Annual Report
2071/72 (2014/15)

Government of Nepal

Nepal Agricultural Research Council

Agricultural Environment Research Division
Khumaltar, Lalitpur, Nepal

2015

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FOREWORD

Agriculture is a prime sector contributing significantly to the national GDP of the country and providing employment to more than $2/3^{rd}$ of the total population. It can be regarded as the backbone of Nepalese economy feeding to ever-increasing population. Assessment of agriculture related environmental issues like global warming, climate change and their consequences on agricultural sector and finding of their solutions are of prime needs for the country today. Agricultural Environment Research Division (AERD) working under Nepal Agricultural Research Council (NARC) has initiated diverse works on such issues independently or in collaboration with different organizations. Efforts are being made to develop a hub for the climatic database of different locations of Nepal to study their seasonal and yearly trend. AERD has started studying the temporal and spatial adaptive capacity of different varieties of various crops under the elevated temperature conditions to find out adaptive measures against climate change effects. Estimating GHGs from different agricultural sectors, management practices and locations are also some of the working areas of this division.

This annual report presents the detail activities and upshots of the research activities conducted in the FY 2071/72 by the division. It is expected that this annual report will serve as a useful resource to agricultural researchers, extension personnel, students as well as policy makers.

I am very thankful to Mr. SK Rai, Mr. GS Malla, Mr. R Rimal, Mr. A Sharma, Mr. HP Devkota, Mr. HL Bhandari and Mr. T Subedi for their precious contributions to bring and shape this annual report. Also, I would like to appreciate the hard work of Mrs. S Basnet, Mr. P Sah and Mr. RK Chalise for their logistics and other supports. Nepal Agricultural Research Council (NARC) holds recognition for its financial support. I would sincerely appreciate the constructive comments and suggestions for the report.

Dr. Anand Kumar Gautam
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List of Abbreviations

°C	Degree Centigrade
°F	Degree Fahrenheit
AGB	Above Ground Biomass
AERD	Agricultural Environment Research Division
AFACI	Asian Food and Agriculture Co-operative Initiatives
ARS	Agriculture Research Station
Av.	Average
AWS	Automatic Weather Station
BGB	Below Ground Biomass
BM	Bed with Mulching
BNM	Bed with no mulching
BP	Branches per plant
BY	Bio-mass yield
C.D.	Critical difference
CC	Climate change
CCAFS	Climate Change, Agriculture and Food Security
CDR	Central Development Region
CO_2	Carbon di-oxide
CO_2- C	Carbon in CO_2 form
cms	centimetres
CT	Conventional tillage
CV	Coefficient of Variation
DF	Days to flowering
DHM	Department of Hydrology and Meteorology
DM	Days to maturity
F.Y.	Fiscal Year
FM	Flat with Mulch
FNM	Flat with no Mulch
GDDs	Growing degree days
GHGs	Greenhouse Gases
GIS	Geographic Information System
gms	grams
GS	Grains per spike
GY	Grain yield
ha	Hectare
hr	Hour
HP	Hills per plot
IWMI	International Water Management Institute
Kg	Kilogram

kg/ha/yr	kilogram per hectare per year
m^2	Square meter
masl	meter above sea level
mg	milligram
mm	Millimetre
MoAD	Ministry of Agricultural development
MoE	Ministry of Environment
MT	Minimum tillage
$N:P_2O_5:K_2O$	Nitrogen, Phosphorous, Potash
NARC	Nepal Agricultural Research Council
ns	not significant
OM	Organic matter
OTC	Open top chamber
PL	Panicle length
PLH	Plant height
PP	Pods per plant
RARS	Regional Agricultural Research Station
S. Em±	Standard error of mean
SP	Seeds per pod
t/ha	ton per hectare
t/ha/yr	Ton per hectare per year
Temp.	Temperature
TGW	Test grain weight
TH	Tillers per hill
Tmax	Maximum temperature
Tmin	Minimum temperature
TR	Tillers per row
VDC	Village Development Committee
wt	weight
ZT	Zero tillage

TABLE OF CONTENTS

FOREWORD..........iii

List of Abbreviations..........v

सारांश..........**xi**

EXECUTIVE SUMMARY..........xii

1. WORKING CONTEXT 1

2. INTRODUCTION 1

2.1 Goal 1

2.2 Objectives 2

2.3 Strategies 2

2.4 Current thrust areas for research 2

2.5 Infrastructure and facilities 2

2.6 Organization structure and human resources 3

3. RESEARCH HIGHLIGHTS 4

3.1 Crop management study under different climate parameters 4

3.2 Estimation of CO_2-C emission from pasture and agricultural land 10

3.3 Assessment of carbon emission from different tillage practices 14

3.4 Carbon sequestration in fruit trees 15

3.5 Weather vulnerability assessment in farmers' perspective 17

3.6 Quinquennial trend of growing degree days (GDDs) 19

4. TECHNOLOGY TRANSFER AND SERVICES 26

5. Visits 26

6. OTHER ACTIVITIES 27

7. BUDGET AND EXPENDITURE 27

8. KEY PROBLEMS 27

9. WAY FORWARD 27

10. REFERENCES 27

11. ANNEXES 28

TABLES

Table 1. Agronomical parameters of rice at Khumaltar, 2071/72 (2014/15) 4
Table 2. Average temperatures of chamber and field for rice growing period, 2071/72 (2014/15) 5
Table 3. Agronomical parameters of wheat at Khumaltar, 2071/72 (2014/15) 5
Table 4. Average temperatures of chamber and field for wheat growing period, 2071/72 (2014/15) 6
Table 5. Agronomical parameters of wheat at Bhairahawa, 2071/72 (2014/15) 6
Table 6. Average temperatures of chamber and field for wheat growing period, 2071/72 (2014/15) 7
Table 7. Agronomical parameters of lentil at Nepalgunj, 2071/72 (2014/15)........... 8
Table 8. Average temperatures of chamber and field for lentil growing period, 2071/72 (2014/15) 8
Table 9. Agronomical parameters of rice at Nepalgunj, 2071/72 (2014/2015) 9
Table 10. Agronomical parameters of rice at Tarahara, 2071/72 (2014/15) 9
Table 11. CO_2-C emission from different pasture field at ARS, Bandipur, 2071/72 (2014/15) 11
Table 12. CO_2-C emission from different pasture field at ARS, Rasuwa, 2071/072 (2014/15) 12
Table 13. Average CO_2-C emission from vegetable field of different stations, 2071/72 (2014/15) 13
Table 14. CO_2-C emission from different tillage practice at Ranighat, Parsa, 2071/72 (2014/2015) 15
Table 15. Carbon sequestration by different types of fruit trees at different locations, 2071/72 (2014/2015)... 16
Table 16. Farmers' perception on diseases insects and weeds incidence in Mahottori district 18

FIGURES

Figure 1: Organizational structure of Agricultural Environment Research Division 3
Figure 2: Average CO_2-C emission by commodity in 2071/72 13
Figure 3: Average CO2-C emission by different crops in 2071/72 14
Figure 4: Effect on climate change on seasonal temperature.................................. 18
Figure 5: Farmers' coping strategies 18
Figure 6: Farmers' food status... 19
Figure 7: Quinquennial (five years’ cycle) trend analysis of growing degree days of different locations of Nepal 25
Figure 8: Temperature and rainfall pattern at Khumaltar, 2014/15 28

ANNEXES

Annex 1. Human Resources, 2071/72 (2014/15) 28

Annex 2. Summary of Progress of NARC Research Projects and Activities, 2071/72 (2014/15) 29

Annex 3. Summary progress of special research projects and activities, 2071/72(2014/15) 31

Annex 4. Publications, 2071/72 (2014/2015) 31

Annex 5. Training/workshop/seminar attended by staff, 2071/72 (2014/15) 32

Annex 6. Paper published, 2071/72(2014/15) 32

Annex 7. Regular annual budget and expenditure record, 2071/72 (2014/15) 33

Annex 8. Special project (AFACI) budget and expenditure record, 2071/72 (2014/15) 34

Annex 9. Special project (NDRI) budget and expenditure record, 2071/72 (2014/15) 35

Annex 10. Special project (PPCR/BRCH/AMIS_NARC project) budget and expenditure record, 2071/72 (2014/15) 36

Annex 11. Revenue status, 2071/72 (2014/15) (*In Nepalese Rupees*) 37

Annex 12. Beruju status, 20671/72 (2014/15) (*In Nepalese Rupees*) 37

सारांश

कृषि वातावरण अनुसन्धान महाशाखाबाट वातावरण मैत्री विभिन्न अनुसन्धान र मौसम परिवर्तनका कारण बालीमा पर्न सक्ने जोखिम सम्बन्धी अध्ययन हुँदै आइरहेको छ । साथै अन्य सीपमूलक कार्यक्रम, क्रपमोडेलिंग, कार्वन स्थिरिकरण र कार्वन उत्सर्जन सम्बन्धी अध्ययन तथा अनुसन्धानात्मक कार्यक्रम संचालन भइरहेको छ । जलवायु परिवर्तन र यसले कृषि प्रणालीमा पार्ने असर सम्बन्धी जानकारीलाई उच्चतम प्राथमिकतामा राखी नयाँ नयाँ अनुसन्धान केन्द्रहरुमा स्वचालित मौसम मापन प्रणाली (Automatic Weather Station) स्थापना गर्दै आएको छ ।

यस आ.व. २०७१/७२ मा मात्र बाखा अनुसन्धान कार्यक्रम बन्दीपुर, तेलबाली अनुसन्धान कार्यक्रम, नवलपुर, राष्ट्रिय सुन्तलाजात अनुसन्धान कार्यक्रम गुल्मी र राष्ट्रिय उखुबाली अनुसन्धान कार्यक्रम, जितपुर गरी ५ स्थानमा स्वचालित मौसम मापन प्रणाली जडान गरिएको छ । यसै आ.व. को अन्त्यतिरबाट जलवायु समुत्थान निर्माण आयोजना (पि.पि.सि.आर.) अन्तर्गत बांके जिल्लामा कृषि मौसम सल्लाह सेवा बुलेटिन मार्फत कृषकहरुलाई सेवा पुर्याई रहेको छ । यस बाहेक यस महाशाखाले विभिन्न राष्ट्रिय अन्तराष्ट्रिय संघ संस्था, अनुसन्धान केन्द्र र कृषि अनुसन्धानमा संलग्न विद्यार्थीहरुलाई कृषि तथा मौसम सम्बन्धी संकलित तथ्याङ्कहरु उपलब्ध गराउदै आएको छ । यस महाशाखाबाट संचालन गरिएका अनुसन्धानात्मक अध्ययनहरुबाट आ.व. २०७१/७२ मा निम्न अनुसारका अनुसन्धान परिणामहरु प्राप्त भएका छन् ।

- बढ्दो तापक्रमको अवस्थामा ओपन टप चेम्बर (OTC) मा धानको जातहरुको परिक्षण गर्दा एन.आर.१०६७ को उत्पादन राम्रो पाइयो।
- मल्टीलोकेशन परिक्षण अन्तर्गत नेपालगंजमा सुख्खा धान र फिल्ड कन्डीसनमा सावित्री धानको उत्पादन राम्रो पाईयो ।
- मुसुरो जात आइ.एल.एल. ७१३५ को उत्पादन बढ्दो तापक्रम (OTC) मा र फिल्ड कन्डीसन दुवै अवस्थामा राम्रो पाइयो तर बढ्दो तापक्रमको अवस्थामा फिल्ड कन्डीसनमा भन्दा ४२ प्रतिशतले उत्पादन घटेको पाइयो ।
- गहुँको जात मुनाल-१ को उत्पादन दुवै अवस्थामा राम्रो पाइयो तर अन्य गहुँको जातको औंसत उत्पादन फिल्ड अवस्था भन्दा बढ्दो तापक्रम (OTC) अवस्थामा कम पाइयो ।
- विभिन्न तरकारी बाली, दलहनबाली, अन्नबाली र कोदोबालीमा गरिएको CO_2-C उत्सर्जन सम्बन्धी अध्ययनमा सबैभन्दा बढी तरकारीमा १३३ मिग्रा/वर्ग मी./घण्टा र सबैभन्दा कम ८३ कि.ग्रा./वर्ग मी./घण्टा कोदोमा पाइयो ।
- घांसेबालीमा गरिएको CO_2-C उत्सर्जन सम्बन्धी अध्ययनमा बाखा अनुसन्धान कार्यक्रम, बन्दीपुरमा सबैभन्दा बढी डेमोडियम ले २६०.१ र रसुवामा सेतारिया घांसले सबैभन्दा बढी २३३ मि.ग्रा/वर्ग मी./घण्टा उत्सर्जन गरेको पाईयो भने दुवै क्षेत्रमा गीनी घांसले न्यूनतम उत्सर्जन गरेको पाइयो ।
- फलफूलका बिरुवामा कार्बन स्थिरिकरणको अध्ययनमा एभोकाडो जातका बिरुवाले कम समयमा बढि स्थिरिकरण गरेको पाइयो भने फलफूलमा स्थिरिकरणको मात्रा बिरुवाको उमेर र बोटको उचाईमा निर्भर रहेको पाइयो । महोत्तरी जिल्लाको सोहरवा गा.वि.स.मा गरिएको जलवायु परिवर्तन र त्यसको कृषिमा असर सम्बन्धी सर्वेक्षणमा उक्त परिवर्तनका कारण रोग कीरा र झारकोप्रकोप पहिले भन्दा बढि भएको पाइयो भने गर्मीयाममा अधिकतम तापक्रम पहिले भन्दा बढेको पाइयो र जाडो याममा न्यूनतम तापक्रम पहिले भन्दा घटेको पाइयो ।

