NARC Publication Serial No. 00723-537/2018/2019

Annual Report

2074/75 (2017/18)

Government of Nepal

Nepal Agricultural Research Council

Agricultural Environment Research Division

Khumaltar, Lalitpur, Nepal

2018

Agricultural Environment Research Division (AERD)
Nepal Agricultural Research Council (NARC)
Khumaltar, Lalitpur
Tel: 977-1-5535981
Email: env.narc@gmail.com
URL: http://www.narc-env.gov.np, http://www.narc.gov.np

Citation:

AERD, 2018. Annual Report. 2017/18 (2074/75). Agricultural Environment Research Division, Khumaltar, Lalitpur, Nepal

Cover Page Photo: AERD Office Building

FOREWORD

Nepal is the fourth most vulnerable country to climate change in the world and agriculture system of the country is highly depend upon monsoon and weather. The country being agro based, climate change and its impacts, vulnerabilities, consequences and adaptation has always been a topic of great concern. Mitigation of climate change, adaptation and climate resilient agricultural technology should always be a prime need and motto of the country. Agricultural Environment Research Division (AERD/NARC) has been working on such issues and in collaboration with different organizations and stakeholders to find solution of such problems. Efforts are being made to develop a hub for the climatic database at different locations of Nepal to study the seasonal and annual trend. It has been studying the various spatial and temporal adaptive capacity of different variety of crops under elevated temperature condition to find out adaptive measures against the effects of climate change. Similarly, collection, analysis and dissemination of agro-meteorological data, screening of impacts of climate change on farmers perspective, agro-met advisory bulletin (AAB) preparation and disseminations, estimation of GHGs and carbon sequestration are some of the works that are being done by AERD. Finally, identification and prioritization of new agri-environment related problems are aimed in coming year and would be main strategy of the division in future.

This annual report presents the detail activities and upshots of the research activities conducted in the FY 2074/75 by the division. It is expected that this annual report will serve as a useful resource to agricultural researchers, extension personnel, students and national policy makers.

I am very much thankful to Mr. Bishnu P. Paudel, Dr. A Timalsina, Mr. R Rimal, Mr. Achyut Gaire and Mr. HL Bhandari for their precious contributions to carry out all the activities of the Division. My special thanks to Mr. Bishnu P. Paudel for preparation of the manuscript of this report. Also, I would like to appreciate the hard work of Mrs. M Chitrakar, Mr. P Sah and Mr. RK Chalise for their administrative, account 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 improvement of the report in days ahead.

Ghanashyam Malla
Senior Scientist and Chief
Agricultural Environment Research Division (AERD)
Khumaltar, Lalitpur, Nepal

LIST OF ABBREVIATIONS

°C	Degree Centigrade
AGB	Above Ground Biomass
AERD	Agricultural Environment Research Division
ARS	Agriculture Research Station
Av.	Average
AWS	Automatic Weather Station
BGB	Below Ground Biomass
BP	Branches per plant
BY	Bio-mass yield
CC	Climate change
CO_2	Carbon di-oxide
CO_2- C	Carbon in CO_2 form
cm	Centimetre
DF	Days to flowering
DHM	Department of Hydrology and Meteorology
DM	Days to maturity
F.Y.	Fiscal Year
GHGs	Greenhouse Gases
GS	Grains per spike
GY	Grain yield
ha	Hectare
Hr	Hour
HP	Hills per plot
Kg	Kilogram
kg/ha/yr	kilogram per hectare per year
m^2	Square meter
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
OTC	Open top chamber
PLH	Plant height

RARS	Regional Agricultural Research Station
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
Wt	Weight

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXES

सारांश

कृषि वातावरण अनुसन्धान महाशाखाबाट वातावरण मैत्री विभिन्न अनुसन्धान र मौसम परिवर्तनका कारण बालीमा पर्न सक्ने जोखिम सम्बन्धी अध्ययन हुदै आइरहेको छ । साथै अन्य सीपमूलक कार्यक्रम, 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 केन्द्रहरूमा स्वचालित मौसम मापन प्रणाली स्थापना गर्दै आएको छ ।

आ.व. २०७३/७४ देखि जलवायु समुत्थान निर्माण आयोजना (पि.पि.सि.आर.) अन्तर्गत २५ जिल्लामा कृषि मौंसम सल्लाह सेवा बुलेटिन मार्फत कृषकहरूलाई सेवा पुर्याई रहेको छ । यस बाहेक यस महाशाखाले विभिन्न राष्ट्रिय अन्तराष्ट्रिय संघ संस्था, अनुसन्धान केन्द्र र कृषि अनुसन्धानमा संलग्न विद्यार्थीहरूलाई कृषि तथा मौसम सम्बन्धी संकलित तथ्याङ्कहरू उपलब्ध गराउदै आएको छ। यस महाशाखाबाट संचालन गरिएका अनुसन्धानात्मक अध्ययनहरूबाट आ.व. २०७४/७५ मा निम्न अनुसारका अनुसन्धान परिणामहरू प्राप्त भएका छन् ।

- बढ्दो तापक्रमको अवस्थामा ओपन टप चेम्बर (OTC) मा धानको जातहरूको परिक्षण गर्दा खुमल-८ को उत्पादन खुला फिल्डमा सबैभन्दा बढी ५.९१ टन पाईयो
- डाँफे, डब्लु.के.१२०४,स्वर्गद्वारी र धौलागिरी गहुँका जातहरूको उत्पादन फिल्डमा भन्दा चेम्बरमा (बढ्दो तापक्रममा) बढी पाइयो ।
- विभिन्न बालीमा गरिएको CO_2-C उत्सर्जन सम्बन्धी अध्ययनमा सबैभन्दा बढी ७० मिग्रा/वर्ग मी./घण्टा र सबैभन्दा कम १९ मि.ग्रा./वर्ग मी./घण्टा खुसानीमा पाइयो ।
- फलफूलका बिरूवामा कार्बन स्थिरिकरणको अध्ययनमा आँप जातका बिरूवाले कम समयमा बढि स्थिरिकरण गरेको पाइयो भने फलफूलमा स्थिरिकरणको मात्रा बिरूवाको उमेर र बोटको उचाईमा निर्भर रहेको पाइयो ।
- ओखलढुंगा जिल्लामा गरिएको जलवायु परिवर्तन र त्यसको कृषिमा परेको असर सम्बन्धी सर्वेक्षणमा उक्त परिवर्तनका कारण गर्मीयाममा अधिकतम तापक्रम पहिले भन्दा बढेको र जाडो याममा न्यूनतम तापक्रम पहिले भन्दा घटेको पाइयो ।

EXECUTIVE SUMMARY

Agricultural Environment Research Division has been contributing and sharing the environment friendly agricultural technologies and knowledge developed through the crop vulnerability studies and other researches. It includes the sharing of knowledge on skilful programs like crop modelling, 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. 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 twenty five districts under PPCR project and four district of FAO 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:

* Among four rice varieties (NR1105,BB27, Khumal-10, Khumal-8 and 08 fan-10), the grain yield of Khumal 8 has increased in average seasonal temperature with higher yield (5.91 t/ha) among varieties and lowest yield (3.51 t/ha) was found under third chamber (6'9" height) by 08 fan-10.

* Similarly, four wheat varieties (Danphe, WK 1204, Swargadwari and Dhaulagiri) grown in open top plastic chamber and open field, Swargadwari resulted higher grain yield (4.69 t/ha in 6'9" height) under both condition. Wheat variety Danphe responded with lowest yield (2. t/ha) among varieties in open condition.

* The CO_2-C flux was recorded the highest of 70.12 mg/ha/hr on vegetable crop (Lady's finger) and the lowest of 19 mg/ha/hr in chilli at Lamjung,

* CO2-C emission was higher (683.04 $mg/m^2/hr$) from open field composted with 20 t/ha as compared to open top chamber (106.49 $mg/m^2/hr$) composted with 10 t/ha.

