 years:

Tmax. increased by 2.6 ^{O}C

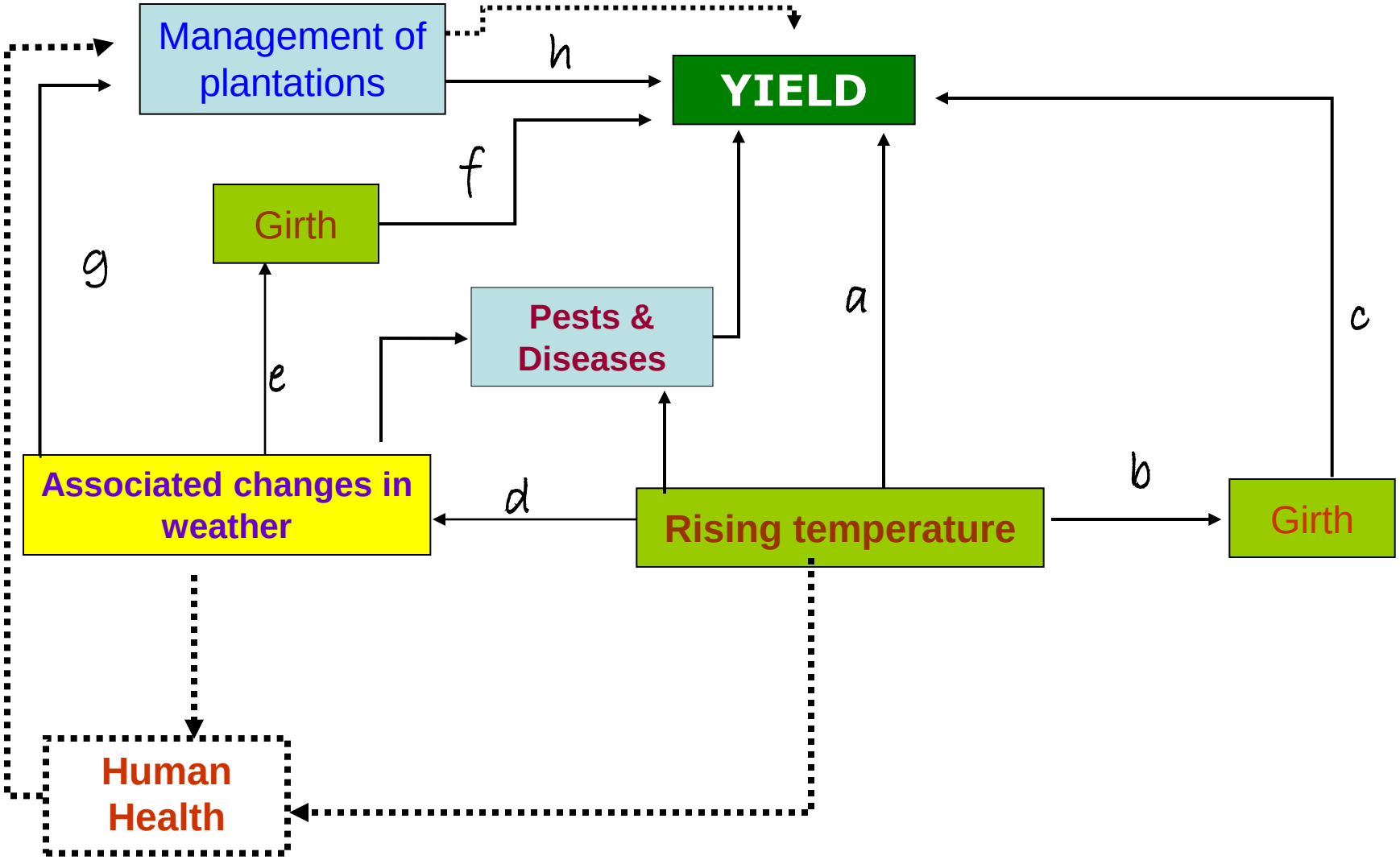
Tmin. increased by 1.5 ^{O}C

Annual rainfall decreased by 375 mm

Long term temperature trends

STATION	PERIOD	TEMPERATURE	MEAN	RATE/YEAR
TURA (Meghalaya)	1995-2008	Tmax	29.3	0.15
		Tmin	16.9	0.05
AGARTHALA (Tripura)	1984-2007	Tmax	30.6	0.02
		Tmin	19.9	0.06
PADIYOOR (Kannur, Kerala)	1998-2009	Tmax	32.8	0.01
		Tmin	21.8	0.11
DAPCHARI (Thane, Maha.)	1986-2009	Tmax	33.2	0.08
		Tmin	20.6	0.03
KOTTAYAM (Kerala)	1956-2009	Tmax	31.2	0.05
		Tmin	22.7	0.03

3. How did these changes impact NR productivity in the past?


Management of plantations
h
YIELD
f
Girth
g
Pests & Diseases
a
c
e
Associated changes in weather
d
Rising temperature
b
Girth
Human Health

y = *f* (weather variables)

- Mean annual yield was estimated as the average g/t/t for 3-13 years from 10 locations in different agro-climatic regions and used as the y variable.
- Mean weather data, estimated from long term meteorological data (10-53 years) for these different locations were used as independent variables (x).
- The different independent variables were:
    1. Mean Annual temperature (Tann.)
    2. Mean Annual maximum temperature (Tmax)
    3. Mean Annual minimum temperature (Tmin)
    4. Mean annual rainfall (RF)
    5. Mean number of annual rainy days (RFday)

Backward Multiple Linear Regression (MLR) was done ((SPSS-Statistical Package for the Social Sciences (now PASW-Predictive Analytics SoftWare) using g/t/t as the y-variable and the five x-variables (Tann, Tmax, Tmin, RF and RFday)

The MLR models obtained for the individual regions for all clones together

Y= 433.43 - 7.87Tmax - 4.83Tmin (CES)

Y=171.01 - 2.54 Tmax - 1.71Tmin (Padiyoor)

Y=204.98 - 1.01Tmax - 5.51Tmin (Dapchari)

Y= 41.25 + 0.67Tmax - 1.13Tmin (Agarthala)

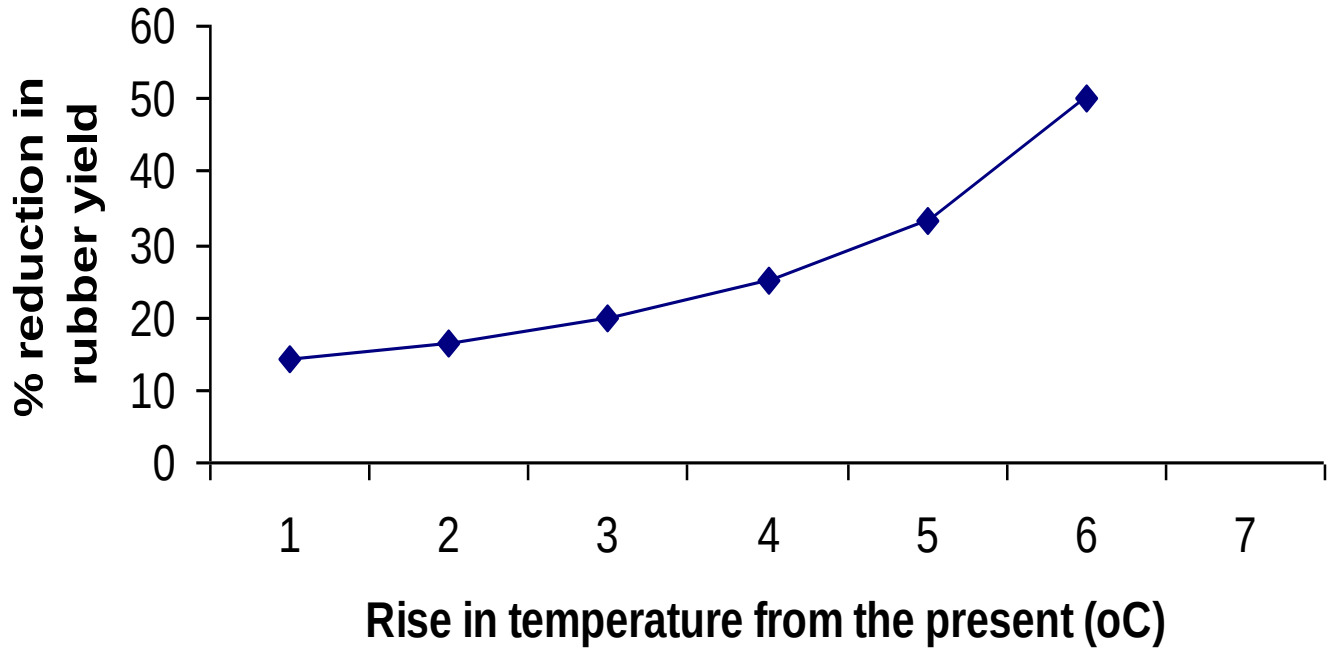
Y=-24.85 + 3.58Tmax - 2.59Tmin (Tura)