EXECUTIVE SUMMARY

Agricultural Environment Research Division has been contributing and sharing the environmentally friendly agricultural technologies and knowledge developed through the crop vulnerability studies and other research. It includes the sharing of knowledge on skilful programs like crop modeling, carbon sequestration and GHGs emission estimation studies. Realizing the importance of climate information to agricultural researchers, the division has continuously emphasized on the establishment of automatic weather stations in different research stations. Five automatic weather stations were established at Agricultural Research Station, Bandipur, Oilseed Research Program, Nawalpur, National Citrus Research Program, Paripatle, Coffee Research Program, Baletaksar and Sugarcane Research Program, Jitpur this year. The division has been providing advisory services on changing climate scenario and its effect on agricultural crops to many of its clients including researchers and organizations. Recently the division has started weekly agro-met based advisory services through bulletins for the farmers of Banke district under PPCR project to minimize the weather induced crop vulnerabilities. Continuous research works are also in action on developing environment friendly agricultural technologies and mitigation options to reduce the crops vulnerabilities under the division. Apart from above mentioned services, the division is also making weather data available of various organizations, research stations and to the students involved in agricultural researches. Following are some of the findings of researches conducted by the division last year:-

- Under elevated temperature condition in an open top chamber (OTC), the rice variety, NR-1067-6-b-1-3-3-3, yielded the highest grain yield, second time in the successive years. However, overall performance of rice varieties under elevated temperature was lower than under open field condition. Under multi-location trial, Sukhadhan-3 was better in elevated temperature condition in Nepalgunj while variety Sabitri performed better in open field condition.
- Lentil variety, ILL 7135, performed better in both OTC and field condition in RARS, Nepalgunj, however the yield was decreased by 42% in elevated temperature condition.
- Munal-1, one of the wheat varieties performed better in OTC than all other varieties at NWRP, Bhairahawa. But the yield as in other crop was lower under elevated temperature condition.
- Among the gas samples of various crops; vegetables, legume, major cereal crop and finger millet, collected from Malepatan, Lumle, Parwanipur, Ranighat and Tarahara, the maximum CO_2-C emission of 133 $mg/m^2/hr$ was

recorded from vegetables while the lowest emission was from fingermillet (83 mg/m^2/hr).

* CO_2-C emission was the highest (260.9mg/m^2/hr) from *Desmodium* pasture crop in Bandipur whereas in Rasuwa, the highest emission was from Setaria (233 mg/m^2/hr). Emission from Gini grass was the lowest at both locations.

* CO_2-C emission was lowered by 60.7% in rice and 59% in wheat when planted on flat bed with no mulch than with mulch. Emission was higher in mulched flat and raised beds than no mulched in both beds.

* The rate of carbon sequestration from fruit trees depends on age, girth size (DBH), types and locations where they are grown. Avocado tree has the highest potential of carbon sequestration than any other plantation trees.

* Report of a survey on climate change of Soharwa VDC of Mahottari district indicated that summer is now hotter and winter cooler than the past years. Occurrences of disease, insect and weeds in crops have also increased these days due to change in climate.

1. WORKING CONTEXT

Nepal is an agrarian country with two third of population involved in this sector. In addition, the increasing population and food demand makes the sector of prime importance in order to become a food secured country. Moreover, global warming, spatial, temporal and weather anomalies are becoming alarming for its crucial role in whole agricultural system and productivity. The database on agro-meteorological record from various stations is helpful to interpret cause and effect whenever it is necessary and to explain and predict production performance in a given set of environment. The agro-meteorological databases can also be helpful in crop modelling. The crop yield is the output of crop genetic make-up, environment and management factors. Study on crop performance under elevated temperature conducted in open top chamber will be helpful for agricultural scientists for planning breeding programs and crop management practices. The contribution of agriculture sector in Greenhouse Gases (GHGs) emission is of great concern and is significantly contributing in the climate change.

Agriculture has also an important role in emission of CO_2 by agricultural practices. Similarly, horticultural fruit crops help sequestrating the CO_2 in the form of trees and organic matters in soil. In this context, the division is currently monitoring CO_2 emission from crops and pasture land under different management practices in different parts of the country. The division is also trying to make inventory of carbon sequestration by different types of fruit trees. With the strategy of working in collaboration, the division is currently working together with national and international organizations in different aspects of researchable issues related to climate change.

2. INTRODUCTION

The Agricultural Environment Unit was established in the F.Y. 2000 in Khumaltar, Lalitpur under the Directorate of Planning and Coordination, Nepal Agricultural Research Council (NARC). It aims to contribute in the protection of the environment with secured and increased agricultural productivity for livelihood enhancement and strengthen the agro-meteorological stations in NARC research stations. Later, it has been upgraded to Agricultural Environment Research Division (AERD) in the Fiscal Year 2013.

2.1 Goal

- To sustain the production and productivity of agricultural system without deteriorating production factors in context of climate change

2.2 Objectives

- Raise awareness and seek solutions for agriculture related environmental issues ensuring a sustainable agricultural development.
- Assess impact of climate change on agriculture and develop adaptation options for reducing vulnerabilities.
- Study agricultural researches and development on system perspective using modern tools like GIS, remote sensing, crop models etc.
- Support commodity programs, divisions and research stations to develop climate resilient technologies.
- Assist NARC in preparing policy guidelines on environment friendly agriculture and climate change issues.

2.3 Strategies

- Identification and prioritization of environment related problems in agriculture.
- Develop system perspective agricultural technologies through decision support tools.
- Support NARC research stations to generate climate resilient agricultural technologies.
- Strengthen the agro-meteorological stations in NARC research stations.
- Strengthen collaboration with national and international institutions.
- Enhance capacity of different stakeholders in understanding climate change and its impact on agriculture.

2.4 Current thrust areas for research

- Understand farmer's perception on climate change.
- Climatic variability of various locations and response of crop.
- Crop performance under simulated environment (e.g. Elevated temperature)
- Yield characterization and forecasting.
- GHGs emission under different agricultural soil and system.
- Carbon sequestration in agricultural, plantation and horticultural crops.

2.5 Infrastructure and facilities

- **Automatic weather station (11):** Daily agro-meteorological data recording (Temperature, rainfall, solar radiation, relative humidity, soil temperature etc.)
- **Open Top Chamber:** Experimentation on elevated temperature and CO_2 level

- **CO_2 Monitor:** Measuring CO_2 emission
- **GPS meter:** Taking coordinates of different locations
- **Soil pH and moisture meter:** Measuring soil pH and moisture
- **Leaf Area Index Meter**

2.6 Organization structure and human resources

The structure of this division is given in Fig 1 and detail of human resources in 2071/72 has been presented in Annex 1.

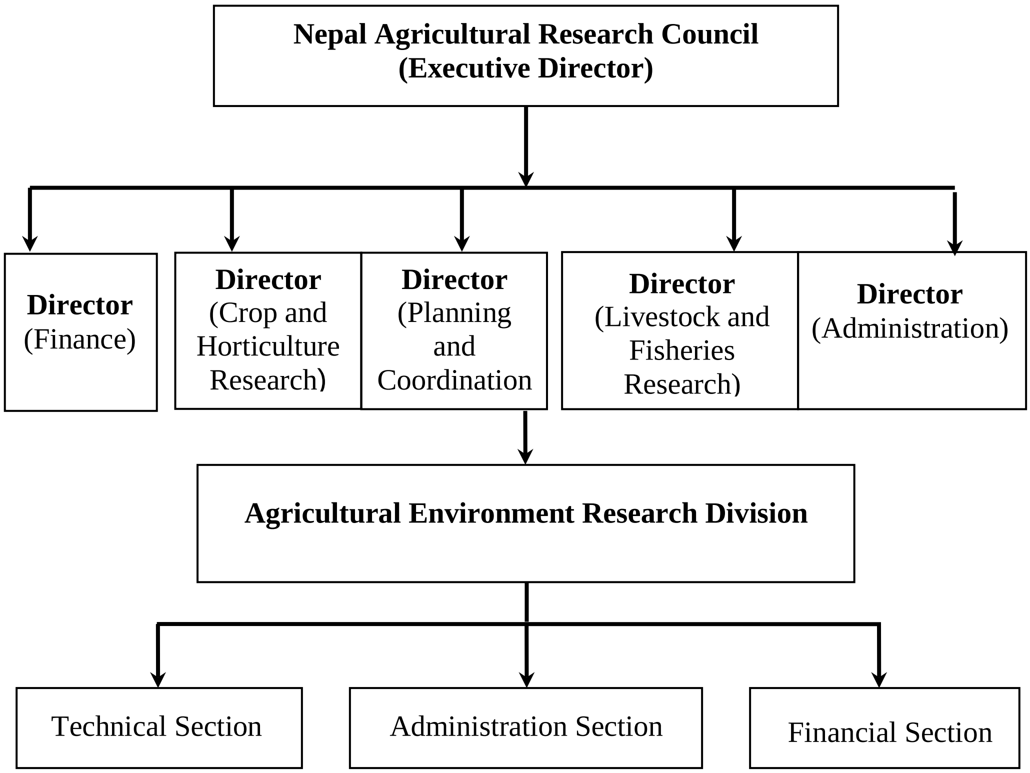


Figure 1: Organizational structure of Agricultural Environment Research Division

3. RESEARCH HIGHLIGHTS

3.1 Crop management study under different climate parameters

Atmospheric air temperature influences crop growth and productivity. Plants have specific requirement of temperature range at which their growth occurs. For example, rice crops can adapt up to 45^0C although the average temperature for growth is considered in between 22-30^0C. Exceed of maximum and minimum temperature negatively affects on crop physiology and thus on crop productivity. In agriculture, farmers take accounts of weather, air, soil temperature, soil moisture etc. for making decision on which variety and when to grow crops. They also monitor weather parameters like cloud, fog, temperature, rainfall etc. to be sure for the occurrence of insects, pest and diseases. Thus, for selection of crop varieties and other production managements, climate information is very much important.

Most of the crops are sensitive to the weather and temperature. Increase in atmospheric temperature directly affects the crop physiology, soil, disease and pests. IPCC predicted future temperature may rise by 4.5 to 5 ^{0}C. In order to study the effect of increasing temperature on crops and find out some crop varieties (rice, wheat and lentil) suitable under increasing temperature, a study has been initiated in an Open Top Chamber (OTC) at Khumaltar and in some other multi-location research stations by the division. The experiment was carried out in a split plot design under OTC and open field in main and crop varieties in sub plots.

Rice at Khumaltar

Twenty four days old rice seedling of Khumal-10, NR-1067-6-B-1-3-3-3, Sukhadhan-1 and NR 11082 were planted on July 10, 2014 with 20 x 20 cm spacing in Open Top Chamber (OTC) and in open field. Recommended dose of fertilizers were applied @ 100:30:30 $N:P_2O_5:K_2O$ kg/ha. Half of the nitrogen was applied as basal and remaining half at panicle initiation stage (Aug 13, 2014). Regular monitoring of soil moisture, disease, insect and pest were done. Phenology and yield parameters were recorded.

Table 1. Agronomical parameters of rice at Khumaltar, 2071/72 (2014/15)

Treatment	DF	DM	PLH (cms)	Tiller /hill	GY (t/ha)	BY (t/ha)
Factor A						
Chamber	95	131	118.9	5.8	6.4	10.1
Field	94	135	111.1	7.9	6.8	13.3
S. Em ±	1.31	0.41	1.31	0.26	0.09	0.34
C.D. at 5%	ns	ns	ns	1.62	ns	2.08
Factor B						
Khumal-10	93	129	129.8	8.4	6.8	11.8

NR-1067-6-b-1-3-3-3	94	131	122.1	6.0	7.2	12.1
SukhaDhan-1	95	130	92.8	7.8	6.8	10.3
NR-11082	95	143	115.4	5.2	6.3	12.8
S.Em ±	1.19	0.60	1.19	0.60	0.48	0.80
C.D. at 5%	Ns	1.85	6.71	1.86	ns	ns
CV %	3.09	1.11	3.09	21.45	17.89	16.79

Table 2. Average temperatures of chamber and field for rice growing period, 2071/72 (2014/15)

SN	Treatment	Av. Tmax. (^{0}C)	Av. Tmin (^{0}C)
1	Open Top Chamber	32.3	17.9
2	Field	26.0	17.4

Results of the study showed no significant effects of chamber on rice grain yield (Table 1). However, the yield under chamber condition having 6.3^{0}C higher maximum temperatures was lower by 6.25% than the yield in open field condition (Table 2). High temperature in OTC showed negative impact on tillers and biomass yield reducing grain yield. All the tested rice varieties were found at par for most phonological data except maturity, plant height and tiller per hill (Table 1). Rice variety NR-1067-6-b-1-3-3-3 produced the highest yield of 7.2 and the lowest of 6.3 ton/ha by NR-11082 (Table 1).

