A Report

On

Consulting Services for Climate Change Impact Study

On IWRMP Sub-projects of Mustang District

Report Submitted to:

Irrigation and Water Resource Management Proect-AF

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Similarly, we are grateful to the Board Members and Portfolios of local cooperatives, Irrigation Consumer Groups, Local farmers for sharing their experiences about apple farming.

List of Abbreviations

ACAP-Annapurna Conservation Area Project

CCNP-Climate Change National Policy

CO_2-Carbondioxide

DADO-District Agriculture Development Office

IDSD-Irrigation Development Sub Division

IPCC-Intergovernmental Panel on Climate Change

ISP-IWRMP Sub Project

IWRMP-Irrigation and Water Resource Management Project

LPCB-Lactophenol cotton Blue

MoEST-Ministry of Environment, Science and Technology

NTNC-National Trust for Nature Conservation

NARC-National Agriculture Research Council

PDA- Potato Dextrose Agar

PPM-Parts Per Million

UNFCCC-United Nations Framework Convention on Climate Change

USDA-United States Department of Agriculture

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Abstract

Mustang district is the capital of Apple production. Like other parts of the world, climate change has hit seriously to the apple production in Mustang also. So, the team aimed to study various impacts of climate change in three different sub-projects of Irrigation and Water Resources Management Project (IWRMP) namely; Syang ISP, Jhongputak ISP and Namgel ISP.

Various methodologies like discussion with concerned stakeholders, field survey and laboratory tests methods were adopted to access the impacts of climate change in the assigned area.

It was found that there is increased incidence of various pests, pathogens and disease which is pushing Apple farming to danger. Similarly, changes were also noticed in the hydrological cycle. The intensity of rainfall is increasing while the snow falling tendency is decreasing. This effect is also putting pressure in the apple farming.

Despite having these challenges, local people are extending their apple farms since it is a good source of income for tiny size of population. But people are unaware of the mitigating measures of climate change and they seem to adopt no any measures against climate change.

Chapter 1: Introduction

1.1 Background

Climate change refers to a change in the statistical distribution of weather pattern which may be due to natural processes, external factors or by anthropogenic changes in the composition of the atmosphere[1]. According to IPCC, the average temperature of the earth's surface has risen by 0.74 degree Centigrade since the late 1800s. There has been an unprecedented warming trend during the 20th century and its effect is increasing at alarming rate. Fourth Assessment Report of IPCC 2007 concluded that the main cause of climate change is due to increase in greenhouse gas concentrations. The average atmospheric CO_2 concentration has increased from 280 ppm in 1850 AD to 365 ppm at present. It could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates[1]. According to report of IPCC 2001, the vulnerability is highest for least developed countries in the tropical and subtropical areas. Hence, the countries with the fewest resources are likely to bear the greatest burden of climate change in terms of loss of life and relative effect on investment and the economy. The global biodiversity is under the risk due to the impacts of the change in climate. The effects of climate change are wide ranging and possibly severe which includes melting of polar ice caps resulting in the rise in sea level, changes in temperature and precipitation pattern.

Response to climate change in Nepal is growing gradually. Action to reduce human contribution to the changing climate are slowly happening but they so far seem too few and too limited to make difference to climate change. Nepal is more vulnerable to the effects of climate change as the major at lies in the Himalayan range. Although Nepal is responsible for only about 0.025% of total annual greenhouse gas emissions of the world, it is experiencing the increasing trends and the associated effects of climate warming. It already observed such as increase in dry period, intense rainfall, flood, landslides, forest fires, glacial retreats. Nepalese livelihood is greatly dependent on agriculture by more than 80% therefore climate change has brought wide range of negative impacts[2]. The severity of effects is widely seen mainly in hilly and mountainous areas of Nepal where the farmers rely on agricultural farming. Developing countries are more vulnerable to the effects of climate change due to its high dependence on climate-sensitive sectors like glaciers, agriculture and forestry, and its low financial adaptive capacity[3]. Developing countries like Nepal are more susceptible to the climate change and its impacts due to their limited capacity to cope with hazards associated with the changes in climate[4]. Nepal has good

reasons to be concerned about climate change. Over two million Nepalese people depend on climate sensitive sectors like agriculture and forestry for their livelihood [5].

In recent years, climate change and its negative effects are affecting in different sectors like water resources, agriculture sector, flora and fauna, health sector, and livelihood. Agricultural productivity has been greatly affected by changes in temperature and precipitation will result in changes in land and water regimes[6]. Although no long term change in climate has been observed, a study by the Department of Hydrology and Meteorology revealed that the average temperature in Nepal is increasing at a rate of approximately 0.06 degree centigrade per year. Increased CO_2 level, global temperature, altered rainfall pattern, affected soil erosion (which are components of climate change) will greatly effect on agriculture ecosystems and food security. The average temperature recorded at the Himalayan region shows an increase in temperature by 1.5ºC with more warming on higher elevation[7]. Scientists reported that the annual temperature is increasing in progressive manner with higher increasing rate in High Himalayan region since 1962. Nepalese agriculture is extremely vulnerable to increasing climatic variations. Due to rapid population growth, shrinking farm size in the terai region, and continued unplanned agriculture in areas prone to climate risks are likely to increase the exposure and loss of livelihood[8]. The variations in monsoon rainfall, intense rainfall events, longer droughts, rapid snow and ice melting from glaciers, expansion of glacier lakes have also been observed widely. Thus, climate change has become of the global challenge of the century[9].

1.1.1 Climate change causes and its effect

The current global warming trend is hugely caused human activities. Industrial revolution is one of the major cause that results in the huge impact in the climate change. Industries like cement factories, brick factories, chemical fertilizers factories, coal and mine factories produces huge amount of harmful particles that pollute the atmosphere and aids in the global warming. Burning of fossil fuels, such as oil and coal, gases Carbon dioxide, carbon monoxide, nitrous oxide, methane, etc. which emits greenhouse gases into the atmosphere has great potential to increase greenhouse effect. Oceans are vital ‘carbon sinks’, meaning that they absorb huge amounts of carbon dioxide, preventing it from reaching the upper atmosphere. Increased water temperatures and higher carbon dioxide concentrations than normal, which make oceans more acidic, are already having an impact on marine ecosystems. Other human activities, such as deforestation, also contribute to the proliferation of greenhouse gases. Due to deforestation there is decrease in water retaining

capacity of the land and the rate of evaporation as well. This ultimately affects the natural condition of the climate. Another main reason of climate change is air pollution. The major composition of air pollution is dust and smoke, a mixture of carbon monoxide and organic compounds formed by the combustion of fossils fuels. As dust and smog ages and reacts with oxygen, it condenses in the form of droplets which increases the haze. This disrupts the visibility of the atmosphere as well as evaporation rate leading to the change in the temperature of the atmosphere. Rising of the seas and increased coastal flooding, more frequent and intense heat waves resulting in drought, dry, desert climate, an increase in extreme weather events like hurricanes, cyclones, tornados, storm, heavier precipitation, change in seasonal patterns, plants and animals range are some of the notable effects of climate change. Global warming is already having significant and costly effects on our communities, our health and our ecosystem. The global biodiversity is already on a potential risks and threats. Already helmed by habitat loss, pollution and overexploitation, the species and natural system are now facing with the need to adopt to the new regimes. Unless we take immediate action to reduce global warming emissions, these impacts will continue to intensify, grow even more costly and damaging which ultimately affect the entire planet.

1.2 Climate change and its impact on agriculture and cost of adaptation:

The unimpeded growth of greenhouse gases emission is raising the earth temperature. The accelerated pace of climate change combined with global population and income growth threaten food security everywhere. Agriculture is extremely affected by the climate change. Higher temperatures eventually reduces the yield of desirable crops while encouraging weed and pest's evolution and proliferation. The ranges and distribution of weeds and pests are likely to increase with climate change. This could cause new problems for farmers' crops previously unexposed to these species. Although, rising CO_2 can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric carbon dioxide reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice. This direct effect of rising CO_2 on the nutritional value of crops represents a potential threat to human health. Human health is also threatened by increased pesticide use due to increased pest pressures and reductions in the efficacy of pesticides. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change

on agriculture are expected to be negative, threatening global food security. Populations in the developing world, which are already vulnerable and food insecure, are likely to be the most seriously affected. Rising temperatures and changes in rainfall patterns have direct effects on crop yields, as well as indirect effects through changes in irrigation water availability. Climate change will have a direct impact on water availability for irrigated crops. Climate change-induced higher temperatures increase the water requirements of crops. The proper need of water for agriculture cannot be met and ultimately it hugely impacts on yields and production.

