Impact of Climate Change on water resources and food production over Langtang Valley

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- Changing Climate and a warming world are the key issues today and the world community faces many risks from climate change

- Large flash flood, frequent flooding, prolonged drought, increase in vector borne diseases and rapid glacier melt are some important results from climate change

GLOBAL WARMING

- The global mean surface temperature has increased by 0.6 ^{0}C during the 20th century (IPCC 2001).
- The third assessment report for Intergovernmental Panel for climate change (IPCC 2001) indicates that warming in Asian region is projected to be 3^{O}C by 2050s.
- D. Douglos 1995, the magnitude of warming was rapid in the 19th century than in the 17th and 18th centuries in Nepal.

Climate Change in Nepal

Analysis of maximum temperature data from 49 stations in Nepal for the period of 1971-1994 reveal warming trends after 1977

Warming Trend

- Middle Mountain and Himalayan regions – 0.06 ^{0}C to 0.12 ^{0}C per year
- Siwalik and Terai regions – 0.03 ^{0}C per year
- Nepal average – 0.2 – 0.6 ^{0}C per decade between 1951 and 2001

- Rainfall increasing – 13mm per year
- Number of rainy days decreasing -0.8 days per year (Rainfall occurring in burst)

(Shrestha et al., 1999,2000; IPCC 2007)

- Chaulagain N., 2007 revealed that the mean annual temperature trend at Langtang is increasing at the rate of 0.27^{0}C per year

Impacts of Climate Change in Nepal

- **Ecosystem** – Change in vegetation, species composition (Benistan , 2003)
- **Weather pattern** – Rainfall increasing -13mm per year, Rainy days decrease by 0.8 days per year (Shrestha et al., 2000)
- **Morphology** – Glacier retreating rate -10-60m per year (ICIMOD-2007)
- **Natural Hazard** – GLOF -25 events in last 70 years, 5 in 60s, 4 in 80s (Mool 2001, NEA 2004, Yamada 1998)

So studies of climate change are urgently needed in **linkage changing climate pattern and increasing natural hazards** and its environmental consequence

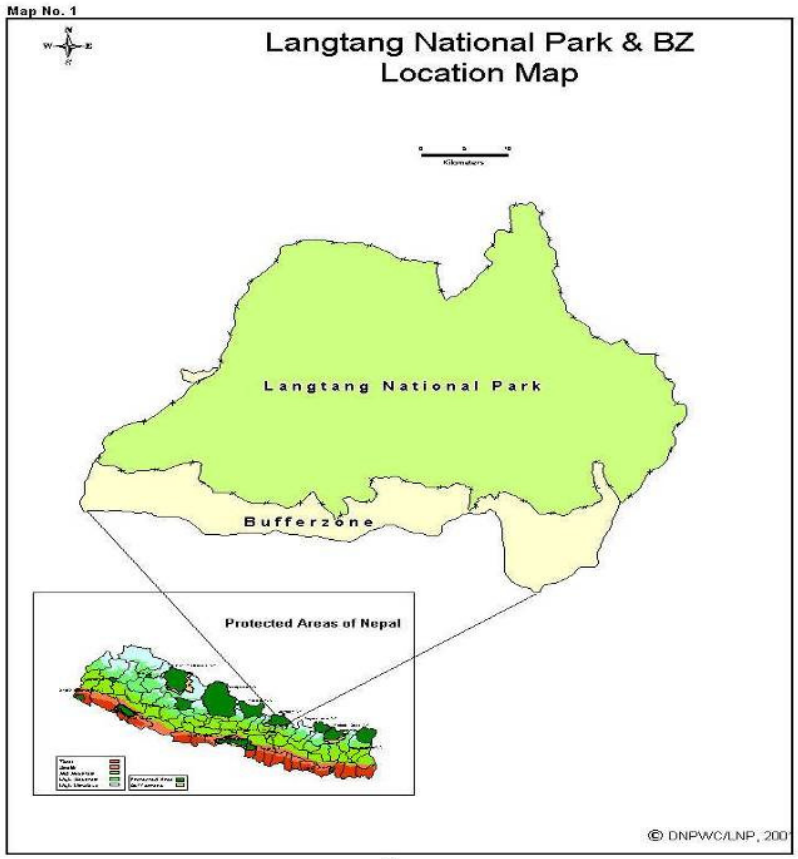
Objectives

- To understand and quantify threats due to the impact of climate change on food production and water resources
- Identification of vulnerability area in terms of the settlement and livelihood of the communities
- To identify mitigation measures and prepare adaptation practices and strategies based on the vulnerability assessment

Methodology

- Review of Literatures
- Collection of Secondary data
- Collection of Primary data

Study Area


Map No. 1
Langtang National Park & BZ
Location Map
Langtang National Park
Bufferzone
Protected Areas of Nepal
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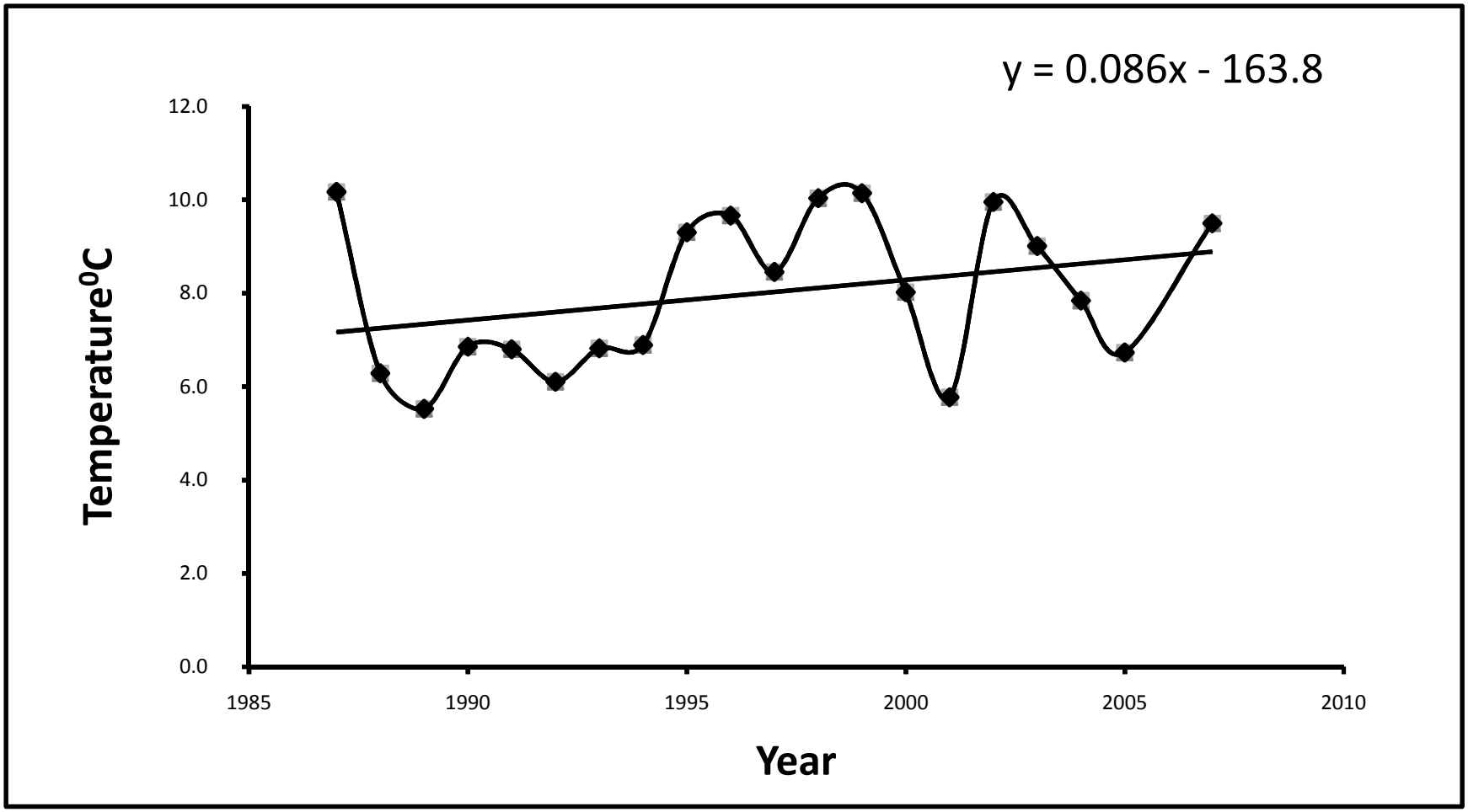
6

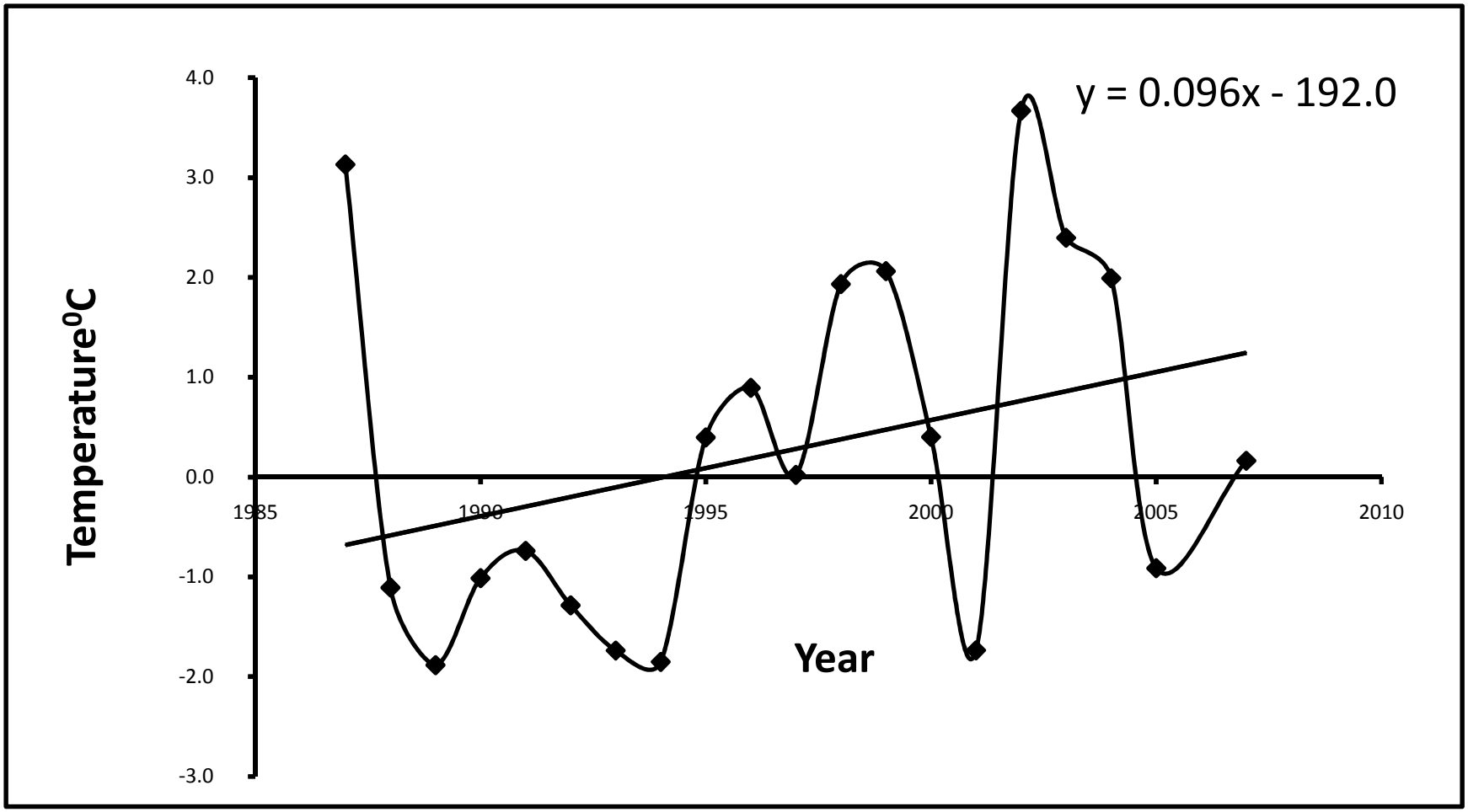
General Information

Area:	1710 km^2
Established:	1976
Buffer Zone:	420 km^2
Buffer Zone Declared:	1998
Altitude:	792 - 7245 amsl
Headquarters:	Dhunche
Latitude:	28° 13' 0N
Longitude:	85° 34' 60E