* Five years aged mango tree of 13.47 m height was found to sequestrate 1.87 ton/carbon per year per tree in terai farm. Similarly, individual orange tree (15 years aged) of 4.2 m height was estimated to capture 0.106 ton/carbon per year in Palpa District.

* In Okhaldhunga district, 80 percent farmers reported winter season is more cooler than past and 67 percent farmers felt summer season is more hot than past decade due to climate change.

1. WORKING CONTEXT

Nepal is an agriculture based 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. Global warming, spatial, temporal and weather anomalies are becoming alarming in whole agricultural system and productivity. The database on agro-meteorological record from various stations is helpful for cause and effect studies and for explanation and prediction of 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.

Agricultural 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 and weather based agro-advisory services related to climate change.

2. INTRODUCTION

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

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.
- Develop farmers friendly agro-met advisory bulletin and disseminate the AAB effective manner

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).
- GHGs emission under different agricultural land and system.
- Carbon sequestration in agricultural, plantation and horticultural crops.
- Mineralization rate of soil organic matter under elevated temperature.

- AAB performance and efficacy under local level / farmer level.

2.5 Infrastructure and facilities

- **Automatic weather station (11):** Daily agro-meteorological data recording (Temperature, rainfall, solar radiation, relative humidity, soil temperature etc.)
- **3 Nos. 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 2074/75 has been presented in Annex 1.

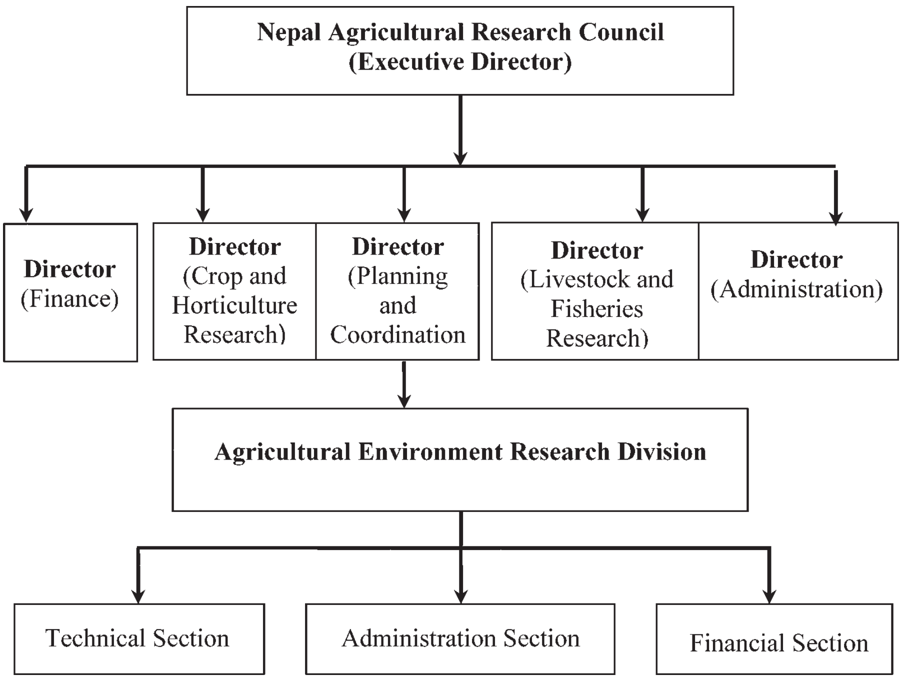


Figure 1: Organizational structure of Agricultural Environment Research Division

3. RESEARCH HIGHLIGHTS

3.1 Study on rice and wheat under changing climate parameters

Air temperature is important to agriculture because it influences plant growth and crop productivity. It affects on different parameters of soil including soil mineralization rate, soil moisture. It also has effects on whole crop phenology like maturity, heading. Farmers use air temperature and weather information to decide when to irrigate crop and to determine incidence of insect pests and plant diseases. Thus, study on effects of temperature on major crops is necessary for knowing adaptability or vulnerability of new crop varieties. The main objective of the study is to select and conserve appropriate rice variety under elevated temperature condition.

Plants have specific requirement of temperature range at which their best growth occurs. When the temperature reaches the upper end of the spectrum, generally there is change in physiological behaviour and photosynthesis declines. Optimal temperature requirement of crops are different from nature of crops, and even different within species. Rice crop can adapt up to maximum temperature of 45^0 C although its average air temperature required for growth is considered 22-30^0 C.

The main objective of study is to find out the rice and wheat crop adaptability in different temperature. Thus, an experiment was carried out in a split plot design in three different type or size of plastic chamber under irrigated condition to know the adaptability and behaviour of rice varieties in 2074/75 at Khumaltar. Four conditions of study [three different height (Table 2) plastic chamber and field] as main plot (factor A) and four varieties as sub-plots (factor B) were carried out.

Rice at Khumaltar

Twenty five days old rice seedling of varieties Khumal-10, NR 1105, B-B 27, Khumal-8 and 08 fan-10 were transplanted in 3 different height open top plastic chamber (OTPC) and open field in July 01, 2017 at 20 x 20 cm spacing. Agronomic parameters taken were presented in Table 1. Fertilizers were applied @ 100:30:30 kg/ha $N:P_2O_5:K_2O$ in rice. Nitrogen was applied in two split doses, half as basal dose and rest at 32 days after transplanting. The phenological parameters and yield were recorded and are presented in table 1.

Table 1: Agronomical parameters of rice at Khumaltar, 2074/75 (2017/18)

Treatment	TH (no.)	PH (cm)	50% HD	MD	PL (cm)	FBM (t/ha)	GY (t/ha)
Chamber 4'							
Khumal-10	9	117.8	91	114	24.4	20.63	5.58
NR1105,BB 27	8	106.7	92	113	22.5	20.83	5.20
Khumal-8	9	93.0	98	120	25.6	22.29	**5.65**
08 fan-10	9	86.3	89	114	23.3	15.83	4.08
Chamber 5'4"							
Khumal-10	8	113.8	93	113	23.0	20.63	5.18
NR1105,BB 27	9	104.5	92	113	21.2	18.75	4.63
Khumal-8	9	95.8	98	122	26.5	22.29	**5.23**
08 fan-10	9	83.7	84	114	23.1	15.83	4.28
Chamber 6'9"							
Khumal-10	7	125	93	110	22.3	20.00	**5.28**
NR1105,BB 27	7	111.3	91	111	23.4	19.17	4.41
Khumal-8	8	104.2	98	118	25.1	18.96	4.64
08 fan-10	8	76	89	111	21.8	13.96	3.51
Open Field							
Khumal-10	7	112.8	93	116	22.4	17.71	5.37
NR1105,BB 27	10	100.8	93	117	21.0	18.13	4.75
Khumal-8	8	98.9	98	124	26.4	23.13	**5.91**
08 fan-10	9	78.7	87	116	23.5	18.33	4.78

TH=Tillers/hill, PH=Plant ht, HD=Heading days, MD=Maturity Days, PL=Panicle length, FBM=Fresh biomass, , GY= Grain yield

Table 2: Average temperature of chamber and field for rice growing period 2074/75 (2017/18)

S.N.	Treatment	T Max. (^{0}C)	T Min (^{0}C)
1	Chamber 4'	38.5	16.2
2	Chamber 5'4"	39.5	17.2
3	Chamber 6'9"	40.7	18.4
4	Open field	34.8	15.6

Average maximum temperature was found 3.7^0 C, 4.7^0 C and 5.9^0 C higher in 4, 5.4 and 6.9' height open top plastic chamber respectively than open field condition. However, increase in minimum temperature (Tmin) was found nominal (0.6^0 C, 1.6 ^{0}C and 2.8 ^{0}C respectively) in three chambers compared to open field condition. The average seasonal increase in temperature were 2.5, 3.3 and 5.2^0 C in three chambers (4', 5'4" and 6'9" height).