			MLR			% Change (for 1^{0}C rise)	% Change (for next 10 year)	g/t/t
			Coeff.	Intercept	R^2			
TURA	2003-08	Tx	3.58	-24.85	0.23	2.72	11.25	35.8
		Tn	-2.60					
AGARTHALA	2003-08	Tx	0.67	41.25	0.07	-1.17	-1.10	37.9
		Tn	-1.13					
PADIYOOR	2007-08	Tx	-2.54	171.01	0.19	-8.72	-4.23	48.6
		Tn	-1.71					
DAPCHARI	2007-08	Tx	-1.01	204.98	0.50	-11.25	-3.70	57.7
		Tn	-5.51					
CES	2003-08	Tx	-7.87	433.43	0.29	-16.23	-6.90	73.0
		Tn	-4.83					

Field Productivity (Kg/ha/yr)

YEARS AND CLONES			MLR			% Change (for 1^0C rise)	y/ha (kg)
			Coeff.	Intercept	R^2		
Kottayam	2008-09	Tx	-6.14	999.53	0.24	**-18.83**	**1965**
		Tn	-27.68				
Thaliparamba	2008-09	Tx	6.14	-7.30	0.12	**-4.15**	**1950**
		Tn	-1.37				
Kanjirapally	2008-09	Tx	-11.33	789.36	0.25	**-15.06**	**1902**
		Tn	-12.68				

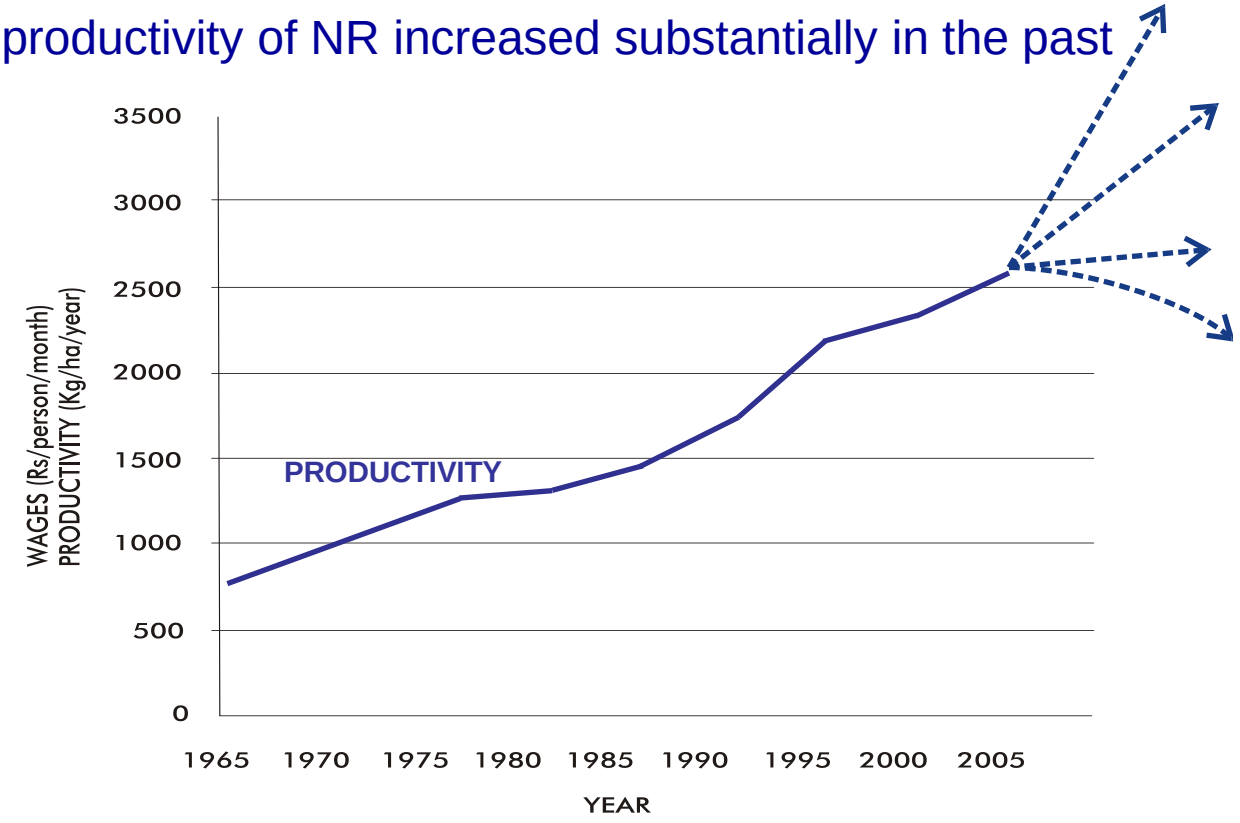
Estimated % reduction in rubber yield for every degree rise in temperature from the present (Direct effect only)



Productivity of RRII 105 (g/t/t) decreased over time under experimental conditions

1980s	Present
>55 to 60	<55

Field productivity of NR increased substantially in the past



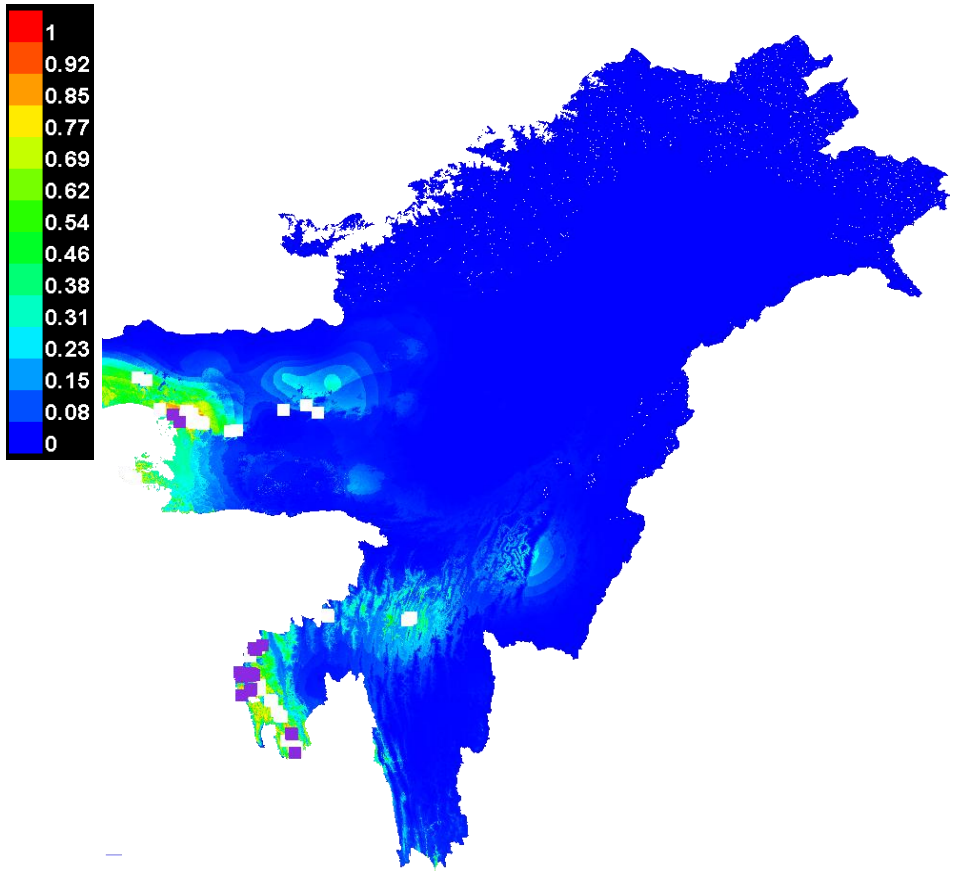
4. What is in store for future?