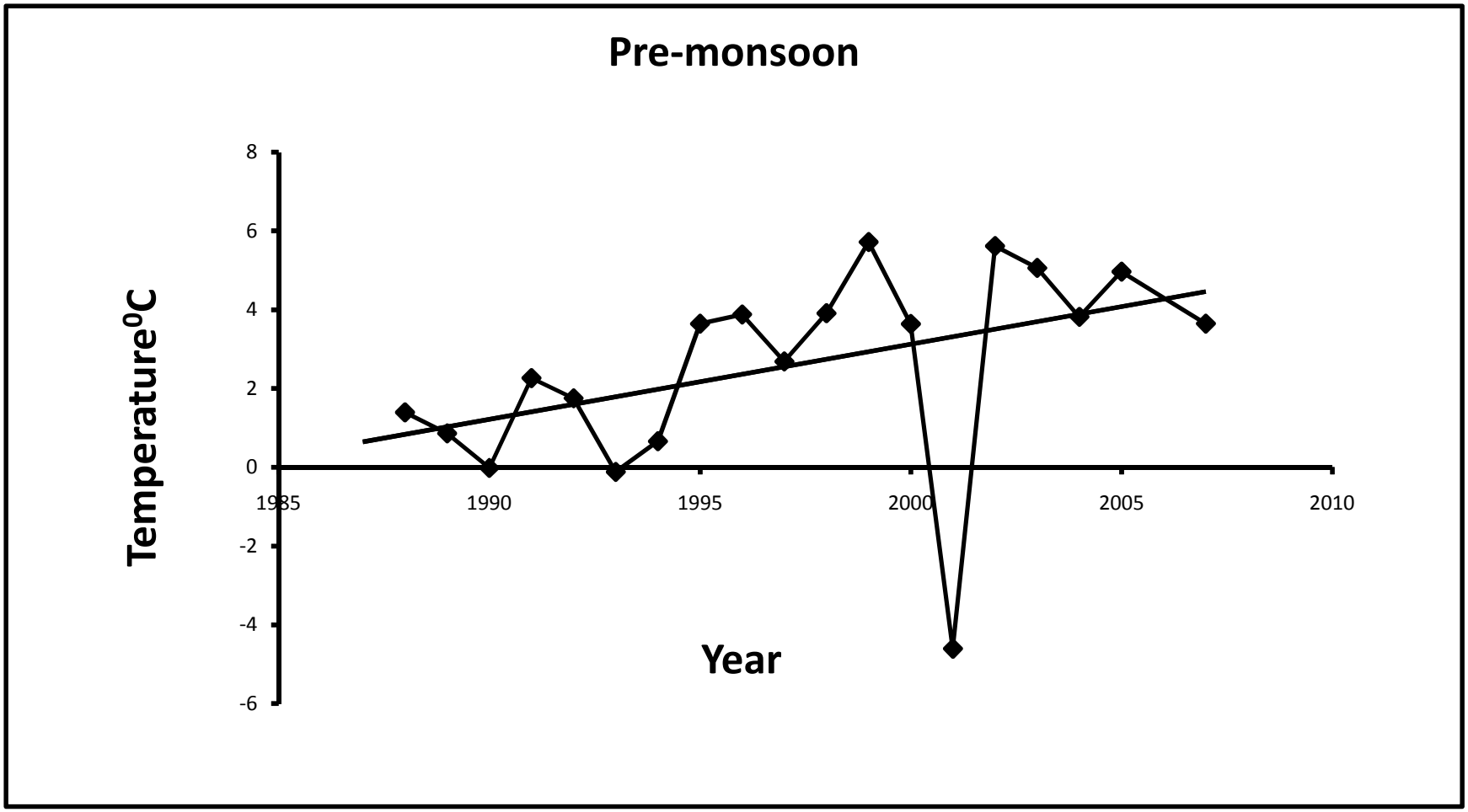
Maximum Temperature

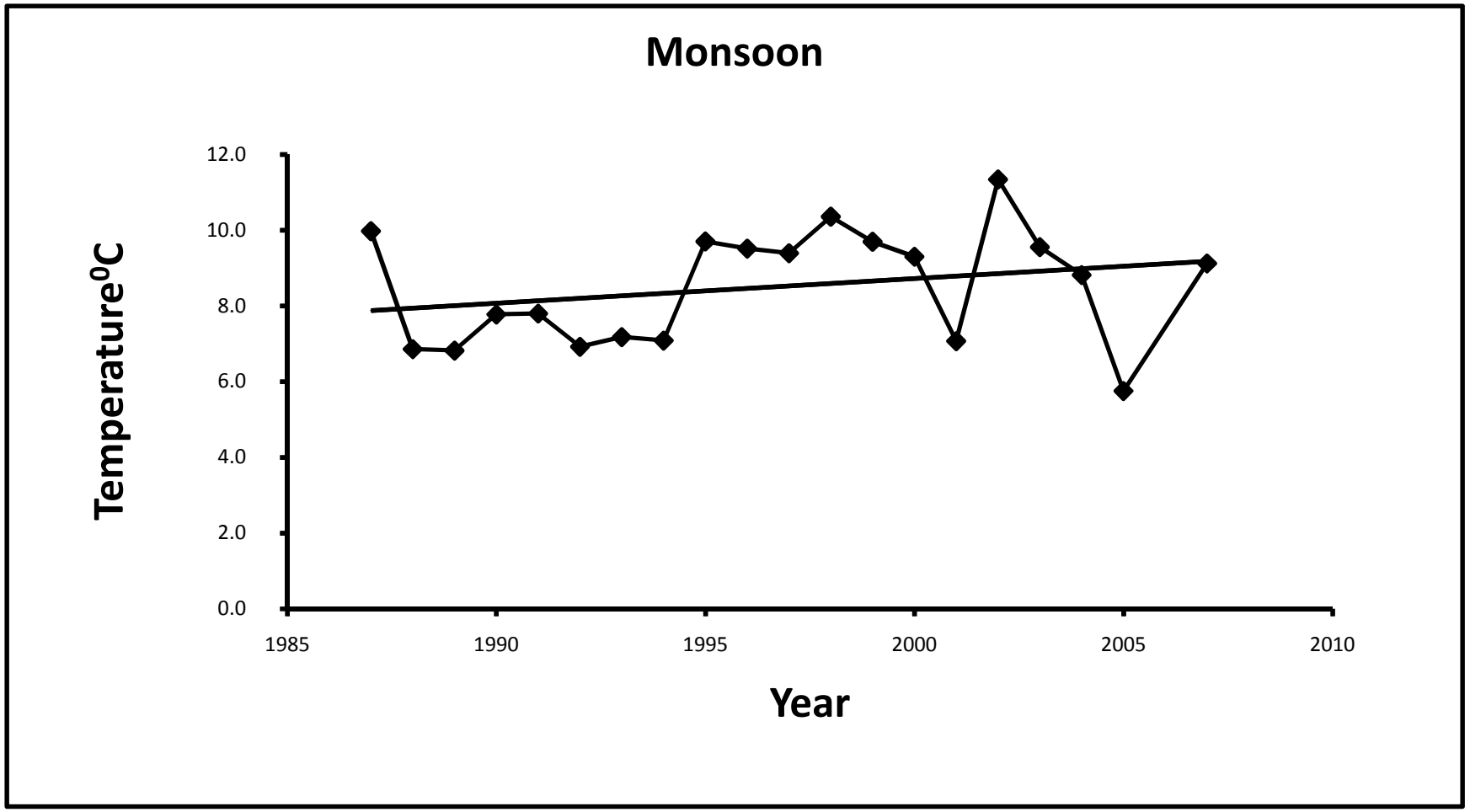


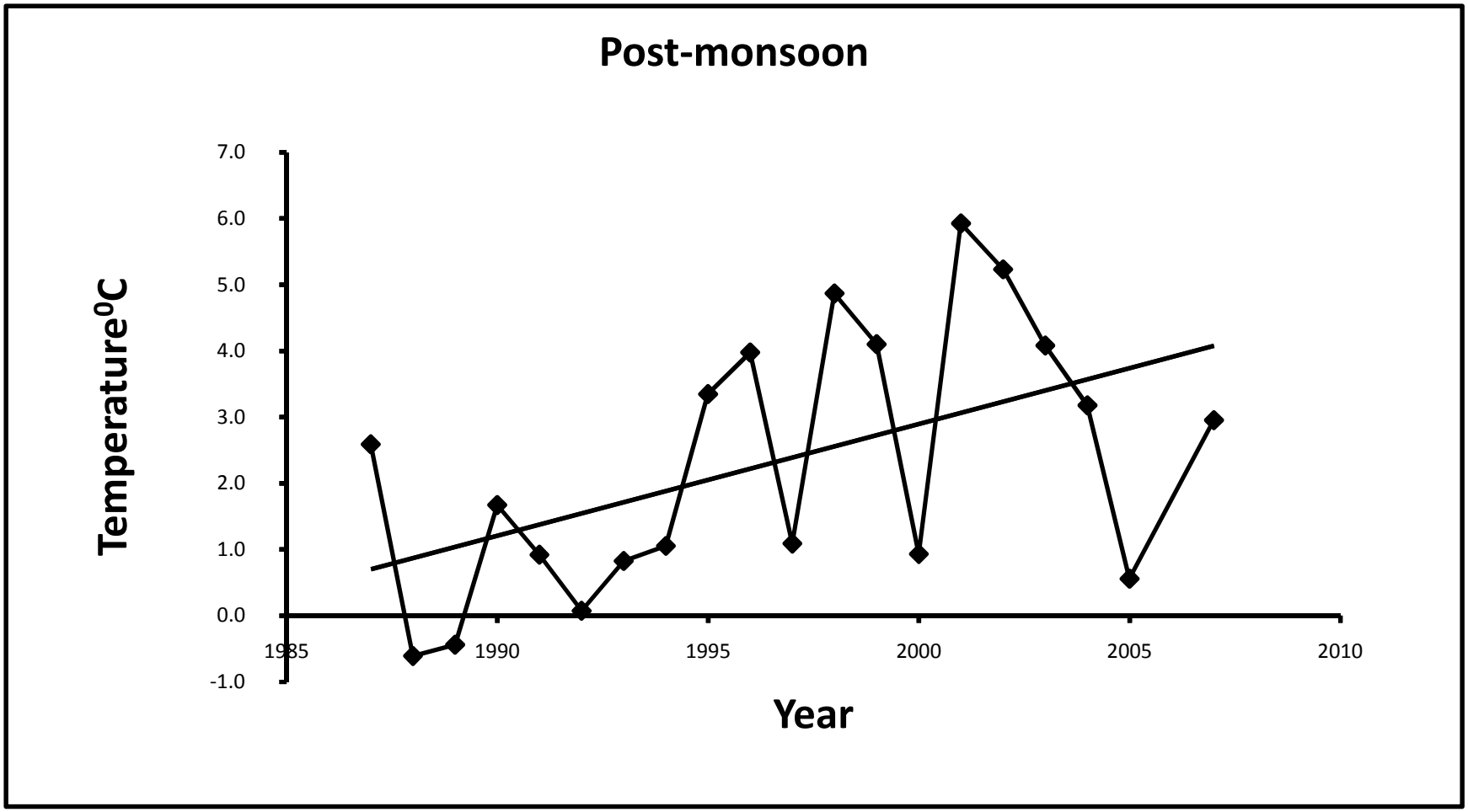
Minimum Temperature

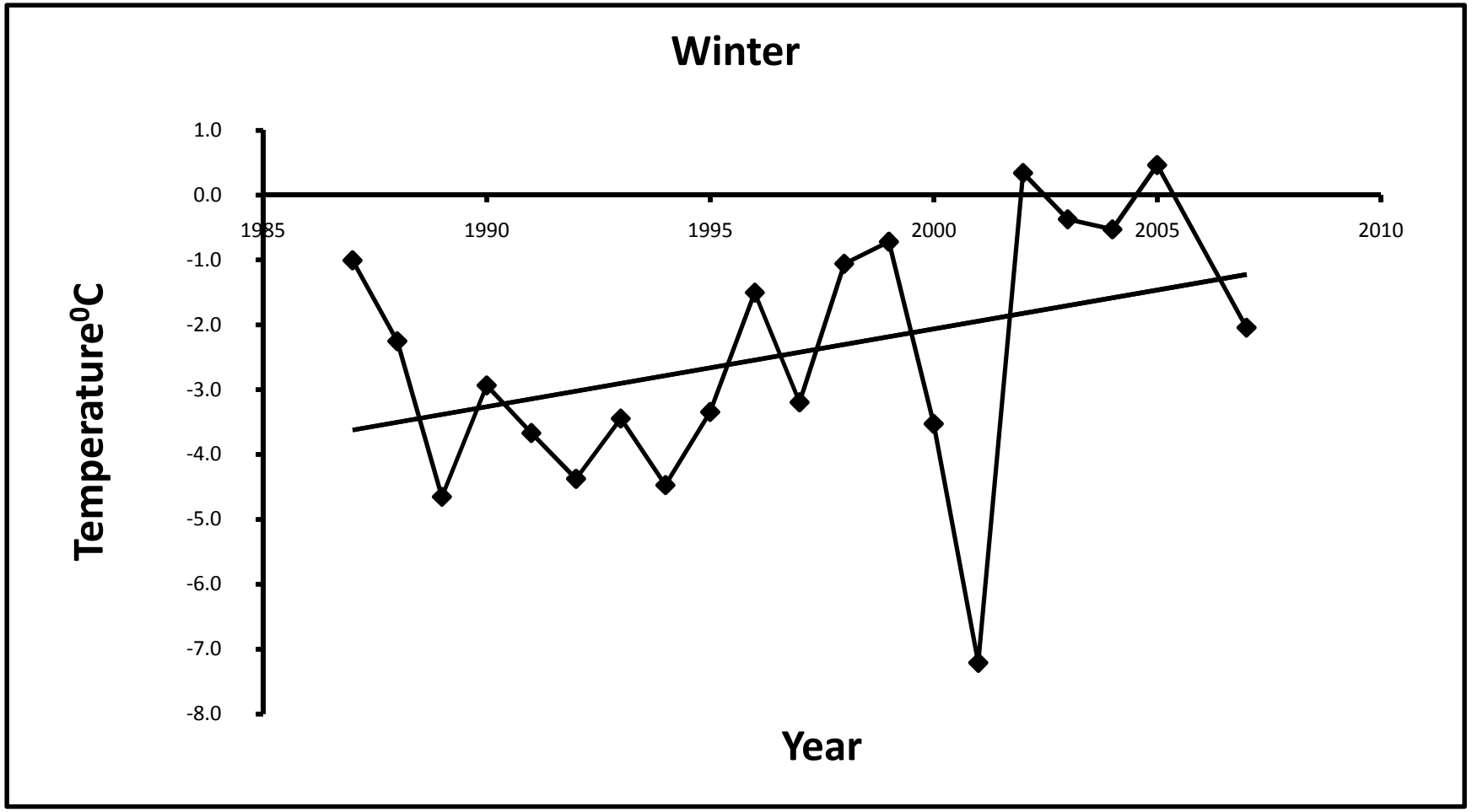


Seasonal Distributions of Temperature

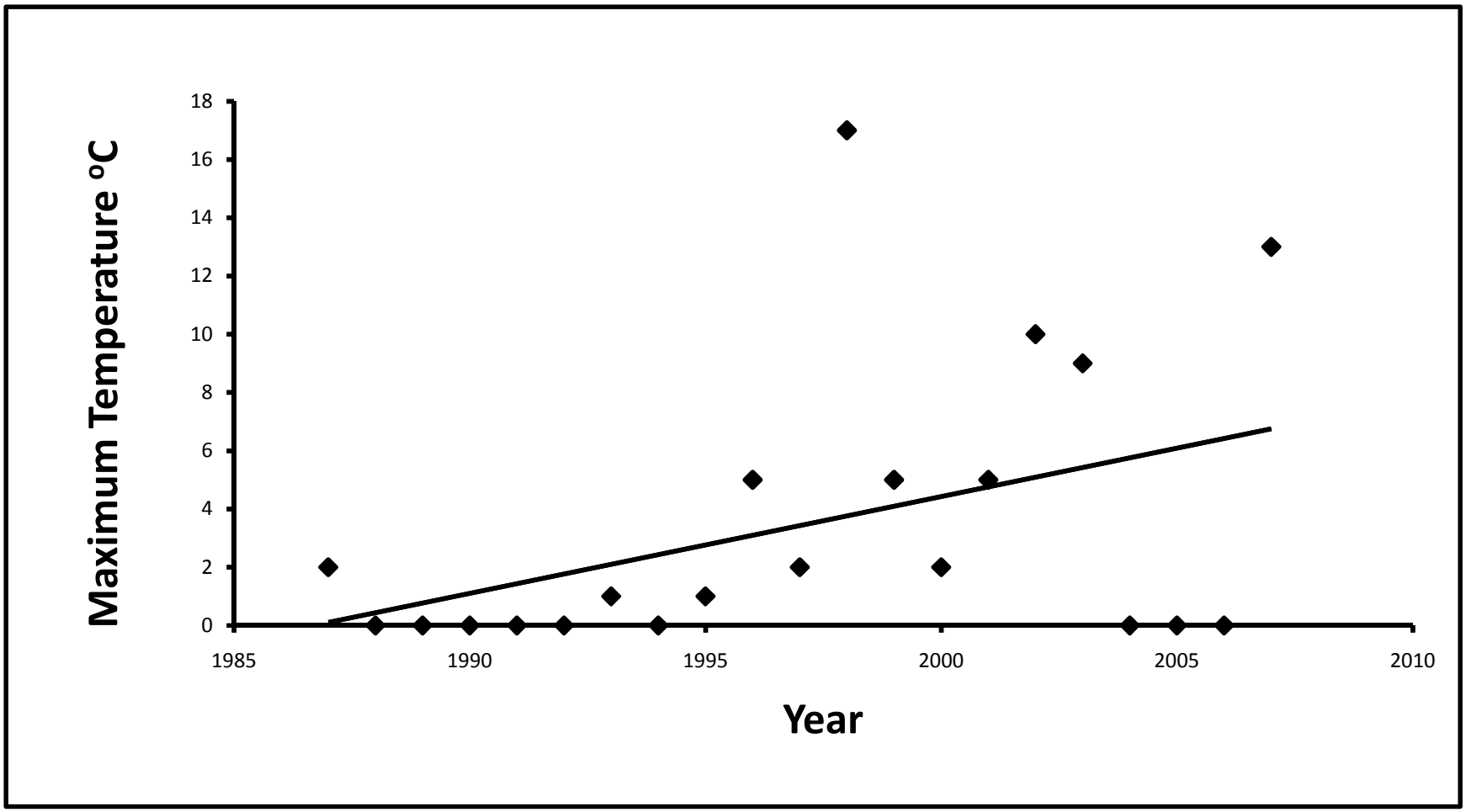



Monsoon
Temperature^{0}C
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1985
1990
1995
2000
2005
2010
Year

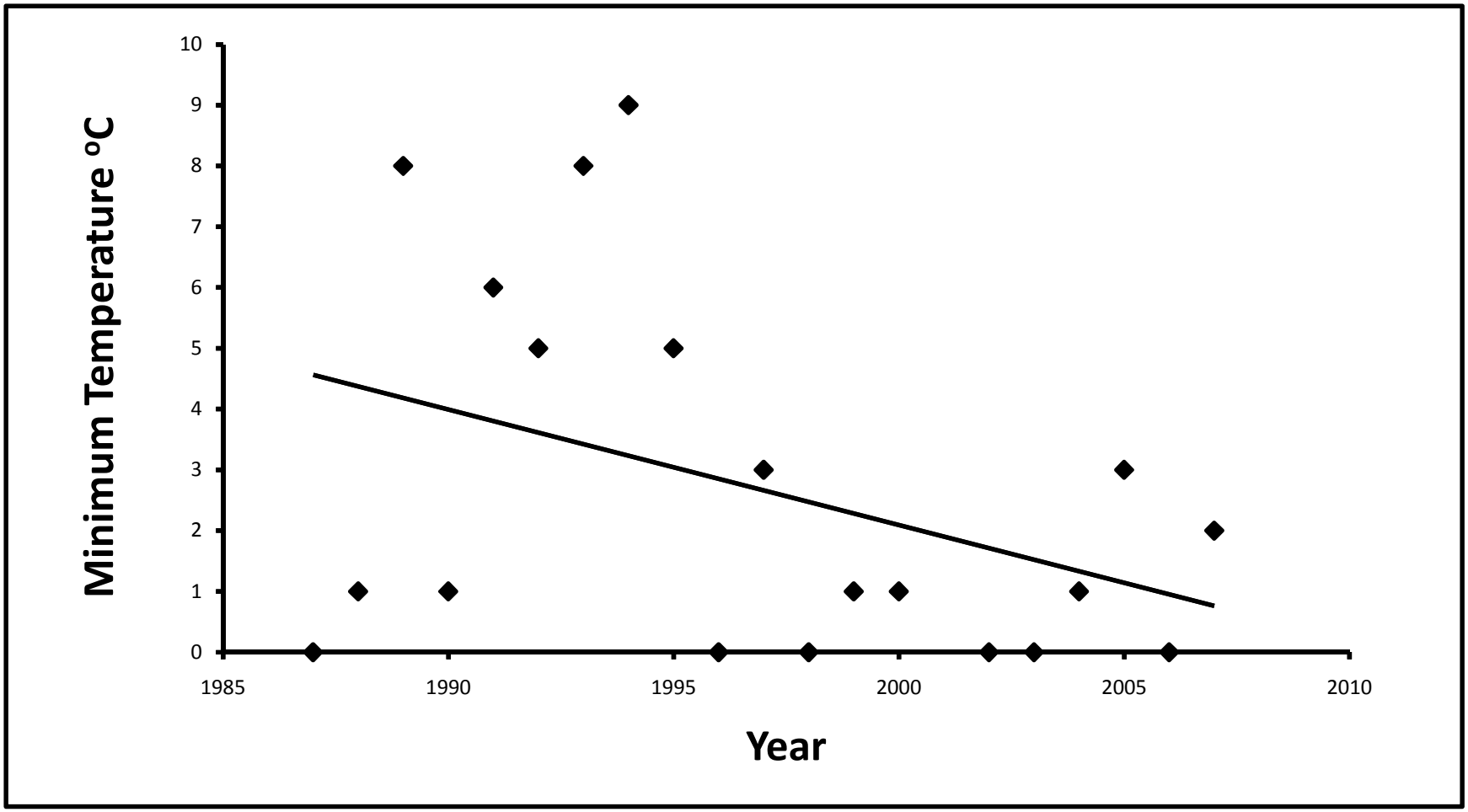

Post-monsoon
Temperature^{0}C
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
1985
1990
1995
2000
2005
2010
Year