Rice crop duration was decreased by 2, 3 and 6 days earlier maturity due to increase in temperature grown under 4, 5.4 and 6.9' height plastic chamber respectively. The grain yield of Khumal 8 has increased in average seasonal temperature with higher yield (5.91 t/ha) among varieties and chamber condition and lowest yield (3.51 t/ha) was found under third chamber by 08 fan-10 and 4.08 t/ha in open condition among four varieties.

Similarly, three varieties Khumal-8 were produced higher fresh biomass yield (23.13 t/ha) in average seasonal temperature as compared to chamber condition followed by first and chamber respectively from same variety.

Wheat at Khumaltar

Wheat was sown on first week of December, 2017 at Khumaltar under same plastic chamber and open field as rice. Seed rate was 120 kg/ha and spacing was 20 cm row to row distance. Fertilizer dose was applied at rate of 100:50:50 N: P_2O_5: K_2O kg/ha. Half of nitrogen was applied as basal and rest half used after one month of basal dose. Irrigation in wheat field was done when as needed. The main objective of the study was to select appropriate wheat variety for increased temperature condition.

Thus, an experiment was carried out in a split plot design in three different type or size of plastic chamber under irrigated condition to know the adaptability and behaviour of wheat varieties in 2074/75 at Khumaltar. Four conditions of study (3 plastic chamber and Field) as main plot (factor A) and wheat varieties (Swargadwari, Danphe, Dhaulagiri and WK 1204) as sub-plots (factor B) were carried out.

The average seasonal temperature increase was about 2.3 to 4.7^0C in chamber than field condition (Table 4).

Table 3: Agronomical parameters of wheat at Khumaltar, 2074/75 (2017/2018)

Treatment	50% HD	MD	PH (cm)	EL (cm)	TP	EW (gm)	GY (t/ha)	FBM (t/ha)
Chamber 4'								
Swargadwari	114	174	79.20	12.70	6.30	3.93	**4.09**	10.00
Danphe	119	176	89.37	9.93	6.00	3.27	3.78	9.79
Dhaulagiri	115	176	91.97	11.53	7.60	3.33	3.75	9.79
WK-1204	120	178	79.73	10.60	7.30	3.47	3.77	9.38
Chamber 5'4"								
Swargadwari	113	176	86.33	12.30	6.50	3.73	**3.92**	7.29
Danphe	119	175	84.93	9.77	7.40	3.27	3.39	10.00
Dhaulagiri	114	175	89.07	10.70	7.20	2.67	2.56	6.25
WK-1204	119	176	85.37	10.77	8.67	3.33	3.48	9.79
Chamber 6'9"								
Swargadwari	113	172	85.73	12.93	6.73	3.80	**4.69**	9.79
Danphe	115	172	95.83	10.40	8.07	3.87	4.07	10.63
Dhaulagiri	111	173	90.97	11.10	8.53	3.07	3.04	8.13
WK-1204	118	173	82.77	10.80	5.80	4.20	4.49	8.96
Open Field								
Swargadwari	114	174	78.67	12.87	9.27	4.53	**3.90**	8.54
Danphe	121	177	89.63	11.03	11.07	3.33	2.54	7.71
Dhaulagiri	116	177	87.50	11.80	10.00	3.60	3.02	7.71
WK-1204	124	181	77.37	11.50	9.40	3.73	3.56	9.17

FD=Flowering days, MD=Maturity days, PH=Plant ht, TP=tillers/plant, EL=Ear length, GP=Grain/panicle,
FBW=Biomass wt, GY=Grain yield

Table 4: Average temperature of chamber and field for wheat growing period, 2074/75 (2017/18)

Treatments	Average Tmax	Average Tmin
Open field	25	8
Small Chamber (4')	28.2	10.7
Medium chamber (5'4")	31	10.9
Large chamber (6'9")	31.6	11.8

Wheat variety Swargadwari flowered earlier under both elevated temperature condition and field condition (113-114 days). Wheat variety WK-1204 and Danphe flowered late as compared to other two varieties in both condition, however, in an open field condition, all varieties flowered late as compared to elevated temperature condition. Wheat variety Swargadwari produced higher grain yield among varieties (Table . Chamber 6'9" height, Chamber 4' and Chamber 5'4" height produced higher grain yield of variety Swargadwari respectively as compared to open field condition (Table Wheat variety Dhaulagiri did not response to elevated temperature compared to open field condition in terms of grain yield.

The fresh biomass was found higher under chamber condition as compared to open field condition with higher fresh biomass of Danphe variety (10.6 t/ha) in third chamber (5.6^{0}C higher than average seasonal temperature).

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

Soil CO_2 flux is the combined result of root respiration and microbial decomposition of soil organic matter (Hanson *et al* 2000). Farming practices including use of excessive fertilizers and mismanagement of natural resources has posed serious threat in contribution of CO_2 emission from soil. However, it is generally believed that CO_2 emission from the soil and CO_2 fixation by the plant during photosynthesis process is a self sustaining system and there is balance between carbon released from soil and fixed by the plant through photosynthesis. CO_2 flux from agricultural soil mainly depends on microbial activities on organic matter and a number of abiotic and biotic factors can also affect it. It generally increases with rise in temperature (Lloyd and Taylor 1994). Low level of soil moisture limits microbial and root respiration. Higher emission of CO_2 from soil depletes the organic matter content and thus reduces the soil productivity as well as fertility. So, it is necessary to monitor CO_2emission rates in different cropping pattern to formulate the plan to reduce overall agricultural emission.

Methodology

The study was carried out at research and farmers' fields from two locations; Lamjung and Khumaltar to estimate CO_2-C emission from different crops and different dose of compost. Selection of the sites and crops were done randomly. Soil temperature, pH and moisture were recorded in the study.

The collection of gas samples was done by Japanese closed chamber technique and finally subjected to measure with help of CO_2 monitor. Soil moisture, and pH were taken by combined soil moisture and pH meter. Soil temperature was taken from 8 cm depth.

The observation taken from different field categorized on the basis of standing crop in field and was analyzed accordingly.

The pH of the soil ranged from 5.1 to 6.5 and soil moisture index ranged from 7.8 to 8. Similarly, range of air temperature during collecting of gas was 25.25 to 27.5° C at Lamjung District. The CO_2-C flux was recorded the highest of 70.12 mg/ha/hr on vegetable crop (Lady's finger) and the lowest of 19 mg/ha/hr in chilly at Lamjung. It was observed that the CO_2-C emission was influenced by both soil temperature, moisture and application of manure and fertilizers in most of the districts. Study and analysis of gas emission showed higher emission in vegetable crop than cereal crops.

It was observed that the CO_2-C emission estimation on different crop was an important study to know the crop contribution in climate change. It help to reduce the emission from soil and will be beneficial for further studies and planning of cropping pattern as well. The presence of crops and fallow land also influences carbon dioxide emission from soil. Sometimes emitted gas absorbed by crop as in photosynthesis process. Thus, emission and contribution in global warming is depend land cover and vegetation.