Wheat at Khumaltar

Table 3. Agronomical parameters of wheat at Khumaltar, 2071/72 (2014/15)

Treatment	DF	DM	PLH (cms)	PL (cms)	GY (t/ha)	BY (t/ha)	TGW (gms)
Factor A							
Chamber	113	155	125.5	10.1	5.1	10.5	45.1
Field	120	171	123.8	9.7	5.7	13.1	46.5
S. Em ±	0.16	0.06	0.47	0.31	0.11	0.41	0.97
C.D. at 5%	0.95	0.36	ns	ns	ns	2.52	ns
Factor B							
Munal-1	116	167	113.3	9.2	6.2	11.7	43.7
WK-1204	116	151	107.8	10.2	5.2	11.9	45.8
Chyakhura	118	167	120.3	10.4	5.3	9.7	45.8
WK-1481	115	167	157.3	9.7	4.9	13.9	47.8
S. Em ±	0.48	0.08	2.06	0.33	0.15	0.50	0.62
C.D. at 5%	1.49	0.26	6.35	ns	0.48	1.52	1.92
CV %	1.02	0.13	4.05	8.12	7.03	10.30	3.33

Table 4. Average temperatures of chamber and field for wheat growing period, 2071/72 (2014/15)

SN	Treatment	Av. Tmax. (^{0}C)	Av. Tmin (^{0}C)
1	Open Top Chamber	27.5	6.2
2	Field	21.3	7.1

Wheat varieties were planted on November 14, 2014 at Khumaltar with recommended fertilizer doze of 100:50:50 N:P_2O_5:K_2O kg/ha. Half of nitrogen was applied as basal and rest half after one month of planting.

Result showed that the effect of increasing temperature in OTC was significant on days to flowering, days to maturity and biomass yield having higher temperature rise of 6.3^{0}C in chamber (Table 4). Higher temperature in OTC did not have positive response on crop phenology like plant height, panicle length, grain yield and thousand grain weights. However, the differences among the varieties were significant for all parameters except panicle length. Munal-1 produced the highest yield of 6.2 ton/ha and WK-1481 the least of 4.9 ton /ha. The effect of increasing temperature on wheat grain yield was adversely affected.

Wheat at NWRP, Bhairahawa

In Bhairahawa, 5 wheat varieties were tested in an OTC in a split plot design, planted in 20 x 20 cms continuous spacing. Fertilizer dose of 100:50:50 N:P_2O_5:K_2O kg/ha was applied with half nitrogen as basal and other half applied at critical root initiation (CRI) stage. Crop phonological data were recorded.

Table 5. Agronomical parameters of wheat at Bhairahawa, 2071/72 (2014/15)

	DH	DM	PLH (cms)	PL (cms)	TR	GS	GY (t/ha)	TGW (gms)	BY (t/ha)
Field condition									
Bhrikuti	77	113	80	7.7	98	34.5	3.2	38	8.0
BL3623	77	114	76	7.2	79	30.0	3.2	46	7.9
Gautam	80	115	87	9.0	87	24.5	2.6	42	8.2
NL1073	78	112	79	8.6	96	35.5	3.1	36	8.8
Vijay	76	113	89	8.0	103	29.8	3.4	43	8.1
Chamber condition									
Bhrikuti	74	103	81	8.2	66	32	0.7	13	3.3
BL3623	73	103	74	8.3	62	33	1.4	26	4.4
Gautam	75	102	82	9.5	64	27	0.4	14	3.5
NL1073	74	103	81	9.1	93	29	1.2	15	3.9
Vijay	73	102	86	7.9	74	23	1.2	26	3.7

Table 6. Average temperatures of chamber and field for wheat growing period, 2071/72 (2014/15)

Conditions	Av. Tmax (^{O}C)	Av. Tmin (^{O}C)
Chamber	30.8	12.3
Field	23.9	12.6

Overall performances of wheat varieties were poor when grown under OTC than in open field. The average maximum temperature during crop growing period inside the chamber is higher (30.8^{0}C) than the open field condition (23.9^{0}C). With the increase in the temperature, the wheat varieties flowered and matured earlier that causes the lower grain yields in almost all varieties. The effect of the increased temperature on plant height was minimal for all tested varieties; however, the effect on grain yield was very prominent for all varieties. Increase in air temperature of about 6.9^{0}C (Table 6) at chamber causes maximum reduction on grain yields of all varieties. The yield reduction by 85% was recorded in Gautam in chamber than in open field while the least of 56% yield reduction was from BL 3623 (Table 5). Likewise, days to heading, days to maturity, tillers per hill, grain weight and biomass yield were also adversely affected with the increase of temperature in the chamber. It can be said that wheat crop is very sensitive to increasing temperature. No varieties tested so far showed resilience to increased temperature, pushing up the need of the selection of newer wheat genotypes screened under elevated temperature condition to cope with the climate change scenarios.

Lentil at RARS, Nepalgunj

Study on effects of temperature on lentil was carried out in Open top chamber (OTC) at RARS Nepalgunj, Banke. Five lentil varieties were tested in in split plot design in both OTCs and field. Lentil seed was sown following the general cultivation practices. Maximum, minimum, dry and wet bulb thermometers were installed in the chambers.

The varieties were sown in continuous with row spacing of 40 cm following the recommended fertilizer application of 20:40:20 N:P_2O_5:K_2O kg/ha as basal. Seed rate was applied at 40 kg per hectare. Irrigation was applied as per general practice and during pod development stage. Crops were harvested from the plots at physiological maturity stage.

Table 7. Agronomical parameters of lentil at Nepalgunj, 2071/72 (2014/15)

	DH	DM	PLH (cms)	PP	BP	SP	GY (t/ha)	TGW	BY (t/ha)
Field condition									
ILL 7715	91	118	34.2	47	7	9	2.1	15	5.4
Khajura Masuro - 2	90	116	30.0	27	5	9	1.6	14	4.2
Maheswor Bharati	93	120	32.5	57	8	9	1.7	17	4.7
Sagun	92	119	32.2	23	5	10	1.8	16	5.1
Simal	93	112	34.7	37	6	9	1.8	16	4.9
Chamber condition									
ILL 7715	96	122	63.0	25	4	9	1.2	16	5.8
Khajura Masuro - 2	91	121	55.5	21	3	10	0.5	15	3.5
Maheswo rBharati	97	127	55.6	20	4	9	0.8	18	5.3
Sagun	94	123	57.6	15	4	9	0.5	17	4.0
Simal	94	123	58.0	28	4	8	0.8	15	4.3

Table 8. Average temperatures of chamber and field for lentil growing period, 2071/72 (2014/15)

Conditions	Av. Tmax (^{O}C)	Av. Tmin (^{O}C)
Chamber	33.3	11.3
Field	26.4	12.7

In lentil, the effect of the temperature increment was observed in almost all plant phonological characteristics planted in both OTC and open field condition, except seeds per pod and thousand grain weight (Table 7). Days to heading, days to maturity and plant height was found increased in varieties grown inside chamber than in field whereas pods per plant, branch per plant and grain yield was decreased in the chamber. Maximum temperature variation was about 6.9^{0}C between OTC and field (Table 8). All the tested lentil varieties were found sensitive to higher temperature resulting into maximum yield reduction of all varieties tested (Table 7). The study indicates the lentil could be one of the vulnerable crops that would most likely to be affected with the future temperature rise. Further assessment of some more lentil varieties in such experiment is required to come with wider adaptive options.

Rice at RARS, Nepalgunj and Tarahara

Five rice varieties were tested at RARS, Nepalgunj and Tarahara in an OTC and open field. All varieties were transplanted in a spacing of 20 x 20 cm with recommended fertilizer dose of 100:30:30 N:P_2O_5:K_2O kg/ha. Half of the nitrogen was applied as basal and remaining half after one month of transplanting. Seed rate of rice was 60 kg/ha. All the required phonological parameters were recorded.

Table 9. Agronomical parameters of rice at Nepalgunj, 2071/72 (2014/2015)

Varieties	DH	DM	PLH (cms)	TH	TGW (gms)	GY (t/ha)	BY (t/ha)
Chamber condition							
Hardinath - 1	76	100	114	10	24	6.5	12.0
IR87377-B-B93-3	86	111	119	10	25	7.1	13.3
Sabitri	106	132	120	14	25	8.9	16.1
Sukhkha Dhan - 3	86	111	119	10	24	7.3	13.8
Swarna Sub-1	111	137	106	13	17	6.7	14.0
Field condition							
Hardinath - 1	79	103	98	10	23	4.8	10.3
IR87377-B-B93-3	92	110	115	13	25	7.2	12.0
Sabitri	112	136	111	12	23	7.3	13.4
Sukhkha Dhan - 3	88	111	112	13	27	8.5	12.9
Swarna Sub-1	111	132	92	11	24	6.3	12.8

At RARS, Nepalgunj

Heading days of most of the rice varieties decreased by 3-6 days inside the chamber while in maturity days, there was not such response (Table 9). A little increment in plant height and biomass yield was recorded in all varieties inside the chamber. Increase in biomass production might be due to faster metabolic activities due to higher temperature inside the chamber. Regarding the grain yield, some genotypes; Hardinath - 1, Sabitri and Swarna Sub-1 produced higher yields inside chamber than in open field indicating somewhat resilience to increased temperature, though results need further confirmations in coming years too.

Table 10. Agronomical parameters of rice at Tarahara, 2071/72 (2014/15)

Varieties	DF	PLH (cms)	TH	HP	BY (t/ha)	GY (t/ha)	TGW (gms)
Chamber condition							
Hardinatha-1	91	106.2	12	127	4.7	3.3	24.2
Sukkha Dhan-3	93	110.3	12	162	6.2	4.2	23.4
Shamba Masuli Sub-1	112	109.0	12	171	6.7	4.3	23.4
Sabitri	99	111.1	09	148	5.0	3.3	26.6
IR 87377-B-B=93-3	91	102.0	20	153	4.8	4.1	24.5
Variety (Field condition)							
Hardinatha-1	93	106.9	12	162	5.5	4.6	26.3
Sukkha Dhan-3	97	105.6	12	175	6.9	7.7	27.1
Shamba Masuli Sub-1	112	96.4	17	216	7.7	4.6	18.4
Sabitri	101	112.5	19	244	14.9	9.9	27.3
IR87377-B-B=93-3	99	108.5	15	189	8.5	6.9	29.5

At RARS, Tarahara

The performance of rice varieties at Tarahara was quite different than in Nepalgunj. The yield performances of all varieties were higher in open field condition than in chamber. In field condition, Sabitri produced the highest yield of 9.9 ton /ha in open field condition and the maximum yield reduction of 66% was also in Sabitri in chamber indicating more vulnerability to increased temperature condition (Table 10). The least reduction was in ShambaMasuli Sub-1 which was the highest yielder in chamber. This variety could be a variety somewhat resilient to increasing temperature that needs further verification. Most of the phonological events were recorded higher for almost all varieties under field condition than in chamber that may indicate that the tested varieties are not resilient to the increased temperature condition as in OTC. Some more rice varieties need to be evaluated for resilience to increasing temperature as a result of climate change.

3.2 Estimation of CO_2-C emission from pasture and agricultural land

CO_2 flux from agricultural soil mainly depends on microbial activities on soil organic matter. Farming practices including use of excessive fertilizers and mis-management of natural resources has posed serious threat in contribution of CO_2 emission from soil. It generally increases with rise in temperature. Flux of gasses from soil is the combined result of root respiration and microbial decomposition of soil organic matter. Low level of soil moisture limits microbial and root respiration.

Higher emission of CO_2 from soil depletes the organic matter content on soil and thus reduces the soil productivity as well as fertility. Therefore, it is necessary to monitor and study CO_2 emission rates under different cropping pattern. Estimation of the gas emission helps to formulate the plan and policy in reducing emission of the gas from agricultural lands.

Carbon emission at ARS Bandipur

In order to estimate the general emission from pasture fields, gas samples from the soils at Bandipur and Rasuwa were taken in September 2014. Soil temperatures at the depth of 8 cms and pH at 5 cms of each collected samples were measured by soil moisture and pH meter. Collection of gas samples were done by closed chamber technique.

Table 11. CO_2-C emission from different pasture field at ARS, Bandipur, 2071/72 (2014/15)

Pasture	Air temp. (^{O}C)	Soil temp. (^{O}C)	Moisture	pH	CO_2 flux (mg/m^2/hr)
Panicum maximum (Gini)	24.0	23.5	8.0	6.5	65.0
Arachis piritui (Badame Ghans)	26.6	26.0	8.0	5.8	83.7
Melinis minutiflora (molases)	26.8	26.8	8.0	5.5	183.6
Desmodium uncinatum (Silver leaf)	24.5	27.7	8.0	5.5	260.9
Paspalum spps.	24.5	26.8	8.0	5.8	218.9
Desmodium intortion (green leaf)	24.0	24.2	8.0	6.0	140.6
Steril setaria	23.8	30.0	7.0	6.2	247.8
Desmodiumc inereum	24.0	27.1	7.5	6.0	210.8
Setaris spps.	23.1	24.2	8.0	6.0	110.3
Eylosanthes guinensis	22.8	24.2	8.0	5.6	152.9
Bracheria decumbens	23.4	24.8	8.0	5.8	159.1
Rschynomehes mericana	23.4	24.2	8.0	6.0	198.4
Chloris gayana	23.8	24.9	8.0	5.9	260.8
Minimum	22.8	23.5	7	5.5	65
Maximum	26.8	30	8	6.5	260.9

Correlation analysis

	Air temp. (^{O}C)	Soil temp. (^{O}C)	Moisture	pH	CO_2 flux (mg/m^2/hr)
Air temp. (^{O}C)	1.000				
Soil temp. (^{O}C)	0.339	1.000			
Moisture	0.118	-0.736	1.000		
pH	-0.346	-0.188	-0.361	1.000	
CO_2 flux (mg/m^2/hr)	-0.110	0.616	-0.381	-0.337	1.000

Emissions from various pasture crops grown in ARS Bandipur vary considerably ranging from 65 mg/m^2/hr from Gini grass (*Panicum maximum*) to the maximum of 260.9 mg/m^2/hr from silver leaf (*Desmodium uncinatum*). Emission from *Chlorisgayana* spp. was also similar to silver leaf (260.8 mg/m^2/hr). Variations in other measured parameters for pasture crops were not much (Table 11).