1.3 Study Area

Mustang:

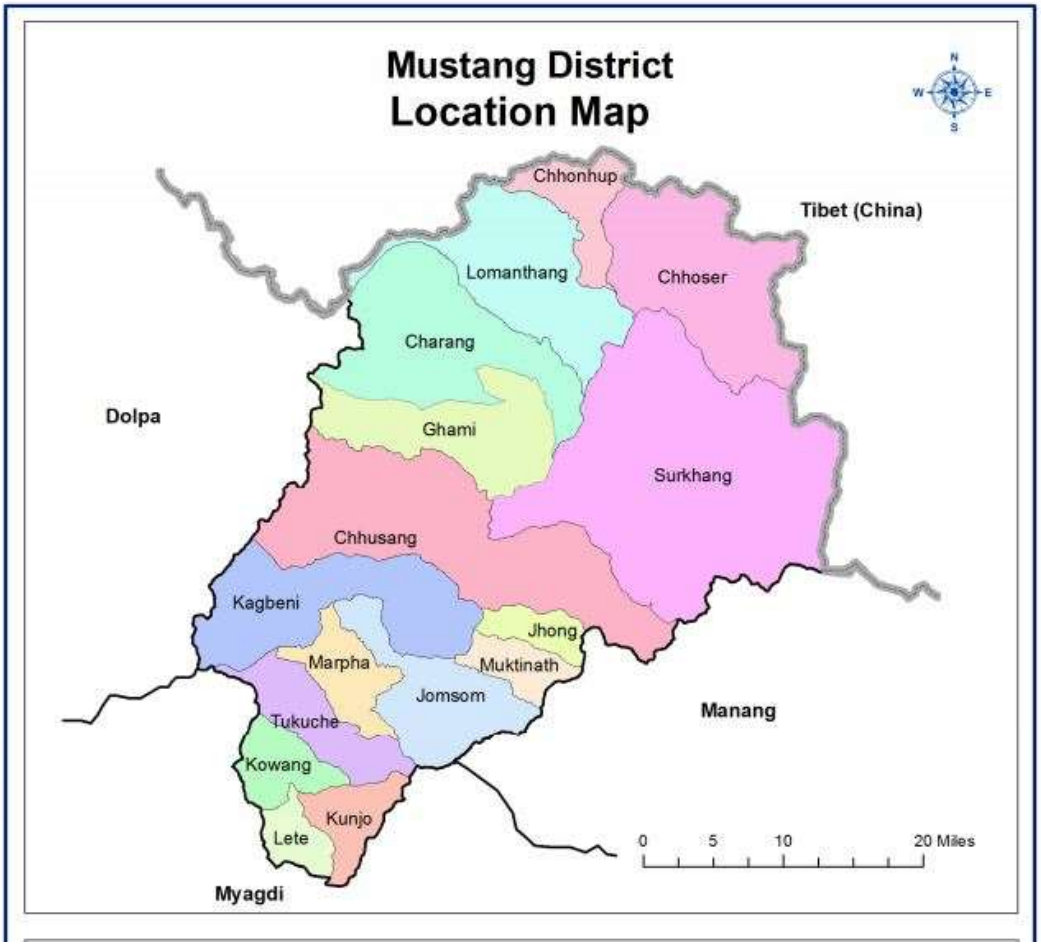


Figure 1: Political map of Map of Mustang District

Mustang is an amazingly beautiful geological location with mesmerizing scenery surrounded by 360º mountain view located on the lapse of Himalayas where abundance of Jurassic-era fossils that can be found lying around. The curly, ridged ammonite fossils are

a multi-million year old reminder of what the earth was once like, before the Himalayas were formed is the main attraction point in Mustang. Mustang district is located in the Province No. 4 in Nepal. Mustang district is located in between 28º 33' 51" North to 29º 19' 52" North latitude and 83º 28' 54" East to 84º 14' 58" East longitude. The district, with Jomsom as its headquarters, covers an area of 3,573 sq. km. The total population of the mustang district according to census 2068 is 13452.Major cast of people living in Mustang district according to National Census 2068 include Gurung (21.44%), Thakali (18.84%), Lhopa (18.67%), Dalit (12.11%), Magar (8.4%), Chhetri (7.13%), Brahmin (3.67%), Tamang (2.26%), Newar (0.98%). The main occupation of the people living in Mustang district are agriculture, animal husbandry, trade, tourism, etc. The Mustang district also includes the Himalayas and extends northward onto the Tibetan plateau. Mustang is one of the remotest areas in Nepal and one of the sparsely populated region of Nepal. The entire district is included within the Annapurna Conservation Area the largest protected area of Nepal. Development programs, tourism management, and so on are under the concern of Annapurna Conservation Area Project (ACAP), a division of the National Trust for Nature Conservation (NTNC). Mustang lies at a lower altitude of 2,500m to the higher altitude at 8,167m the summit of Dhaulagiri.

1.3.1 Geographical divisions of Mustang district:

According to Nation Trust for Nature Conservation (NTNC), Mustang is divided into 3 zones.

i. **Northern Area/Upper Mustang:** It includes the upper Mustang and covers 58.12 percent of total area of Mustang district and is characterized by dry, arid climate and cold desert type landscape. Due to cold climatic conditions, water scarcity and poor irrigation facilities, majority of the villages in this area harvest crops only once a year. This area includes Ghami, Charang, Lo-Manthang, Chhosher, Chhonup and Surkhang.

ii. **Central Area/ Lower Mustang:** This region with the area of 36.06 percent also falls under the rain shadow area but has better moisture condition as compared to the Northern Area. The villages in this area are either located along the Kali Gandaki river or on the surrounding valley side slopes. Majority of villages in this area have better irrigation facilities and harvest crops twice a year. Thus, this area is by far the most productive region in the entire district and includes Tukuche, Marpha, Jomsom, Kagbeni, Muktinath, Jhong and Chhusang.

iii. **Southern Area/Lower Mustang**: This area cover with 5.81 percent of total land, receives more rain than the Northern and Central areas. Due to relatively more favourable amount of rainfall, the landscape in this area is covered by evergreen forests, particularly pine and far species and sub-tropical, temperate and alpine types of climate in this area. This area includes Kowang, Kunjo and Lete.

The area receives an average annual rainfall of less than 260 mm at Jomsom in the Lower Mustang. Spring and autumn are generally dry, but some precipitation is brought by summer monsoons. The mean minimum monthly air temperature falls to -2.7 °C in winter while the maximum monthly air temperature reaches 23.1 °C in summer.

Only about 40.3 square kilometers, about 1 percent of the total land area, is cultivated and 1,477 square kilometers, about 40%, is pasture land. The Kali Gandaki River is the principal river and is the source of water for irrigation in the areas. It flows south towards the northern Indian plains through the ancient kingdom of Mustang. Mustang is also known as the capital of apples in Nepal. District Agriculture Development Office (DADO) reports that despite the fact that a total of 1,115 hectares of land is considered suitable for apple-farming in Mustang, apple is planted in only 415 hectares of land. Barley, wheat and buckwheat are grown in terraced farms, while vegetables and fruits are grown in orchard.

1.4 Apple: The main Cash crop

Apple (*Malus domestica*) are pomaceous fruits produced by apple tree that belongs to the *Rosaceae* family. Apples are some of the most popular and delicious fruits on the planet. Apples are generally found at 1800-5000m above the sea level. They grow in soils that are well supplied with water and grows at pH levels of 5.5-8.5.

1.4.1 Nutritional Facts: Raw apples with skin- 100gms

Table 1: Nutritional facts of raw apple

Energy - 52 kcal	Carbohydrates - 13.81 g
Fat - 0.17 g	Protein - 0.26 g
Water - 85.56 g	Sodium - 1 mg
Beta-carotene - 27 µg	Lutein and zeaxanthin - 29 µg
Thiamin (vitamin B1) - 0.017 mg	Vitamin A equiv - 3 µg
Riboflavin (vitamin B2) - 0.026 mg	Niacin (vitamin B3) - 0.091 mg
Pantothenic acid (vitamin B5) - 0.061 mg	Vitamin B6 - 0.041 mg
Folate (vitamin B9) - 3 µg	Vitamin C - 4.6 mg

Source:USDA

There are more than 7,500 varieties of these delicious fruits and they come in a variety of colors namely red, yellow, and green. Apples are free of fat, sodium, and cholesterol. Antioxidants, high dietary fiber, vitamin C, and a few vitamin B are responsible for the long list of health benefits attributed to apples. They are energy-dense and water-rich fruits. They are rightly called 'nutritional powerhouse'.

The other important nutrients in apple include vitamin K, potassium, copper, manganese, and magnesium. Apples are very good sources of dietary fiber and single serving provides 12% of the daily fiber requirement.