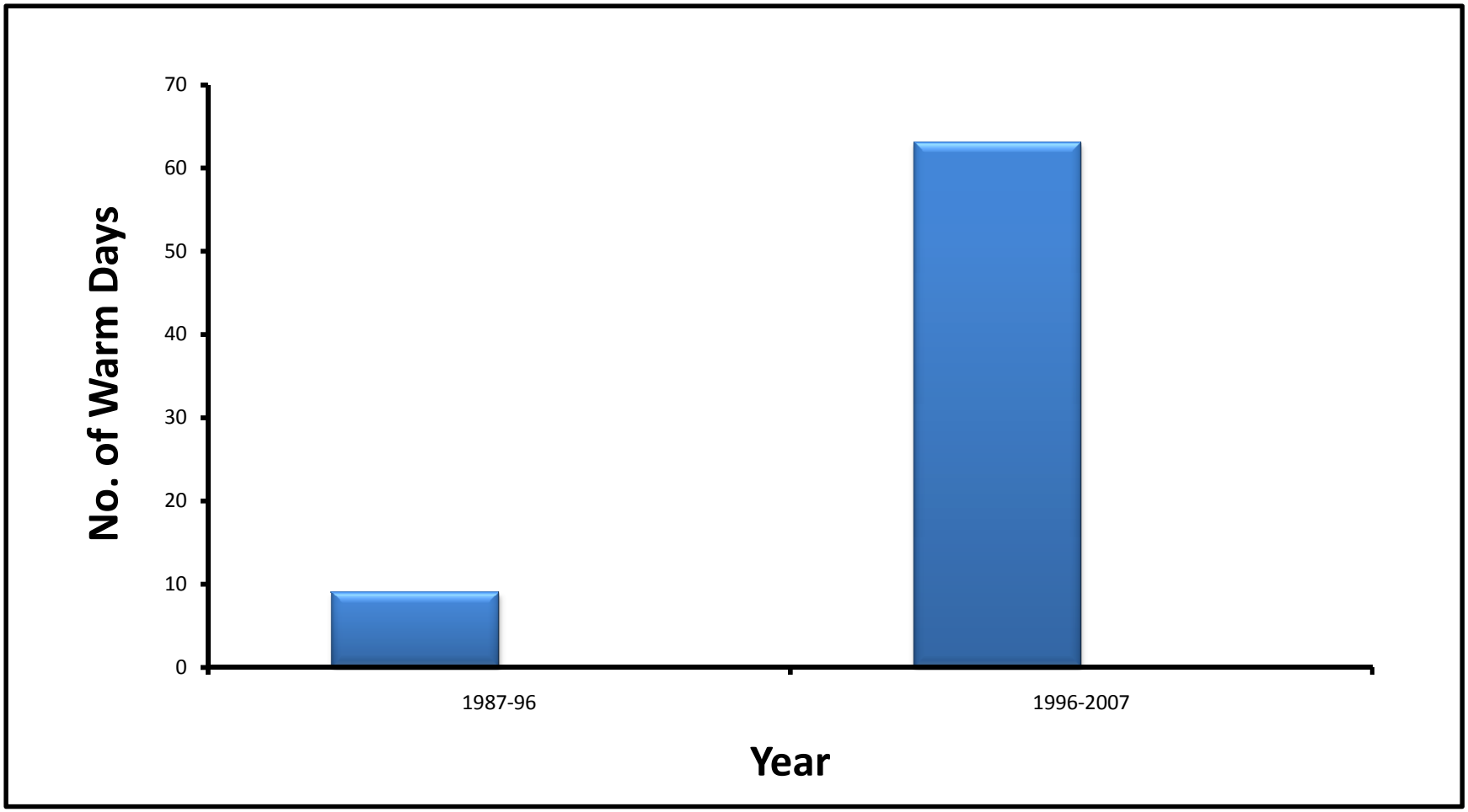

Winter
Temperature^{0}C
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
1985
1990
1995
2000
2005
2010
Year

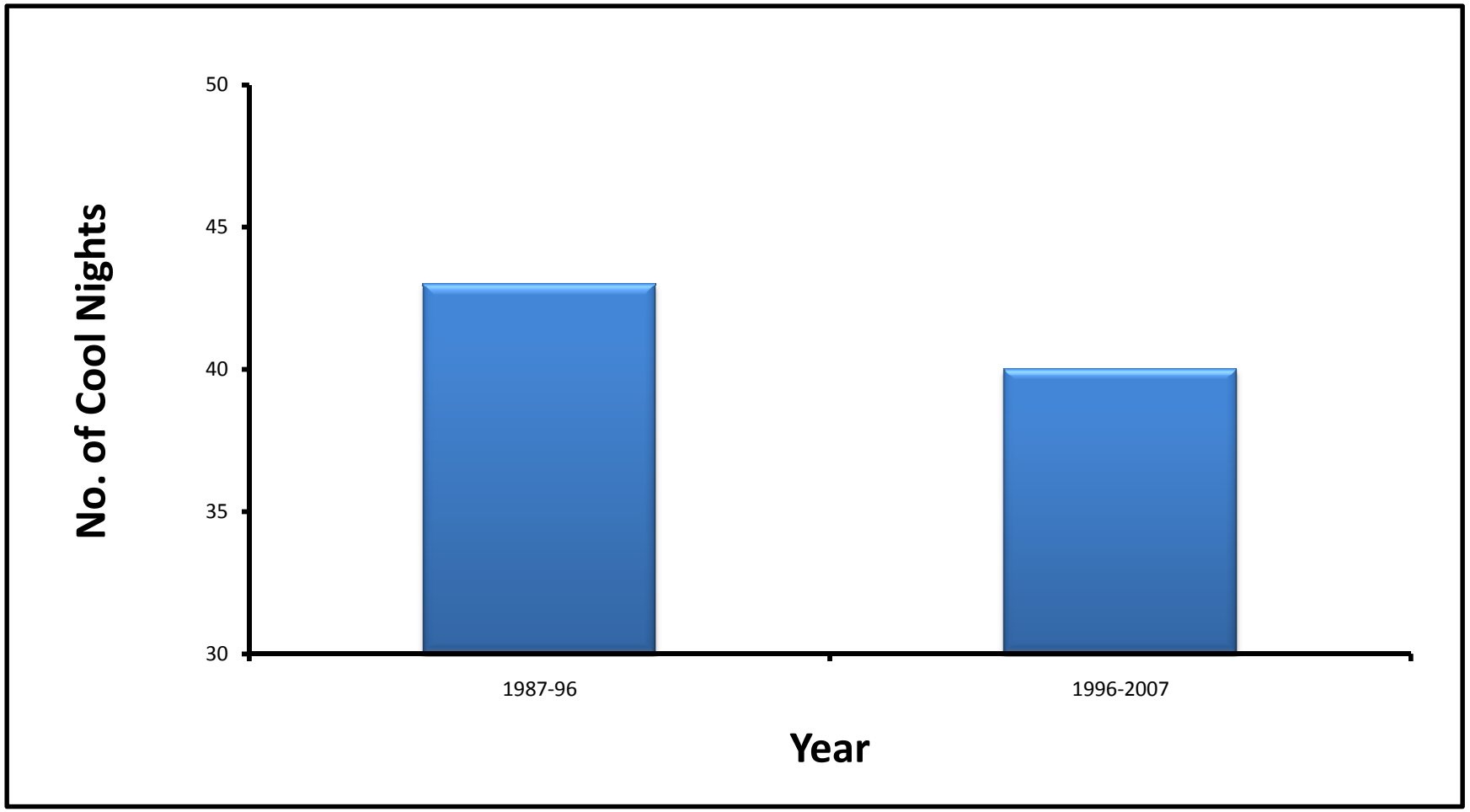
Warm Days


Maximum Temperature °C
18
16
14
12
10
8
6
4
2
0
1985
1990
1995
2000
2005
2010
Year