CO_2 emissions from pasture crops were found more correlated with soil temperature. Increase in soil temperature enhances the soil microbial activities which act upon the organic matter i.e. organic carbon within the soil and thus respire more carbon di-oxide causing its emission. Negative correlations were observed for other rest parameters. Strong negative correlation between soil temperature and moisture was observed at ARS Bandipur (Table 11).

Carbon emission at ARS, Rasuwa

Table 12. CO_2-C emission from different pasture field at ARS, Rasuwa, 2071/072 (2014/15)

Pasture	Air temp. (^{O}C)	Soil temp. (^{O}C)	Moisture	pH	CO_2 flux ($mg/m^2/hr$)
Cock Foot	25.0	21.0	8	6.7	31.6
Phurke Khasro	21.0	23.0	8	6.5	59.9
Cock Foot (creeping)	24.2	25.0	8	6.9	93.4
Phurke Masino	27.3	22.3	8	6.2	141.0
Aerrw Leaf Clover	25.6	24.3	8	6.0	194.8
Buki	27.0	24.1	8	5.9	155.0
Sindure spps	25.0	24.2	8	5.8	193.7
Rumba	27.0	23.1	8	6.2	113.6
Pangther Chhi	28.0	23.5	8	6.7	160.4
Pang chyamu	22.0	24.2	8	6.9	109.9
Dismodium spps	21.0	23.9	8	6.5	156.0
Tall Fescue (creeping)	22.0	24.3	8	6.3	177.9
Dhimchi	23.0	25.1	8	5.9	28.1
Tall Fescue (Demeter)	25.0	22.9	8	5.8	246.2
Red clover	21.0	25.3	8	6.3	78.7
Sindure spps	25.0	23.4	8	5.8	50.9
Paspalum spps	24.0	21.3	8	6.2	120.3
Chitre	26.0	22.9	8	6.7	248.1
White clover	25.0	21.3	8	6.8	141.6
Setaria spps	28.3	22.7	8	5.9	233.1
Minmum	**21.0**	**21.0**	**8**	**5.8**	**28.1**
Maximum	**28.3**	**25.3**	**8**	**6.9**	**248.1**

Correlation					
	Air temp. (°C)	**Soil temp. (°C)**	**Moisture**	**pH**	**CO_2 flux ($mg/m^2/hr$)**
Air temp. (^{O}C)	1.00				
Soil temp. (^{O}C)	-0.35	1.00			
Moisture			1.00		
pH	-0.24	-0.16		1.00	
CO_2 flux ($mg/m^2/hr$)	0.41	-0.06		-0.19	1.00

The result showed that the emission ranges from 31.6 (*Dhimchi*) to 248.1 mg/ha/hr (*Chitre*). At Rasuwa, moisture condition was at full saturation for almost all samples (Table 12). Correlations between CO_2 emissions with other parameters except air temperature were negative. Somewhat positive correlation found existed between CO_2 emission and air temperature but not very strong (Table 12). Air temperature at Rasuwa was higher than at Bandipur. All the samples at Rasuwa was taken in the month of June and was the reason for higher air temperature at Rasuwa. No correlation was observed between moisture and other parameters which were due to higher moisture in samples.

Carbon emission from vegetables fields

More than 60 samples from vegetable crops were analysed for CO_2 emissions from different farmers' field from Lumle, Malepatan, Tarahara and Parwanipur. Observations on air temperature, soil moisture, soil temperature and soil pH were also recorded for each samples. Nine different vegetable crops were used for study. The highest CO_2 emission of 194.65 $mg/m^2/hr$ was from cabbage while the least of 86.85

mg/m^2/hr was from potato (Table 13). Looking at the correlation, soil moisture was found somewhat more positively correlated to CO_2 emission than any other parameter (Table 13). Higher correlation exists between soil and air temperature that often holds true.

Table 13. Average CO_2-C emission from vegetable field of different stations, 2071/72 (2014/15)

Vegetables	Air temp. (°C)	Soil temp. (°C)	Moisture	pH	CO_2 flux (mg/m^2/hr)
Broad leaf mustard	31.7	29.9	8.0	5.2	87.53
Tomato	30.0	29.1	8.0	4.7	111.31
Cauliflower	30.1	30.1	8.0	6.0	144.67
Chinese lenthus	22.5	22.6	8.0	6.0	171.39
Chilly	21.3	22.5	8.0	5.7	173.46
Cabbage	20.6	24.1	8.0	5.8	194.65
Radish	17.9	14.8	6.4	6.5	87.90
Potato	20.4	15.7	8.0	6.1	86.85
Brinjal	22.5	23.4	8.0	5.6	137.53
Minimum	**17.9**	**14.8**	**6.4**	**4.7**	**86.85**
Maximum	**31.7**	**30.1**	**8.0**	**6.5**	**194.65**
Correlation					
	Air temp. (°C)	**Soil temp. (°C)**	**Moisture**	**pH**	**CO_2 flux (mg/m^2/hr)**
Air temp. (°C)	1.00				
Soil temp. (°C)	0.90	1.00			
Moisture	0.46	0.58	1.00		
pH	-0.70	-0.72	-0.54	1.00	
CO_2 flux (mg/m^2/hr)	-0.21	0.20	0.41	0.06	1.00

Emission from various crop commodities

Samples were also analysed from the field where different types of crop commodities comprising of cereals (rice, wheat and maize), grain legumes (soyabean, pea, lentil and horse gram), vegetables and finger millet were grown.

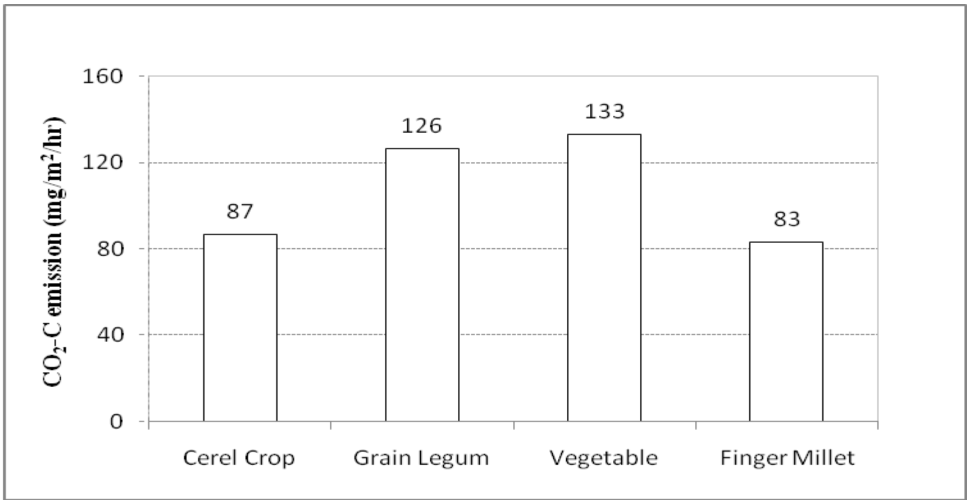


Figure 2: Average CO_2-C emission by commodity in 2071/72

Results showed that cereals (Rice, wheat and maize), grain legume (soyabean, pea, lentil and horse gram), vegetables and finger millets had different rates of emission. The analysis showed higher emission of 133 mg/m^2/hr from vegetable grown fields as compared to other commodities. The emission from vegetable field might be due more organic matter/FYM application for their cultivation which is the general practice. Grain legume, cereal and finger millet fields emitted 126, 87 and 83 mg/m^2/hr respectively (Fig 2). Grain legume fields also showed higher emission of 126 mg/m^2/hr It may be due to higher microbial activities in legume root. Lower emission from finger millet was due to minimal use of fertilizer and organic matter and cultivation of crops in marginalized lands

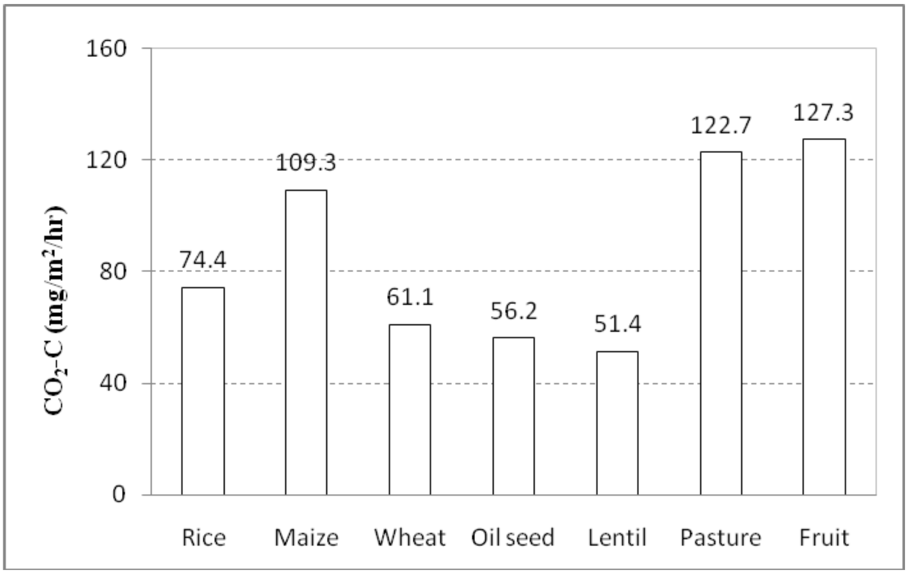


Figure 3: Average CO_2-C emission by different crops in 2071/72

3.3 Assessment of carbon emission from different tillage practices

Tillage practice plays a vital role on improvement of physical, chemical and biological properties of the soil. It helps in making soil environment favourable for better availability of nutrient to plants. It also plays an important role on emission of carbon-dioxide gas from soil. Studies conducted in other parts of the world has also reflected that most of the emission from wheat fields are mainly due to management practices such as; moisture availability, availability of soil organic matter and soil microbes in the soil, whereas, lower gas emission in rice is due to anaerobic condition in rice fields. Therefore, appropriate management of soil would be a favourable option to reduce the gas emission from agricultural soil. Reducing gas emission by management of soil contributes to increase soil carbon in the soil. With all these views, a study on carbon emission from rice and wheat field under different tillage practices was done at

Ranighat, Parsa to estimate and analyze the patterns of emission. Two types of resource conservation practices (mulch and no-mulch) under two different planting practices (flat and raised beds) were used for studying carbon emission in rice and wheat crop. Observations on soil and CO_2-C emissions were taken and analyzed.

Table 14. CO_2-C emission from different tillage practice at Ranighat, Parsa, 2071/72 (2014/2015)

Tillage	Air temp (°C)	Soil temp (°C)	Moisture	pH	CO_2 flux ($mg/m^2/hr$)
Rice					
FM	29.6	24.3	8	6.1	122.21
FNM	29.6	24.6	8	6.2	76.02
BM	30.3	25.3	8	6.4	93.50
BNM	30.3	25.2	8	5.9	78.63
Wheat					
FM	16.5	22.2	8	6.7	143.00
FNM	16.5	22.5	8	6.5	73.89
BM	16.5	19.6	8	6.4	98.10
BNM	17.0	23.8	8	6.5	40.38

In rice, emission from mulched planting was higher in both flat and raised bed than non-mulched (both flat and raised bed). The highest CO_2-C emission (122.21 $mg/m^2/hr$) was recorded from flat mulched planting (Table 14). A lower emission of 60.8% was in flat non-mulched than flat mulched planting. However, the difference in emission was lower between mulched and non-mulched in raised bed planting than flat planting. Emission was higher by 30.7% in flat mulched than bed mulched planting.

Similar pattern of CO_2-C emission was observed in wheat crop. Higher emissions were in mulched planting both in flat and raised bed. Emission in general was higher in wheat than rice. In wheat also, the highest emissions (143 $mg/m^2/hr$) was from flat mulched plating as in rice. The emission was higher by 45.8% in flat mulched than bed mulched planting. The highest difference of 143% in emission was between mulched and non-mulched in bed planting. Higher CO_2-C emission from mulched plots could be due to addition of carbon in the soil through mulching as the samples taken from the fields were the experimental plots continuing since three years.

3.4 Carbon sequestration in fruit trees

Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and reduce or stabilize climate change. Fruit trees helps stabilize CO_2 concentration in the atmosphere by sequestrating and absorbing for long time. Agriculture plays an important role in atmospheric CO_2 emission andfixation of carbon dioxide (CO_2) and sequestration (CCS) from plantation crop could play a vital role in reducing atmospheric greenhouse gas concentration. In carbon sequestration process, either CO_2 is captured from atmosphere or added into the soil as organic compound. Atmospheric carbon gets sequestered into the soil and helps in building the soil health.

In the present global climate change scenario, efforts are being made to estimate the carbon sequestration by fruit crops. At present, the research works in carbon sequestration is very limited in Nepal. Above and below ground biomass of the fruit trees capture atmospheric carbon thus helps decreasing carbon concentration in the atmosphere. This research has been carried out to estimate the quantity of carbon sequestered by plantation crops mainly fruit trees.