Future trends in NR productivity

STATION	% Change in next decade		RATE/YEAR (degrees C/Year)
TURA (Meghalaya)	11.3		0.15
			0.05
AGARTHALA (Tripura)	-1.1		0.02
			0.06
PADIYOOR (Kannur, Kerala)	-4.2		0.01
			0.11
DAPCHARI (Thane, Maha.)	-3.7		0.08
			0.03
KOTTAYAM (Kerala)	-6.9		0.05
			0.03

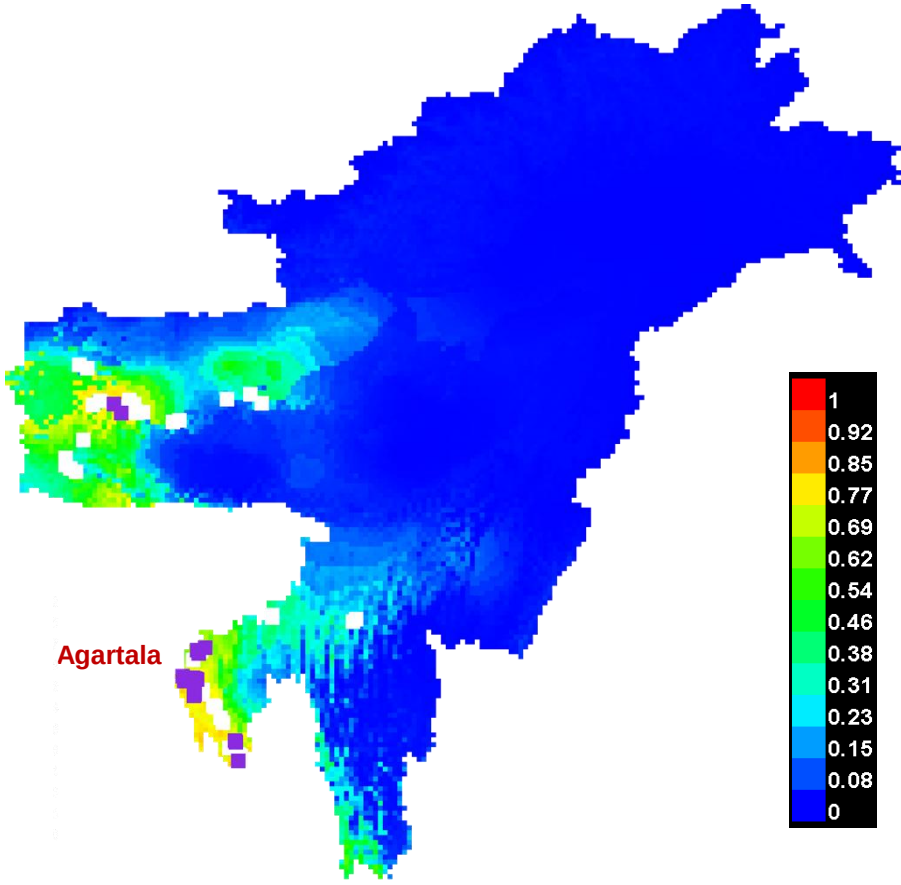
- In the next ten years, NR productivity in India can go down by 5.6% in the traditional regions and by 3.7% in the dry and hot non-traditional regions as a result of warming conditions.

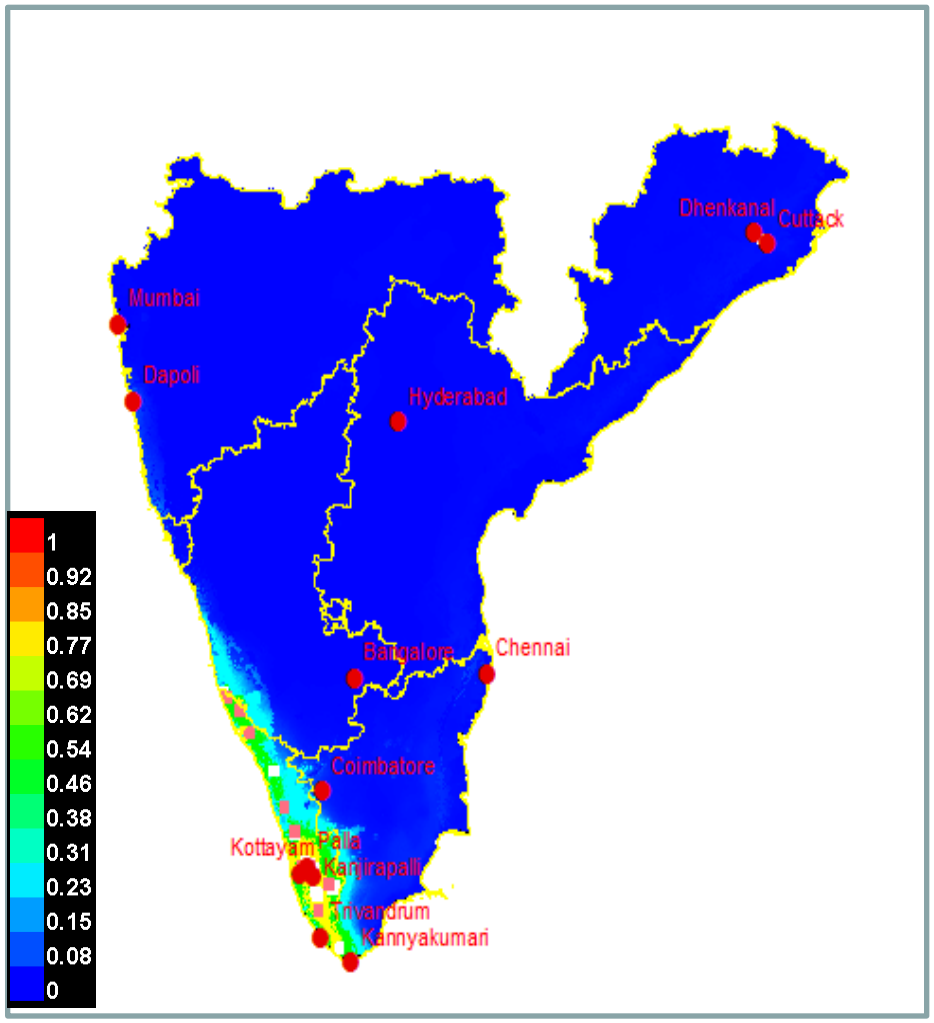
- But in the NE region, which is also a non-traditional region, productivity may go up in the next decade.



NR in NE India 2012
(Maxent model)

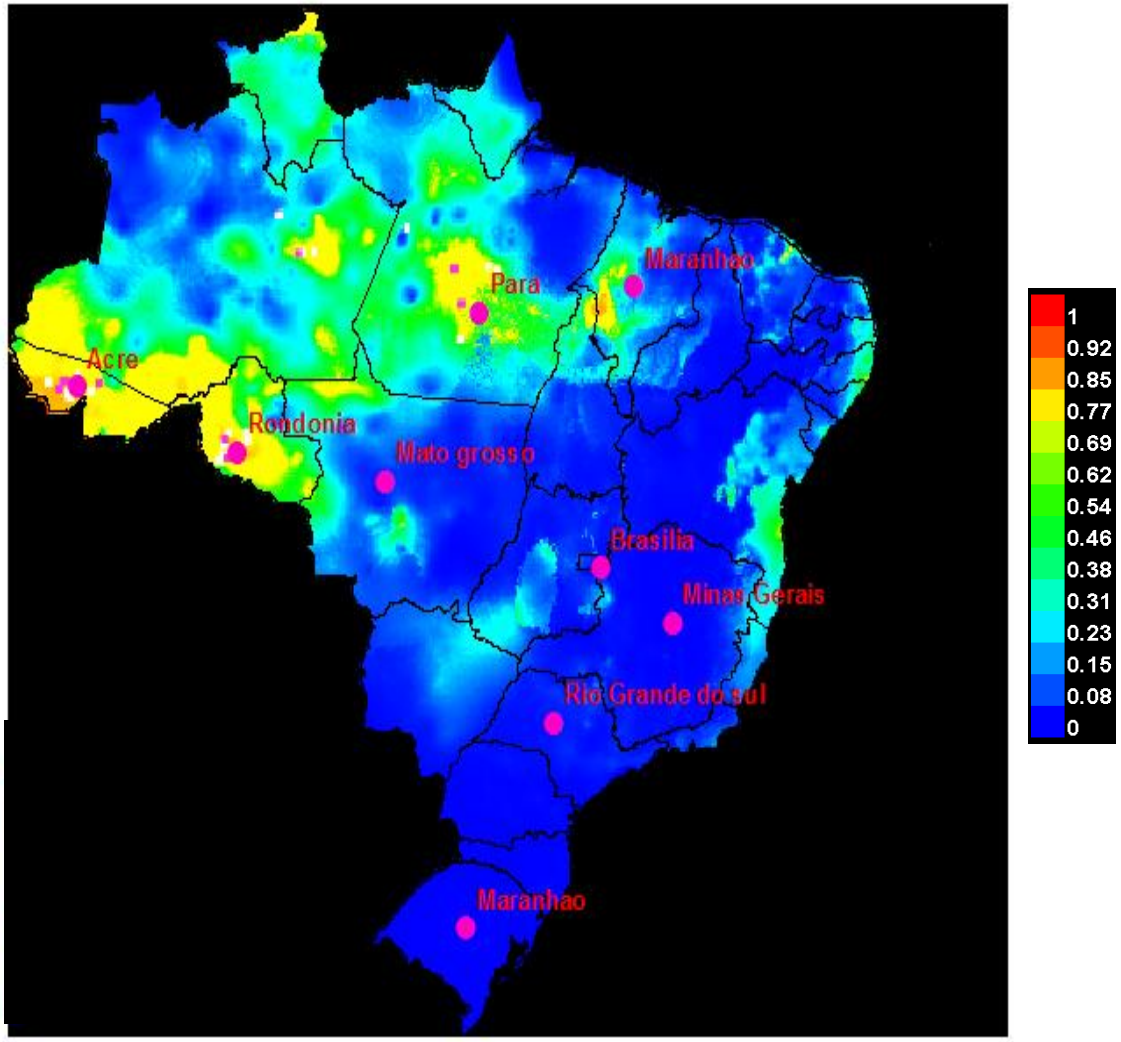
NR in NE India 2050
(Maxnet model)