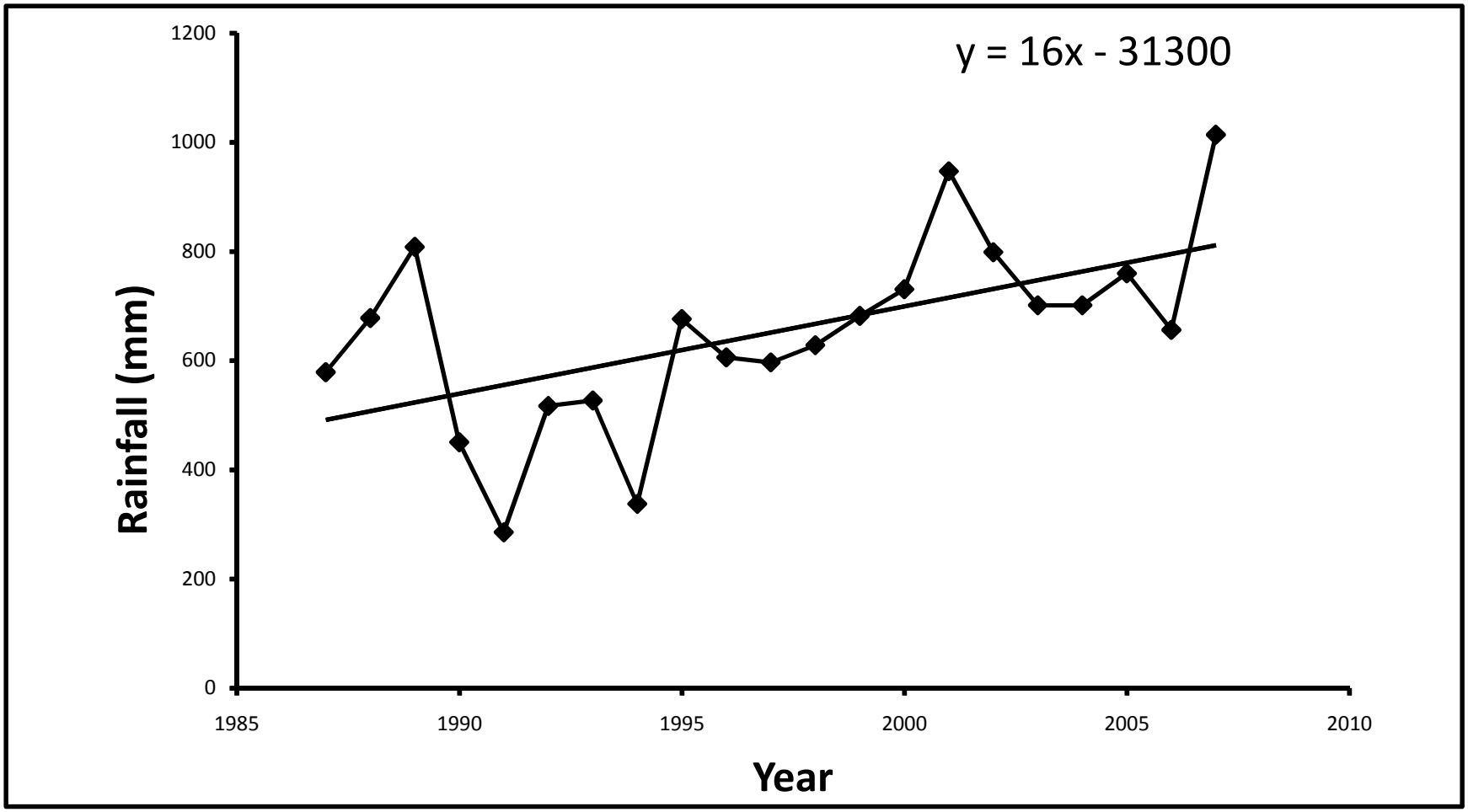
Cool Nights


Minimum Temperature °C
10
9
8
7
6
5
4
3
2
1
0
1985
1990
1995
2000
2005
2010
Year

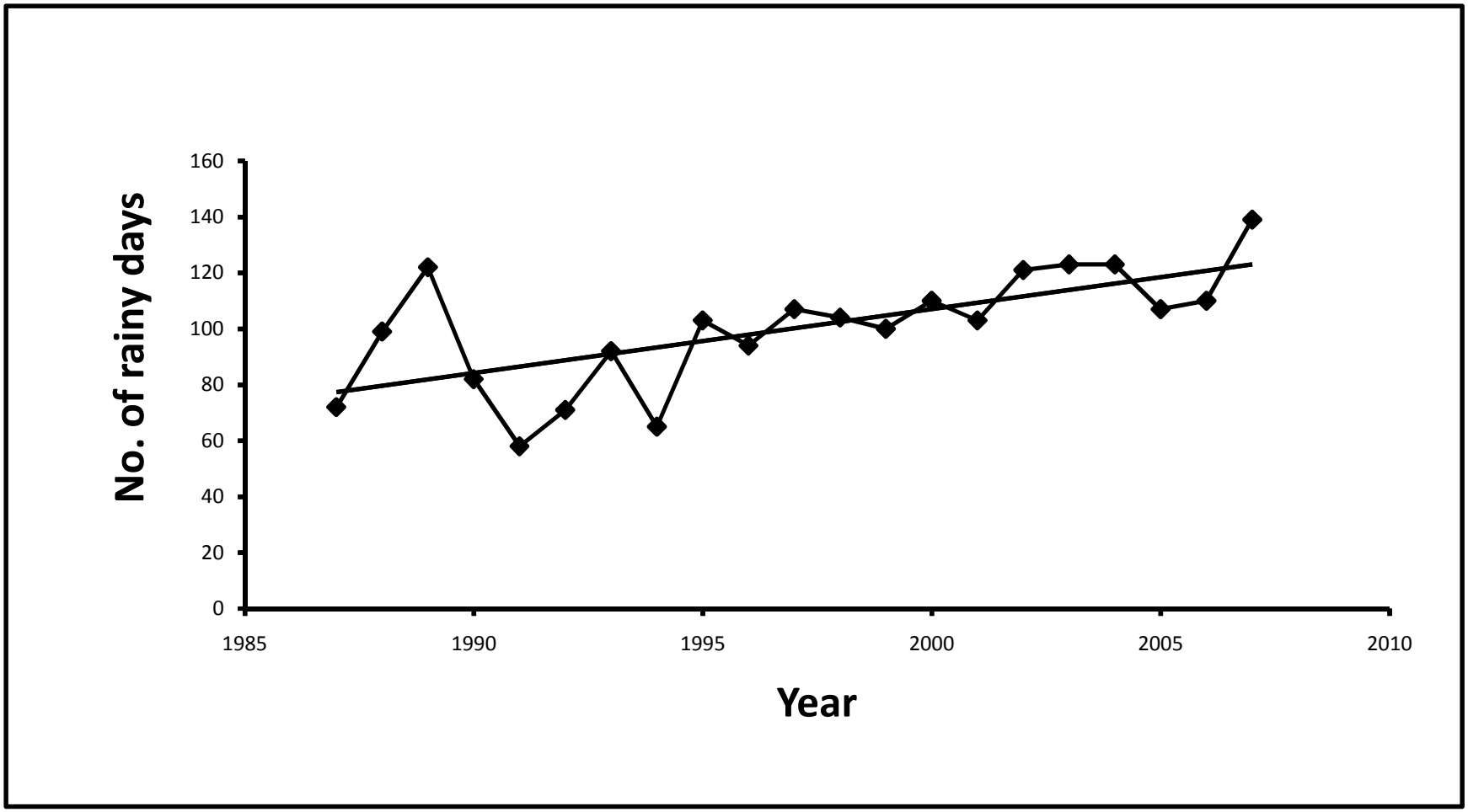

No. of Warm Days
70
60
50
40
30
20
10
0
1987-96
1996-2007
Year

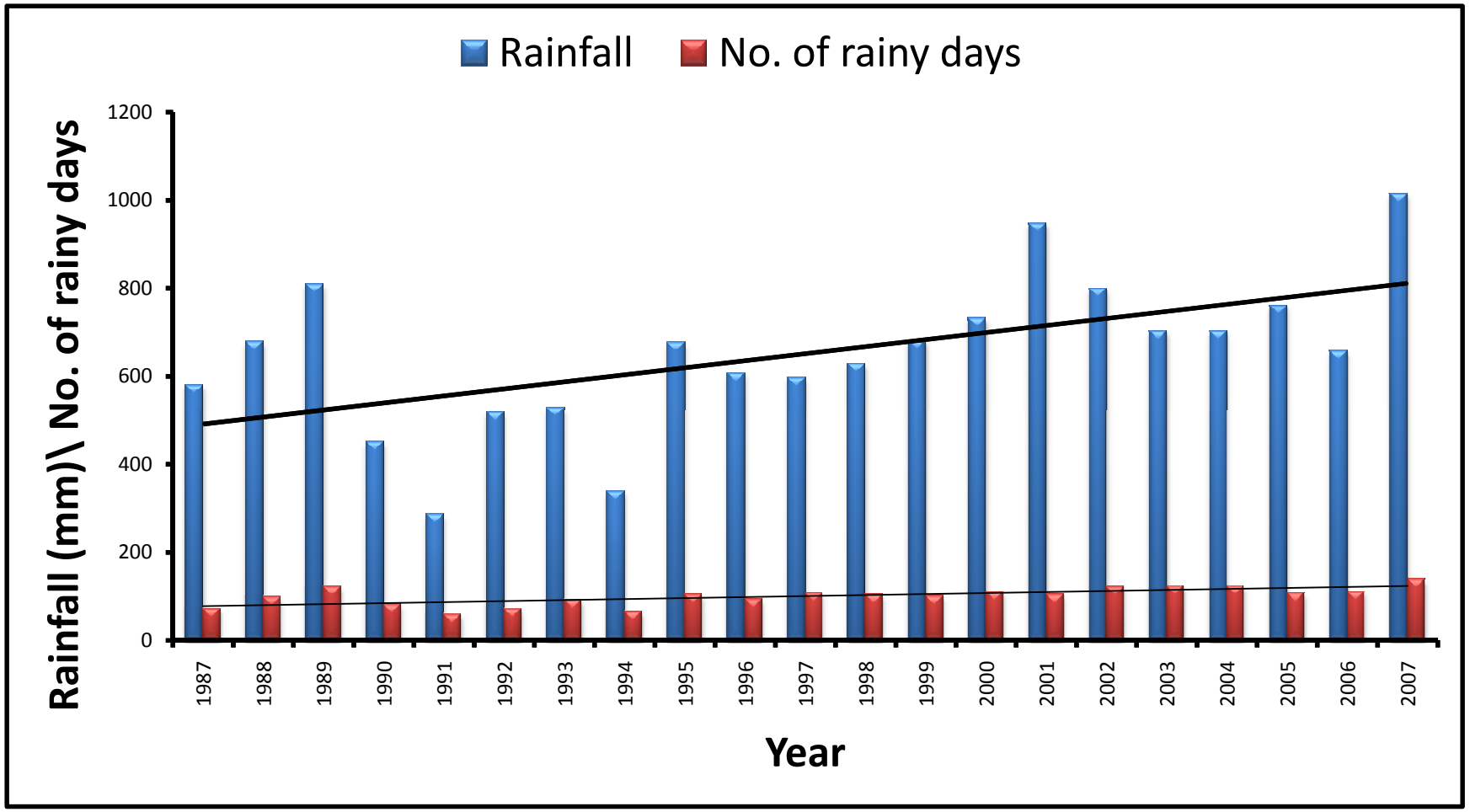

No. of Cool Nights
50
45
40
35
30
1987-96
1996-2007
Year

Rainfall

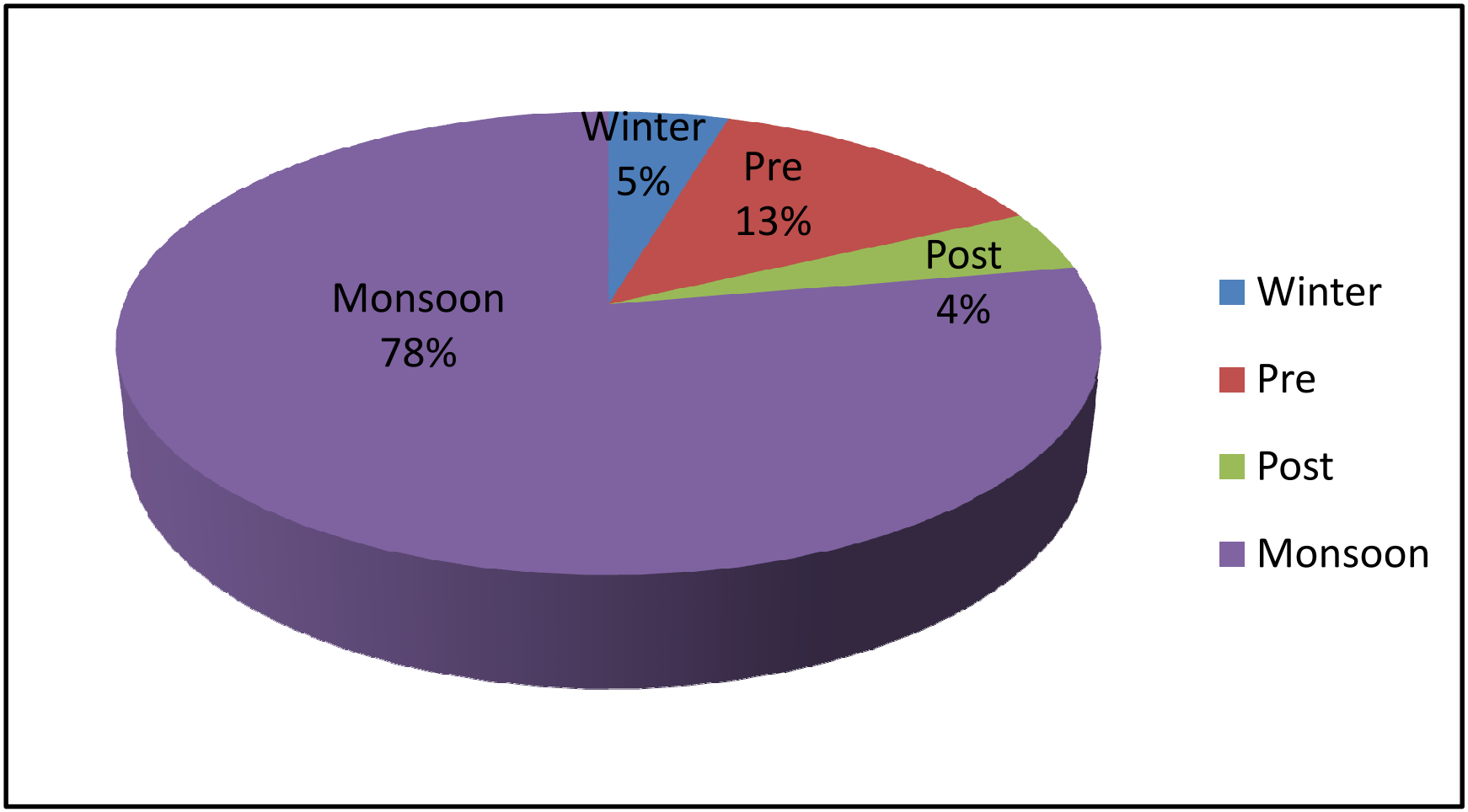

y = 16x - 31300
Rainfall (mm)
1200
1000
800
600
400
200
0
1985
1990
1995
2000
2005
2010
Year

No. of Rainy Days

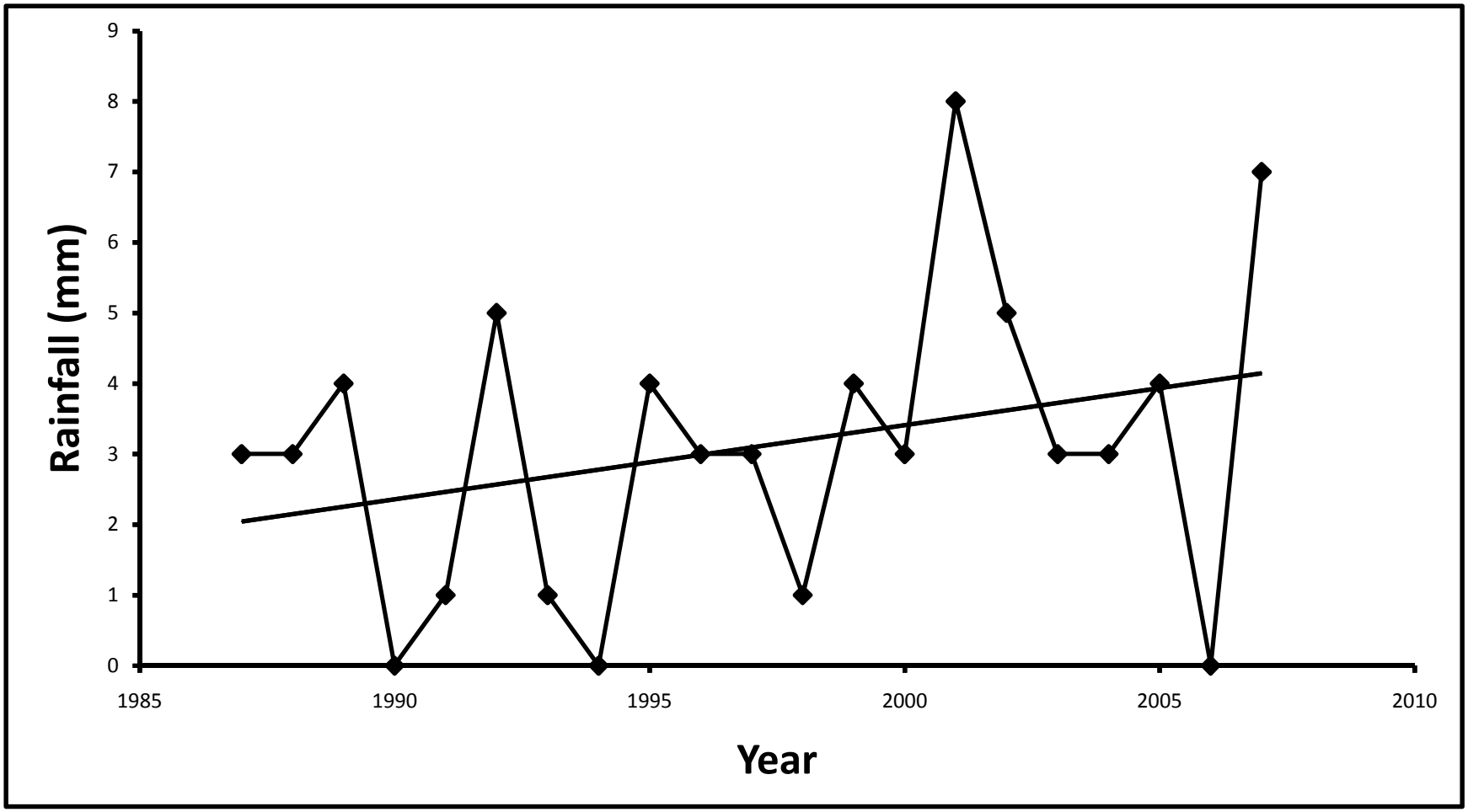



Rainfall
No. of rainy days
Rainfall (mm)\ No. of rainy days
1200
1000
800
600
400
200
0
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