Table 5: CO_2-C Emission on different crops at Lamjung, 2074/75

S.N.	Crop	Air Temp. (⁰C)	C flux mg/m sq/ha	Soil Temp. (⁰C)	Soil pH	Moisture (%)
1	Maize	25.25	41.91	26.05	6.5	7.8
2	Zinger	27.5	60.23	28.8	6.2	8.0
3	Chilly	26.7	19	26.7	5.5	8.0
4	Ladies finger	27	70.12	26.5	5.1	8.0

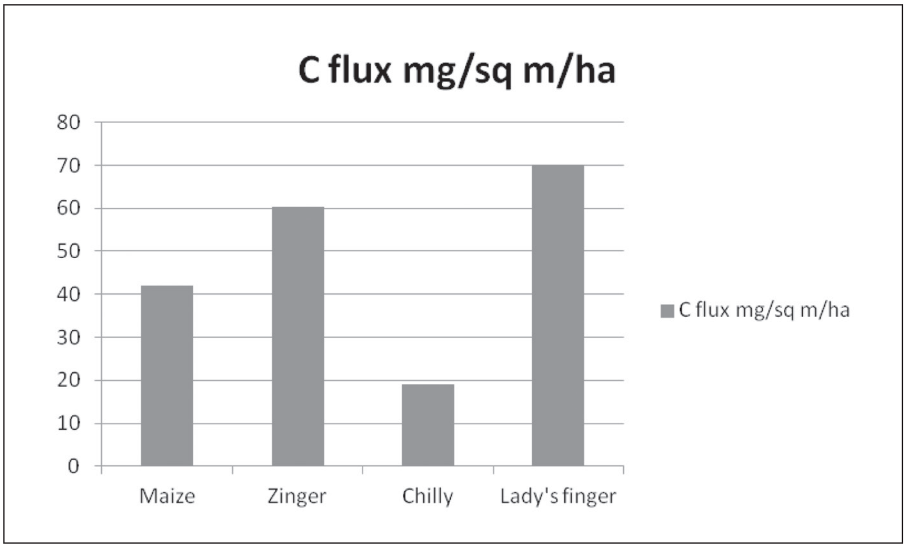


Fig. 2: CO_2- C emission from different crops

CO_2-C emission from different doses of compost

During mineralization process of soil organic matter, carbon dioxide is released by soil microorganism.

Table 6: CO_2-C Emission from different doses of compost at Khumaltar, 2074/75

S.N.	Treatment	Air temp (^{0}C)	C flux mg/m 2/ ha	Soil Temp. (^{0}C)	Soil pH	Mois-ture (%)
Open Top Chamber						
1	5 t/ha	30	195.95	29.5	5.5	8.0
2	10 t/ha	30	106.49	29.5	6.0	6.5
3	15 t/ha	30	428.03	29.5	6.0	7.5
4	20 t/ha	30	230.72	29.5	6.2	6.0
Open Field						
1	5 t/ha	30	466.8708	28.9	5.3	7.0
2	10 t/ha	30	220.4085	28.9	5.5	8.0
3	15 t/ha	30	328.6606	28.9	5.0	8.0
4	20 t/ha	30	683.0492	28.9	5.5	8.0

The CO_2-C flux was recorded the highest of 683.04 mg/ha/hr on application of 20 t/ha compost followed by 466.87 mg/ha/hr on application of 5 t/ha compost in open field. The CO_2-C flux was recorded the lowest of 106.49 mg/ha/hr on application of 10 t/ha compost followed by 195.95 mg/ha/hr on application of 5 t/ha compost in chamber condition.

3.3 Carbon sequestration in fruit trees

The research works in carbon sequestration is very limited in Nepal. Only few study of atmospheric carbon sequestration on forestry is going on. While the study on fruit trees in Nepal is very limited. In this context, while reviewing the past works, there are very few and scattered research works found in the country. Carbon and its sequestration into the soil by fruit plants are very important. Above ground biomass (AGB) and below ground biomass (BGB) of the fruit trees has been considered as carbon sequestration. That increasing biomass of trees helps to reduce carbon concentration in the atmosphere. Because, the green trees continuously absorb carbon during photosynthesis. This study has been carried out to estimate carbon balance and atmospheric carbon sequestration from fruit trees. Carbon sequestration estimation from fruit trees is an important study which helps to estimate actual contribution of horticulture in mitigating global warming. It might also be helpful for increasing the sequestration in soil and earth system by increasing fruit cultivation.

In carbon sequestration process, either CO_2 is captured from atmosphere or added in to the soil. Forestry and agriculture plays an important role in atmospheric CO_2 fixation. The horticulture, especially plantation crop contributes significantly to global CO_2 capture and offers opportunities of sequestering it into the soil, vegetation and wood products. Fruit trees help stabilize CO_2 concentration in the atmosphere by sequestrating and absorbing for long time. Atmospheric carbon gets sequestered into the soil and helps in building the soil health.

Study was carried out in varied fruit trees in different farmers tree garden. In this study, carbon stock was estimated by calculating Above Ground Tree Biomass (AGTB) and Below Ground Tree Biomass (BGTB).

Table 7: Carbon Sequestration study on different fruits trees, 2074/75 (2017/18)

S.N.	Fruit tree/Station	No. of samples	Age of tree years	DBH (m)	Height of tree (m)	C Sequestrated (t/yr/tree)
1	Mango (Terai Farm)	25	5	2.25	13.47	1.87
2	Mango (Chamolous Farm)	30	11	2.44	7.37	1.24
3	Orange (Palpa)	20	15	0.75	4.2	0.106

Carbon sequestration in fruit trees depend upon their canopy size, age of tree, type of fruit and girth diameter. The study on carbon sequestration at Palpa in 2074/75 showed that 15 years old orange trees (sample size 20) sequestrated about 0.106 ton carbon Mango trees of 5 years old in terai farm sequestrated 1.87 ton/year (sample size 25) and Mango trees of 11 years old in Chamolous farm sequestrated 1.24 ton/year Variations in the sequestration from plant to plant were due to their age, size and species. Further study is required to conclude sequestration rate of the fruit trees.

3.4 Effect of high temperature on mineralization rate of soil organic matter

Soil micro-organisms that mineralize organic matter to plant available form are highly affected by soil temperature, soil moisture, organic matter content in soil and soil pH. An experiment was conducted to study the effect of elevated temperature on mineralization rate of soil organic matter depends upon soil temperature, soil organic matter content and microbial activities. The methodology was designed as average seasonal temperature (open field) and open top plastic chamber (elevated temperature condition). Four different doses of organic manure (5 ton/ha, 10 ton/ha, 15 ton/ha and 20 ton/ha) was applied per square meter within the same open field and chamber replicated thrice. The daily temperature of open field and chamber was taken accordingly. The soil samples were collected every week from all the treatments up to three months to study the trend of mineralization rate. All the soil samples are in laboratory to analyze organic carbon and soil pH so the results of this experiment will be presented in next report.

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 is 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 Okhaldhunga district in 2074/75. Selection of the district was based on the climate change vulnerability index ranking.

Impact of climate change on farm income and food security

Farmers' practically observe changes in the surrounding nature and describe a number of responses to the impacts of climate change. Everyone accepted the changes; however, there was considerable variation among the communities regarding the intensity that they perceived. Because of change in variety and composting, the rice production has increased by 66 percent than past decade.

Change in the cultivation practices of crop in the last 10 years

The study took resident's perception about the changes in the cultivation practices of specific crops. The results showed that the time of sowing and maturity/harvesting of agricultural crops have undergone considerable change. The sowing time for rice, wheat and maize has been delayed by one to two weeks due to the delayed in monsoon by one-two weeks; but the maturity time of rice has been delayed by 2 weeks. In contrast, the sowing and maturity time of other crops as well as vegetables and fruits has not been shifted backward or forward.

Change in agricultural production and food security

Cropping pattern

Most of the farmers had followed maize-finger millet in rainfed area whereas most of the farmers followed maize-rice-wheat and maize-rice-wheat or potato in irrigated low land. They have not significantly changed cropping pattern but with the water harvesting facility, now they are cultivating vegetables in uncultivated land. Due to even climate change impacts on agricultural sectors and inclination of farmers to change in cropping pattern is not observed in Okhaldhunga district.

Perception on climatic factors

The farmers of selected VDCs of Okhaldhunga district were asked whether they had observed any changes in temperature and precipitation over the previous decade.

Most pressing problems and rank in order of Priority

The study took farmer's view about the most pressing problem due to climate change and the priority for action needed to cope up with the problems. As the study area is in hilly region, more than fifty percent respondents reported that cold in winter and hot in summer has been increased, and number of rainy days in both winter and summer has been decreased.

Perception on temperature

Farmers' perception on temperature variation due to climate change varied on Okhaldhunga district. Forty eight percent of farmers responded that winter are cooler now a days than before and 66 percent farmers agreed that summer is getting hotter than the past years.