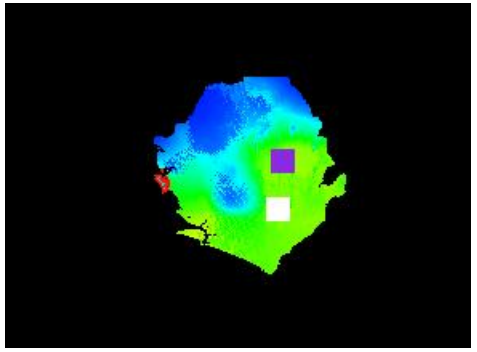


Present NR distribution
In South India.

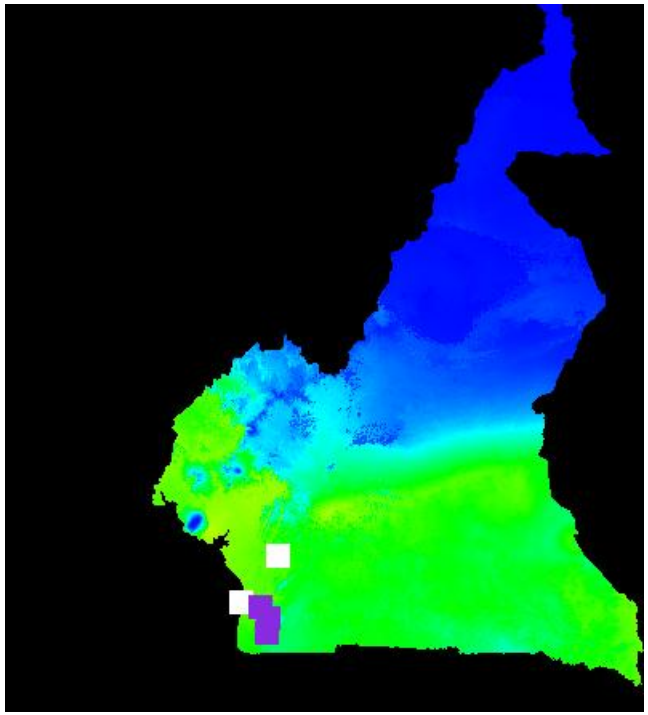
South Kerala appears
to be better niche for NR
in South India
(Mexent model)