1.4.2 Standard for apples

Minimum requirements: In all classes, subject to the special provisions for each class and the tolerances allowed, the apples must be:

- Whole, the stalk (stem) may be missing, provided the break is clean and the adjacent skin is not damaged
- Clean, practically free of any visible foreign matter;
- Practically free of pests and damage caused by them affecting the general appearance of the product
- Free of abnormal external moisture, excluding condensation following removal from cold storage
- Free of any foreign smell and/or taste
- Free of damage caused by low and/or high temperatures
- Practically free of signs of dehydration
- The apples must have colour that is characteristic of the variety and the area in which they are grown. The development and condition of the apples must be such as to enable them to withstand transport and handling and to arrive in satisfactory condition at the place of destination.

1.4.3 Classification

In accordance with the defects allowed Maximum Allowance for Defects, apples are classified in three classes defined below:

Extra class: Apples in this class must be of superior quality. The flesh must be sound. They must be free of defects, with the exception of very slight superficial defects, provided

these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package.

Class I: Apples in this class must be of good quality. The flesh must be sound. The following slight defects, however, may be allowed, provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package.

- A slight defect in shape and development
- A slight defect in colouring
- Slight skin or other defects

Class II: This class includes apples which do not qualify for inclusion in the higher classes, but satisfy the minimum requirements. The following defects, however, may be allowed, provided the apples retain their essential characteristics as regards the quality, the keeping quality and presentation.

- A slight defect in shape and development
- A slight defect in colouring
- Slight skin or other defects.

Standard size of Nepali apple according to Fruit Development Directorate, Kirtipur is given in below table.

Table 2: Standard size of Nepali apple

Grade	Apple Fruit size (mm)
A	75+
B	65-74
C	60-64
Very Small	59 and less

Source: Fruit Development Directorate, Kirtipur

1.5 Apple Production in Mustang

Mustang district is considered as the capital place for apple production, thus the major source of income of people and more people are attracting on apple farming. The attraction towards the apple farming among the people is rapidly increasing. DADO, the main

government office is playing major role to promote and encourage people of Mustang. Irrigation facilities aided by different irrigation projects also helps in the smooth running of apple orchards.

1.6 Objectives:

- To find the increased incidence of in agriculture, identify it and find the loss in quantity and quality from these diseases and their remedy.
- To find the effect of temperature in apple quality and loss in production
- To find the adoption measures being adopted to address those impacts and recommend mitigation measure to overcome the negative impact of climate change

Chapter 2: Material and Methods

The study was conducted using following materials and methods:

2.1 Consultation with experts and governmental officials:

The Research Team carried out various rounds of discussion with experts in the concerned field to devise the best and appropriate methodology for the study. For this the team consulted with Dr. Rajan Bhattarai, Prof. Dr. Niranjan Parajuli, Dr. Bishnu Prasad Marasini, Dr. Trishnana Manadhar, Mitesh Shrestha (the Senior Research fellow at National Academy of Science and Technology), experts of NARC and Department of Agriculture. The consultation was done prior to the field visit.

Similarly, Research Team carried out Interaction with the officials of District Agriculture Development Office, Mustang at Jomsom. The Team mainly discussed with Mr. Anup Nainabasti, the focal person of IWRMP. The team extracted information about the overall status of agriculture in the Mustang district with special priority in apple farming. Besides, the team also noted important data required for the studies.

The team also consulted with the officials of Irrigation Development Sub- division (IDSD), Mustang at Jomsom. The team consulted with Er. Mohan Acharya, the Head of IDSD along with other officials. The team noted important data about the overall irrigation status of the district. More focus was given to the IWRMP subprojects in the district. In addition to this, considering that Irrigation Structures possess serious threats due to the implications of climate change, information regarding the unpredicted damage of Irrigation Structures and Bridges was also taken. Similarly, the change in hydrological pattern in Mustang experienced by the officials during their stay in the office was noted. Those information and experiences could greatly help in the study. The team also took necessary data of the apple based Cottage Industries from the District Industry Development Office Mustang.

2.2 Discussions with Local Farmers, Board members of Cooperatives and Consumers' groups:

The data were obtained with the help of structured questionnaire survey. Before conducting the survey, we informed and discussed with the participants about the nature of the research. The subject's participation was voluntary. Altogether 15 households were randomly sampled and information were collected on various parameter including perception of farmers on the temperature and precipitation on apple farming. Farmers were

interviewed on the trends in snowfall, extreme events, cropping system, pest attack, income etc. The questionnaire is included in the Annex Section of this Report. The list of the local people engaged in farming with whom Discussions were held is given in the table below:

Table 3: list of the local people engaged in farming with whom Discussions were held

S. No.	Name	Age/Sex	Address	Remarks
1.	Mr. Purna Thakali	62/M	Jomsom	Apple farmer
2.	Sete Thakali	65/M	Syang	Apple farmer
3.	Laxmi Thakali	56/F	Syang	Apple farmer
4.	Aita Sing Thakali	55/M	Syang	Ex-Chairman, Syang Khola Community Agriculture Cooperative
5.	Aita Chhiring Thakali	28/M	Syang	Secretary, Syang Khola Irrigation Consumer Commiitee
6.	Raju Thakali	25/M	Syang	Apple farmer
7.	Chhirinamgel Gurung	40/M	Jhong	Ward Chairman-Jhong, Apple farmer
8.	Dhorje Gurung	29/M	Jhong	Member, Jhong Khola Irrigation Consumer Commiitee
9.	Purna Gurung	24/M	Muktinath	Apple farmer/Apple Product Producer
10.	Sonam Bhotiya	30/F	Putak	Apple farmer
11.	Tashi Chiiring Gurung	44/M	Putak	Apple Farmer
12.	Mingur Thakali	41/M	Putak	JTA
13.	Nima Thakalai	19/F	Putak	Agriculture Student
14.	Pemba Thakali	45/M	Putak	Teacher/farmer
15.	Karsang Amo	40/F	Jhong	Teacher/farmer

2.3 Field Visit:

Field Visit was the most important tool used in the study. Research Team visited three Apple farms (orchards) that are under irrigation supply by IWRMP Subprojects. Team carried out Field visit in following apple orchards:

1. Syang ISP
2. Jhong-Putak ISP
3. Namgel ISP

The Study was more focused in Synag ISP and Jhong-Putak ISP because of their easy accessibility from Jomsom and Muktinath respectively. These two farms are among the largest producers of Apple in the district. A total of around 500 families are involved in those farms. Besides, Mustang is equally popular for the least population density in Nepal, meeting people in their home or farms was thought to be a challenging job. But we could interact with the farmers easily here in these farms/village. So study was focused more in these two farms.

Jhongputak ISP covers an area of 50 hectors. About 165 households are involved in apple production. The apple farms are managed in community basis. However people are also running their private farms. Altogether 300 households are getting benefitted by irrigation services provided by IWRMP project.

Apple farming has been done in a total of 52 hector of land in Synag ISP. About 200 household are directly involve in Apple Orchards. Apple Orchards are managed through Local Co-operative, private companies and on personal basis. In an average some 300 tress are planted in one hector of land. With this calculation, there are approximately 2000 apple trees in the Syang ISP alone.

Namgel ISP (the than Chonhup VDC ward no.-4) lies in the upper Mustang, didn't have any organized farms except few small farms managed at private ownership with few number of trees. According to DADO data, 160 Apple plantlets were distributed in Namgel. Unfortunately, the team couldn't meet with any farmers since they shifted to Jomsom, Myagdi, Pokhara or Kathmandu to skip the extreme weather condition. So, the team just studied the farms on sight only.

The Research team was divided into two groups each headed by Principal researcher Uddav Khadka and Arun Simkhada. A detail horizontal and vertical cross sectional study

was carried out in the field. The Team carried performed the survey with highest standards of professional and ethical competence and integrity.

The Research team used tools like insect trap, measuring tape, alcohol vials, plant material collection sheets, herbarium sheets, camera etc.

A detail study was carried out about productivity and disease pests of apples, cropping patterns, irrigation availability to apples orchard and other crops in the sub projects.

Also, necessary soil and plant material samples were collected with standard protocols and transported to Kathmandu for carrying out required tests in the laboratory.