Table 8. Farmers' perception on seasonal temperature in Okhaldhunga District, 2074/75 (2017/18)

Farmer's Perception	Summer Season, %	Farmer's Perception	Winter Season, %
More hot	66	More cool	48
Same	33	Same	40
Less hot	1	Less Cool	12

Rainfall pattern and Rainfall related disasters: comparison between present and past

Majority of the farmers responded that rainfall magnitude has been decreased in rainy (monsoon) season in Okhaldhunga district. More than ninety percent have experienced a decrease in frequency of rainfall and delay onset of monsoon season, On the other hand, farmers responded that rainfall magnitude has been decreased in other seasons as well. eighty percent of the respondents have a consensus that frequency of rainfall in other seasons have been decreased and total respondents have claimed that duration of rainfall in other seasons have decreased in last 10 years.

Coping strategies against climate change

The adaptation practices were also identified through the field survey. The data and interpretations of local people's adaptation mechanisms against climate change impacts are described below.

Adaptation strategies followed by community against CC impacts

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.

Adaptation strategies in Agriculture sector in Okhaldhunga District

On the response to what adaptation strategies farmers are adapting, 53% of the total responded farmers indicated that the diversified to vegetable production instead of rice and cereal crops is the better adaptation strategy to minimize such weather vulnerability. In Okhaldhunga district, they have no any other coping strategy to minimize such weather vulnerability so it can be concluded that Okhaldhunga district is more vulnerable to climate change effect.

Table 9. Farmers' perception on adaptation strategies in agricultural sector in Okhaldhunga District, 2074/75 (2017/18)

Strategies	Farmer's response (in %)	
	Yes	No
Use of short duration variety of crops	5	95
Diversified to vegetable production instead of rice and cereals crops	53	47
Application of more chemical fertilizers and pesticides	46	54
Use of hybrid/improved crop varieties	7	93
Drought resistant crops	0	100

Issues that community likes to discuss

Only fourty eight percent of the respondents in Okhaldhunga district said that the community would like to discuss on climate change related issues. They are worried about the consequences of climate change on cropping pattern and people's livelihood.

Food security

As the climate change has adverse impact on agricultural sector and cropping pattern, the survey had tried to find out the latest food security condition, surface water availability and the activities or trainings farmers wanted to get for coping up with CC consequences. The results are described below.

Food security condition

Food security in most parts of the country have been affected by the climate change; neverthless, the surveyed districts were more effected .

In Okhaldhunga district, only nine percent farmers had food sufficiency for more than twelve months, 30 percent farmers had food sufficiency for more than nine to twelve months. Similarly, fifteen percent of the respondents had food sufficiency for more than six to less than nine months, whereas only nine percent farmers had food sufficiency for less than three months.

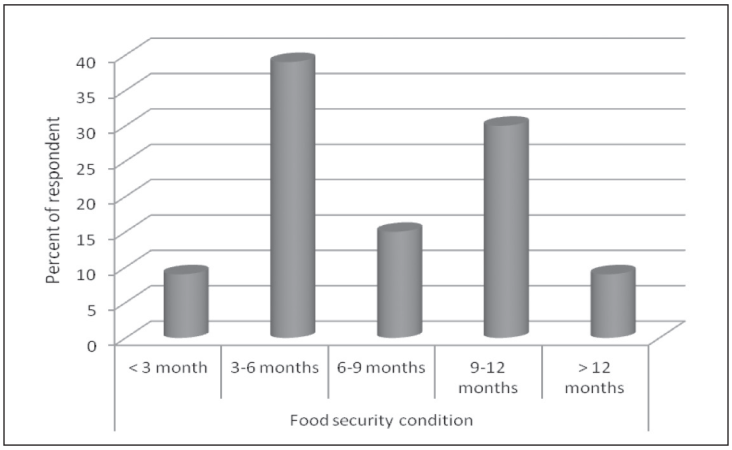


Fig. 3. Farmers' food status in Okhaldhunga district

3.6 Climate Extreme

An event which rarely occurs at a certain place in any time due to atmospheric phenomena is termed as extreme climatic event that causes huge economic and human losses and damages with various environmental disruptions (Alexander and Tebaldi, 2012). Climate extremes are influenced by factors at regional and local scales including urbanization, elevation and proximity to water bodies (Choi, G et al., 2009). Human activities have led to unprecedented changes in the composition of the Earth's atmosphere. We now have credible evidence to show that these changes have the potential to influence Earth's climate ("IPCC. 2013. Climate Change 2013: The Physical Science Basis Contribution of Working Group I to the Fifth Assessment

Report of the Intergovernmental Panel on Climate Change. [In: Stocker T.F, Qin D, Plattner G.K, Tignor M.M, Allen S.K, Boschung J, Nauels A," no date). Although climatological data clearly shows that the Earth is warming, there are significant differences among different regions.

In Nepal, climate extremes are increasingly becoming more pronounced and devastating, they can account for more than half of the total economic and human losses due to natural disasters every year. Thunderstorms, floods, heavy rainfall (resulting in landslides), hailstorms, windstorms, snowstorms, droughts, heat waves and cold waves are the most common climate induced disasters occurring in different seasons and regions. Climate change and its effects can be related to the amount, intensity and frequency of extreme events

Extreme Climate Indices

Climate extremes are the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.

There are hundreds of indicators or indices for extreme climate events devised by many scientists. Among those indices, the Commission for Climatology (CCl) / World Climate Research Programme (WCRP) of World Meteorological Organization, project on Climate Variability and Predictability (CLIVAR) and the Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI), has developed the extreme climate indices for the climate monitoring and detection of change in climate. A total of 27 indices are considered to be core indices for the extreme climate analysis. (http://etccdi.pacificclimate.org/indices.shtml). They are based on daily temperature values or daily precipitation amount (Karl, Nicholls and Ghazi, 1999).

Data and Methodology

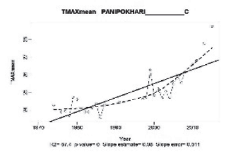
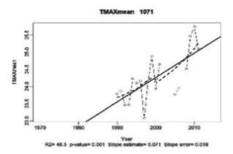
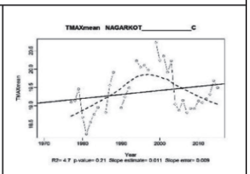
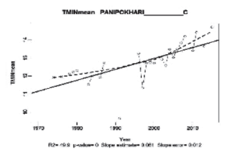
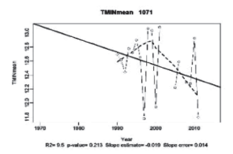
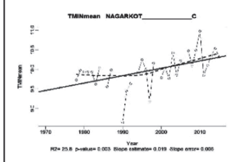
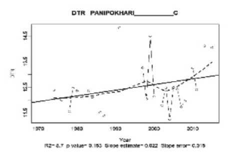
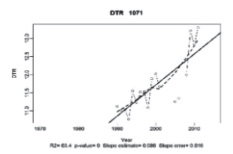
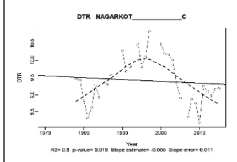
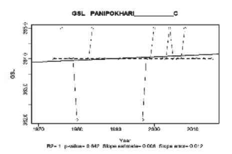
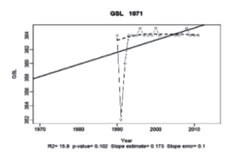
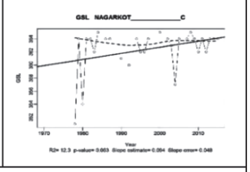
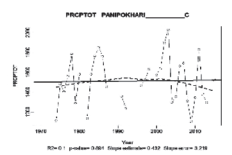
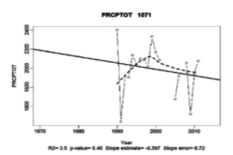
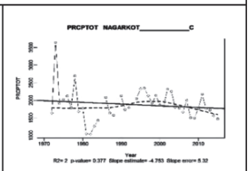
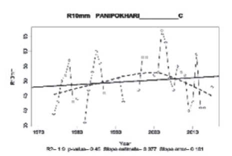
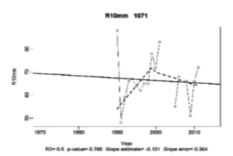
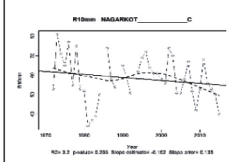
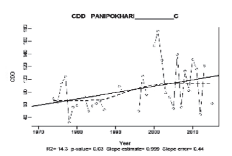
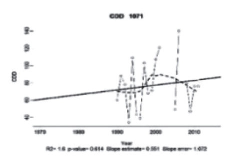
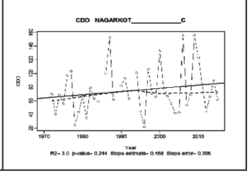
The data used in this study were weather variables such as daily maximum temperature; minimum temperature and precipitation (1970-2015) from Department of Hydrology and Meteorology (DHM), Government of Nepal. In this study only the stations that had the historical records of both temperature and precipitation data for the period of 1970-2015 is considered. Therefore, three climatological stations within the Kathmandu valley were selected for the study. The following procedures were used to handle missing data for a station (Karl et.al 1995): i) If 5 years of random or 3 years of continuous data missing were rejected ii) If more than 15 days of missing values within a year was rejected iii) If more than 3 days of missing value in a month was rejected and monthly value was not calculated.