NR Distribution in Brazil



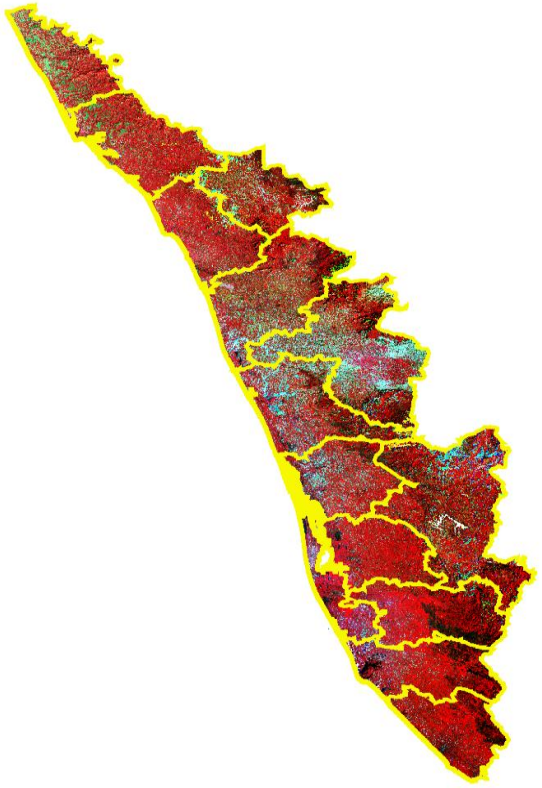
Sierra Leone

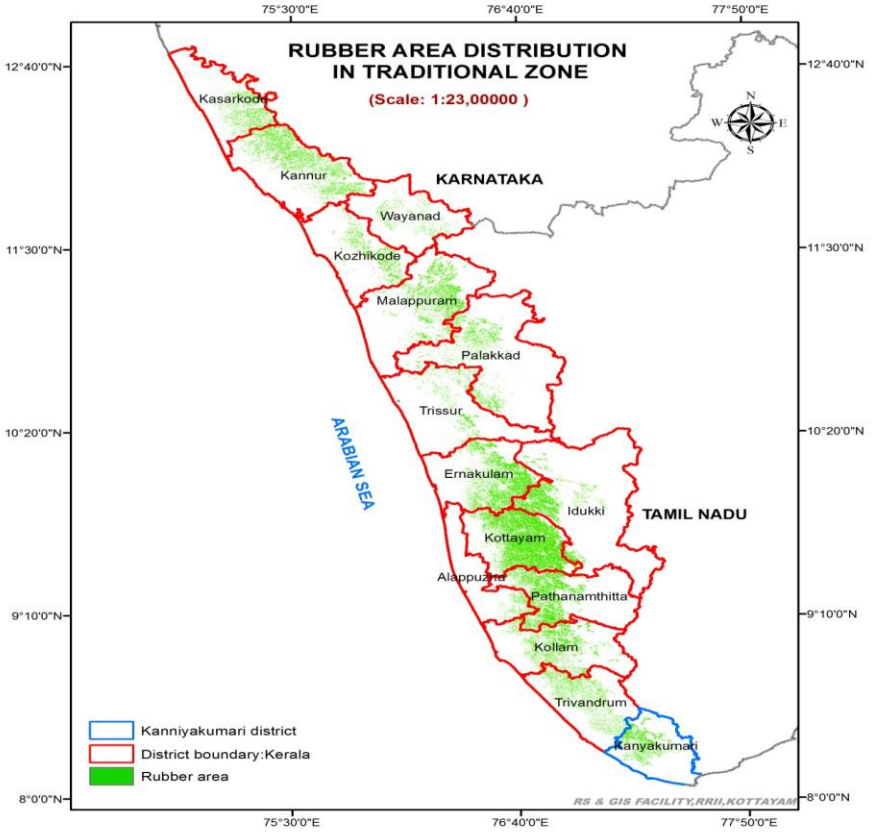


Cameroon

5. Geo-informatics and Ecological Niche Modeling

IRS P6 Satellite image of Kerala





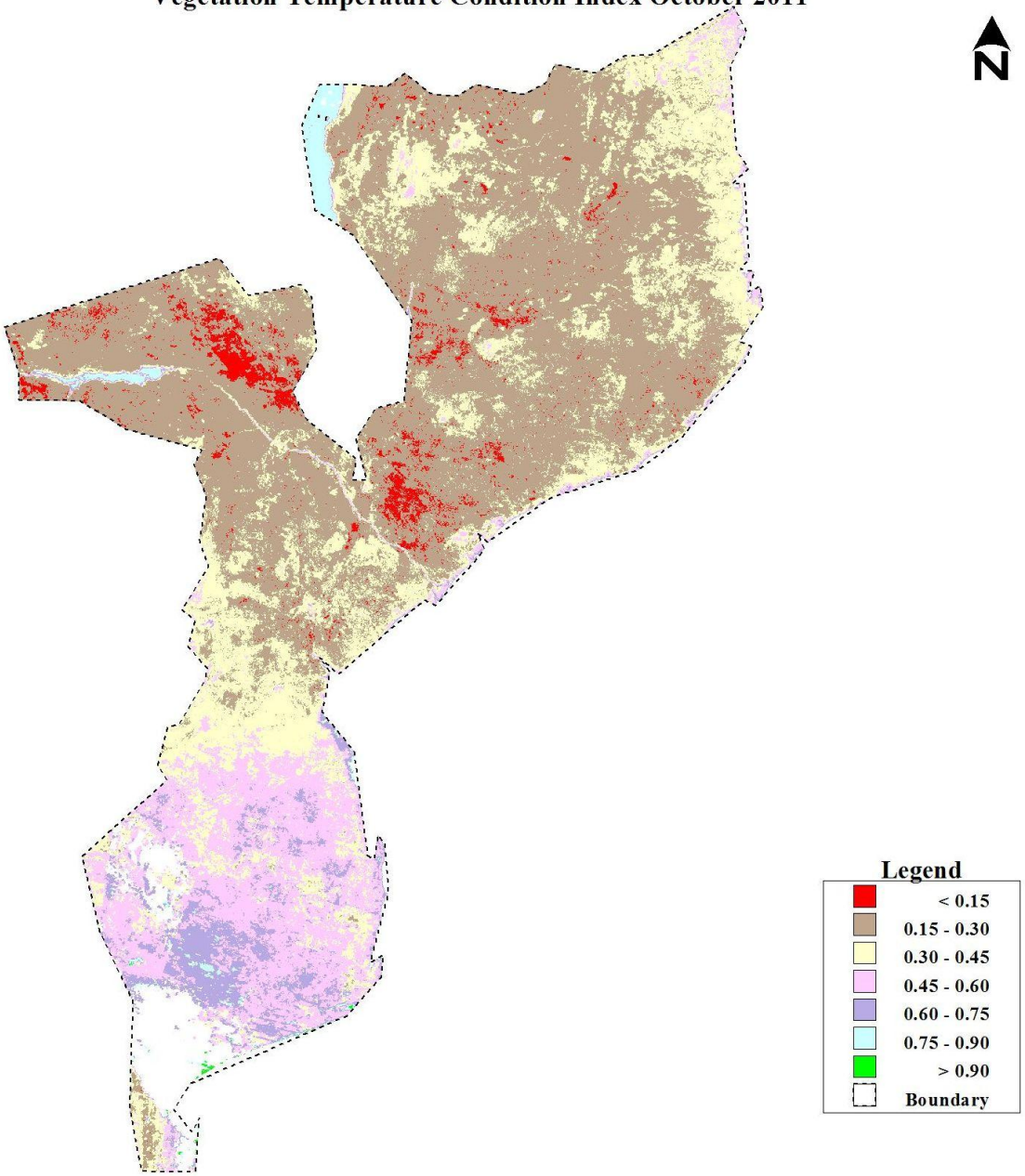
Established GIS facility to map rubber distribution for traditional area using remote sensing and bring in all the information related to rubber for meaningful analysis, visualization and interpretation. Red colour indicates all vegetation

Comparison of satellite based rubber area with ground statistics

District	Ground survey statistics (ha) (2005 - 06)	Satellite based rubber area (ha)	Variation Compared to ground survey statistics (%)	% of geographical area under rubber
Thiruvanathapuram	30 009	27 527.23	-8.27	12.61
Kollam	35 665	37 271.97	4.50	14.96
Pathanamthitta	49 551	51 766.25	4.47	20.54
Alapuzha	3 934	5 770.57	46.68	3.74
Kottayam	1 11 635	1 06 793.22	-4.33	48.19
Idukki	38 844	37 103.46	-4.48	7.39
Ernakulam	58 309	56 654.19	-1.10	23.58
Trissur	14 058	13 927.41	-0.92	4.59
Palakkad	31 952	28 420.82	-11.05	6.33
Malappuram	32 588	36 633.61	12.41	10.30
Kozhikkode	18 237	18 751.59	2.821	7.96
Wyanad	7 777	8 976.98	15.42	4.21
Kannur	38 366	49 477.40	28.96	16.74
Kasargod	25 374	20 052.69	-20.97	10.08
Kanniyakumari	18 225	20 781.71	14.02	12.36
Total	**5 14 524**	**5 19 909.10**	**1.04**	**12.28**