2.4 Laboratory Tests:

Soil sample, plant materials (Roots, Leaves, flowers, bark) and fruits were safely brought to the laboratory and necessary tests were carried out. List of the laboratory screening and tests are given below:

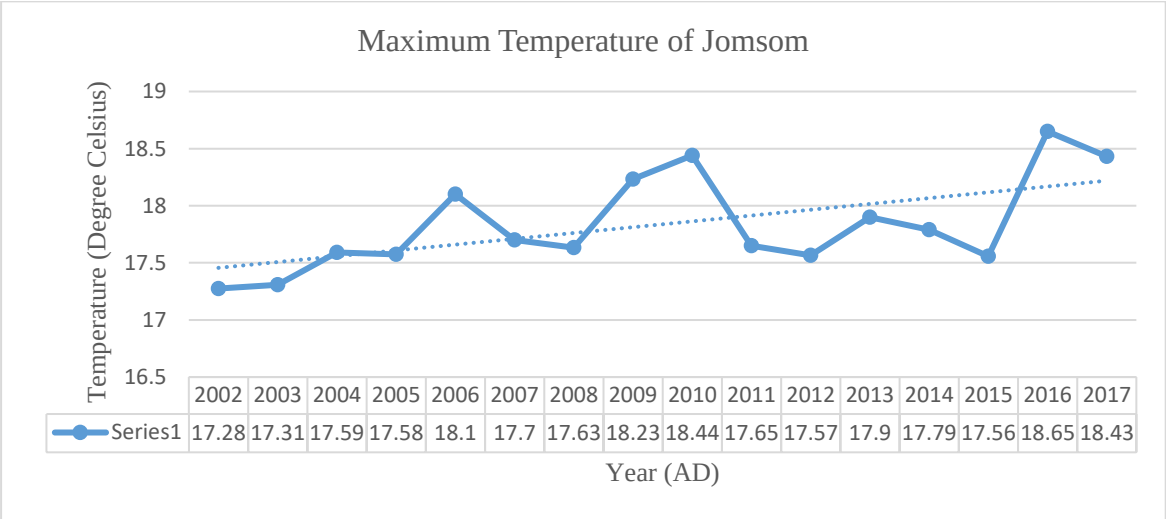
- Isolation and Characterization of fungus
- Soil test: Routine Test: pH, Organic matter, Nitrogen, Phosphorus, Potassium
- Apple quality test: Proximate Analysis and Mineral Analysis

Chapter 3: Results and Discussions

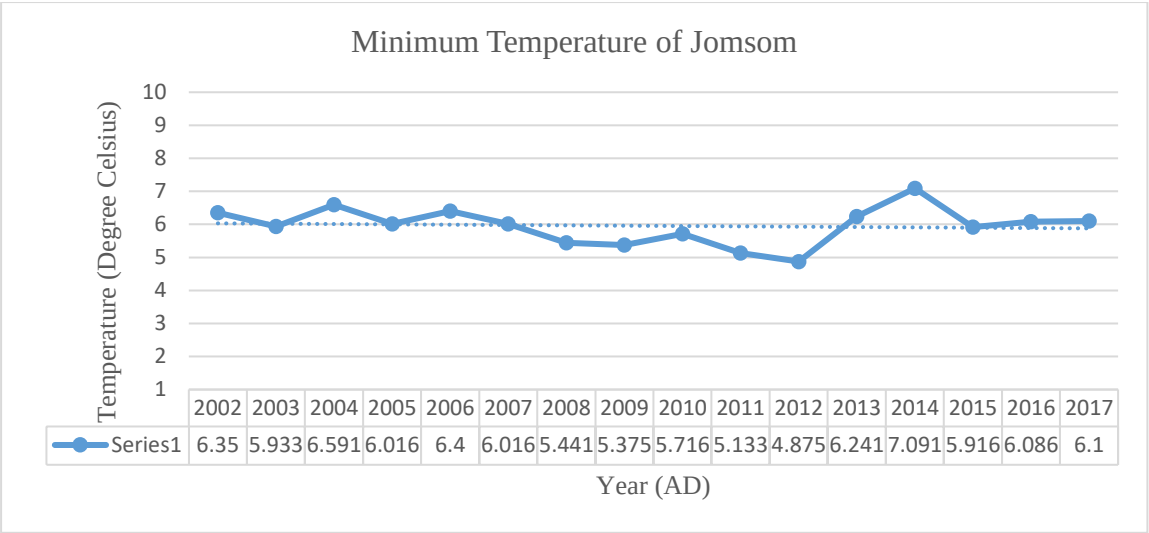
3.1 Analysis of Climate Parameters

The data of Jomsom and Marpha Meteorological Stations of average rainfall, temperature and humidity were taken from Western Regional Climate Office, Pokhara and analyzed using MS-Excel 2013. The data of Rainfall and Temperature recorded at Jomsom and Marpha (2002 to 2017 AD) were processed in the form of line graph. Both temperature and rainfall showed signals of increasing pattern in the graph.

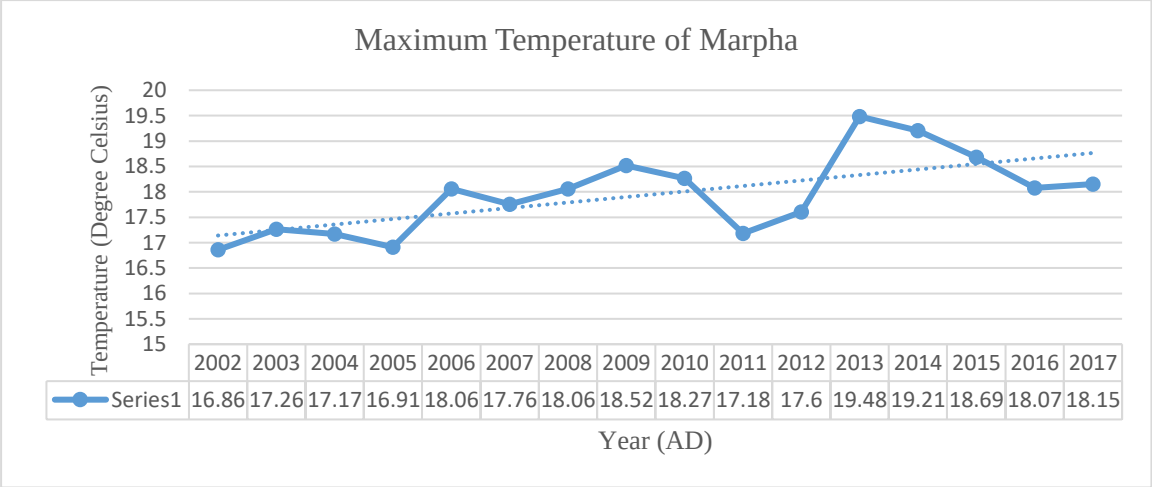
There is no provision of recording the data of snowfall in Nepal due to the lack of the sophisticated instrumentation. But we can easily correlate the decreasing pattern of snowfall by combing the increasing trend of temperature and rainfall. Our discussion with the local farmers gave us sufficient evidences to mention that the snow fall is gradually decreasing while the rainfall is increasing. But the exact rate at which the snowfall is decreasing cannot be analyzed in the absence of the snowfall data. The graphs of temperature and rainfall of Jomsom and Marpha are given below:



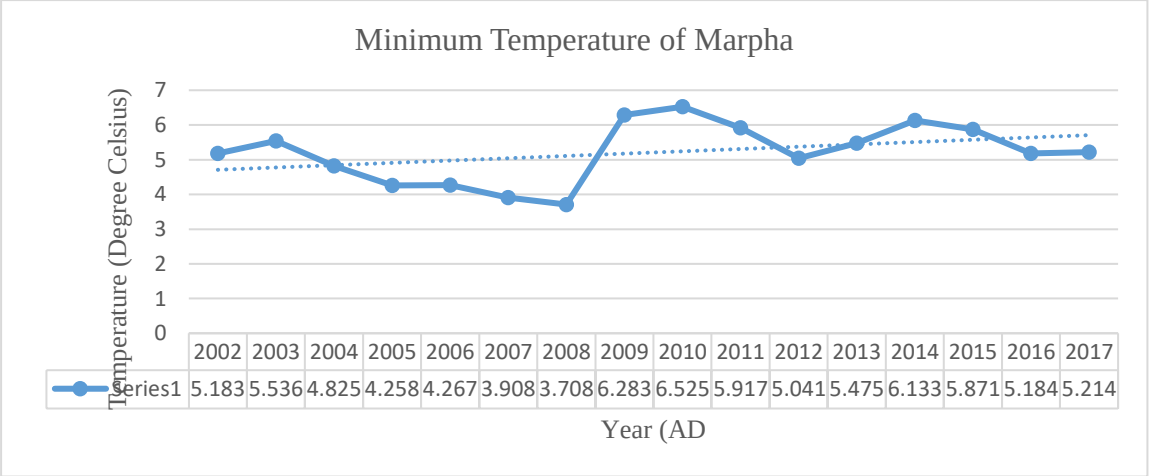
Graph 1: Graph showing Average Maximum Temperature of Jomsom