The data quality was evaluated whether the recorded data were consistent with actual precipitation values (i.e., above 0 mm) and whether the daily maximum temperature less than the minimum temperature and vice versa. Data quality was further checked by using RClimdex software (WMO-ETCCDI, 2009), which identifies potentially unrealistic climatic records, such as negative values of daily temperature range, outliers (typically exceeding 4 standard deviations difference from the mean), and negative values for daily precipitation.

This study considered the analysis of extreme temperature and precipitation events using 4 temperature and 3 precipitation indices out of the total 27 extreme climate indices set by the World Meteorological Organization (WMO) Commission for Climatology and the Research Program on Climate Variability and Predictability (CCl/CLIVAR) Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI). The four temperature indices include Growing Season Length (GSL), Diurnal Temperature Range (DTR). Similarly, precipitation indices include number of heavy precipitation days (R10) and Consecutive Dry Days (CDD) and annual total wet-day precipitation (PRCPTOT). The definitions of indices are as follows.

ID	Indicator Name	Definitions	Units
Temperature Indices			
DTR	Diurnal temperature range	Monthly mean difference between maximum temperature (TX) and monthly mean temperature (TN)	°C
GSL	Growing Season Length	Annual (1st Jan to 31st Dec in NH) count between first span of at least 6 days with TG > 5°C and first span after July 1 (in NH) of 6 days with TG < 5°C	Days
Precipitation Indices			
PRCPTOT	Annual total wet-day precipitation	Annual total PRCP in wet days (RR >= 1mm)	mm
R10	Number of heavy precipitation days	Annual count of days when PRCP >=10mm	Days
CDD	Consecutive dry days	Maximum number of consecutive days with RR <1mm	Days

In addition to above mentioned indices graphs regarding temperature indices viz. monthly mean of maximum temperature (TMAXmean) and that of minimum temperature (TMINmean) are depicted in following table.

ID	Panipokhari	Budhanilkantha	Nagarkot
Temperature Indices			
TMAXmean			
TMINmean			
DTR			
GSL			
Precipitation Indices			
PRCPTOT			
R10			
CDD			

Results and Discussions

The results show that the amount, frequency, intensity and duration of temperature and precipitation related extreme events are fluctuating in all three stations. The precipitation extremes show increasing trend in total and heavy precipitation events at all the stations. Annual precipitation showed a decreasing trend at Budhanilkantha and Nagarkot Stations whereas seems almost constant at Panipokhari station. Number of heavy precipitation (R10mm) days is in decreasing trend at Budhanilkanta and Nagarkot but it is in increasing trend at Panipokhari. The evidence suggests complex processes in precipitation extremes, but at the same time there is indication that more weather related extreme events like floods, landslides can be expected in future.

General increasing trend has been observed in the temperature extremes. The noticeable feature in the long-term temperature record is that mean maximum temperature trend is increasing at all three stations. The trend in mean minimum temperature are slightly mixed. The trend for mean minimum temperature is decreasing only at Budhanilkantha station and that is increasing at other two stations. The graphs for consecutive dry days as well as growing season length shows increasing trend at all three -Budhanilkantha, Nagarkot and Panipokhari stations. It can be seen on the graph that the maximum value for consecutive dry days within study period is found 121 at 2001 AD for Budhanilkantha station. Diurnal temperature range shows increasing trend at Budhanilkantha and Panipokhari stations but shows decreasing trend at Nagarkot.

The findings of this analysis offer strong evidences of changing climate in Kathmandu valley. The results provide reliable information for understanding climate extremes in Kathmandu valley and will be useful for planning and management of disasters and climate adaptation programs.

References:

Alexander, L. and Tebaldi, C. (2012) “Chapter 10 - Climate and Weather Extremes: Observations, Modelling, and Projections BT - The Future of the World’s Climate (Second Edition),” in. Boston: Elsevier, pp. 253–288. doi: https://doi.org/10.1016/B9780-12-386917-3.00010-5.

Choi, G. *et al*. (2009) “Changes in means and extreme events of temperature and precipitation in the Asia-Pacific Network region, 1955-2007,” International Journal of Climatology, 29(13), pp. 1906–1925. doi: 10.1002/joc.1979.

Hyndman, R.J., and Y. Fan, 1996: Sample quantiles in statistical packages. The American Statistician, 50, 361-367.

Karl, T. R., Nicholls, N. and Ghazi, A. (1999) “CLIVAR/GCOS/WMO Workshop on Indices and Indicators for Climate Extremes Workshop Summary BT - Weather and Climate Extremes: Changes, Variations and a Perspective from the Insurance Industry,” in Karl, T. R., Nicholls, N., and

Ghazi, A. (eds.). Dordrecht: Springer Netherlands, pp. 3–7. doi: 10.1007/978-94-015-9265-9_2.

Ministry of Environment (2010). National Adaptation Programme of Action to Climate Change. Kathmandu, Nepal.

National Climate Change Policy, 2011: Government of Nepal.

www.clivar.org: Climate and Ocean-Variability, Predictability and Change.

Zhang, X., G. Hegerl, F.W. Zwiers, and J. Kenyon, 2004: Avoiding inhomogeneity in percentile-based indices of temperature extremes. J. Climate, submitted.

4. TECHNOLOGY TRANSFER AND SERVICES

Services

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

Publications

Besides the annual report publication of division, 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 Trichandra Multiple Campus, 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.

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 6 to Annex 7. Revenue generated from various activities and Beruju status of the division is provided in Annex 8 and Annex 9, respectively.

8. KEY PROBLEMS

- Insufficient technical human resources to represent 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 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 researches.
- Coordination with different organizations to provide agro-met advisory based on weather forecasting for agriculture use.

10. REFERENCES

Hensen *et al*., 2000. Global Warming in the Twenty first century: An alternative scenario. Proc. Natl. Acad. Sci.

LIoyd and Taylor, 1994. On the Temperature Dependence on Soil Respiration, Functional Ecology, Vol. 8, No. 3, (June, 1994), pp 315-323.