Table 15. Carbon sequestration by different types of fruit trees at different locations, 2071/72 (2014/2015)

SN	Name of tree	No. of trees	Age (yrs)	PLH (m)	AGB (t/ha)	BGB (t/ha)	Total Biomass (t/ha)	C stock (t/ha)	C Se (t/ha/yr)	C Se (kg/ha/yr)
1	Avocado *(Percia americana)*	12	3	5.9	0.09	0.022	0.112	0.055	0.0183	18.3
2	Coconut *(Cocos nucifera)*	21	37	14.0	0.63	0.165	0.795	0.400	0.0108	10.8
3	Bel -RARS, Parwanipur *(Aeglem armelo)*	8	10	10.6	0.41	0.107	0.517	0.258	0.0258	25.8
4	Bel –RARS, Banke	7	5	3.7	0.04	0.010	0.050	0.023	0.0045	4.5
5	Litchi *(Litchi chinensis)*	20	13	4.6	0.46	0.119	0.579	0.289	0.0222	22.2
6	Litchi	20	13.5	5.0	0.51	0.132	0.642	0.320	0.0237	23.7
7	Mango-ORP, Nawalpur *(Mangifera indica)*	38	20	7.9	0.90	0.233	1.123	0.564	0.0282	28.2
8	Mango-ORP, Nawalpur	34	20	5.0	0.97	0.253	1.223	0.613	0.0307	30.7
9	Mango-RARS, Banke	25	13	4.8	0.12	0.030	0.150	0.074	0.0057	5.7
10	Mango-RARS, Banke	25	13	4.8	0.13	0.034	0.164	0.083	0.0063	6.3
11	Mango-RARS, Parwanipur	25	12	6.9	0.31	0.081	0.391	0.197	0.0164	16.4
12	Orange-ARS, Paripatle	10	48	14.5	0.73	0.161	0.891	0.446	0.0093	9.3
13	Orange F1	12	12	4.6	0.59	0.014	0.604	0.302	0.0252	25.2
14	Orange F2 *(Citrus reticulata)*	16	13	4.4	0.14	0.036	0.176	0.088	0.0068	6.8
15	Amala – RARS, Banke *(Phylanthus emblica)*	10	10	5.6	0.52	0.135	0.655	0.328	0.0328	32.8
16	Mecademia nut- ARS, Pokhara *(Mecdemia intergrifolia)*	25	22	6.3	0.23	0.059	0.289	0.142	0.0065	6.5

Correlation

	Age (yrs)	*PLH (m)*	*AGB (t/ha)*	*BGB (t/ha)*	*Total Biomass (t/ha)*	*C stock (t/ha)*	*C Se (t/ha/yr)*	*C Se (kg/ha/yr)*
Age (yrs)	1.00							
PLH (m)	0.80	1.00						
AGB (t/ha)	0.54	0.41	1.00					
BGB (t/ha)	0.52	0.43	0.89	1.00				
C Se (kg/ha/yr)	-0.19	-0.06	0.66	0.57				1.00

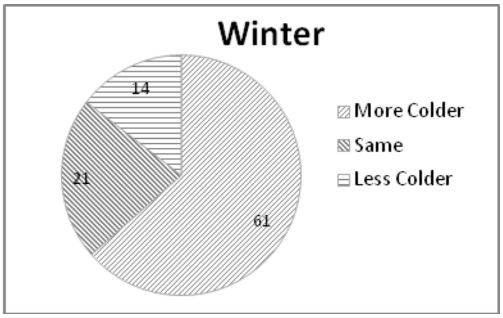
The above ground tree biomass (AGTB), below ground tree biomass (BGTB), age, height and girth size of fruit plants like avocado (*Percia americana*), coconut (*Cocos nucifera*), bel (*Aeglem armelo*), litchi (*Litchi chinensis*), mango (*Mangifera indica*), orange (*Citrus reticulata*), amala (*Phylanthus emblica*) and mecademia nut (*Mecdemia intergrifolia*) from different ARS and RARS were collected. From these samples, carbon stock was estimated. Analysis of the samples indicated the highest carbon sequestration of 32.8 kg/ha/yr from 10 years old Amala (*Phylanthus emblica*) collected from Banke district (Table 15). The second highest carbon sequestration of 30.7 kg/ha/yr was from 20 years old mango tree at Nawalpur, Sarlahi district. The least of 4.5 kg/ha/yr was from Bel tree which were 5 years old from RARS, Banke district. Correlation analysis of the parameters shows positive correlation between AGB and BGB with carbon sequestration. However, there was negative correlation between carbon sequestration and age and plant height (Table 15).

3.5 Weather vulnerability assessment in farmers' perspective

Weather vulnerability and its impact on Nepalese agriculture is a matter of increasing concern especially in the context of climate change. Various effects in agriculture as a result of climate change and weather variability are being observed in most of the part of country presently. Impacts are not only on crop productivity, but threats are also on environment and human health as well. There are reports time and again from many places about such vulnerabilities induced by weather change on agriculture. Effects are more serious and intense in rural areas than in urban. It's very important to know farmers' knowledge level and coping mechanism to such climate change/weather variability effects. This will help to design and implement programs more efficiently and more appropriately. With this view, a survey was conducted in Mahottari district in 2071/72. Selection of the district was based on the climate change vulnerability index ranking. A total of 100 farmers from three villages of Soharwa VDC (Hardiya, Badegaun and Soharwa) were interviewed with structured questionnaire. VDC was selected in consultation with District Agriculture Development Office, Mahottari.

Temperature

Farmers' perception on temperature variation due to climate change varied in Mahottari district. Sixty one percent of farmers responded that winter are getting cooler these days than before while for summer, 93 percent farmers agreed that summer is hotter now than past years (Figure 4).



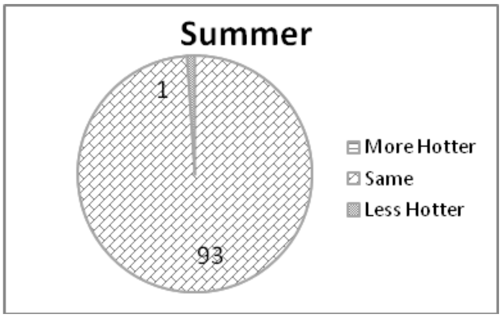


Figure 4: Effect on climate change on seasonal temperature

In the context of climate change, the responses of the farmers on the query to status of disease, insect and weeds these days as compare to past indicated that incidences of all these have increased significantly for almost all crops under study. Almost all farmers in the survey area have consensus that all these crops have become vulnerable to disease, insect and weeds more these days than in the past (Table 16).

Table 16. Farmers' perception on diseases insects and weeds incidence in Mahottori district

	Diseases			Insects			Weeds		
	Increase	Decrease	Same	Increase	Decrease	Same	Increase	Decrease	Same
Rice	86	5	3	84	6	2	53	4	31
Wheat	76	5	9	74	7	9	52	4	30
Pulse	60	4	4	63	3	4	45	1	18
Vegetables	52	0	1	53	1	1	44	2	7
Fruit	45	1	6	55	1	3	40	4	11

Coping strategies

Farmers of the study area have the understanding that there are adverse effects of climate change in their agricultural production and have their own coping strategies. On the response to what adaptation strategies farmers are adapting to minimize such weather vulnerability, 33.5% of the total responding farmers indicated the application of chemical fertilizers and pesticide is the better strategy. Use of shorter duration crop varieties was another most adapted strategy as reported by 18.3% farmers. Seventeen per cent farmers have used hybrid or improved seeds of crops to mitigate weather vulnerability. About 21.7% farmers reported that they have shifted from agriculture to other occupation due to the severe effect of weather vulnerability on overall agriculture.

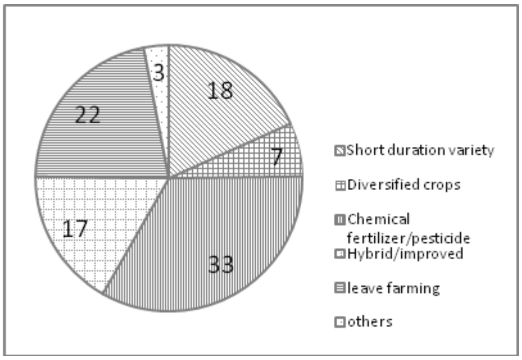


Figure 5: Farmers' coping strategies

Food security

Despite the effect of climate change on food security in other parts of the country, the surveyed district seems to have less affected. More than 44% farmers reported to have surplus food situation while 21% farmers have food sufficient for 9-12 months. More than two third of the surveyed farmers are reported to have food sufficiency for more than 6 months indicating less effect of weather vulnerability in the surveted VDC.

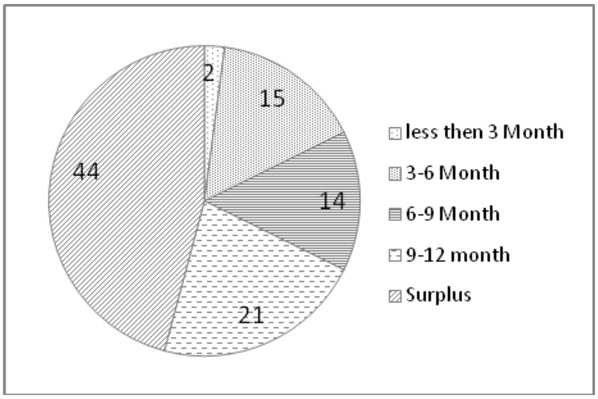


Figure 6: Farmers' food status

3.6 Quinquennial trend of growing degree days (GDDs)

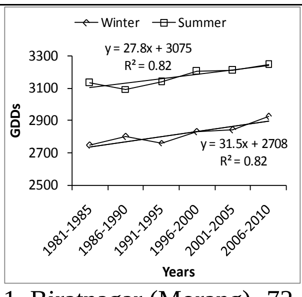
The trend analysis has indicated that global average surface air temperature has increased by 0.7 ^{0}C in twentieth century (Jones and Moberg, 2003) and it will continue to increase in the future. One of the major effects of climate change is seasonal alteration in the temperature of any place. The temperature determines the thermal unit or degree days. The thermal unit i.e. growing degree days or degree days is one of the agro-meteorological indices that helps to determine growing/development period of the crops and organisms especially insects and pathogens. There is strong relationship among growing degree days (GDDs), vegetative growth of crops and crop growing season and also among growth and development of insects and pathogens. It has speculated major influence on the agro-ecological environment as a whole (Feng and Hu, 2004). GDDs also called growing degree units are a measure of heat accumulated which can be used by horticulturists, agronomist, plant breeders, gardeners and farmers to predict plant and pests development rates.

It takes four to five years for scaling-up of new cultivation practices and varieties of crops at farmers level and may be adopted by farmers lasting for five to fifteen years depending on the suitability of the technology. During this period, the GDDs may be increased due to increasing temperature caused by climate change. The information on the quinquennial (cycle of five years) trend of GDD could help the agriculturist to understand how the abrupt seasonal warming or cooling during the crop growth and development period has altered and will continue to change the agricultural environment and affect the crops and organisms. It may also help to answer - is the warming climate creating a more stressful environment for crops and livestock? Is the changing climate increasing or decreasing the growing season favouring or not favouring the production? Does it changes in the life cycle of pests and pathogens? In this context, cumulative seasonal (summer and winter) trend in Quinquennial GDDs has been analyzed. For summer and winter, the period from June to November and from November to April was considered, respectively, and the average of five years period was calculated. The GDDs was calculated using the following formula:

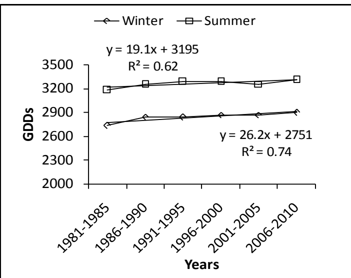
GDD =[(Maximum Temperature + Minimum Temperature)/2] – Base Temperature

Base temperatures for summer and winter season have been taken as 10 ^{0}C and 5.5 ^{0}C, respectively.

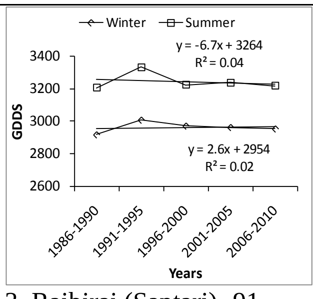
The analysis showed that most of the places had increasing trend of quinquennial GDDs both during summer and winter season (Figure 7 and Table 17). Seven locations had decreasing trend in summer and winter and other seven locations had decreasing trend in summer but increasing in winter season. Increasing trend in summer but decreasing in winter season has been observed at RARS, Khajura only. In general, GDDs should be in increasing trend. However, the observation indicated location specific trend. Location to location variability on the climatic parameters and their indices depends on the differences in the micro-climate of these locations. Analysis of location wise GDDs trend indicated that the agriculturists should further study on the effect of climate change on the cropping pattern; crop growth and development duration of agricultural crops (cereals, oilseed, legumes, fruit crops, vegetables etc); pests life cycle, changes in their out-break and their management and agro-ecosystem.