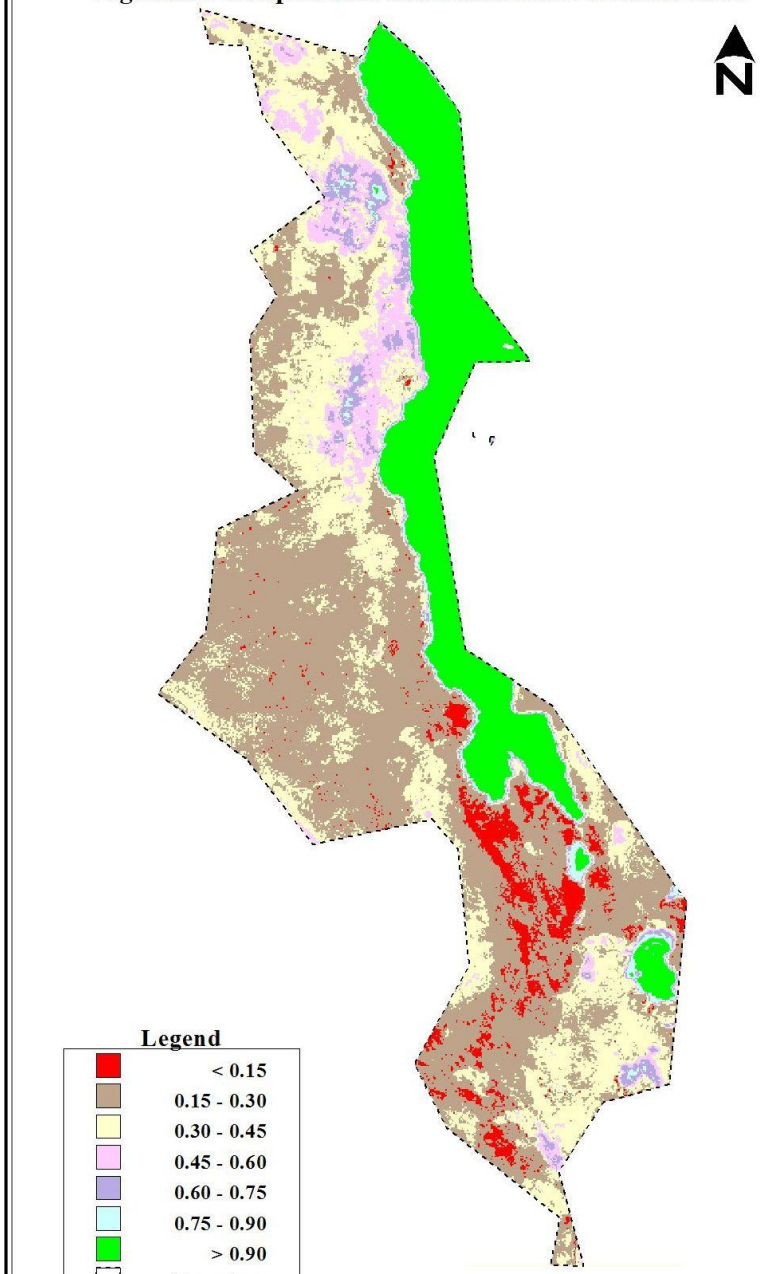
Mozambique

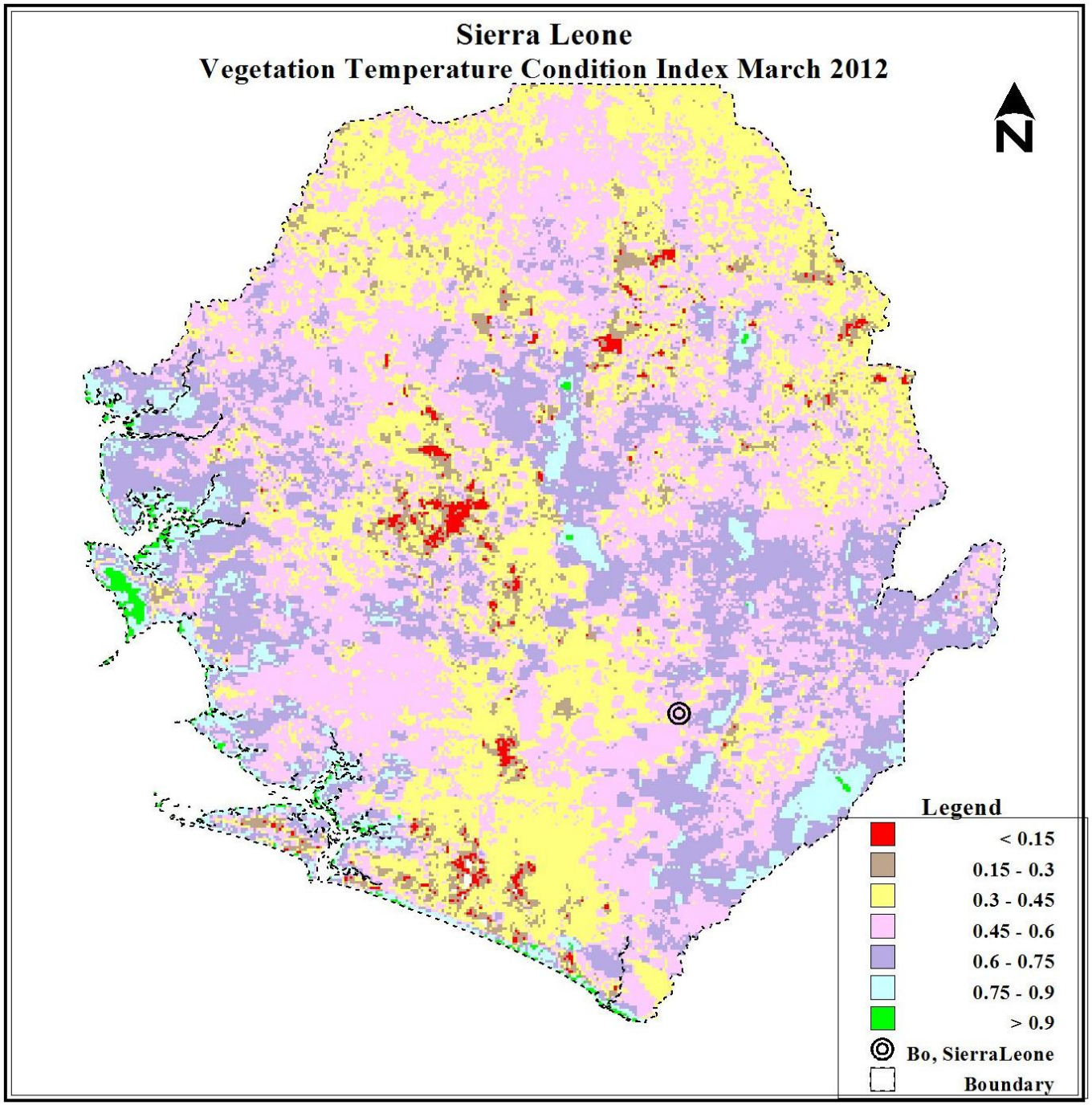
Vegetation Temperature Condition Index October 2011