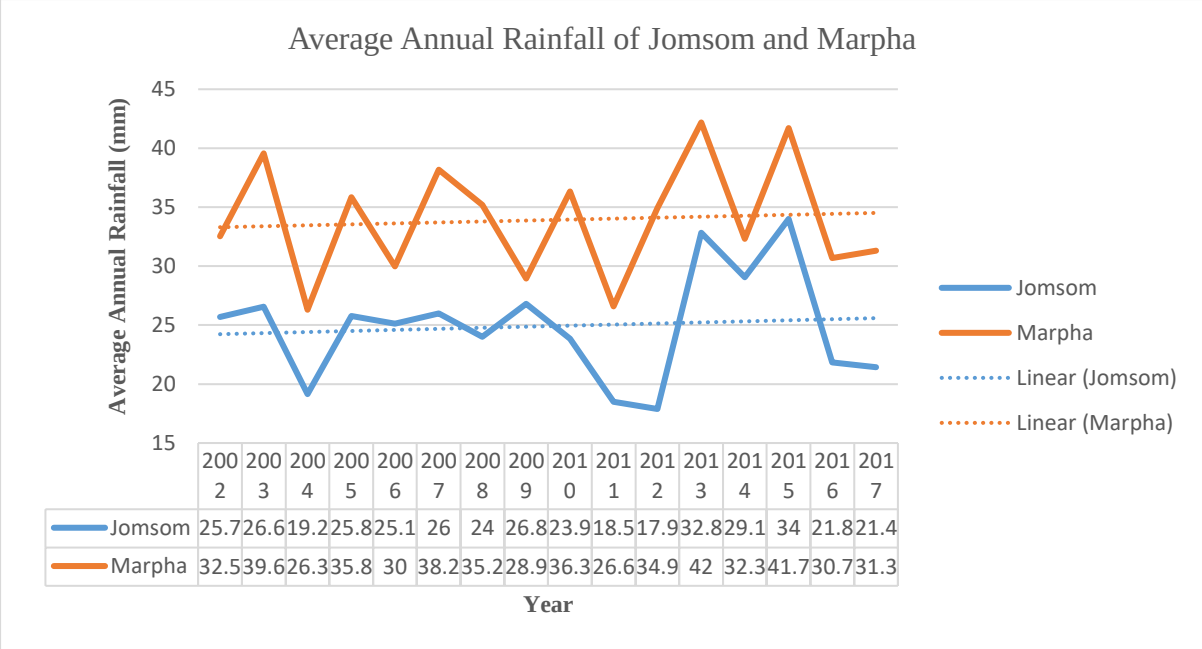
Graph 2: Graph showing Average Minimum Temperature of Jomsom



Graph 3: Graph showing Maximum Temperature of Marpha



Graph 4: Graph showing Minimum Temperature of Marpha



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jomsom	25.7	26.6	19.2	25.8	25.1	26	24	26.8	23.9	18.5	17.9	32.8	29.1	34	21.8	21.4
Marpha	32.5	39.6	26.3	35.8	30	38.2	35.2	28.9	36.3	26.6	34.9	42	32.3	41.7	30.7	31.3

Graph 5: Graph showing average annual rainfall of Jomsom and Marpha

Snow is very crucial factor for Apple production. Snow remains in frozen state throughout the winter which becomes a source of water for apple trees. On the other hand, the sandy soil of Mustang does not retain rain water for apple trees to use in the months which experience low or no rainfall. So, snowfall is a critical parameter in the production of apples in Mustang. Secondly, snowfall is also associated with natural pest controlling strategy. The lifecycle of many insects is interrupted due the frozen snow. Also, many research have pointed out the role of snow in flowering and fruiting of apples pointing the activation of certain hormones and enzymes that determine the quality of apple.

The effects of Climate change has been manifested in Mustang District. People are experiencing a significant alteration in the hydrological patterns. The frequency and intensity of rainfall is increasing while the snowfall is decreasing at an accelerated pace. This change is affecting all spheres of ecosystem and social lives. But agriculture system is influenced at the largest magnitude. Since apple is grown as the main cash crop, climate change is seriously hitting apple production in this area.

The southern villages of district like (that are in close proximity to Myagdi) Lete, Ghasa were considered as the pocket area of apple production before 20 years. But the research team noticed almost no farms at all in these areas. There has been a noticeable alteration in the climatic pattern in these villages. There has been low snowfall for the last three years, temperature has risen up, and rainfall intensity has increased. All these changes have put pressure on the ecosystem as a result apple trees could no longer give yield.

According to the locals, they have shifted to other crops and wholly depend on potatoes and buckwheat. The trend of foreign employment has increased considerably. Also more than half of the families shifted to Pokhara, Chitwan or Kathmandu pursuing for better income.

3.2 Study of Pests:

For this the research team made a detailed study in Syang ISP (about 2700 meters (above the sea level) and Jhongputak ISP (about 3700 above the sea level). The apples were at their early fruiting stage by completing flowering period in Syang ISP, while in Jhongputak ISP, apples farms were blooming.

The study team classified the apple trees into three groups on the basis of age 0-10 years, 10-20 years and 20 above. The classification was done based on the morphological features and age information provided by the concerned farmers. The incidence of potentially harmful insects was studied on the age range of the trees.

Caterpillars were the most predominating class of insects in the field. These caterpillars feed on the young and tender leaves. They make a strong white colored net-like canopy structure and feed on the leaves, fruits and steam. Later, when the apple fruit become mature, these caterpillars are metamorphosed into butterflies and they feed on the sap of the apple by pricking deep into the apples. An age wise caterpillar count is given below:

Table 4: Age wise Distribution of Caterpillars in Apple Trees

Age Group (Years)	No. of Caterpillar	No. of caterpillar canopy	Remarks
0-10	158	3	Prevalence highest
10-20	300	7	in 10-20 years
20-30	225	5	trees

Other significant apple insect pest in the study area included wooly aphid, codling moths, Plague thrips, dimpling bug, mites, wooly apple aphid and fruit fly. Among them Codling moths (*Cydia pomonella)* are the most significant pests. The larvae of moths tunnel into the apple fruit and cause damage. These larvae hide in their cocoons during the winter to escape from the extreme environmental condition. In the spring pupation occurs and they emerge as adults. Then mating occurs and female lays eggs. These eggs are hatched into

larvae which move into the fruit and tunnel in. They feed on flesh, sap and seed of apple fruit.

But the recent trend of rise in temperature has altered the time period of their larval stage. Due to increase in temperature, the pupation and emergence as new adult takes place earlier (since the extreme cold condition no more exists due to increase in temperature) the apple trees have to encounter the larvae for a long period of time which greatly damages the fruits.

The Plague thrips (*Thrips imaginis)* were also significantly found in the farms. They feed on wide range of host plants. They are mostly found in flowers of potatoes, onions, pears plants, walnut plants. The feed various parts of flowers like anther, styles, calyx, corolla etc. and damage the host flower and ultimately to the production. These insects later change their host and transfer to the apple flowers where they cause the similar damage.

Wooly apple aphids (*Eriosoma lanigerum)* are the most proliferating insects in the trees. The have at least 20 generation in a season. They affect all parts of the trees stem, leaves, fruits, flowers etc. They damage the health of the trees. They make a tight cluster and fur like canopy and reside.

Other pests include Zygaena moth (*Agalope hyaline)*, Sanjose scale, stink bug, Lygus bud, Leaf folder, red spider mites etc.

3.3 Study of Disease:

The most frequently seen apple diseases in Mustang identified by field survey, laboratory tests and farmer's experience sharing were Black spot, leaf blotch, fruit blotch, Powdery mildew, crown gall disease, fire light disease, steam and root rot. Most of these diseases are fungal while few are bacterial.

Black spots are fond in apple fruits. It is also called black scab. This disease is caused by the fungus *Venturia inaequalis*. This disease mainly deteriorates the appearance of apples and changes the taste to slightly sour. The disease is transmitted to the fresh young and tender leaves and buds from the shaded leaves of other infected trees, the rainfall of Baishakh and Jestha is responsible for spreading the disease in the entire apple orchards. As the frequency and intensity of rainfall has increased due to climate change, the disease is becoming more challenging. The incidence of the disease was found higher in Syang ISP than in Jhogputak ISP.

Leaf and Fruit Blotch is another fungal disease caused by *Alternaria* species. The disease symptoms include irregular light brown-reddish shaped lesions on the leaves. The disease symptoms seems similar to general leave damage making diagnosis more difficult. Under suitable condition of temperature and rainfall blotches will continue to expand and cause severe defoliation due to the spread of the leaf blotch symptoms. At the end, the entire leaves lose their greenery and ultimately photosynthetic efficiency causing direct impact to the production. Since the fungal spores are transmitted by rain, the increased rainfall intensity in Mustang is increasing the incidence of disease.