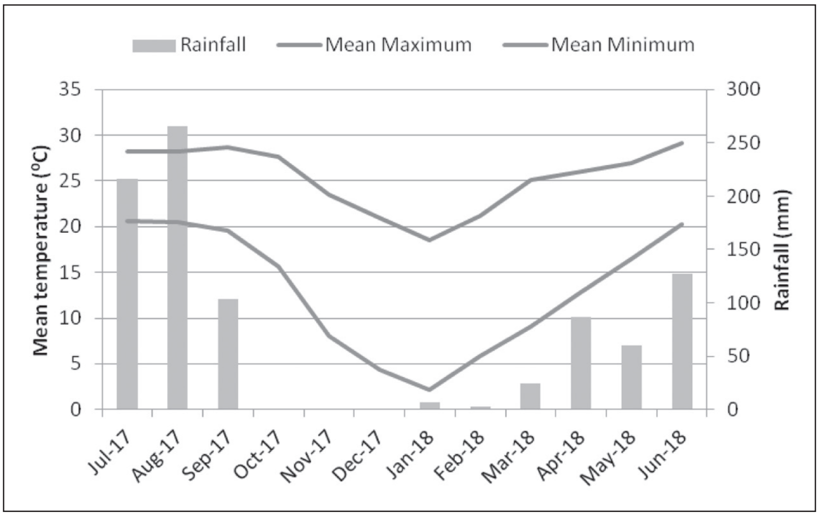


Figure 4: Temperature and rainfall pattern at Khumaltar, 2074/2075 (2017/18)

11. ANNEXES

Annex 1. Human Resources, 2074/75 (2017/18)

S.N.	Name of the Staff	Designation	Remarks
1	Dr. Deepak Bhandari	Principal Scientist (S-5)	Chief
2	Mr. Ghanashyam Malla	Senior Scientist (S-4)	Deputed from AD
3	Mr Bishnu Prasad Paudel	Senior Scientist (S-3)	
4	Dr. Amit Prasad Timilsina	Scientist (S-1)	Deputed from HCRP
5	Mr. Rameshwar Rimal	Technical Officer (T-6)	
6	Mr. Alok Sharma	Technical Officer (T-6)	On study leave
7	Mrs. Mandira Chitrakar	Admin. Officer (A-6)	
8	Mr. Prabhat Sah	Account Officer (A-6)	
9	Mr. Achyut Gairhe	Technical Officer (T-6)	PPCR/BRCH/AMIS
10	Mr. Hem Lal Bhandari	Technician (T-5)	
11	Mr. Raj Kumar Chalise	Driver	Deputed from NASRI
12	Mrs Reena Maharzan	Lower Technician	

Annex 2. Summary of Progress of NARC Research Projects and Activities, 2074/75 (2017/18)

Project code number	Name of project/activity	Project/ Activity Leader	End Year	Major progress/achievements
32970002	**Vulnerability of climate change in agriculture**	**D Bhandari**	**Continuous**	
Activity 1	Collection, analysis and dissemination of agro- meteorological database of various locations of Nepal	R Rimal	,,	Meteorological database of 11 stations of NARC collected and analysed (Average precipitation, max and min temp).
Activity 2	Weather vulnerability assessment in farmers perspective	B P Paudel	,,	Survey conducted in Okhaldhunga district. Farmers' perception is that summer is becoming hot and cooler winter.
Activity 3	Crop vulnerability study under different climatic variability	G Malla	,,	Among the varieties, Khumal-8 performed highest grain yield of 5.9 ton/ha in both open field and chamber condition.
Activity 4	Crop management study under changing climatic parameters	G Malla	,,	Wheat variety Swargadwari performed better than other varieties like WK-1204, Swargadwari and Dhaulagiri under elevated temperature in OTC. Yield of wheat variety Danphe was lowest among varieties.
Activity 5	Estimation of GHGs emission from pasture agricultural land and livestock sectors	H Bhandari		The CO_2-C flux was recorded the highest of 70 mg/ha/hr on vegetable crop (Lady's finger) and the lowest of 19 mg/ha/hr in Chilli at Lamjung District.

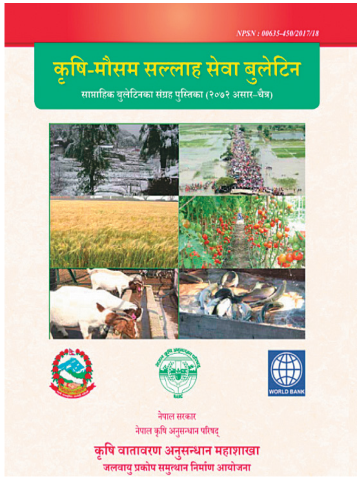
Project code number	Name of project/activity	Project/ Activity Leader	End Year	Major progress/achievements
Activity 6	Effect of temperature on mineralization rate of soil organic matter	BP Paudel		An experiment was conducted with four treatment in open field and chamber condition. Soil samples were collected every week and the results will be presented in next report
Activity 7	Estimation of atmospheric C sequestration by fruit plants and in orchard	G Malla	,,	Mango tree in terai farm is highly potential to carbon sequestration (1.87 ton/yr/tree) whereas only 0.106 ton/year/tree was sequestrated by Orange in Palpa District.
32900001	**FMP/AOE 329**	**Division Chief**	**Time bound**	**Activities accomplished**
Activity 1	Farm security	Division Chief		Farm security well maintained
Activity 2	Research support (admin Lab services, etc)	,,	,,	All research supports made available as per requirements
Activity 3	Annual Report Publication	B.P.Paudel	,,	100 units of Annual Report was Published

Annex 3. Summary progress of special research projects and activities, 2074/75 (2017/18)

Name of project /activity	roject/ Activity Leader	Begin Year	End Year	Major progress /achievements
PPCR	D Bhandari	2014	2019	Publication of Weekly Agro-met based advisory bulletin for 25 Districts (Jhapa, Morang, Sankhuwsabha, Dhankuta, Sunsari, Saptari, Siraha, Dolakha, Mahottari, Kavrepalanchoke, Bara, Dhading, Chitawan, Kaski, Mustang, Palpa, Rupandehi, Rukum, Dang, Banke, Surkhet, Jumla, Kailali, Doti and Darchula).
HELVETAS				Four drought tolerant rice varieties were distributed to validate climate resilient technologies. A training program to farmers was conducted in Dolakha.

Annex 4. Publications, 2074/75 (2017/2018)

SN	Title of publication	Type	Language	Author	No. of copies
1.	Annual Report 2073/74 (2016/17). Agricultural Environment Research Division, Khumaltar, Lalitpur, Nepal	Report	English	Agricultural Environment Research Division, Khumaltar	100
2.	कृषि मौसम सल्लाह सेवा वुलेटिन	सँग्रह पुस्तिका	नेपाली	विषय विशेषज्ञ समूह	



Annex 5. Training/workshop/seminar attended by staff, 2074/75 (2017/18)

SN	Name of staff	Position	Name of Training/seminar/workshop	Duration	Place/ Country	Organizer
1.	Mr. Ghanshyam Malla	S. Scientist (S4)	Interaction with ILRI Scientist and to introduce NARC Scientist With the activities of ILRI in South Asian Region	15-19 Feb, 2018	India	CSIP-Nepal
2.	Mr. Bishnu P Paudel	S. Scientist (S3)	Good Agricultural Practices (GAP) Assessor/Auditor Training	26-28 Dec, 2017	Nepal	FRD
3.	Mr. Bishnu P Paudel	S. Scientist (S3)	Training and Workshop on Experimental Design Statistical Procedure Using R	20-24 May, 2018	Nepal	SSD
4.	Dr. Amit P Timalsina	Scientist (S1)	Crop Modelling Training	25-29 June, 2018	Nepal	PPCR

Annex 6. Regular annual budget and expenditure,(NARC) 2074/75 (2017/18)