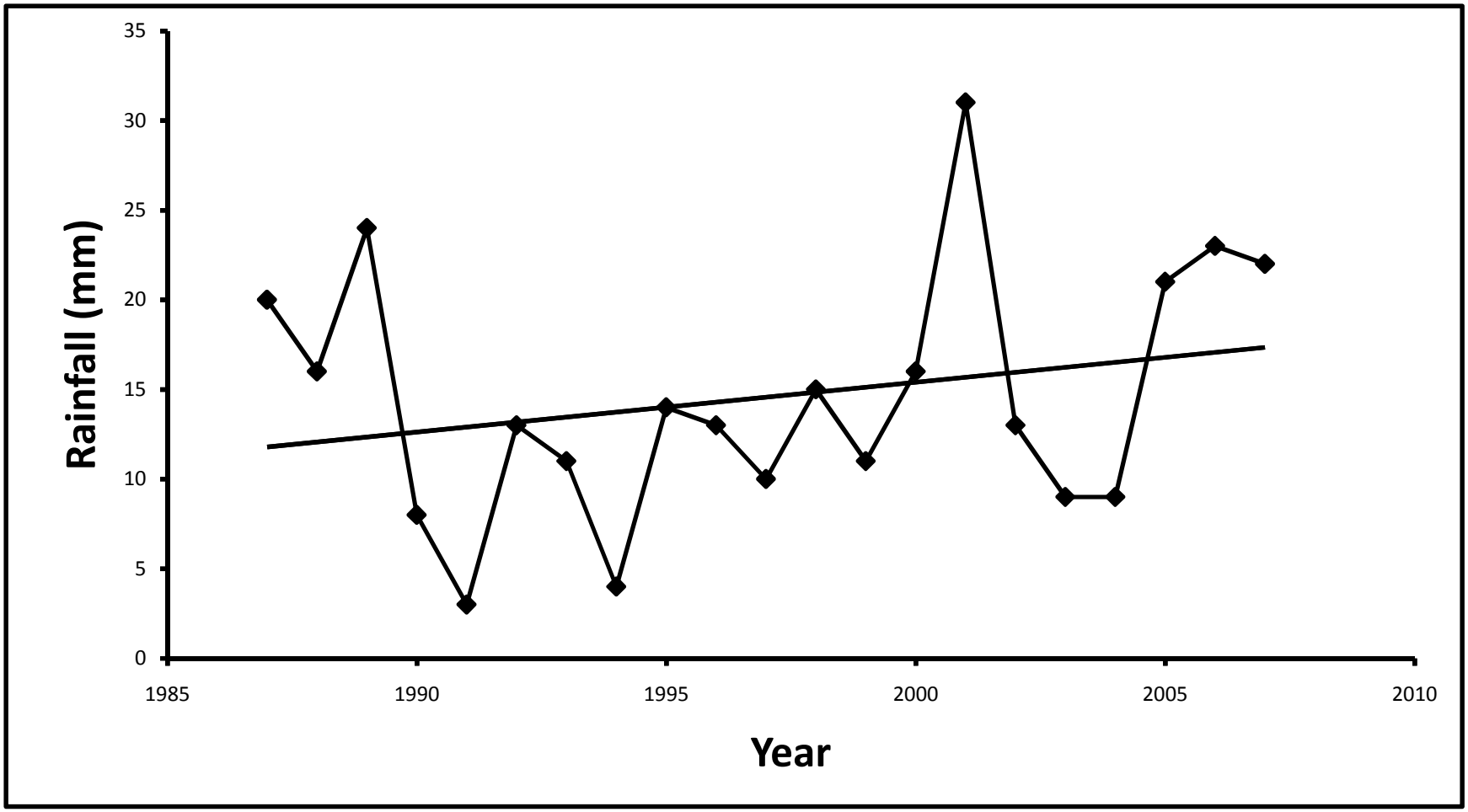
Seasonal Contribution of rainfall

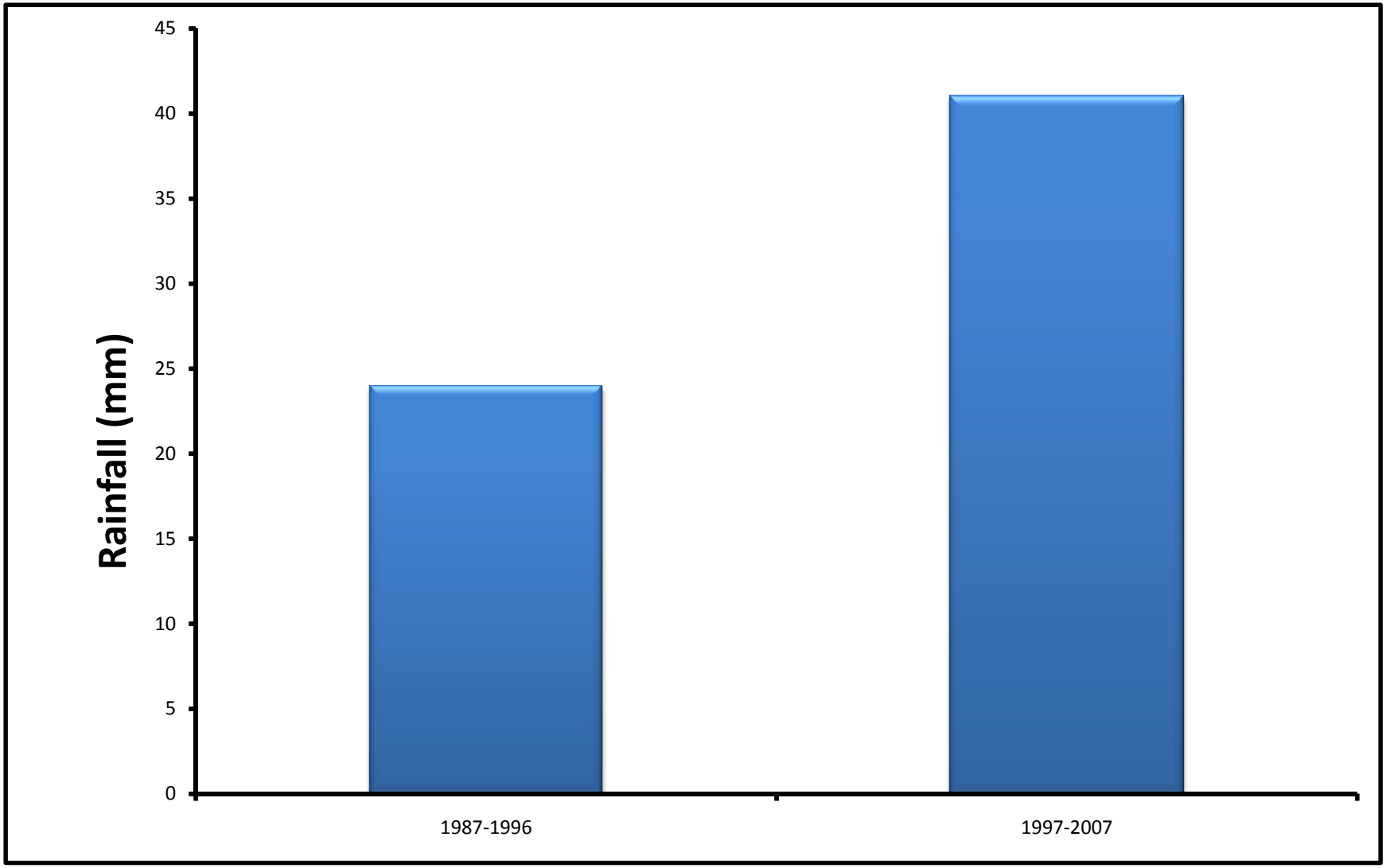


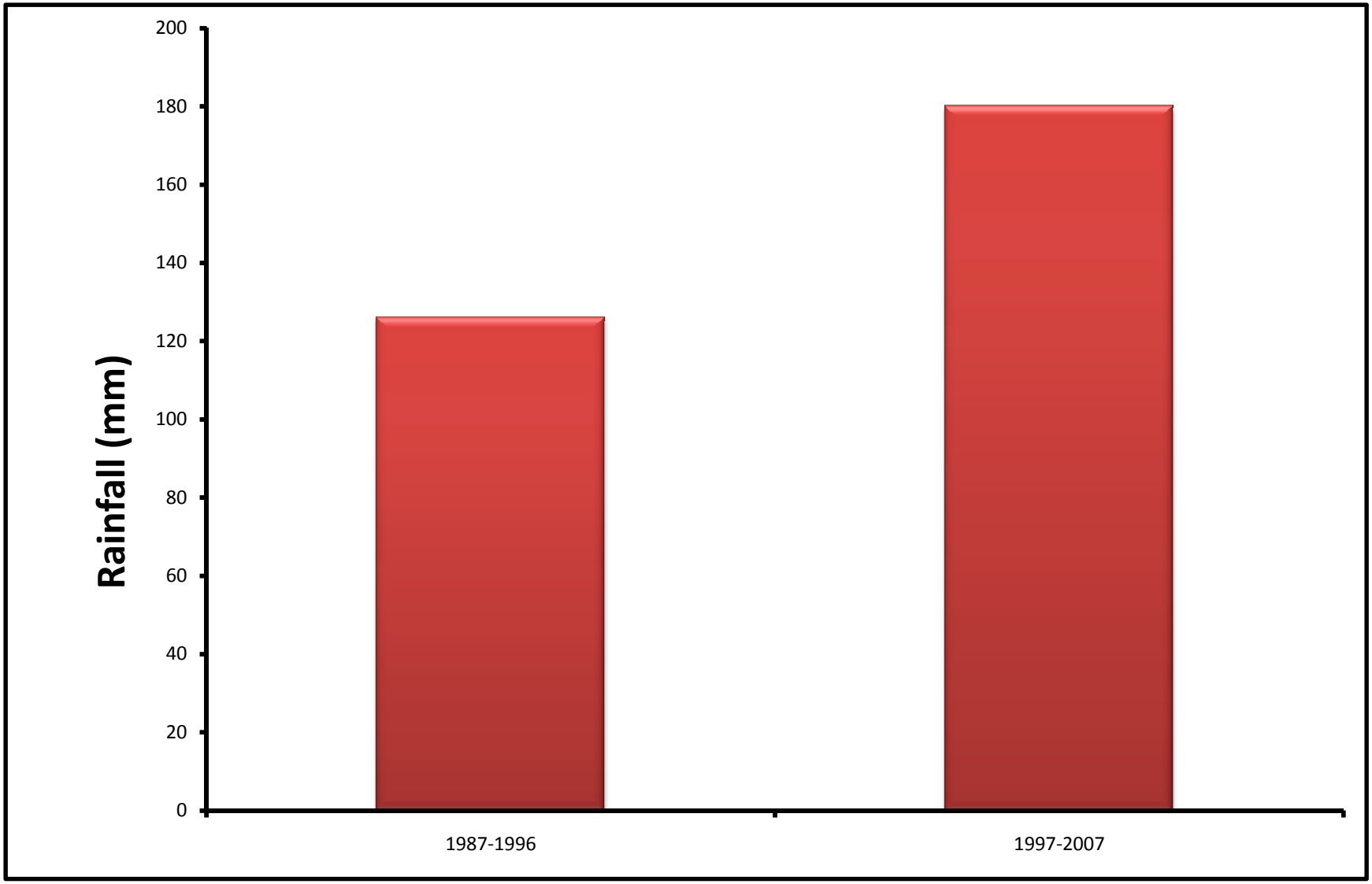
Extreme Events(>20mm)



Heavy Events(10-20mm)



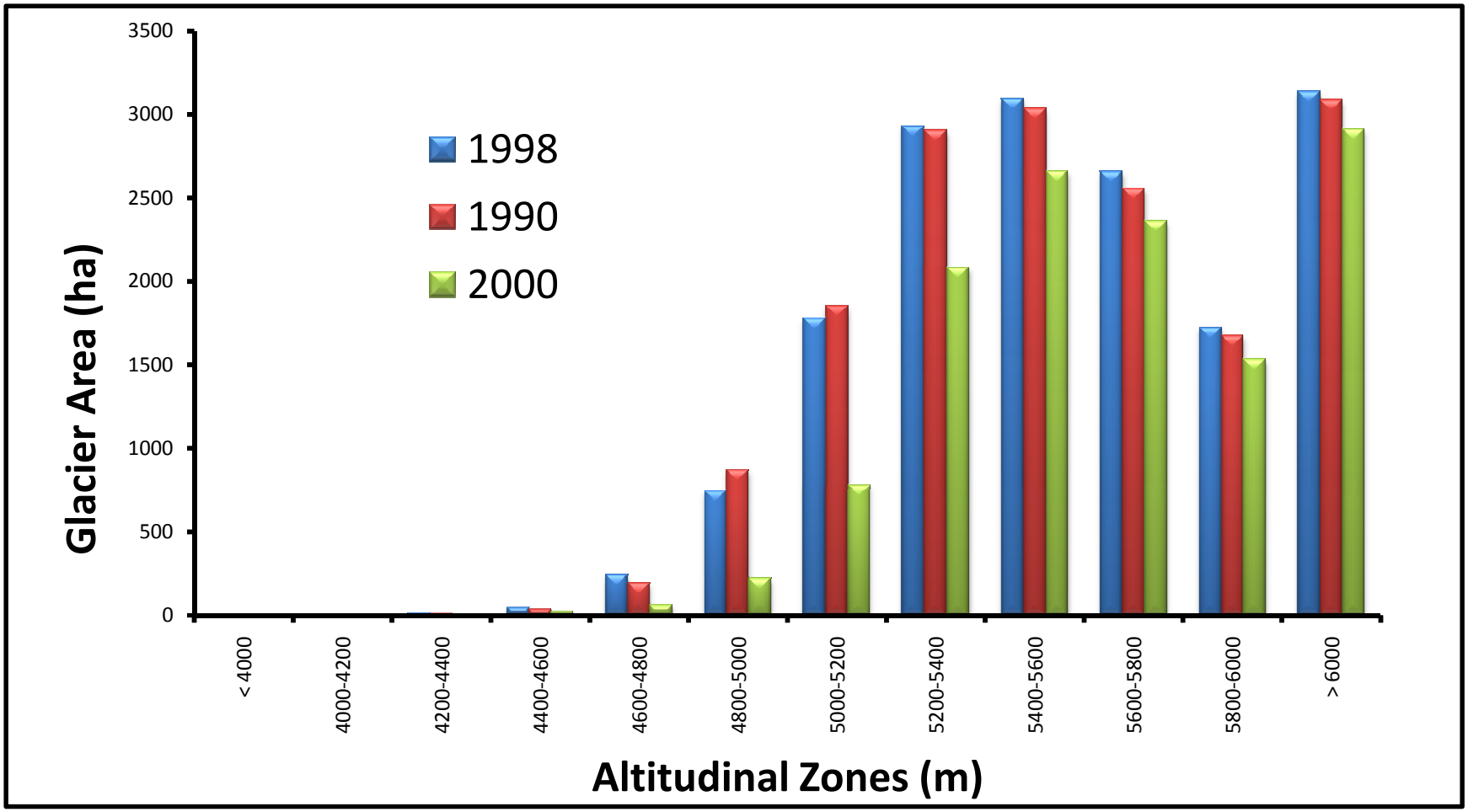

Rainfall (mm)
45
40
35
30
25
20
15
10
5
0
1987-1996
1997-2007


Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
1987-1996
1997-2007

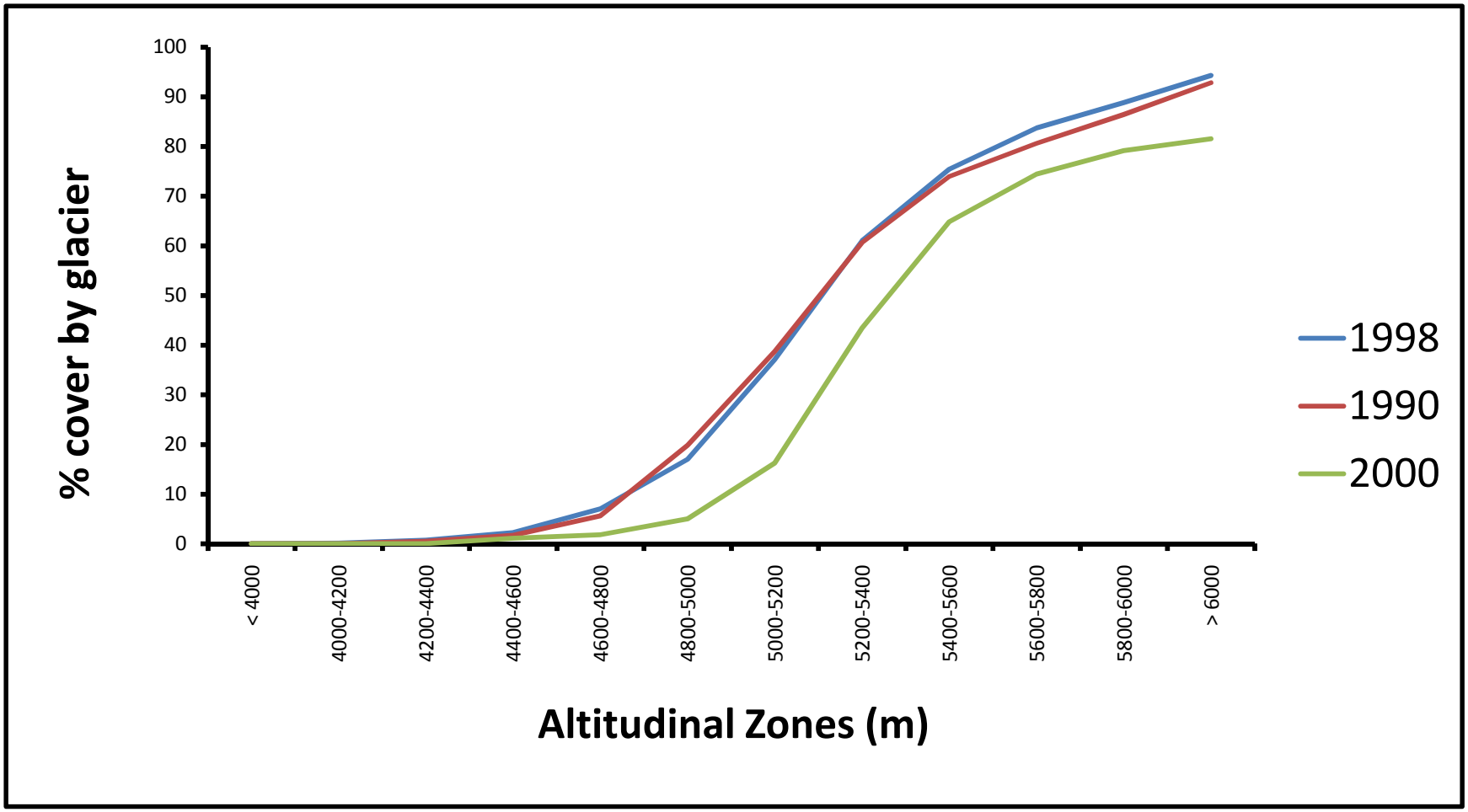
Altitudinal Variation in Glacier

Elevation Zones(m)	Area (ha)	Oct-88		Dec-90		Nov-00	
		Glacier area (ha)	% cover by glacier	Glacier area (ha)	% cover by glacier	Glacier area (ha)	% cover by glacier
< 4000	1326.2	0	0	0.2	0	0	0
4000-4200	1346.8	1.5	0.1	0	0	0.1	0
4200-4400	1607.8	11.9	0.7	7.9	0.5	0.8	0
4400-4600	2070	46.6	2.2	35.4	1.7	23.2	1.1
4600-4800	3419.6	239.6	7	192.3	5.6	61.7	1.8
4800-5000	4367	741.4	17	866	19.8	217.6	5
5000-5200	4795	1777.5	37.1	1853.4	38.7	778.6	16.2
5200-5400	4791.8	2928	61	2902.3	60.6	2081	43.4
5400-5600	4102.1	3092.9	75.4	3032.6	73.9	2659.4	64.8
5600-5800	3169.8	2653.3	83.7	2553.3	80.6	2357.2	74.4
5800-6000	1937.5	1720.1	88.8	1674	86.4	1532.3	79.1
> 6000	3324.3	3133.5	94.3	3086.1	92.8	2908.7	81.5
Total	36258	16346.3	45.1	16203.6	44.7	12620.5	34.8

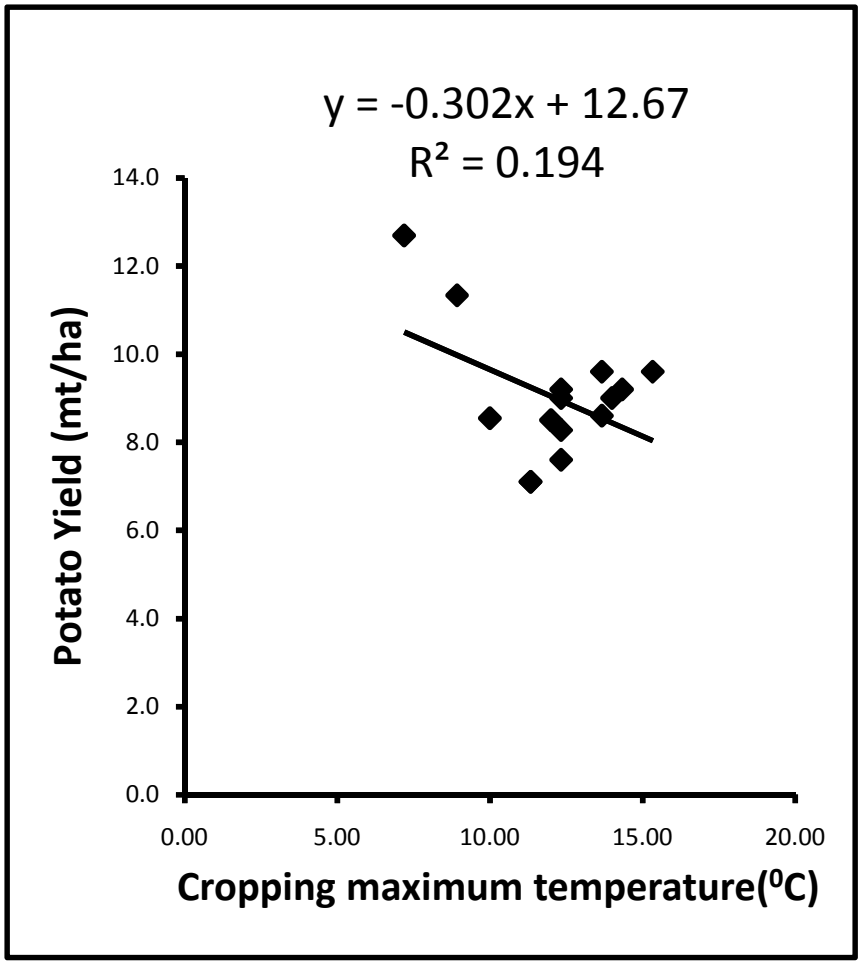
Altitudinal zone wise glacier cover (ha)