Powdery mildew is another fungal disease found in the apple tress during the study. The disease is caused by *Podosphaera leucotricha*. The disease is found to attack both leaves, shoots, twigs, blossom and fruit. The disease is named so because of the dust-like appearance. The disease is so common that farmers could easily recognize the disease despite of having technical knowledge. The disease was so rampant in Syang ISP that all most all the apple trees taken into consideration were affected. While in Jhongputak ISP the incidence was normal. From this study, we found the association of temperature and the fungus; the incidence being more in higher temperature (Syang) and lower in lower temperature (Jhongputak).

A single case of Crown gall Disease was reported during the study in Syang ISP. The disease is caused by *Agrobacterium tumeficians.* The bacterium enters in the plant body through the ruptured surfaces and causes the disease. Once infested, the disease cannot be cured. So excision of plant part, protecting plant from the physical damage can control the disease.

Fire light disease is a bacterial disease that transmit in the similar manner like crown gall disease. Protection measures are also the same. The cases were just few. Though the research team tried to isolate bacteria from the suspected sample but couldn’t succeed.

Infestation of pest and diseases such as apple scab, scale root and canker were some the indicators of climate change that increased the cost of production due to increase in use of pesticides and chemical fertilizers[10]. According to the Local Farmers Red Ants are the new predominating class of insects that are seen for the last five years. These ants are root borers initially and slowly progress to the stem. These colonial pests mostly attack the young apple trees of below 10 years since young trees comparatively contain soft tissues. The ants are responsible for complete necrosis (death) of the tree. The farmers reported

that almost 10-12% of the necrotic (dead) young tress were removed from the farm due to the infestation of ants. Since such trees were already removed from the field, the research could however could not visualize them but the cut basal portion were seen in the farms. These ants could infest apple farms due to increased temperature suitable for proliferation.

3.4 Apple Quantity and Quality

3.4.1 Quantity of apples

The systematic data of production of apple in the study area was not found. However, from the perception study, the annual production and income of farmers in village is found declining every year. According to the study, the income is decreasing for various reasons like decline in production, infestation of disease, market status etc.

The data of total cultivated area, production and Production per unit hector shows increasing pattern of apple cultivated area and annual production also. However, the production per unit hector is gradually decreasing. Data of six years is though not enough to analyze the entire scenario but it gives the decreasing trend of production.

The data of total area and production of last six years is given in the table no. 5

Table 5: Table showing total area and production of apple

Fiscal Year	Total Area (Hector)	Total Production (M. ton)	Production per Hector
2068/69	285	3700	12.98
2069/70	300	4000	13.33
2070/71	315	3500	11.11
2071/72	330	5000	15.15
2072/73	350	5000	14.28
2073/74	400	4000	10.0

3.4.2 Apple Quality

Apple quality was determined by two ways; through questionnaire and from the laboratory tests.

3.4.2.1 Questionnaire Method

In the questionnaire, size of apple was considered as quality parameter while in the laboratory Proximate test and Mineral Analysis were carried out.

Among 15 households taken into consideration for interview, none of the household had maintained the record of apple production, size, income etc. But they had verbally shared that the quantity of 'A' class apples were not more than 40%. They also shared that production of 'A' class apples is decreasing every year.

Generally, 'A' class apples are sold in in the early days of ripening i.e. in August. According to the data obtained from Syang Khola Agricultural Cooperative Ltd, apples of NRs. 27,000,00 (NRs. Twenty Seven lakhs) were sold at NRs. 100/Kg from Syang Orchards alone in 2074 BS. Taking this data, we calculated that 27000 Kg of 'A' class apples were produced in Syang which is nearly 30% of the total production of Syang (No any data of Jhongputak and Namgel ISPs were found). This data also shows that the production of the best quality apples is not satisfactory.

According to the farmers, huge quantity of diseased, damaged apples need to be discarded as they fetch no demand from the market. Though no accurate data is available, DADO officials mentioned that farmers loose more than 20% of their production due to disease. Similarly, farmers also use various anti-biological chemical (pesticides, insecticides, fungicides) which requires huge amount of money. Mr. Purna Thakali who owns an apple orchard with 200 apple trees bought such anti-biological chemicals of Rs. 20,000/- (Rs. Twenty Thousands). So farmers incurred a huge economic loss due to disease and for their control measures.

3.4.2.2 Laboratory Test:

i. Proximate Analysis:

Moisture, ash, crude fat, crude fiber, and crude protein (Kjeldahl N X 6.25) were determined by following the standard method, while Carbohydrate contents were calculated by difference [100-(protein + crude fat + ash + crude fiber)]. The values of analyses were the means of three determinations.

Proximate compositions of red and golden apples expressed on dry matter basis are shown in Table 5. Results showed that red apple contained higher amounts of moisture content (79.20%) and very low amount of crude protein (0.21%). Similarly golden apple contained higher amount of moisture (80.13%) and lowest amount of ash (0.25%).

Ash, crude fat, crude fiber and carbohydrates were expressed more in red apple than in golden apple. While moisture, crude protein were expressed more in golden apples than in red apples.

Table 6: Proximate Analysis table of Red and Golden Apple

Components (%)	Red Apple	Golden Apple
Moisture	79.20±0.04	80.13±0.03
Crude Protein	0.21±0.02	0.25±0.04
Ash	0.29±0.02	0.27±0.03
Crude Fat	0.41±0.02	0.39±0.04
Crude Fiber	1.72±0.02	1.68±0.04
Total carbohydrates	18.17±0.01	22.46±0.04

Values are means± standard deviation of three determinations (n=3)

ii. Mineral Analysis:

The minerals (Zn, Fe, Cu, M n, N a, K, Mg, and Ca) were analyzed separately, using the spectrophotometer. Phosphorus was analyzed by the phosphovanado molybdate method. The data reported represent the average of three determinations.

Table 7: Mineral Analysis table

	Red Apple		**Golden Apple**	
Minerals (mg/100gm)	**Pulp**	**Seed**	**Pulp**	**Seed**
Iron (Fe)	0.81±0.01	1.21±0.01	0.68±0.01	0.99±0.01
Zinc (Zn)	11.21±.005	2.87±0.01	14.60±0.5	1.17±0.01
Manganese (Mn)	1.25±0.04	0.10±0.01	2.21±0.01	1.57±0.01
Cupper (Cu)	0.17±0.02	0.57±0.01	0.22±0.01	0.29±0.01
Potassium (K)	11.29±2.5	1.80±1.5	6.44±0.05	2.1±0.0
Sodium (Na)	18.49±0.5	21.30±0.09	22.0±0.01	22.5±0.01
Magnesium (Mg)	71.48±3.5	63.17±1.5	78±3.5	59±1.50
Calcium (Ca)	168.30±3.5	87.45±5.5	201.17±5.00	93±3.50
Phosphorus (P)	0.50±0.05	1.0±0.01	0.50±0.05	1.1±0.01

Values are means± standard deviation of three determinations (n=3)

From various literatures, it is learnt that the standard proximate analysis and mineral test varies from one species of apple to another. Also, there is variation in these tests between same species of apples of different area. Since no such previous study has been reported

yet, comparative status of various nutritional parameters cannot be reported. But it can be reference for future studies for new researchers.

3.5 Soil Test

Soil quality index is increasingly proposed as an integrative indicator of environmental quality food security and economic viability. Therefore, it would appear to be an ideal indicator of production of apple. Soil sample were collected from Syang ISP and Jhongputak ISP in adequate quantity with standard procedures. Properties such as pH, soil organic carbon, total nitrogen, available phosphorus, and available potassium were determined. Soil of both the ISPs showed slightly alkaline pH (8.4&8.6) respectively. Though no previous studies were found in these regions, the p H of the soil is expected to get normalized as the intensity of the rainfall increases.

Organic matter was Syang ISP 44.6t/hector Syang ISP and Jhongputak ISP 37.4 t/hector in Jhongputak. This is due to altitudinal variation. Greater the rainfall and higher the temperature higher will be the organic matter due to high microbial load and ultimately their activity[11].

Total Nitrogen was same in both the ISPs with a mean of 0.23%. Nitrogen was higher at top soil (0-20cm) a lower at the depth (40-60cm). Total nitrogen in the soil is solicited because the nitrogen in the soils occurs in several forms band it takes into account all the nitrogen in organic and inorganic forms. Some scientists argue that Total Nitrogen does not give good indication of productivity because only a small portion of Total Nitrogen is available to plants. 2 to 3 % of Total Nitrogen is in the inorganic form, mostly ammonium (NH^{4+}) and Nitrate (NO^{3-}) which is only available to the plants[12]. Others present a different view that organic and inorganic forms of nitrogen are always interchangeable and it would be better to consider the total nitrogen to investigate production and soil quality.