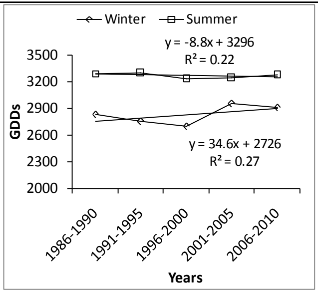
1. Biratnagar (Morang)- 72 masl



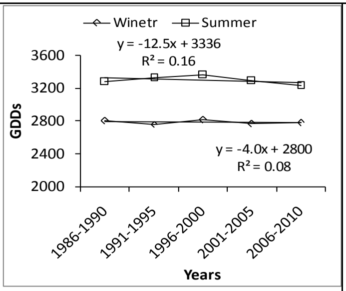
2. JNK Airport (Dhanusha)- 90 masl



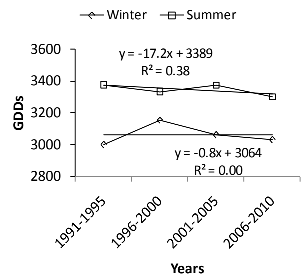
3. Rajbiraj (Saptari)- 91 masl



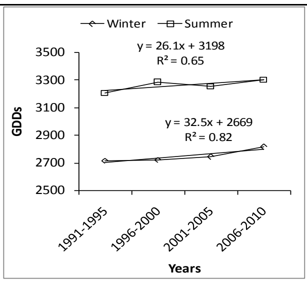
4. Taulihawa (Kapilbastu)- 94 masl



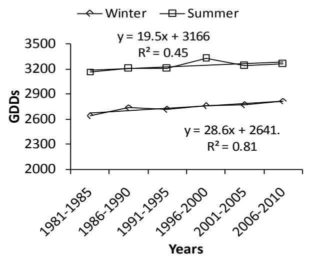
5. Manusmara (Sarlahi)- 100 masl



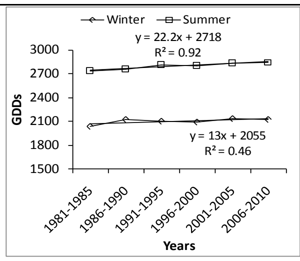
6. Phattepur (Saptari)- 100 masl



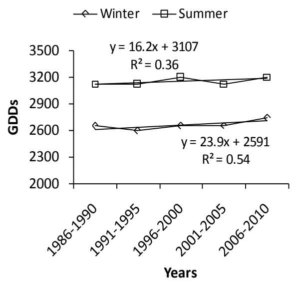
7. Bhairahawa Airport (Rupandehi)- 109 masl



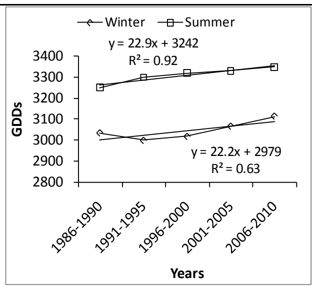
8. RARS, Parwanipur (Bara)- 115 masl



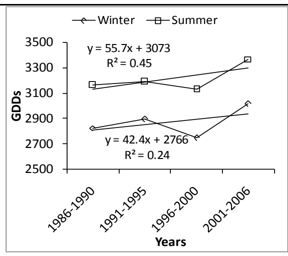
9. NWRP, Bhairahawa (Rupandehi)- 120 masl



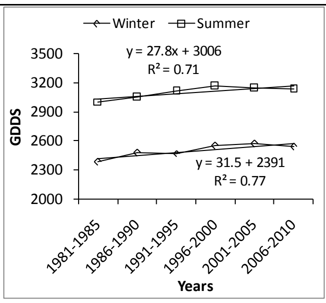
10. Simara Airport (Bara)- 130 masl



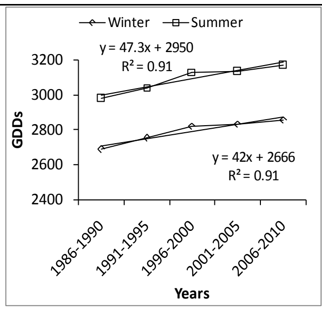
11. Karmaiya (Sarlahi)- 131 masl



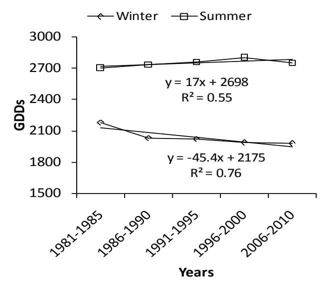
12. Lahan (Siraha)- 138 masl



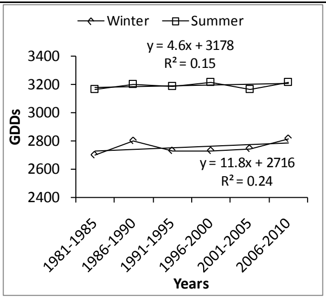
13. Tikapur (Kailali)- 140 masl



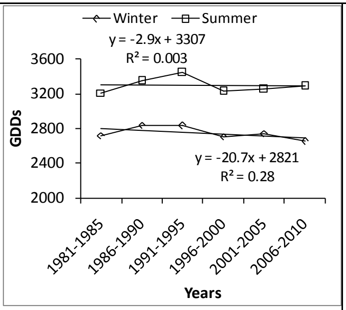
14. Gainda, Kankai (Jhapa)- 143 masl



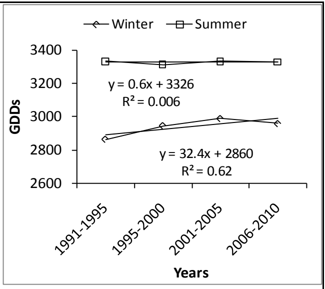
15. RARS, Khajura (Banke)- 144 masl



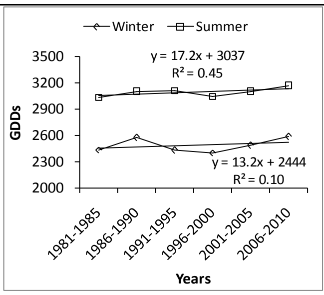
16. Dumkauli (Nawalparasi)- 154 masl



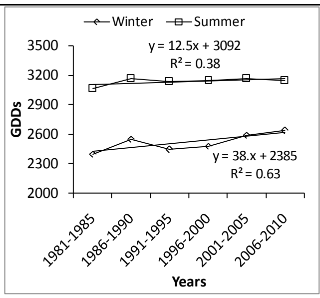
17. Simari (Nawalparasi)- 154 masl



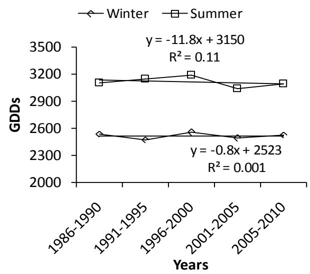
18. Jaleswor (Mahottari)- 172 masl



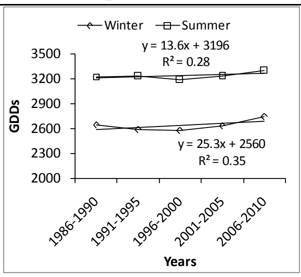
19. Mahendranagar (Kanchanpur)- 176 masl



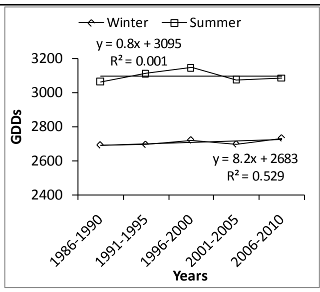
20. Dhangadhi (Kailali)- 187 masl



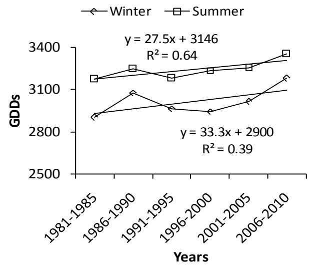
21. Sikta (Banke)- 195 masl



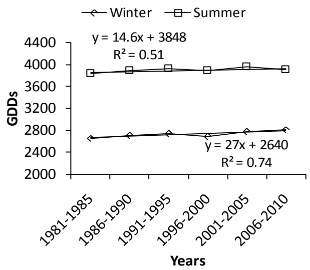
22. Rani Jaruwa (Bardiya)- 200 masl



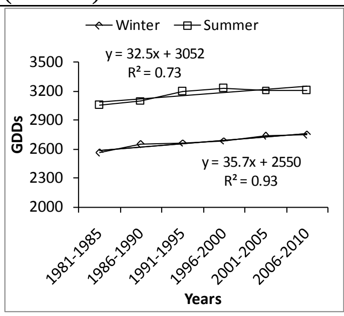
23. RARS, Tarahara (Sunsari)- 200 masl



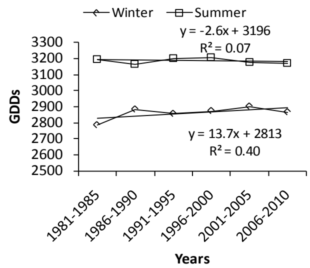
24. Butawal (Rupandehi)- 205 masl



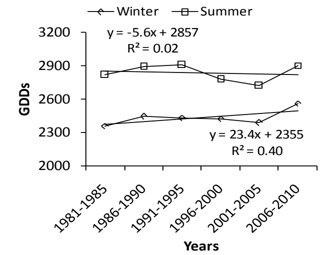
25. Chisapani (Karnali) (Bardiya)- 225 masl



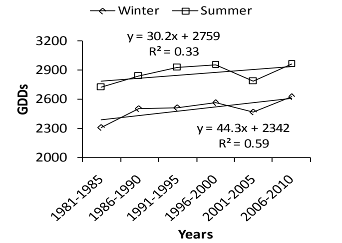
26. NMRP, Rampur (Chitwan)- 256 masl



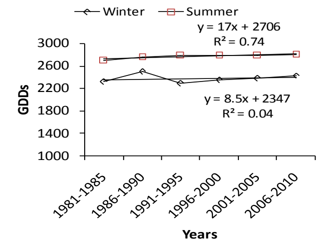
27. Godawari (West) (Kailali)- 288 masl



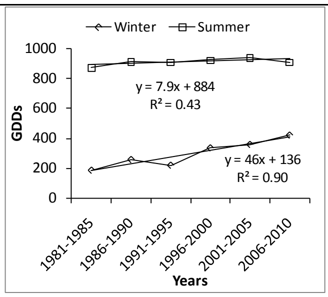
28. Chhapkot (Syangja)- 460 masl



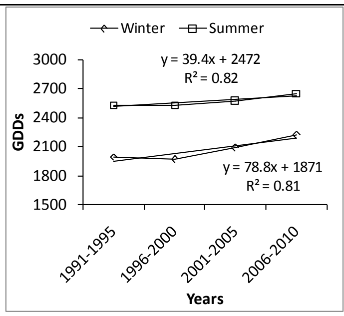
29. Hetauda (Makawanpur)- 474 masl



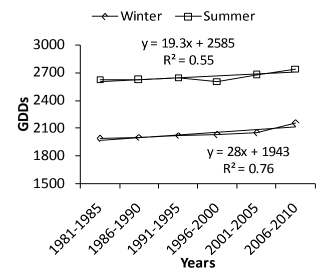
31. Tulsipur (Dang)- 725 masl



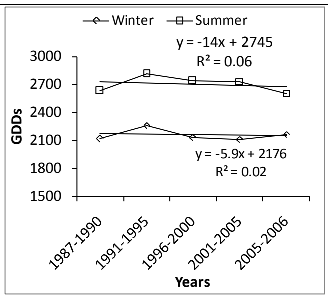
31. Jomsom (Mustang)- 2744 masl



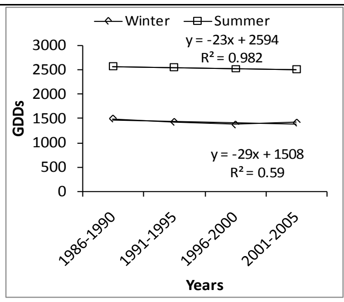
32. Malepatan Pokhara (Kaski)- 856 masl



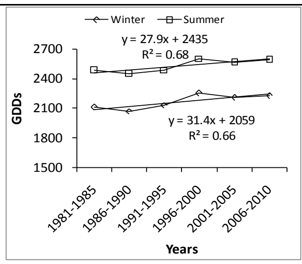
33. Panchkhal (Kabrepalanchok)- 865 masl



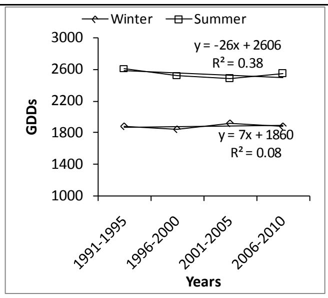
34. Chaurjahari (Rukum)- 910 masl



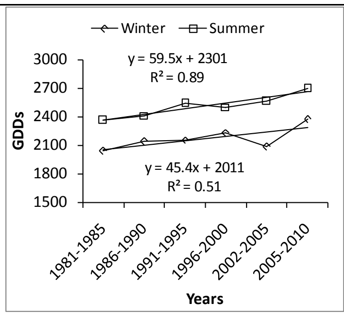
35. Pusma Camp (Surkhet)- 950 masl



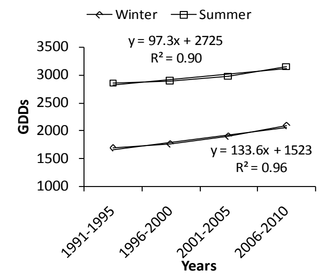
36. Dhunibeshi (Dhading)- 1085 masl



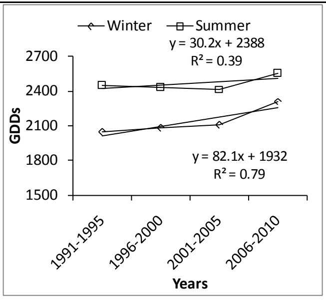
37. Darchula (Darchula)- 1097 masl



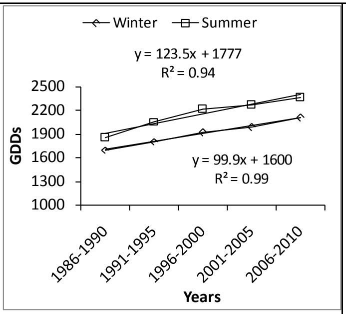
38. Gorkha (Gorkha)- 1097 masl



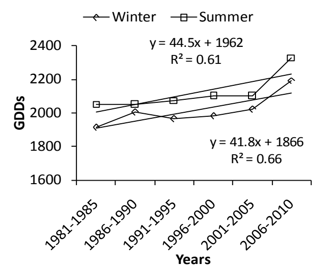
39. Udayapur Gadhi (Udayapur)- 1175 masl