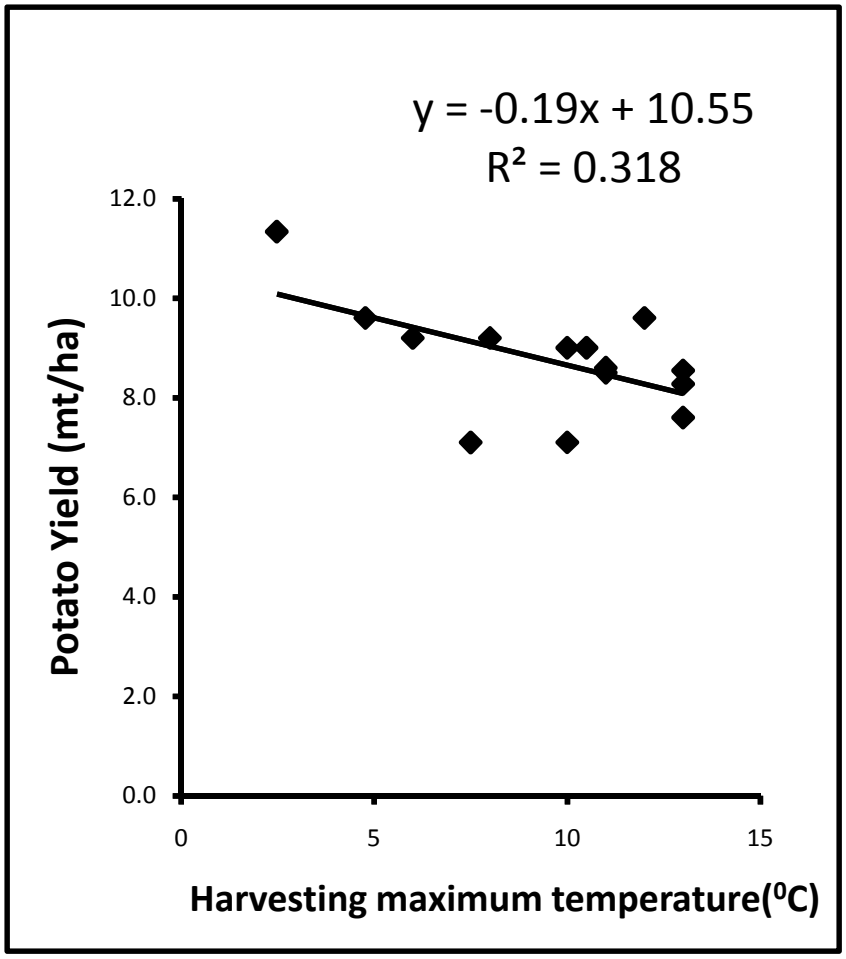


Percentage cover by glacier in different altitudinal zones

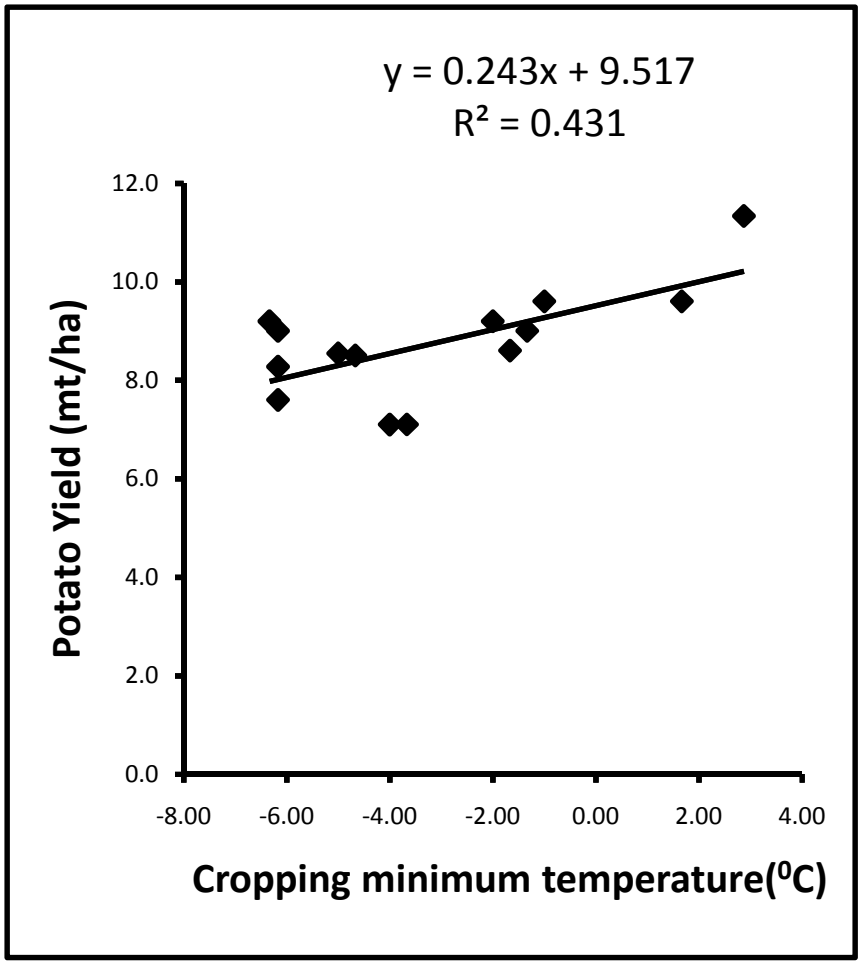


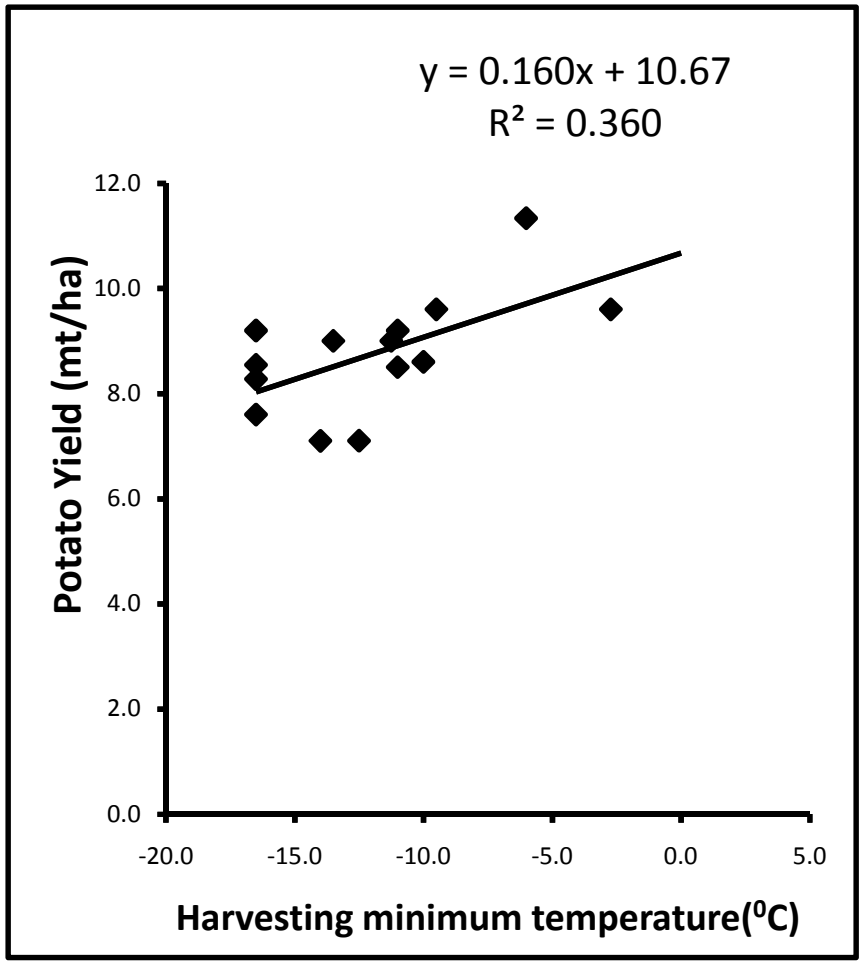
Correlation between Potato yield (cropping & harvesting) and maximum temperature (1990-2006)



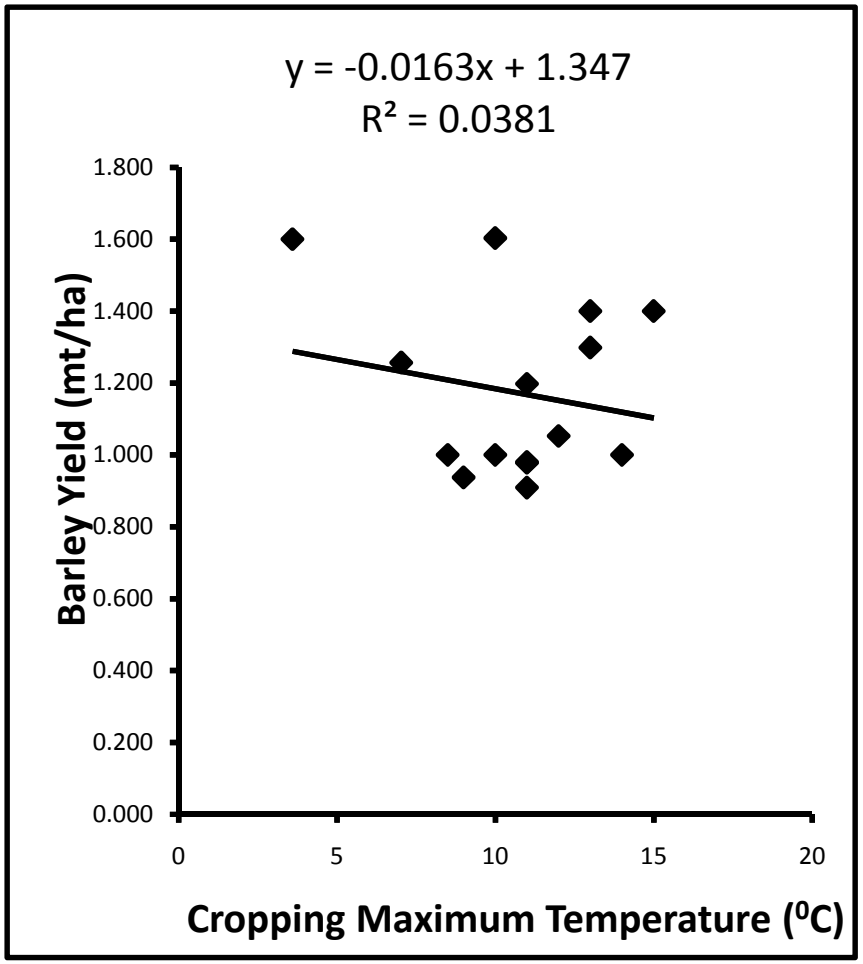


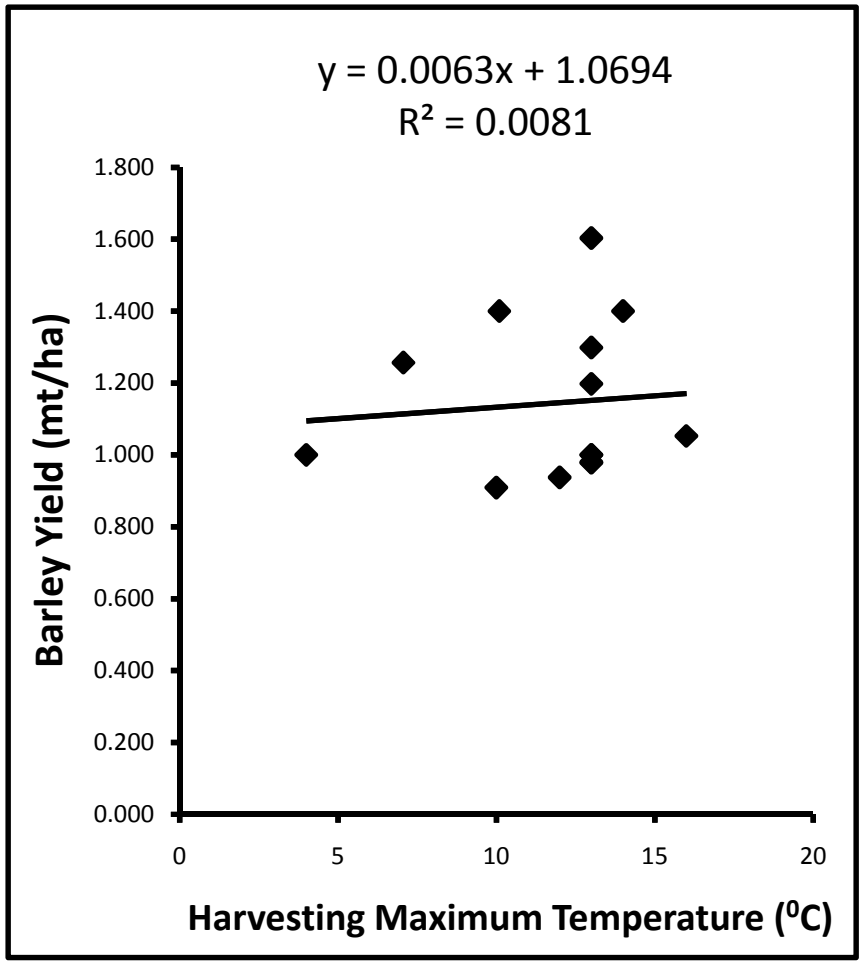
Correlation between Potato yield (cropping & harvesting) and minimum temperature (1990-2006)



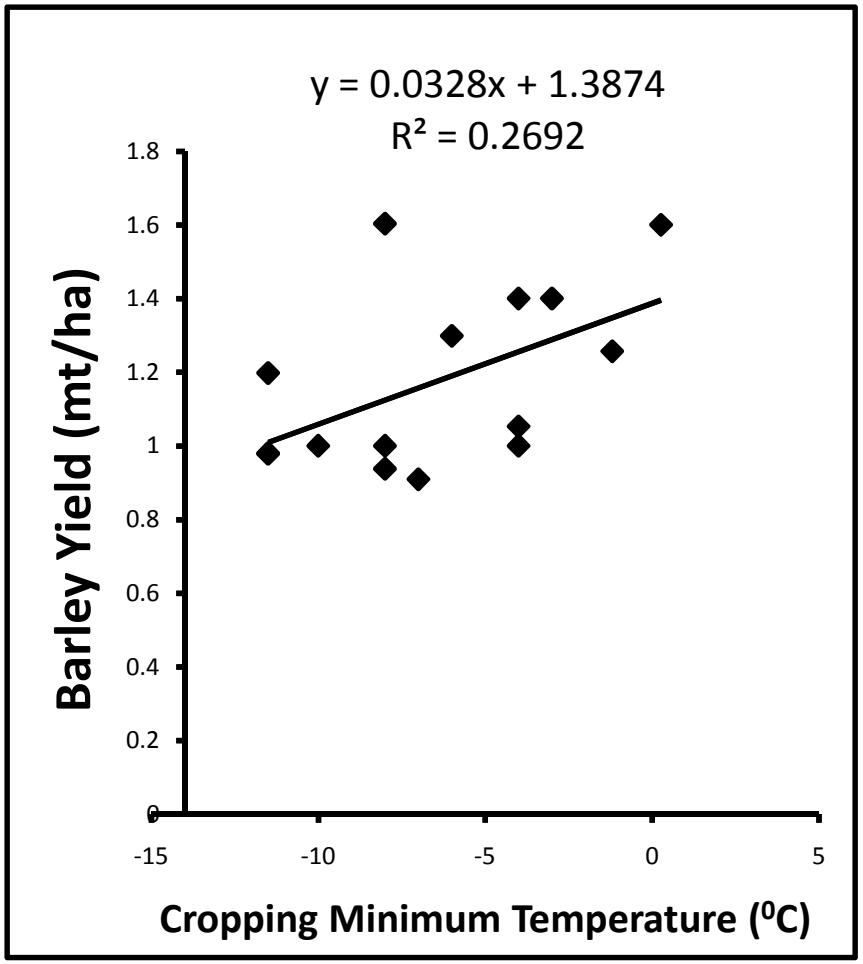


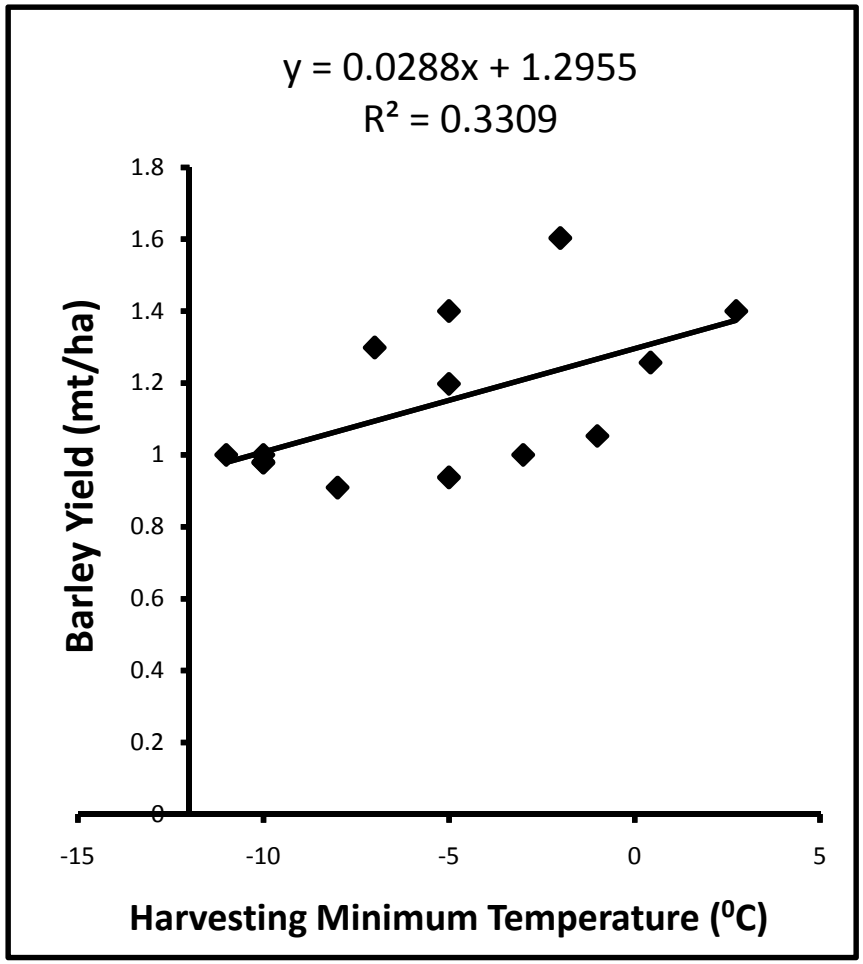
Correlation between Barley yield (cropping & harvesting) and maximum temperature (1990-2006)