Available phosphorus is high at Jhongputak ISP (58kg/hector) while followed by Syang ISP (54kg/hector). Available Phosphorus is directly proportional to the pH[13]. So, available phosphorus is a critical factor to study the impact of climate change. But in the absence of previous data of soil test, comparative study couldn’t be carried out and result couldn’t be interpreted on its basis. This study becomes the reference for the researchers in the coming days.

Available Potassium was high at Jhongputak ISP (490.42kg/ha) followed by Syang ISP aspect (410.21kg/ha). Available Potassium was gradually decreased with increasing altitude. Available Potassium was gradually decreased with increasing soil depth.

3.6 Production of other Crops

Apple is no doubt, the main cash crop of the people in the command area, but the local people also cultivate other crops and vegetables as food crops in significant area of their land. Unlike apples, farmers are not practicing 'community cultivation practices' for food crops. Even in the apple farms inter cropping is done. They have planted pear, walnut, peach etc. Similarly, cereals particularly barley and maize were also cultivated throughout the farms. The major crops cultivated in the command area are:

Cereals: Barley, buckwheat, Wheat, Maize

Vegetables: Potatoes, Cauliflower, Cabbage, carrot, Cucumber, Beans, Pea, Onion, Garlic, Mushroom, Chilly

Fruits: Pear, Walnut, Peach, Plum etc.

3.7 Trend of farmers shifting from apple production due to climate change:

People are found to be worried about the implications of climate change on apple farms but no trend of shifting from apple production to other crops have been in the command area. But people are thinking of shifting from lower Mustang to Upper Mustang to skip from the impact of climate change. We may verify this finding with the data of DADO Mustang in which it is mentioned that each year apple plantation is added in around 100 hectors. However, people of Lete, Ghasa completely shifted from apple production to other crops/foreign employment/tourism/migration. These southern villages are affected most seriously and are losing their biodiversity. Similarly, in Kobang also the production is decreasing gradually and these people are shifting to the Upper Mustang areas for apple farming.

3.8 Climate Change tackling strategy:

Local farmers are aware of the negative consequences of climate change in their agriculture, biodiversity, ecosystem and socio-economy. But they are unaware of 'how to tackle with' these implications. They are simply using various chemical anti-biological agents against 'climate change induced' disasters particularly diseases and pathogens.

Secondly they are shifting to higher altitudes where implications of climate change has not hit so brutally.

3.9 Impact of Apple Farming in Socio-economy:

Apple farming is the principal source of income of Mustang District. According to DADO Mustang, in the fiscal year 2074/075 alone, 53 metric tons of apples were produced of which 80% were marketed directly from the field which generated income of 40 Crore. The remaining 20% apples were also used for apple based industrial products like Apple Brandy (popularly known as Marpha), dried slices (s*ukuti*), juices etc. which is even rated higher. People engaged in apple farming have a good economic status.

During our discussions with the local farmer, we talked informally about where there children/grand children were schooled. 12 out of 15 families taken into consideration for the study said that they siblings were schooled in top ranking schools in Kathmandu and Pokhara. This shows their increased economic status on one side while the high priority given to education on the other side. Besides these a new arena of agri-business is slowly rising i.e. Apple Nursery for Production of Apple Plantlet. A government managed 'Temperate Horticulture Development Centre' located at Marpha has been producing apple saplings through seeds and grafting technique. But this center is not being able to meet the demand of the farmers. There are 9 private owned nurseries in the District at various locations. Ms. Sarita B.K. who owns Nilgiri Apple Nursery at Jomsom shared her experience of increasing and high demands of apple saplings from the farmers each season.

Chapter 4: Conclusion

From this study, it is concluded that the apple farms of Mustang district are negatively affected by climate change. Upon analyzing the data of rainfall and temperature, we reported a slight increasing trend of temperature and rainfall in the district. Since climate change study requires the analysis of data of very long and extended period of time, analysis of 15 years of climatic parameters may not be sufficient to report about climate change. But this analysis gives some signal of climate change in the area. However from the perception study among the local farmers they mentioned about the reluctant changes in the temperature, rainfall, snowfall, wind velocity etc.

There is increased incidence of disease and pathogens (pests and fungi) due to increase in temperature. The main insects that infested the farms were wooly aphid, codling moths, Plague thrips, dimpling bug, mites, wooly apple aphid and fruit fly. Among them Codling moths (*Cydia pomonella*) were the most predominating ones. Their caterpillars were spread throughout the farms causing huge damage of tender leaves, flower and fruits. Likewise, various insect like Zygaena moth (*Agalope hyaline*), Sanjose scale, stink bug, Lygus bud, Leaf folder, red spider mites etc. were also found causing negative implications. The fungal diseases like black spot, leaf blotch, fruit blotch, Powdery mildew, crown gall disease, fire light disease, steam and root rot were prominent in the farms.

The prevalence of diseases and pathogens are greatly manifested in the southern part of the districts and slowly progressing to the north. Even though farmers are well known about the effects of climate changes they are encountering but they are unaware about the various mitigating strategies of negative impacts of climate change.

Chapter 5: Recommendations

Climate change is an evolutionary global phenomenon. Anthropogenic input through huge emission of carbon into the atmosphere is accelerating its rate. We cannot pause the phenomenon of climate change but we can mitigate its negative impacts in our ecosystem or more interestingly we can 'exploit' the consequences of climate change for human welfare.

5.1 Control strategies:

Apple diseases can be effectively managed through the combined use of culture, sanitation, resistance, and fungicide sprays. This integrated approach to disease control minimizes the reliance upon one type of control over the others and usually results in a high percentage of quality fruit[14].

i. Culture: Cultural methods include maintaining tree vigor by proper planting, fertilizing, and pruning and by following general practices that help to minimize tree stress.
ii. Sanitation: Sanitation involves pruning and removing affected or dead portions of the tree and removing diseased foliage or fruit which are often important sources of inoculum for the next season.
iii. Resistance: Resistance involves selection and planting of varieties with genetic resistance to specific diseases. This effectively reduces or eliminates occurrence of the disease in question.
iv. Fungicide sprays: Proper selection, timing, and application of these sprays are important. Thorough coverage of all parts of the tree is necessary and sprays should be applied until run-off. The fungicide label will contain information on plant hosts and diseases, dosage rates, days to harvest interval, and safety precautions.

Pesticides (a general purpose tree fruit spray) available under a variety of trade names, is effective for control of many of the common diseases and insect pests of apple. This mixture usually contains **captan** as the fungicide component and **methoxychlor** and **malathion** or **carbaryl** as the insecticide component.

Alternative fungicides for control of specific diseases can be used to supplement or can substitute for the general purpose mix. These include:

1. Coppers (fixed)- early season control of scab and fire blight
2. Fenarimol- control of scab, mildew, and rust
3. Ferbam- some control of scab, rust, black rot, and the summer diseases; causes undesirable black residue when used late in season
4. Maneb, mancozeb- control of rust, scab, fruit rots, and summer diseases;
5. Myclobutanil- control of scab, powdery mildew and cedar-apple rust
6. Sulfur- for control of mildew; some control of scab, summer diseases, and fruit rots; can be phytotoxic to some cultivars and may cause fruit russetting and/or yield reduction when sprayed after bloom
7. Thiram- some control of scab, rust, and summer diseases
8. Thiophanate-methyl- control of scab, fruit rots, and summer diseases
9. Triadimefon- very good control of powdery mildew and rust

5.2 Alternative approaches suggested for reduced incidence of diseases:

The alternative approaches include those practices that do not involve the use of chemical pesticides as the first option but only as the last resort. They include:

i. Use of Tissue Culture Sapling: Saplings generated from tissue culture technology are considered 'disease free' because they are generated using disease free explants (the part of the plant taken for tissue culture). So, taking healthy seeds reduces the incidence of disease for obvious reasons.
ii. Use of Resistant varieties: Resistant varieties are generated through gene modification techniques. Resistance is acquired against increased temperature or against the pathogens. The seeds can be purchased from the market in India. But there has been a strong voice against such genetically modified seeds by 'Green Groups' in the favor of organic farming.
iii. Integrated Pest Management (IPM): IPM involves various strategies ranging from use of biological enemies against pathogens, physical barriers, Inter-cropping to the use of chemical pesticides as the ultimate weapon. However this technique is more useful against insect diseases and less effective against bacterial, viral or fungal diseases.