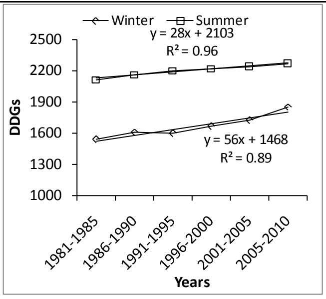
40. Phidim (Panchthar)- 1205 masl



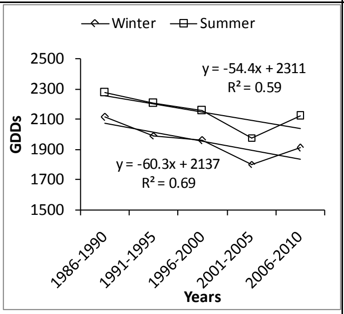
41. Dhankuta (Dhnkuta)- 1210 masl



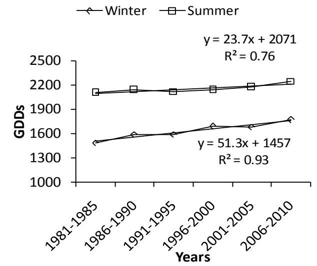
42. Ilam Tea state (Ilam)- 1300 masl



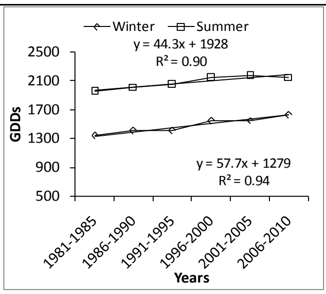
43. Chainpur west (Bajhang)- 1304 masl



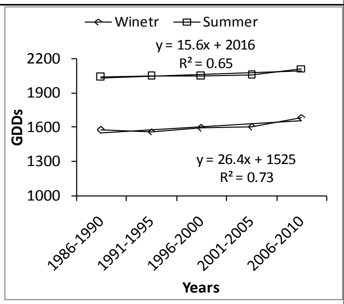
44. Chainpur (East) Sankhuwasava- 1329 masl



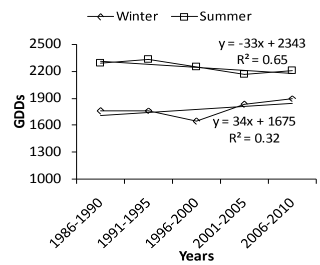
45. KTM airport (Kathmandu)- 1337 masl



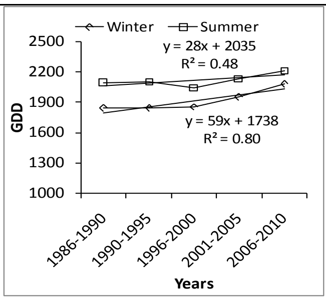
46. Khumaltar (Lalitpur)- 1350 masl



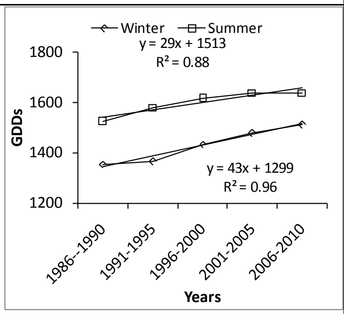
47. Budhanilkantha (Kathmandu)- 1350 masl



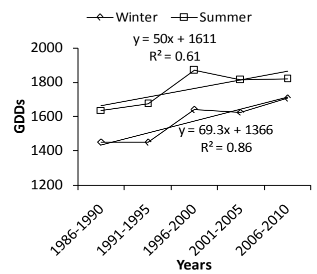
48. Silgadhi Doti (Doti)- 1360 masl



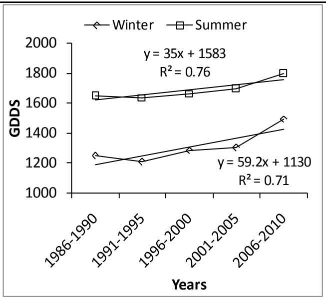
49. Salyan Bazar (Salyan)- 1457



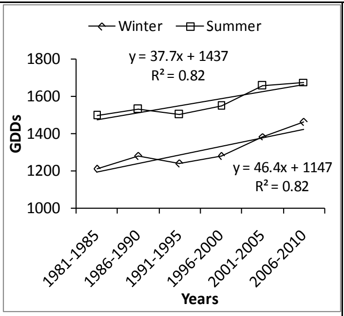
50. Pakhribas (Dhankuta)- 1680 masl



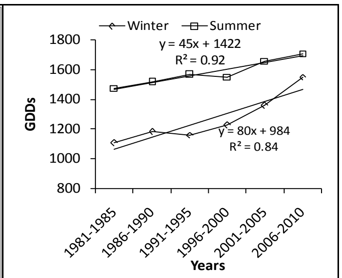
51. Okhaldhunga (Okhaldhunga)- 1720 masl



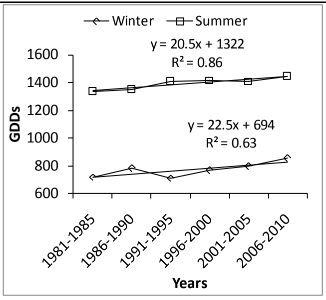
52. Taplejung (Taplejung)- 1732 masl



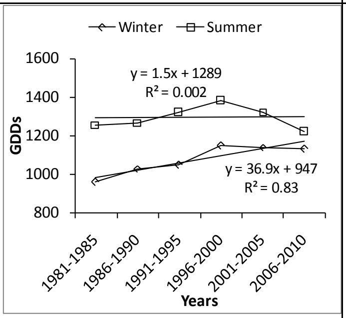
53. Lumle (Kaski)- 1740 masl



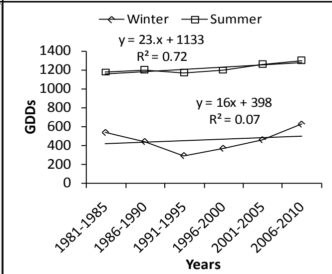
54. Dadeldhura (Dadeldhura)- 1848 masl



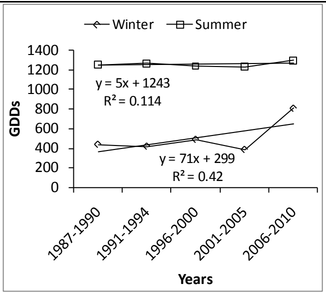
55. Jiri (Dolakha)- 2003 masl



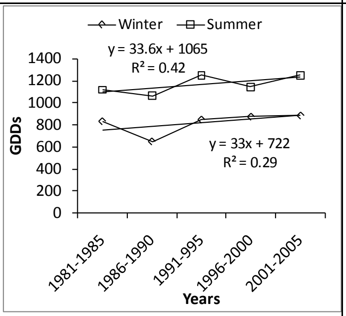
56. Nagarkot (Bhaktapur)- 2163 masl



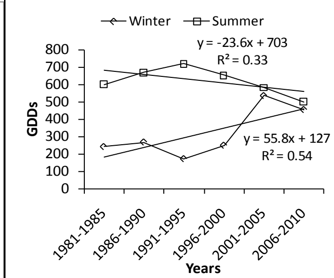
57. Jumla (Jumla)- 2300 masl



58. Dipalgaun (Jumla)- 2310 masl



59. Daman (Makawanpur)- 2314 masl



60. Chame (Manang)- 2680 masl

Figure 7: Quinquennial (five years' cycle) trend analysis of growing degree days of different locations of Nepal

Table 17. Locations with different trends of quinquennial GDD

Increasing in summer and winter season	Decreasing in summer and winter season	Increase in summer but decrease in winter season	Decrease in summer but increase in winter season
Biratnagar, JNK airport, Bhairahawa Airport, RARS Parwanipur, NWRP Bhairahawa, Simara Airport, Karmaiya, Lahan, Tikapur, Kankai, Dumkauli, Jaleswar, Mahendranagar, Dhangadhi,	Phattepur, Simar, Sikta, Manusmara, Chaurjahari, Pusma camp	RARS Khajura	Rajbiraj, Chame, Taulihawa, Godawari west, Chhapkot,

Ranijaruwa, ARS Tarahara, Butwal, Chisapani, NMRP Rampur, Hetauda, Tuslipur, Malepatan Pokhara, Panchkhal, Dhunibesi, Gorkha, Udayapur Gadhi, Phidim, Dhankutta, Ilam Tea State, Chainpur west, KTM airport, Khumaltar, Budhanilkantha, Pakhribas, Salyan Bazar, Okhaldunga, Jiri, Nagarkot, Jumla, Dipalgaun, Daman and Jomsom	and Chainpur East.	Darchula and Silgadhi Doti.

4. TECHNOLOGY TRANSFER AND SERVICES

Training and workshop

One-day workshop was organized in 2072/3/23 at National Maize Research Program (NMRP) Rampur, Chitwan participated by DADO/DLSO office, technical personnel from districts. Scientists of NMRP/NARC also participated in the workshop. The objective of the workshop was to share information and hold interaction among stakeholders about the activities, the division has been implementing on PPCR activities, climate change outlooks and agro-met based advisories.

Services

The division made available of meteorological data to various stakeholders including research stations, students and other concern organization. Technical information regarding agri-environment and its important on agricultural productivity and its impacts in agriculture was provided to various concern stakeholders.

Publications

Besides the annual publication of division, number of research articles, posters, factsheet and papers has been published (Annex 4).

Information through media

Various interviews related to climate change and its impact on Nepalese agriculture were broadcasted/published on various media

5. VISITS

Visit of students from HICAST, Environment Science, Tribhuvan University regarding meteorological and climate change information.

6. OTHER ACTIVITIES

Participation in different training and workshop by different personals from the division is given in Annex 5 and the papers presented/published are given in details in Annex 6.

7. BUDGET AND EXPENDITURE

The total annual budget and expenditure of the division for regular as well as special projects are provided in details in from Annex 7 to Annex 10. Revenue generated from various activities and Beruju status of the division is provided in Annex 11 and Annex 12, respectively.

8. KEY PROBLEMS

- Insufficient laboratory Facilities and the office space
- Insufficient technical human resources in different disciplines.
- Lack of equipment like Gas Chromatography for GHGs analysis.

9. WAY FORWARD

- Expansion of climate change research activities to other research stations.
- Establishment of Environment Unit in each Regional Agricultural Research Stations, divisions and commodity program of NARC.
- Strengthening research stations in terms of manpower and laboratory to conduct research related to climate change.
- Installation of Automatic Weather Station (AWS) in different research stations for agro-meteorological database and to support the research.
- Coordination with different organization to provide agro-met advisory based on weather forecasting for agriculture use.

10. REFERENCES

Jones, PD and A Moberg. 2003. Hemispheric and large scale surface air temperature variation: an extensive revision and an update to 2001. J Climate 16:206-223.

Feng, S and Q. Hu. 2004. Changes in agro-meteorological indicators in the contiguous United States: 1951-2000. Theor. Appl. Climatol. 78, 247-264.

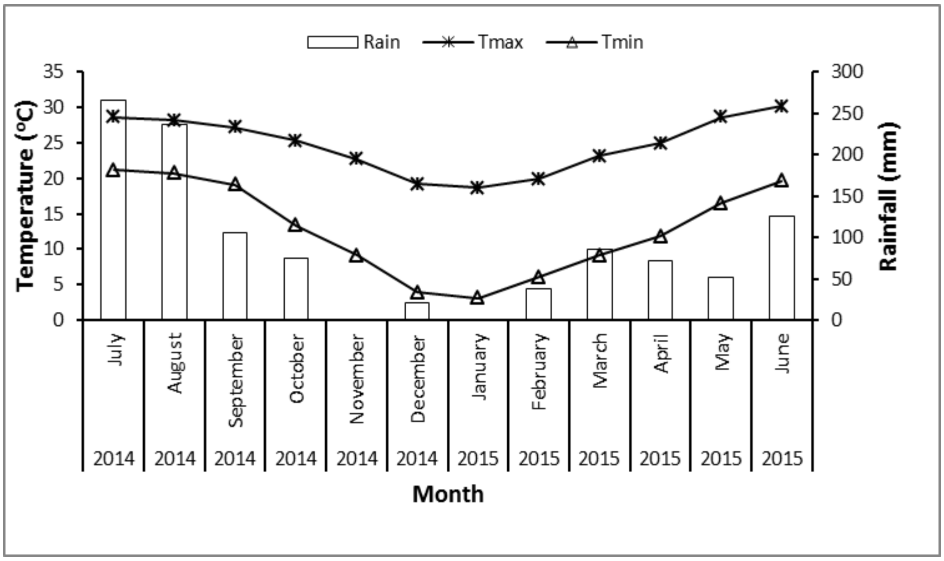


Figure 8: Temperature and rainfall pattern at Khumaltar, 2014-15

11. ANNEXES

Annex 1. Human Resources, 2071/72 (2014/15)

S.N.	Name of the Staff	Designation	Remarks
1	Dr. Anand Kumar Gautam	Senior Scientist (S-4)	Chief
2	Mr. Suresh Kumar Rai	Senior Scientist (S-4)	Deputed from NARC
3	Mr. Ghanashyam Malla	Senior Scientist (S-3)	Deputed from CPDD
4	Mr. Amit Prasad Timilsina	Scientist (S-1)	Deputed from HCRP
5	Mr. Rameshwar Rimal	Scientist (S-1)	PPCR/BRCH/AMIS Project
6	Mr. HariDevkota	Technical Officer (T-6)	
7	Mr. Alok Sharma	Technical Officer (T-6)	Deputed from PAC
8	Mr. AnupTiwari	Technical Officer (T-6)	PPCR/BRCH/AMIS Project
9	Mrs. Sarala Basnet	Admin. Officer (A-6)	
10	Mr. Pravat Sah	Account Officer (A-6)	
11	Mr. Hem Lal Bhandari	Technician (T-5)	
12	Mr. Tirtha Subedi	Technician (T-5)	
13	Mr. Raj Kumar Chalise	Driver (T-3)	Deputed from NASRI