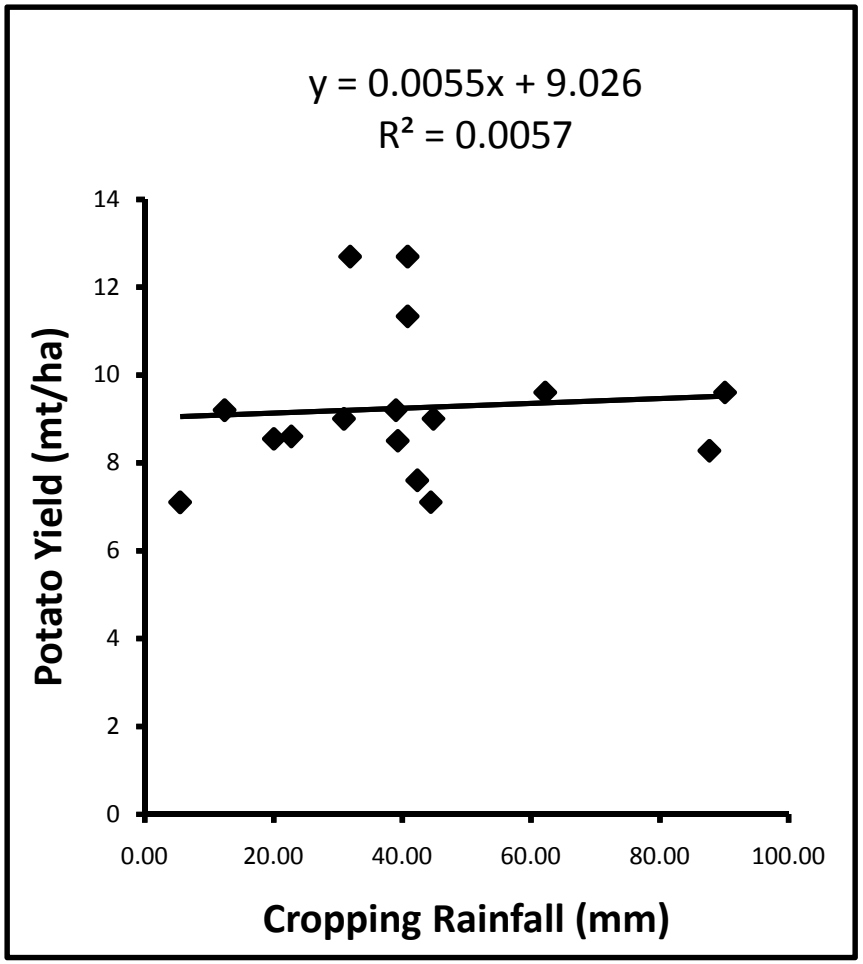


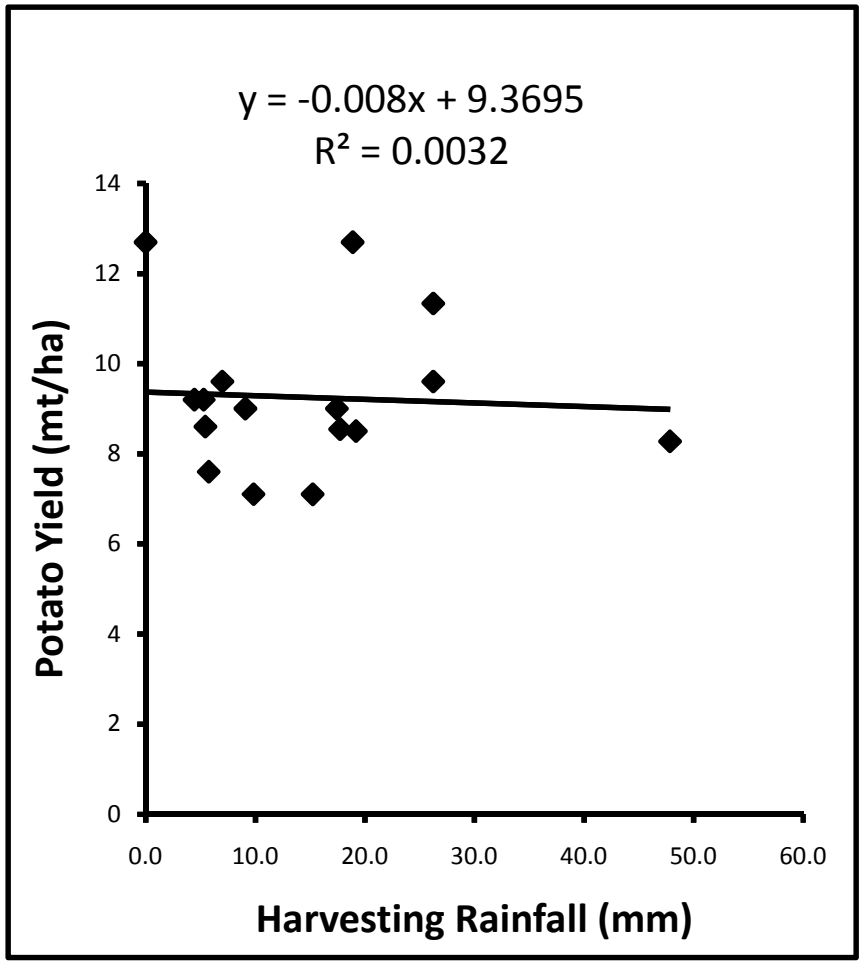
Correlation between Barley yield (cropping & harvesting) and minimum temperature (1990-2006)



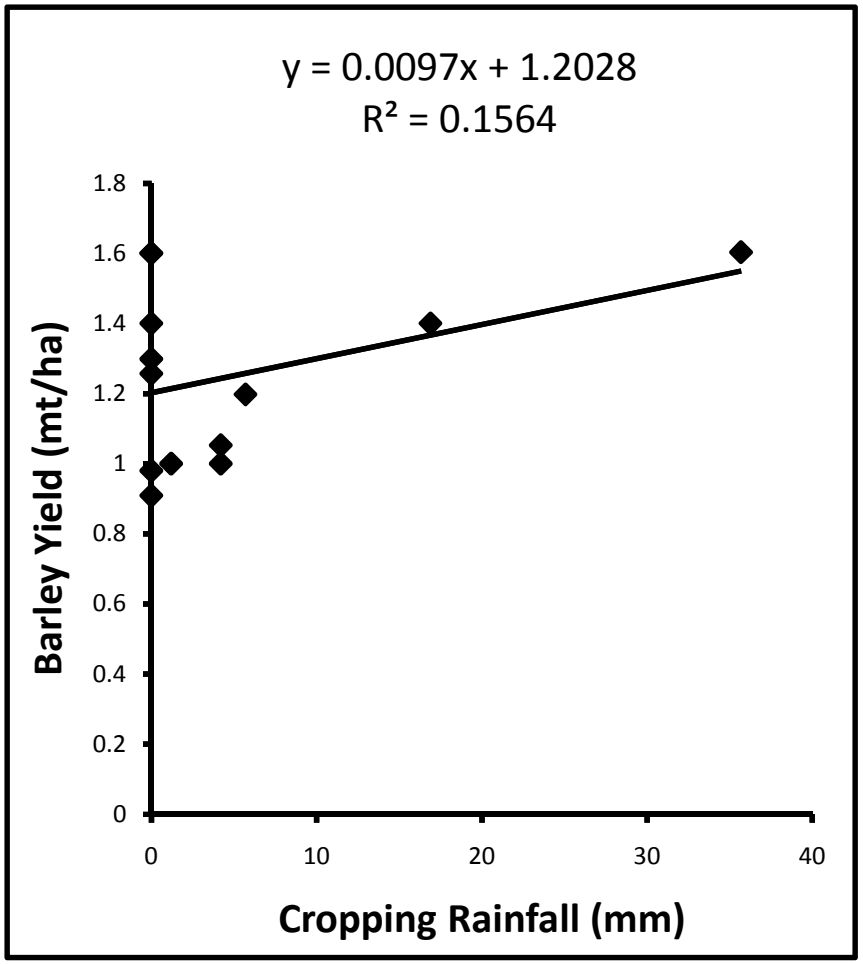


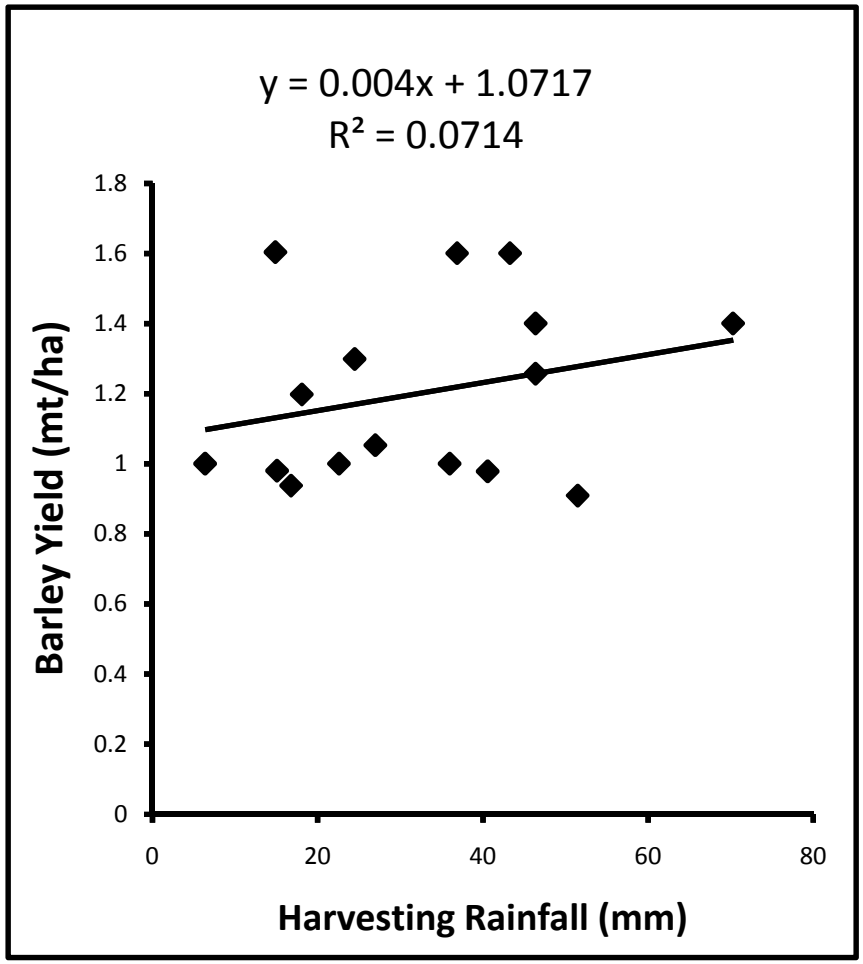
Correlation between Potato yield (cropping & harvesting) and Rainfall (1990-2006)



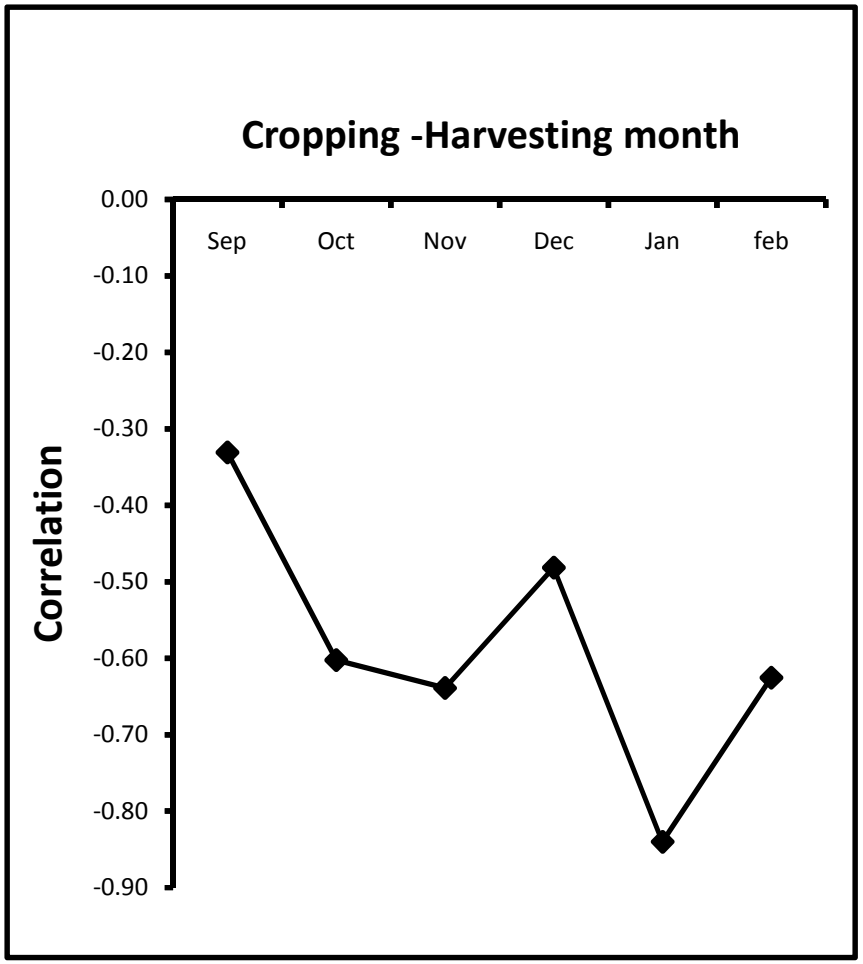


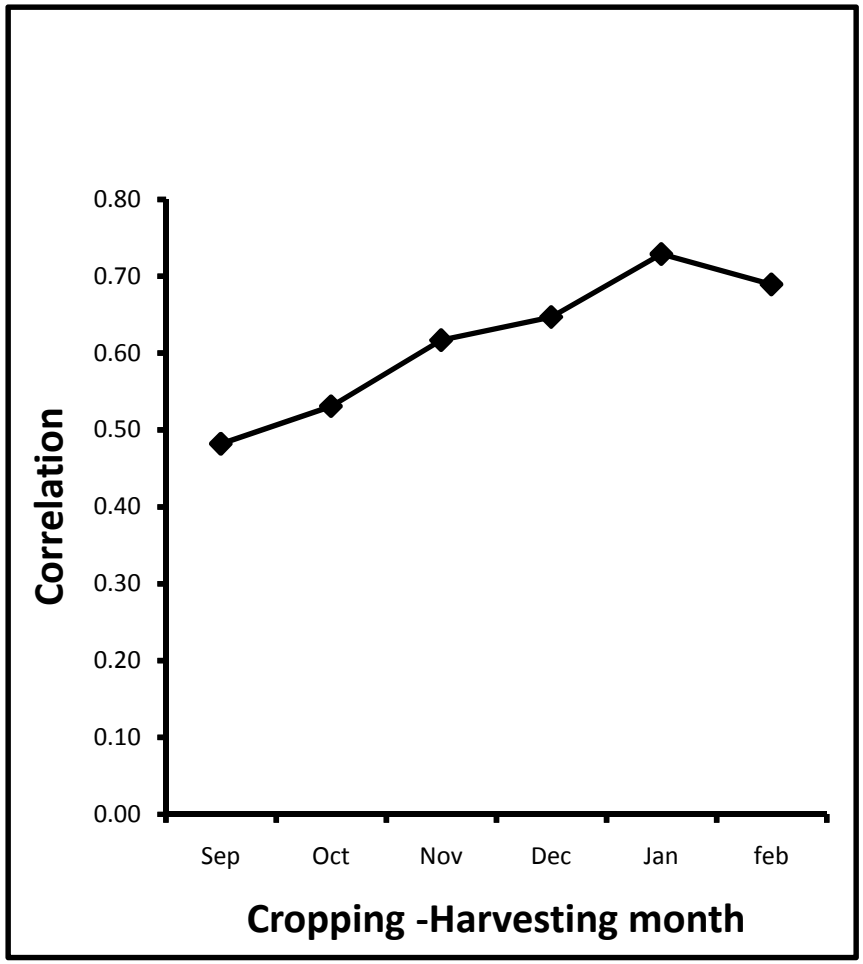
Correlation between Barley yield (cropping & harvesting) and Rainfall (1990-2006)



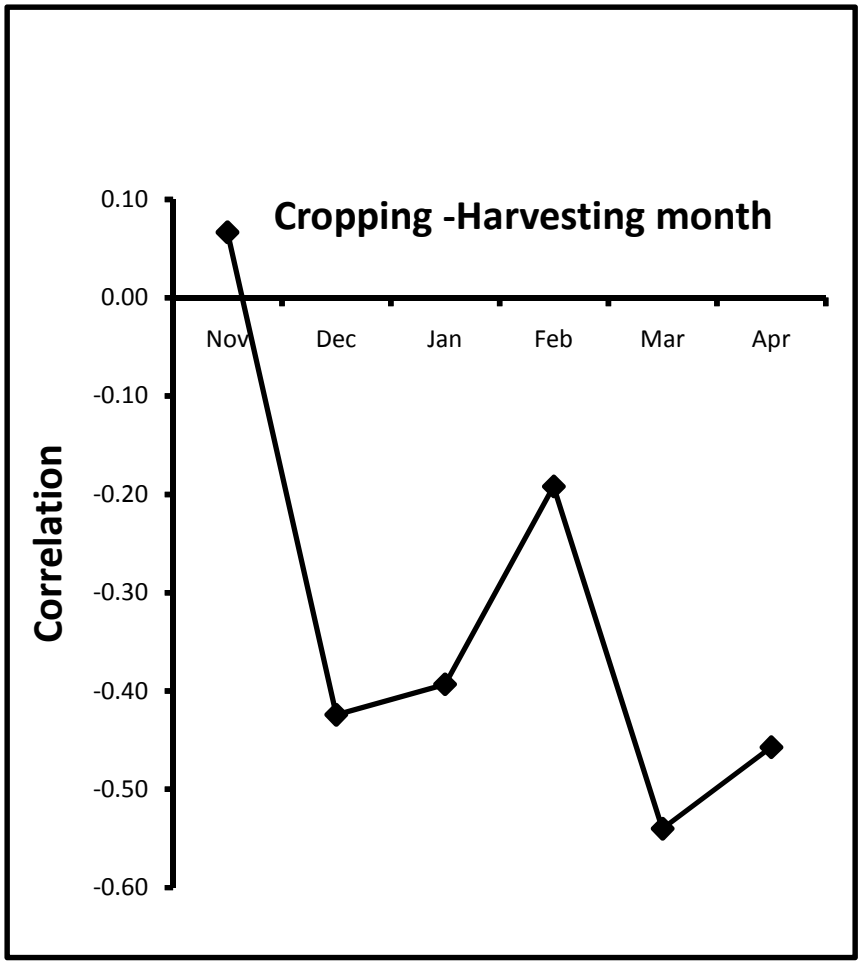


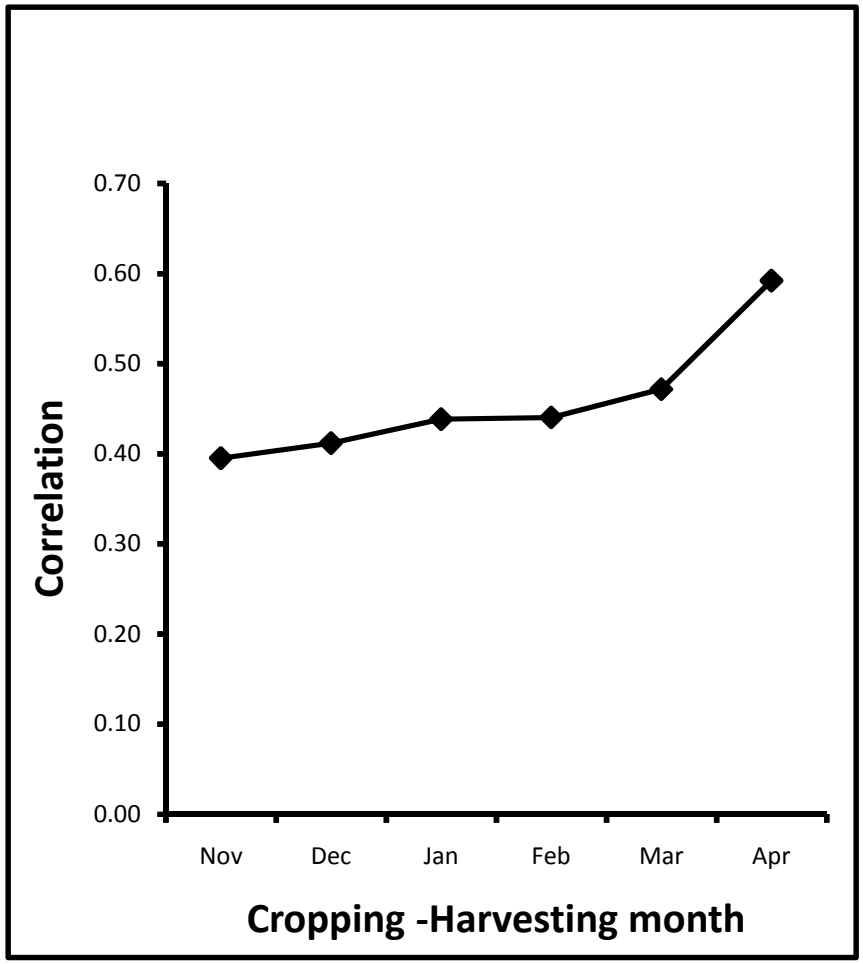
Correlation between Potato (cropping to harvesting) and temperature (maximum & minimum) (1990-2006)