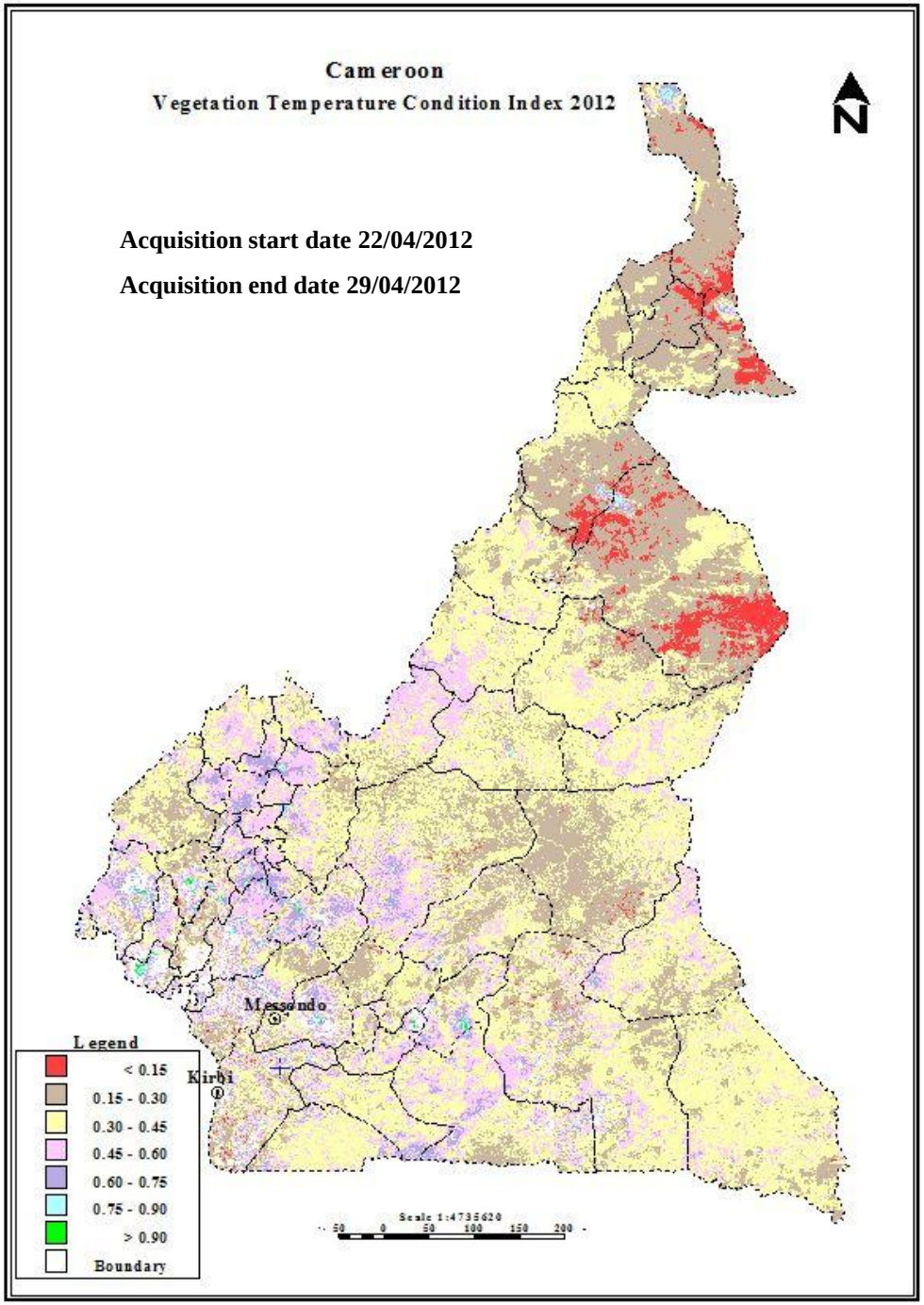


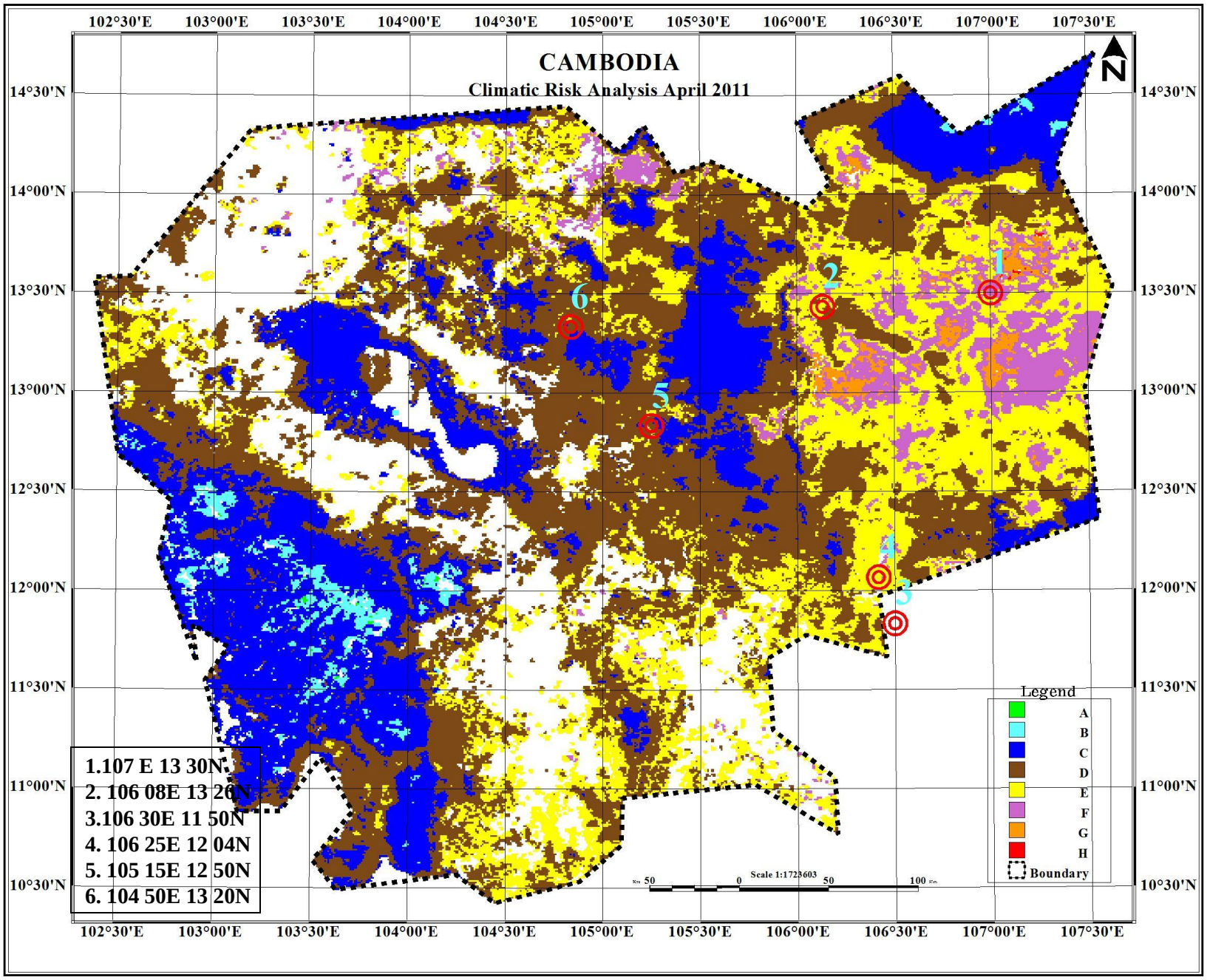
Malawi

Vegetation Temperature Condition Index October 2011



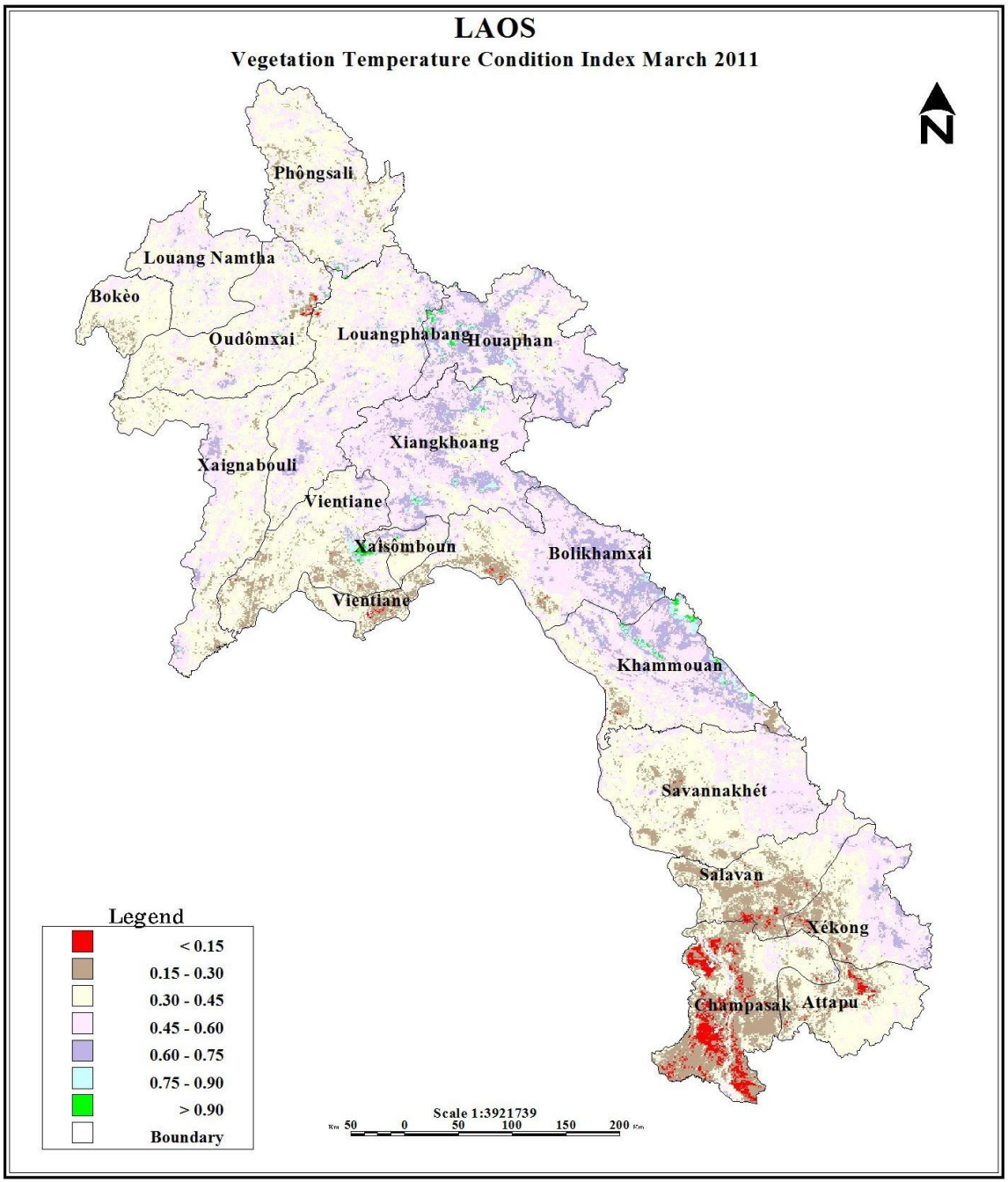

Sierra Leone
Vegetation Temperature Condition Index March 2012
N
Legend
< 0.15
0.15 - 0.3
0.3 - 0.45
0.45 - 0.6
0.6 - 0.75
0.75 - 0.9
> 0.9
Bo, SierraLeone
Boundary


Cameroon
Vegetation Temperature Condition Index 2012
N
Acquisition start date 22/04/2012
Acquisition end date 29/04/2012
Messondo
Kirbi
Legend
< 0.15
0.15 - 0.30
0.30 - 0.45
0.45 - 0.60
0.60 - 0.75
0.75 - 0.90
> 0.90
Boundary
Scale 1:4735620
50 0 50 100 150 200


CAMBODIA
Climatic Risk Analysis April 2011
N
102°30'E
103°00'E
103°30'E
104°00'E
104°30'E
105°00'E
105°30'E
106°00'E
106°30'E
107°00'E
107°30'E
14°30'N
14°00'N
13°30'N
13°00'N
12°30'N
12°00'N
11°30'N
11°00'N
10°30'N
1
2
3
4
5
6
1.107 E 13 30N
2. 106 08E 13 20N
3.106 30E 11 50N
4. 106 25E 12 04N
5. 105 15E 12 50N
6. 104 50E 13 20N
Legend
A
B
C
D
E
F
G
H
Boundary
Scale 1:1723603
50
0
50
100