Budget Code	Budget heads	Annual Budget	Expenses	Balance	
21* **	**Staff expenses**				
21111	Basic Salary	5165573.70	5165573.70	00.0	
21113	Allowance	132000.0	126918.0	5082.0	
21119	Other allowance	0.0	0.0	0.0	
21121	Cloth	90000.0	82500.0	7500.0	
22* **	**Operational and Administrative expenses**				
22111	Water and electricity	42000.0	39057.89	2942.11	
22112	Communication	112000.0	110285.0	1715.0	
22211	Fuel vehicle	335000.0	334758.0	242.0	
22212	Operation maintenance	370000.0	366833.57	3166.43	
22213	Insurance	20000.0	20000.0	0.0	
22311	Office expenditure	500000.0	490131.95	9868.05	
22314	Fuel others	40000.0	10350/0	29650.0	
22321	Existing Assets	Maintenance	0.0	0.0	0.0
22412	Other service	452000.0	422299.0	29701.0	
22521	Production materials/ Service expenditure	1250000.0	1153492.80	96507.20	
22612	Travel expenses	550000.0	546839.0	3161.0	
22711	Contingency	60000.0	59000.0	1000.0	
	Total	**9621000.0**	**8977892.81**	**643107.19**	
29* **	**Capital expenses**				
29231	Capital Improvement	0.0	0.0	0.0	
29311	Furniture and Fixers	30000.0	24408.0	5592.0	
29411	Vehicle	0.0	0.0	0.0	
29511	Machinery and Equip	577000.0	563338.90	13661.10	
	Total	**607000.0**	**587746.90**	**19253.10**	
	Grand Total	**10228000.0**	**9565639.71**	**662360.29**	

Annex 7. Special project (PPCR/BRCH/AMIS-NARC Project) Budget and expenditure, 2074/75 (2017/18)

Budget Code	Budget heads	Annual Budget		Expenses		Balance
		Gov. Nepal	IDA	Govt. Nepal	IDA	
2100	**Labour Expenses**					
21111	Basic Salary		1223000.0		792197.0	430803.0
21113	Allowance		36000.0		24207.0	11793.0
21119	Other Allowance		1505000.0		1105200.0	399800.0
21121	Cloth		23000.0		7500.0	15500.0
2200	**Operational Expenses**					
22111	Water and electricity					
22112	Communication					
22122	Other Rent		400000.0		211490.0	188510.0
22211	Fuel vehicle		255000.0		121132.0	133868.0
22212	Operation maintenance		200000.0		199775.0	225.0
22311	Office expenditure		510000.0		501490.0	8510.0
22313	Publications (Books and others)		800000.0		480024.0	319976.0
22411	Service and consultant					
22412	Other service					
22511	Staff training					
22512	Workshop (skill, people, awareness)	154000.0	2846000.0		0.0	3000000.0
22522	Program expenditure	125000.0	2731000.0		2061406.0	794594.0
22611	Monitoring evaluation		500000.0		148407.0	351593.0
22612	Travel Expenses		300000.0		280462.0	19538.0
22711	Contingency	85000.0	425000.0		381411.0	128589.0
	Total	**364000.0**	**11754000.0**		**6314701.0**	**5803299.0**
2900	**Capital Expenses**					
29311	Furniture and fixtures	65000.0	435000.0	63939.44	432503.74	3556.82
29411	Vehicle	250000.0	0	217900.0	0	32100.0
29511	Machinery & equipment Vehicles	594000.0	3966000.0	492000.0	3789931.6	278068.40
29611	Construction					
29612	Capital improvement					
29712	Software Expenses	400000.0		378521.75		21478.25
	Total	**1309000.0**	**4401000.0**	**1152361.19**	**4222435.3**	**335203.47**
	Grand Total	**1673000.0**	**16155000.0**	**1152361.19**	**10537136**	**6138502.4**

Annex 8. Special project: Food and Agriculture Organization (FAO) Project budget and expenditure, 2074/75 (2017/18)

Budget Code	Budget heads	Annual Budget	Expenses	Balance
2100	**Labour Expenses**			
21111	Basic Salary	0.0	0.0	0.0
21113	Allowance	0.0	0.0	0.0
21119	Other Allowance	460000.0	413000.0	47000.0
21121	Cloth			
2200	**Operational Expenses**			
22111	Water and electricity	0.0	0.0	0.0
22112	Communication	5000.0	0.0	5000.0
22122	Other Rent	0.0	0.0	0.0
22211	Fuel vehicle	0.0	0.0	0.0
22212	Operation maintenance	0.0	0.0	0.0
22311	Office expenditure	30000.0	0.0	30000.0
22314	Fuel others			
22411	Service and consultant			
22412	Other service			
22511	Staff training			
22512	Workshop (skill, people awareness)			
22522	Program expenditure			
22611	Monitoring evaluation			
22612	Travel Expenses	30000.0	0.0	30000.0
22711	Contingency	30000.0	29850.0	150.0
2900	**Capital Expenses**			
29311	Furniture and fixtures			
29411	Vehicle	500000.0	489800.0	10200.0
29511	Machinery &equipment Vehicles			
29611	Construction			
29612	Capital improvement			
29712	Software Expenses			
Total		**1055000.0**	**932650.0**	**122350.0**

Annex 9. Special project (Prayas- HELVETAS) Project budget and expenditure, 2074/75 (2017/18)

Budget Code	Budget heads	Annual Budget	Expenses	Balance
2100	**Labour Expenses**			
21111	Basic Salary	0.0	0.0	0.0
21113	Allowance	0.0	0.0	0.0
21119	Other Allowance	270000.0	270000.0	0.0
21121	Cloth			
2200	**Operational Expenses**			
22111	Water and electricity	0.0	0.0	0.0
22112	Communication	0.0	0.0	0.0
22122	Other Rent	60000.0	37230.0	22770.0
22211	Fuel vehicle	20000.0	11501.0	8499.0
22212	Operation maintenance	10000.0	8707.0	1293.0
22311	Office expenditure	70000.0	30000.0	40000.0
22314	Fuel others			
22411	Service and consultant			
22412	Other service			
22511	Staff training			
22521	Production materials	70000.0	20270.0	49730.0
22521	Production, Labour	15000.0	0.0	15000.0
22512	Workshop (skill, people awareness)	500000.0	184740.0	315260.0
22522	Program expenditure			
22611	Monitoring evaluation			
22612	Travel Expenses	200000.0	45600.0	154400.0
22711	Contingency	10250.0	0.0	10250.0
2900	**Capital Expenses**	0.0	0.0	0.0
29311	Furniture and fixtures			
29411	Vehicle			
29511	Machinery &equipment Vehicles			
29611	Construction			
29612	Capital improvement			
29712	Software Expenses			
Total		**1225250.0**	**608048.0**	**617202.0**

Annex 10. Revenue status, 2074/75 (2017/18) (*In Nepalese Rupees*)

Source	Total	Remarks
Administration Income	36000.00	
Research materials	1170.00	
Grand Total	**37170.00**	

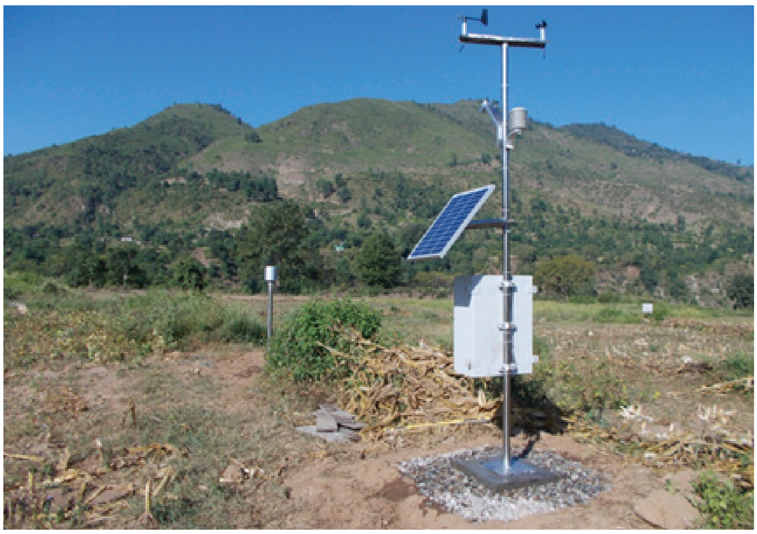
Annex 11. Beruju status, 2074/75 (2017/18) (*In Nepalese Rupees*)

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

Preparation of Agro-Advisory Bulletin

Regional Interactive seminar at Bhadrapur, Jhapa

Collection of CO2-C emission from rice field



Automatic Weather Station at RARS, Doti