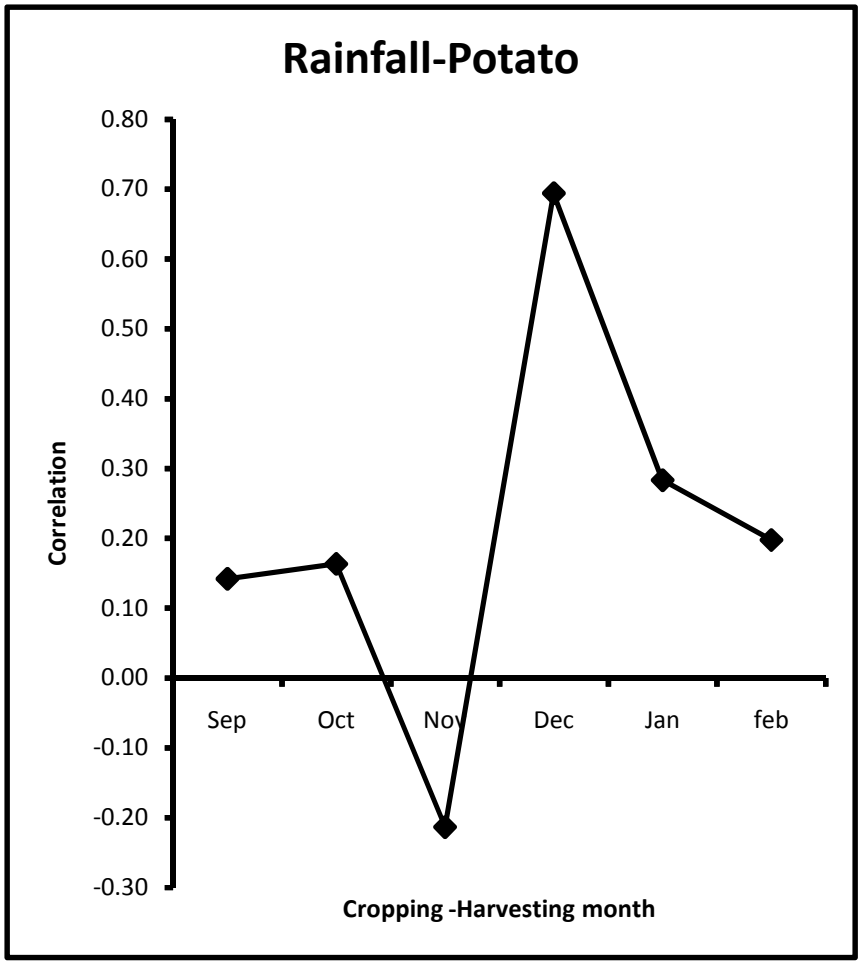


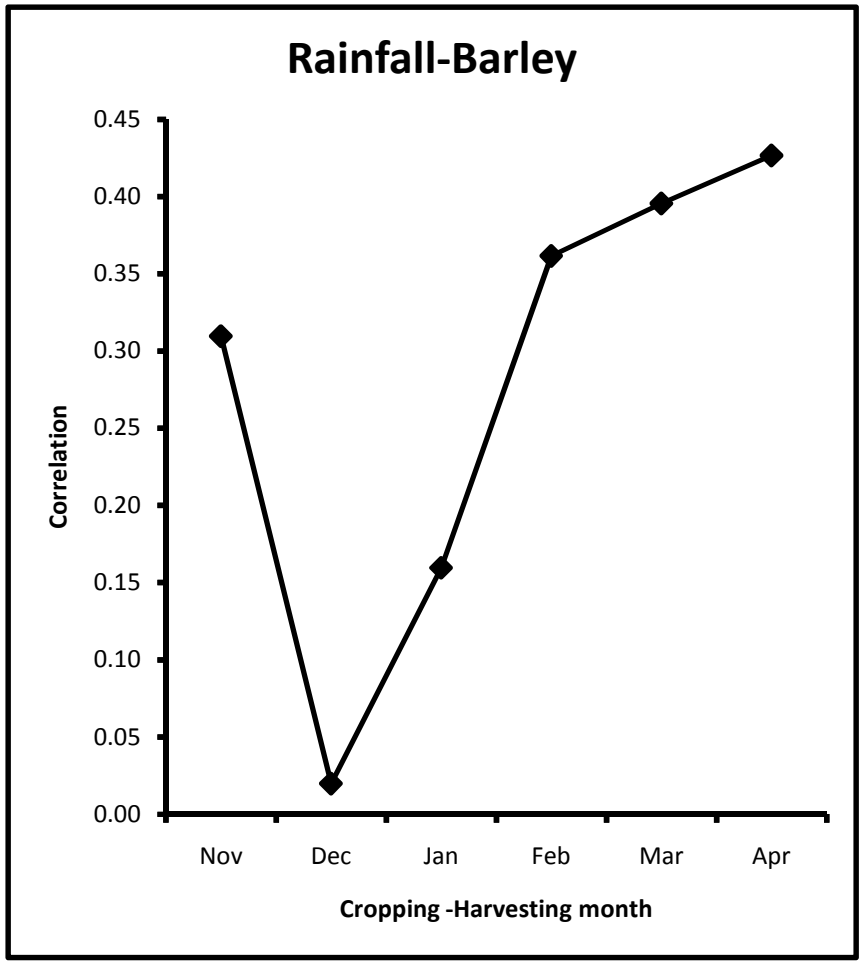
Correlation between Barley (cropping to harvesting) and temperature (maximum & minimum) (1990-2006)





Correlation between rainfall and potato/barley (cropping to harvesting) yield (1990-2006)





Potato yield and temperature and rainfall

	Max Temp		Min Temp		Rainfall		
	CORR	STDEV	CORR	STDEV	CORR	STDEV	CV
Cropping (Sept-Oct.)	-0.441	2.14	0.753	3.29	0.076	23.255	56.794
Harvesting (Jan-Feb)	-0.564	3.271	0.601	4.134	-0.056	11.862	80.482

Barley yield and temperature and rainfall

	Max Temp		Min Temp		Rainfall		
	CORR	STDEV	CORR	STDEV	CORR	STDEV	CV
Cropping (Nov)	-0.195	2.86	0.519	3.774	0.395	10.306	197.324
Harvesting (April)	0.090	3.062	0.575	4.309	0.267	16.989	52.597

Potato monthly yield and temperature and rainfall

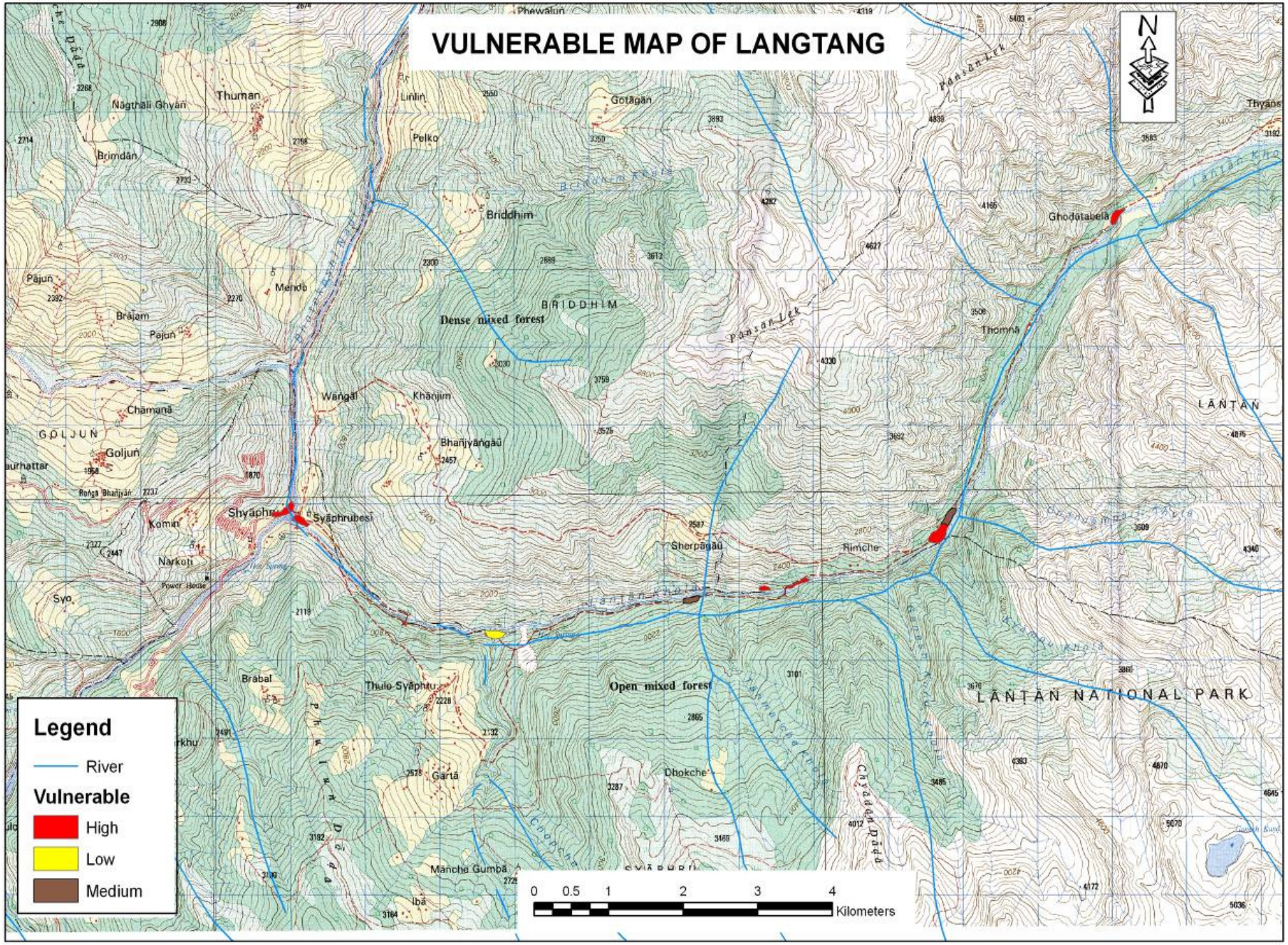
	Max Temp		Min Temp		Rainfall		
	CORR	STDEV	CORR	STDEV	CORR	STDEV	CV
Sep	-0.33	1.52	0.48	2.53	0.14	41.19	51.29
Oct	-0.60	3.01	0.53	4.19	0.16	46.02	167.76
Nov	-0.64	3.46	0.62	3.65	-0.21	10.31	197.32
Dec	-0.48	3.44	0.65	4.27	0.69	2.31	144.61
Jan	-0.84	3.98	0.73	4.86	0.28	10.90	90.75
Feb	-0.63	3.73	0.69	4.69	0.20	15.62	80.68

Barley monthly yield and temperature and rainfall

	Max Temp		Min Temp		Rainfall		
	CORR	STDEV	CORR	STDEV	CORR	STDEV	CV
Nov	-0.39	3.46	0.47	3.65	0.40	10.31	197.32
Dec	-0.19	3.44	0.59	4.27	0.43	2.31	144.61
Jan	-0.54	3.98	0.39	4.86	0.31	10.90	90.75
feb	-0.46	3.73	0.41	4.69	0.02	15.62	80.68
Mar	-0.32	3.44	0.57	4.66	-0.15	18.53	77.67
Apr	-0.45	3.14	0.37	4.67	0.32	17.71	57.67

Vulnerability

- Settlements at Syaphru Bensi, Bamboo, Lama Hotel, Rimche and Ghodatabela are highly exposed to flood and landslide.
- Settlement at Bamboo has been affected by monsoon flood since 1997.
- Some of the lodges in Lama Hotel had been swept away by flood in 7/8 years ago .
- Domen can be considered in less vulnerable area
- Questionnaire survey revealed that in Kyanjgin people has already felt the scarcity of water supply during winter season. The rate of snowfall as compared to past have also been decreased.
- Old people, children and women are the most vulnerable groups.


VULNERABLE MAP OF LANGTANG
N
Legend
River
Vulnerable
High
Low
Medium
0 0.5 1 2 3 4
Kilometers
Dense mixed forest
Open mixed forest
LANGTANG NATIONAL PARK
Thuman
Nagthali Ghyan
Brimdan
Pelko
Linlin
Gotagaon
Briddhim
BRIDDHIM
Mendo
Pajun
Brajam
Chamana
GOLJUN
Goljun
Wangal
Khanjim
Bhanjyangau
Shyaphru
Syaphrubesi
Komin
Narkoti
Syo
Brabal
Thulo Syaphru
Garta
Manche Gumba
Iba
Sherpagau
Rimche
Dhokche
Ghodatabela
Thomna
LANGTAN

Landslide at Rimche

Flood exposed settlement at Rimche

Flood exposed settlement at Bamboo

Landslide at Ghodatabela

Mitigation Measures

Some of the mitigation measures that should be adopted are as follows

- Education and awareness campaigns for the vulnerable communities in terms of risk, disaster management practices, prevention actions, response measures, working closely with media and alerts in local languages
- Improving community resilience to climate change through the development of sustainable livelihoods
- Promotion of crops which are resistant to drought (e.g. sweet potatoes and cassava) and replacement of crops which are vulnerable to diseases
- Improving agricultural production under erratic rains and changing climatic conditions
- Providing access to improved seeds for agriculture
- Improvement of the information systems, public participation in disaster reduction and vulnerability reduction
- Improved forecasting for farming, extreme events and disaster management
- Fund raising to support and train local communities to deal with natural disasters

Adaptation Strategies Identified

- Establishment of a simple early warning system to communicate and forecast the weather and flood dated information
- Providing information about rainfall is important because it triggers all floods
- Enhance understanding concerning the influence of human interventions on flooding
- Retaining and stabilizing rivers bank
- Training and building the capacity of local communities
- Preparing VDC- level plan for adaptation
- Civil society involvement in planning and programme designing for prevention, response measures and rehabilitation of the affected areas
- Strengthen Agricultural Research Station and commodity program to run effective researches related to climate change
- Breeding new plant species and crops that are more tolerant to changed climate condition
- Altering the timing of planting dates to adapt to changing growing conditions

Conclusion

- The annual mean maximum and minimum temperature are increasing
- Winter, Pre monsoon and Post monsoon closely resembles the yearly distribution, with the Pre monsoon season showing the greatest and the winter season showing the lowest rate of increase
- The warm days are increasing more in the latest year (1997-2007) as compared to previous year (1987-1996) and cool nights are decreasing in the latest year. It reveals that warm days are increasing and cool nights are decreasing
- The mean annual precipitation is found to be 651mm with coefficient of variation 27%
- The total annual rainfall and number of rainy days are also increasing
- The number of extreme events (>20mm/ day) and heavy events (10-20mm/day) are increasing
- Extreme events are almost double in the latest ten years (1997-2007) as compared to the previous year (1987-1996). Similarly heavy events are also increasing In the latest year
- Total glacier cover varies from 45% to 35% from the years 1988 to 2000, highest in 1988 and lowest in 2000

- Potato yield shows positive correlation with minimum temperature than the maximum temperature. In barley, maximum temperature shows negative correlation and minimum temperature shows positive correlation on net yield. But the result is less significant in minimum temperature
- A relationship between potato/barley yield and rainfall shows poor correlation on both cropping and harvesting period
- Net crop yield are more sensitive to the variation of the minimum temperature than maximum temperature and are not dependable on rainfall
- Settlements at Syaphru Bensi, Bamboo, Lama Hotel, Rimche and Ghodatabela are highly exposed to flood and landslide. These areas are considered as highly vulnerable area whereas Domen is considered on low vulnerable area
- Education and awareness campaigns for the vulnerable communities should be prioritize
- Training and building the capacity of local communities
- Establishment of information centers related to climate change
- Strengthen Agricultural Research Station and commodity program to run effective researches related to climate change

Recommendations

- The problem of missing data and poor quality data were found which should be controlled and upgraded as soon as possible for determining the actual trend
- The climate information and yield data are limited for meaningful analysis to find their relationship. The result of such analysis should be constantly upgraded
- Non-parametric test should have been done to identify the significant trend
- The monitoring situation with respect to agricultural meteorology must be improved with increased coordination and collaboration between Department of Hydrology and Meteorology (DHM) and Department of Agriculture for determining the impacts of climate change on agriculture

THANK YOU