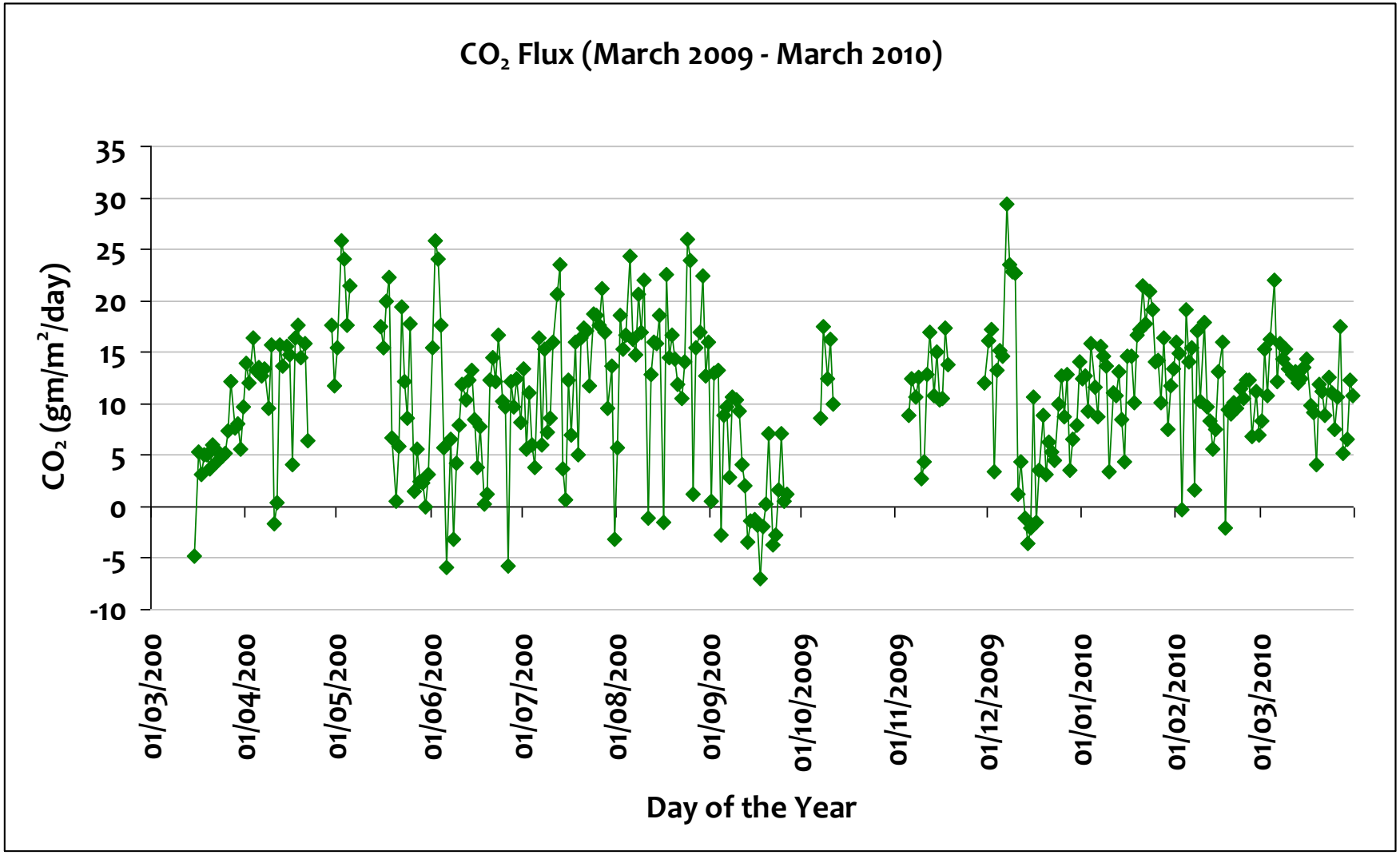
LAOS

Vegetation Temperature Condition Index March 2011

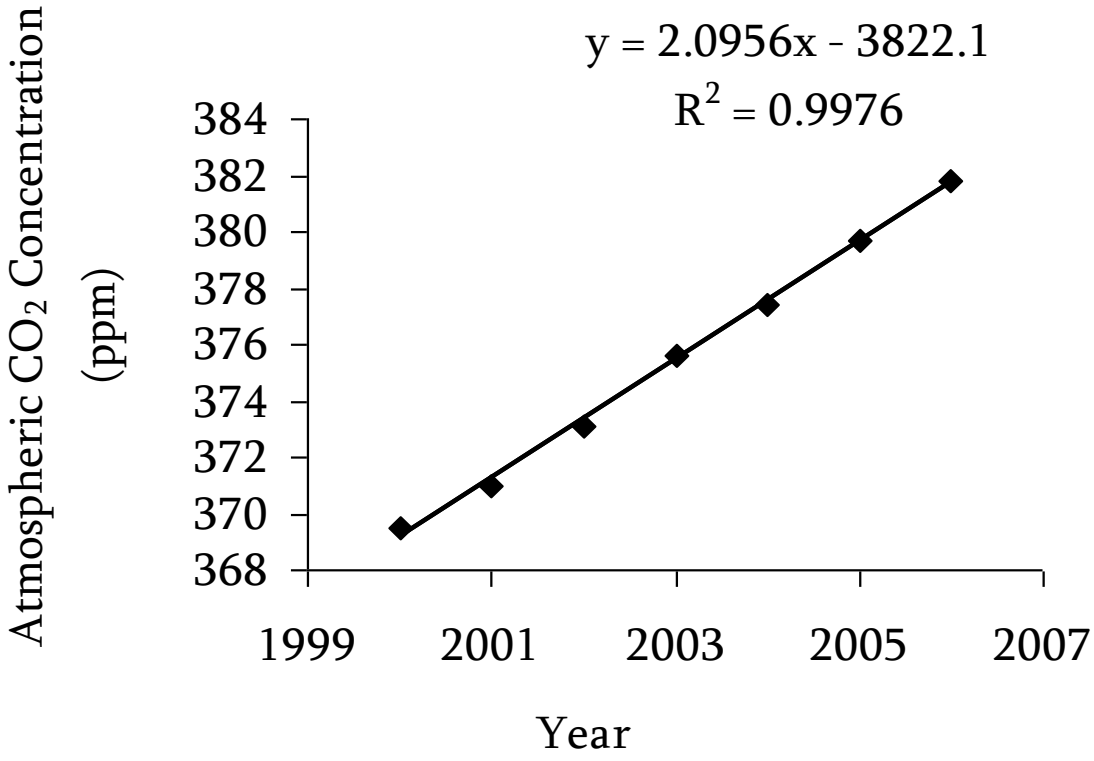


6. Are trees the answer to global warming?

CO_2 sequestration potential of five years old plants calculated from Eddy Covariance System



3350 gm/m^2/year = 33.5 ton CO_2/ha/year


y = 2.0956x - 3822.1
R2 = 0.9976
Atmospheric CO2 Concentration (ppm)
384
382
380
378
376
374
372
370
368
1999
2001
2003
2005
2007
Year

Taking a modest rate of 25 T CO_2 / ha / year, world's 10.5 m ha of natural rubber plantations help to offset the current rate of build up of CO_2 in the atmosphere to the tune of 1.6%.

Natural rubber provide invaluable ecosystem services to humanity that should not go unappreciated.

NR plantations in India sequester about 20 million ton CO_2 every year which is roughly 1.3% of the annual emissions from fossil fuels in the country!

(Gt C/yr)	1980s	1990s	2000-2005
Emission	5.4	6.4	7.2
Ocean fixation	1.8	2.2	2.2
Land fixation	0.3	1.0	0.9
Net addition to atmosphere	3.3	3.2	4.1

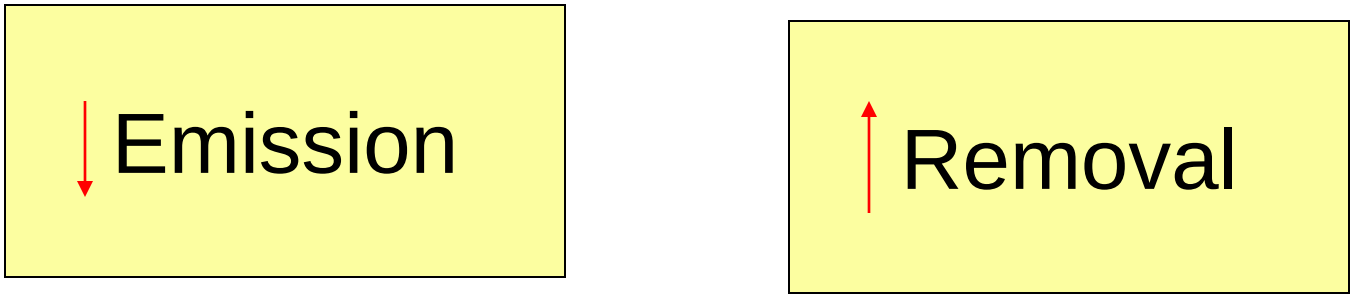
Total terrestrial vegetation area: 15000 m ha
Current fixation : 3303 m MT CO2
Fixation rate: 220 x 10^{-9} m MT CO2/ha/yr
Net addition to atmosphere: 10151 m MT CO2
Required (additional) rate to offset this: 3.07 T CO/ha/yr
(0.9 +3.07= 3.97 T CO2/ha/yr)

- At the present rate of emission and rate of fixation by terrestrial vegetation, we need an additional land area of around 46141.0 m ha for planting trees so as to fully offset the current rate of increase in atmospheric CO2 concentration (1.30 ppm per year).

- This is equal to the terrestrial vegetation area of three planets.

- Even if we take the sequestration capacity of the land and ocean together, we will still require one more additional planet to keep the atmospheric CO2 concentration stabilized at the present level.

- Further rise in concentration can be avoided by deliberate reduction in the amount of anthropogenic CO2 emission into the atmosphere and not by increasing sequestration alone.


Emission
Removal

In conclusion:

Warming conditions seem to have adversely affected NR productivity in the past and may mess up the shape of things to come.

NR productivity will be adversely affected in some places and stimulated in other places as climate warms in future.

Existing areas may become less congenial and new areas may become more favorable for NR cultivation as climate warms.

Geoinformatics and Ecological Niche Modeling help to predict how NR landscape may change as climate warms.

Further rise in atmospheric CO2 concentration can be avoided by deliberate reduction in the amount of anthropogenic CO2 emission into the atmosphere and not by increasing its removal by planting trees.

THANK YOU

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