Annex 2. Summary of Progress of NARC Research Projects and Activities, 2071/72 (2014/15)

Project code number	Name of project/activity	Project/ Activity Leader	End year	Budget allocated for this year	Major progress/achievements
32970002	**Vulnerability of climate change in agriculture**	**AK Gautam**	**Continuous**	**800**	
Activity 1	Collection, analysis and dissemination of agro-meteorological database of various locations of Nepal	A Sharma	,,		Meteorological database of 61 locations of Nepalcollected and analyzed (Decadal average precipitation, max and min temp).
Activity 2	Weather vulnerability assessment in farmers perspective	AK Gautam	,,		Survey conducted in Soharwa VDCs of Mahottari district. Farmers' perception is that summer i shotter and winter cooler, Incidence of disease, insect and weeds increased due to climate change.
Activity 3	Crop vulnerability study under different climatic variability	G Malla	,,		NR-1067-6-b-1-3-3-3 performed better in OTC than other varieties with yield of 7.2 t/ha and the lowest of 6.3 t/ha by NR-11082. Swarna sub-1 in Nepalgunj produced 6.3 t/ha yield while Sukhadhan-3 yielded 7.2 t/ha. In open field condition Sabitri was superior (8.9 t/ha).
Activity 4	Crop vulnerability study under different climatic variability	G Malla	,,		Lentil variety ILL 7135 performed better in both OTC and field condition yielding 2.1 t/ha in field and 1.22 t/ha in OTC. About 42% yield reduction observed in the chamber due to rise in temperature.
Activity 5	Crop management study under changing climatic parameters	G Malla	,,		Wheat variety Munal-1 performed better than other varieties like WK-1204, Chyakhuraand WK-1481 under elevated temperature in OTC. Yield of wheat varieties was 12% lesser in OTC than field condition.
Activity 6	Estimation of GHGs	A Sharma			In Bandipur, *Desmodium* had the highest CO_2-C

	emission from pasture agricultural land and livestock sectors				emission of 260.9 mg/m^2/hr and the lowest in Gini (65mg/m^2/hr).
32970001	Carbon sequestration in agricultural land and plantation crop	G Malla		405	Vegetable, legume, cereal and finger millet fields showed 133,126,87and 83 mg/m^2/hr of CO_2-C emission, respectively.
Activity 1	Study on atmospheric sequestration under different tillage practice	G Malla	,,		CO2-C emission was 60.7% lower in flat planting with no mulch as compared to flat mulched planting in rice whereas the gas emission was 59% lower in flat planting with no mulch as compared to flat mulch planting of 98.1 mg/ha/hr in wheat.
Activity 2	Estimation of atmospheric C sequestration by fruit plants and in orchard	G Malla	,,		Avocado tree is highly potential to carbon sequestration as compared to other plantation trees.
Activity 3	Estimation of atmospheric C sequestration by pasture land	G Malla			
32900001	**FMP/AOE 329**	**Division Chief**	**Time bound**	**705**	
Activity 1	Farm security	Division Chief			Farm security well maintained
Activity 2	Farm maintenance		,,		Farm maintenance good and well.
Activity 3	Research support (admin Lab services, etc)		,,		All research supports made available as per requirements
Activity 4	Annual Report Publication	B.P.Poudel	,,		100 units of Annual Report was Published

Annex 3. Summary progress of special research projects and activities, 2071/72(2014/15)

Name of project /activity	Project/ Activity Leader	Begin Year	End Year	Budget allocated for this FY	Major progress /achievements
Agro-meteorological Information and Services (AMIS) Project	AK Gautam	2012	2015	8,70,000	Sunsari district experiencing decreasing trend in mean Tmax during rice growing season. Dhanusha, Rupendehi and Banke experiencing increasing trend Sunsari and Banke districts experiencing decreasing trend in Tmax in winter season. Central, western and mid- western Terai experiencing higher trend of growing degree days both during rainy and winter season Some infrastructure development of coordinate office and designed agro advisory bulletin for farmers.
PPCR	AK Gautam	2014	2019		Agro-met based advisory bulletin for Banke districts started in 2014

Annex 4. Publications, 2071/72 (2014/2015)

SN	Title of publication	Type	Language	Author	No. of copies
1.	Annual Report 2070/71(2013/14). Agricultural Environment Research Division, Khumaltar, Lalitpur, Nepal	Report	English	Agricultural Environment Research Division, Khumaltar	100

Annex 5. Training/workshop/seminar attended by staff, 2071/72 (2014/15)

SN	Name of staff	Position	Name of Training/seminar/workshop	Duration	Place/Country	Organizer
1	Ananda Kumar	Chief	Agro-meteorological information for	June 3-7, 2014	Mongolia	AMIS
	Gautam	Senior	adaptation to Climate Change (CC)	Sep 30-Oct 3,		
2.	G.Malla	Scientist	Forum on mitigating negative	2014	Indonesia	APO
3	A.Sharma	Senior	Effects of CC on Agriculture	March 11-17,	India	
		Scientist	Strengthening and dissemination of climate	2015		
		Technical	based agro advisory for small holders			
		officer				

Annex 6. Paper published, 2071/72(2014/15)

SN	Title of paper	Authors	Name of proceeding or journal
1.	Adaptation to Climate change Impact on Crop production in Nepal	AK Gautam	Adaptation to CC Impact on Crop production in SAARC member countries, (SAC), Dec 2014.
2.	Innovative Measures for Mitigating Negative Effect of Climate Change on hill in Nepal	G Malla	Indian society of hill agriculture, GB Panta University

Annex 7. Regular annual budget and expenditure record, 2071/72 (2014/15)

Budget Code	Budget heads	Annual Budget	Expenses	Balance
40**	**Staff Expenses**	**4088634.0**	**4067994.0 -**	**20640.0**
4000	Basic Salary	3253940.0	3253940.0	0.0
4010	Allowance	144000.0	124000.0	20000.0
4020	Provident fund	325394.0	325394.0	0.0
4040	Cloth	82500.0	82,500	0.0
4050	Dasain expenses	258000.0	257360	540.0
4080	Insurance	24800.0	24800	0.0
41**	**Operational Expenses**	**1610000.0**	**1593293.16**	**16706.84**
4100	Travel Expenses	440000.0	419186.0	814.0
4110	Vehicle Fuel Lubricants	393000.0	379365.08	13634.92
4120	Wages to Labour	410000.0	409800.0	200.0
4130	Lab. & Research Supply	95000.0	95000.0	0.0
4140	Farm Supply	170000.0	169819.33	180.67
4150	Library & Publication	75000.0	73884.0	1116.0
4160	Training workshop seminar	0.0	0.0	0.0
4180	Farm management project	27000.0	26238.75	761.25
42**	**Administrative Expenses**	**1000000.0**	**927405.85**	**72594.15**
4200	Rent Utilities	230000.0	223822.66	6177.34
4210	Communication Expenses	70000.0	67824.0	2176.0
4220	Repair & Maintenance	565000.0	531537.89	33462.11
4230	Office Supplies	75000	74481.30	518.7
4260	Contingencies	60000.0	29740.0	30260.0
43**	**Capital Expenses**	**6325000.0**	**4103930.13**	**2221069.87**
4330	Furniture and fixtures	100000.0	100000.0	0.0
4340	Machinery & equipment	6000000.0	3779624.0	2220376.0
4360	Computer and software	75000.0	74806.0	194.0
4370	Other Fixed Assets	150000.0	149500.13	499.87
Total		**13023634.0**	**10692623.14**	**2331010.86**

Annex 8. Special project (AFACI) budget and expenditure record, 2071/72 (2014/15)

Budget Code	Budget heads	Annual Budget	Budget released	Expenses	Balance
40**	**Staff Expenses**	**0.00**	**0.00**	**0.00**	**0.00**
4010	Allowance	218,000.0	218000.0	218,000.0	0.00
4020	Provident fund	-	-	-	-
41**	**Operational Expenses**	**218,000.0**	**218,000.0**	**4,83,543.00**	**106,000.0**
4100	Travel Expenses	2,25,000.00	2,25,000.00	22925.00	202075.00
4110	Vehicle Fuel Lubricants	40,000.00	40,000.00	16612.00	23388.00
4120	Wages to Labour	0	0	0	0
4150	Library & Publication	140,000.00	140,000.00	0	140,000.00
4160	Training workshop seminar	255,000.00	255000.00	92475.00	162525.00
4180	Farm management project	0	0	0	0
42**	**Administrative Expenses**	**660,000.00**	**660000.00**	**132012.00**	**527988.00**
4200	Rent Utilities	127399.00	127399.00	126180.00	1219.00
4210	Communication Expenses	0	0	0	0
4220	Repair & Maintenance	30,000.00	30,000.00	3100.00	26900.00
4230	Office Supplies	25,000.00	25,000.00	0	25,000.00
4260	Contingencies	25000.00	25,000.00	25,000.00	0.00
43**	**Capital Expenses**	**2073990.00**	**2073990.00**	**154280.00**	**53119.000**
4330	Furniture and fixtures	-	-	-	-
4340	Machinery & equipment	-	-	-	-
Total		**1085399.00**	**1085399.00**	**504292.00**	**581107.00**

Annex 9. Special project (NDRI) budget and expenditure record, 2071/72 (2014/15)

Budget Code	Budget heads	Annual Budget	Budget released	Expenses	Balance
40**	**Staff Expenses**	**294000.0**	**294000.0**	**294000.0-**	**0.0**
4000	Basic Salary	-	-	-	-
4010	Allowance	294000.0	294000.0-	294000.0	0.0
41**	**Operational Expenses**	**80000.0**	**80000.0**	**69600.0**	**10400.0**
4100	Travel Expenses	30,000.00	30,000.00	30,000.00	0.00
4110	Vehicle Fuel Lubricants	20,000.00	20,000.00	20,000.00	0.00
4120	Wages to Labour	30,000.00	30,000.00	19600.0	10400.0
42**	**Administrative Expenses**	**50,000.00**	**50,000.00**	**649950.0**	**50.00**
4220	Repair & Maintenance	20,000.00	20,000.00	20,000.0	0.0
4230	Office Supplies	20,000.00	20,000.0	20,000.	0.0
4260	Contingencies	40,000.00	40,000.00	40,000.0	0.0
43**	**Capital Expenses**	**0.0**	**0.0**	**0.0**	**0.0**
4330	Furniture and fixtures	-	-	-	-
4340	Machinery & equipment	0.0	0.0	0.0	0.0
4150	Vehicles	0.0	0.0	0.0	0.0
4360	Computer and software	0.0	0.0	0.0	0.0
4370	Other Fixed Assets	0.0	0.0	0.0	0.0
Total		**454000.00**	**454000.00**	**443600.00**	**10400.0**

Annex 10. Special project (PPCR/BRCH/AMIS-NARC Project) budget and expenditure record, 2071/72 (2014/15)

Budget Code	Budget heads	Annual Budget	Budget released	Expenses	Balance
2100	LabourExpenses	995000.00	427355.64	427355.64 -	0.00
21111	Basic Salary	400000.0	48445.16	48445.16	0.0
21113	Allowance	15000.0	1935.48	1935.48	0.0
21119	Other Allowance	550000.00	376975.00	376975.00	0.0
21121	Cloth	30000.00	-	-	-
2200	Operational Expenses	2555000.00	1483894.34	1483894.34	0.0
22111	Water and electricity	50000.00	0.00	0.00	0.00
22112	Communication	50,000.00	29745.00	29745.00	0.00
22122	Other Rent	0	0	0	0
22211	Fuel vehicle	200000.00	155518.30	155518.30	0
22212	Operation maintenance	150000.00	114815.00	114815.00	0
22311	Office expenditure	1300,000.00	777746.04	777746.04	0
22314	Fuel others	30000.00	0	0	0
22411	Service and consultant	100000.00	0	0	0
22412	Other service	0	0	0	0
22511	Staff training	0.0	.00	0.00	0.0
22512	Workshop (skill, people awarenes)	300000.00	97250.00	97250.00	0.0
22521	Production/supplies	0.0	0.0	0.0	0.0
22611	Monitoring evaluation	0.0	0.0	0.0	0.0
22612	Travel Expenses	325,000.0	258520.0	258520.0	0.0
22711	Contingency	50,000.0	50,000.0	50,000.0	0.0
2900	Capital Expenses	20050000.00	19037390.50	19037390.50	0.0
29311	Furniture and fixtures	850000.00	571328.0	571328.0	0.0
29411	Vehicle	0.0	0.0	0.0	0.0
29511	Machinery &equipment Vehicles	17900000.0	17282562.5	17282562.5	0.0
29611	Construction	0.0	0.0	0.0	0.0
29612	Capital improvement	0.0	0.0	0.0	0.0
29712	Software Expenses	1300000.0	1183500.0	1183500.0	0.0
Total		**23600000.00**	**20948640.48**	**20948640.48**	**9022140.70**

Annex 11. Revenue status, 2071/72 (2014/15) (*In Nepalese Rupees*)

Source	Total	Remarks
Administration Income	25250.00	-
Research materials	422.50	
Grand Total	**25672.50**	

Annex 12. Beruju status, 20671/72 (2014/15) (*In Nepalese Rupees*)

Beruju	Amount	Remarks
Beruju till last year	0	0
Beruju cleared this FY	0	0
Remaining Beruju	0	0