The symptoms and control measures[15] of some of the major apple diseases are given in the table below:

Table 7: Main Apple Diseases, symptoms and control measures

Disease/Symptoms	Control
1. Fire Blight Shoots blight from tip downward; leaves turn brown (apple). Shoot tip bends, resembling shepherd's crook. Blossoms wilt suddenly and turn brown. Limb and trunk blight occur when the infection moves downward from infected shoots or fruit spurs	**Chemical:** Apply streptomycin sulfate during bloom period only, every 3 to 5 days. A late dormant application of a fixed copper spray or Bordeaux mixture is helpful. Streptomycin sprays are not effective after the bloom period. Fixed copper sprays during the growing season are helpful, but are not recommended if fruit are present because of the risk of russet. **Cultural:** Plant resistant varieties. Avoid excessive nitrogen fertilizer applications. Cankers and blighted shoots should be pruned out before the growing season begins
2. Powdery Mildew On leaves, the fungus appears as whitish, felt-like patches that spread and engulf the entire leaf. Infected leaves are narrower than normal, folded and stiff. Infected fruit have a netlike russeting.	**Chemical:** The most effective materials are Flint, Indar, Inspire Super, Pristine, Rally, Procure,Merivon, Luna, and Sovran. Topsin M and sulfur are also effective. The most important sprays are the springtime sprays, beginning at tight cluster. **Cultural:** The fungus overwinters on buds infected the previous summer. Many varieties are resistant.
3. Apple Scab Spots on the fruit are small, dark and circular. These spots usually do not begin to appear until the fruit are well grown, and tend to be concentrated at the stem end. The skin may toughen and crack. Forty to 70 days elapse from the time the spore lands on the fruit until the spots appear.	**Chemical:** The most effective materials are Abound, Adament, captan, chlorothalonil, Gem, and Topsin M. Begin sprays at shuck split and repeat every 10 to 14 days until 40 days before harvest. The fungus overwinters in twig lesions. Spores are most abundant two to six weeks after the shuck split stage of development.
4. Cherry Leaf Spot Small, circular, purple spots on leaves. Only a few lesions per leaf can cause the leaves to turn yellow and fall. The fruit on trees severely defoliated by leaf spot fail to mature properly and are soft and watery.	**Chemical:** Apply captan, Gem, Indar, Pristine, Rally, or Adament, beginning at petal fall and repeating at 10- to 4-day intervals until harvest. Rotate classes. Homeowners can use captan or Immunox. **Cultural:** The fungus overwinters in infected leaves on the ground. Rake and destroy fallen leaves
5. Black Spot Leaf spots are small and brown, black or red, more numerous at the leaf tips. The centers of the leaf spots fall out, creating a "shothole" effect. Infected leaves may turn yellow and fall to the ground. Fruit sometimes develop dark pits in the skin.	**Chemical:** The most effective materials are fixed coppers and Mycoshield/Flameout/FireLine. Chemical control is limited. **The use of coppers after petal fall may cause burn.** **Cultural:** Use of resistant varieties is the primary method of control, and is highly recommended. Adequate fertility is important in minimizing the effects of this disease

5.3 Cost of Disease management:

Management of Disease is undoubtly a costlier phenomenon. The cost of chemical pesticide is determined by the market trend and is generally considered expensive with potentially hazardous to environment and living beings.

According to a paper published in Research Gate in 2016, a total of $22/acre of apple farms is required in Nepalese farms. They calculated taking **Captan-carbomyl** as reference.

However, the Research Team strongly suggests to adopt **Alternative approaches suggested for reduced incidence of diseases** since new farms are being set up rapidly. These approaches are economical, environment friendly and posing no threat to living beings like use of pesticides. There is decreased probability of infestation by pathogens.

Tissue culture technology is a cheaper technology. There are many Biotech Companies that produces saplings of various plants using tissue culture techniques. They are distributed in major cities of Nepal.

The cost of each sapling ranges from $2 to $4 depending upon the location and cultivars. So in a hector of farms where 300 saplings are planted, a cost of $ 600 to $ 1200 should be spent which is nearly equivalent to the saplings generated from conventional grafting techniques.

Resistant varieties saplings are however quite expensive due to the monopoly of manufacturers internationally. Unless any subsidy is given, farmers may not be attracted towards this approach. According to the distributors based in Kathmandu, the cost of resistant varieties exceeds $ 150 per sapling in Indian market.

IPM is the most economic approach among the above mentioned alternative approaches. A hector of land can be managed with $ 20. Farmers can use local resources also. But this technique is effective against insects, birds etc.

Mustang is seriously hit by climate change impacts. Mustang is facing significant changes in its hydrological cycle. This change has brought numerous challenges in all aspects of ecosystem including the agriculture. Mustang or Nepal alone cannot tackle those problems, it requires complex international collaboration and takes time.

At National Level, government and concerned authorities can raise the issue at various international forums so that attention of the world community will be drawn to protect the right of food security of people of Mustang/Nepal. At local level general public must act

responsibly such that the emission of carbon is lowered at individual level. General public can reduce the use of fossil fuels and should focus on bio-fuel.

Figure 2: Caterpillars in young Apple branch

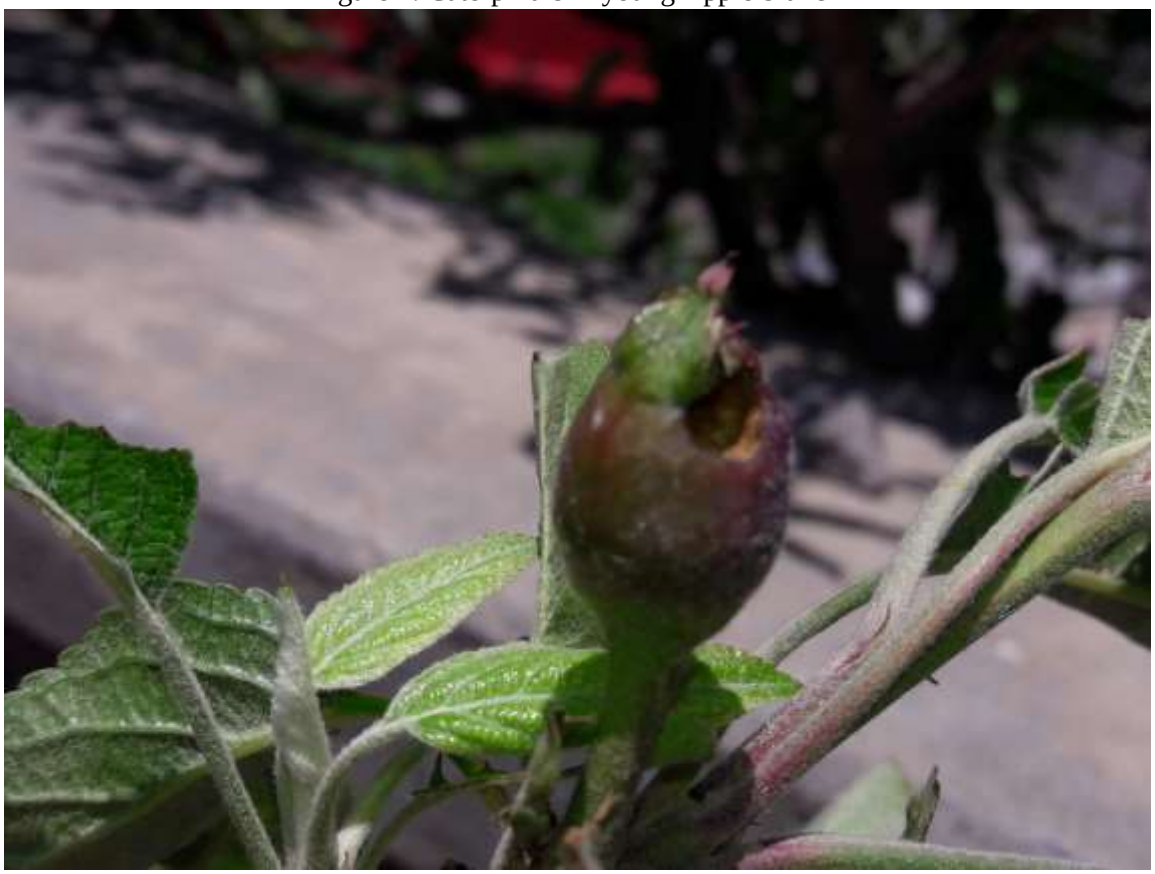


Figure 3: Young Apple fruit tunneled by codling moths

Figure 4: Powdery mildew on leaves

Figure 5: Leaf blotch disease and dipteral insects feeding on leaves

Figure 6: A single case of Crown gall disease reported from Syang ISP

Figure 7: Fungus attacking the twigs

Figure 8: Canopy of Apple bugs

Figure 9: Leaves fed by Caterpillars

Apple Scab

Leaf Blotch

Figure 10: Various disease of Apple

Figure 11: Ripen Apples in Jomsom

Figure 12: Black Spots disease caused by fungus *Venturia inaequalis*

Figure 13: Apple Nursery at Syang ISP

Figure 14: Interaction with local farmers

Figure 15: Apple blooming at Jhongputak ISP

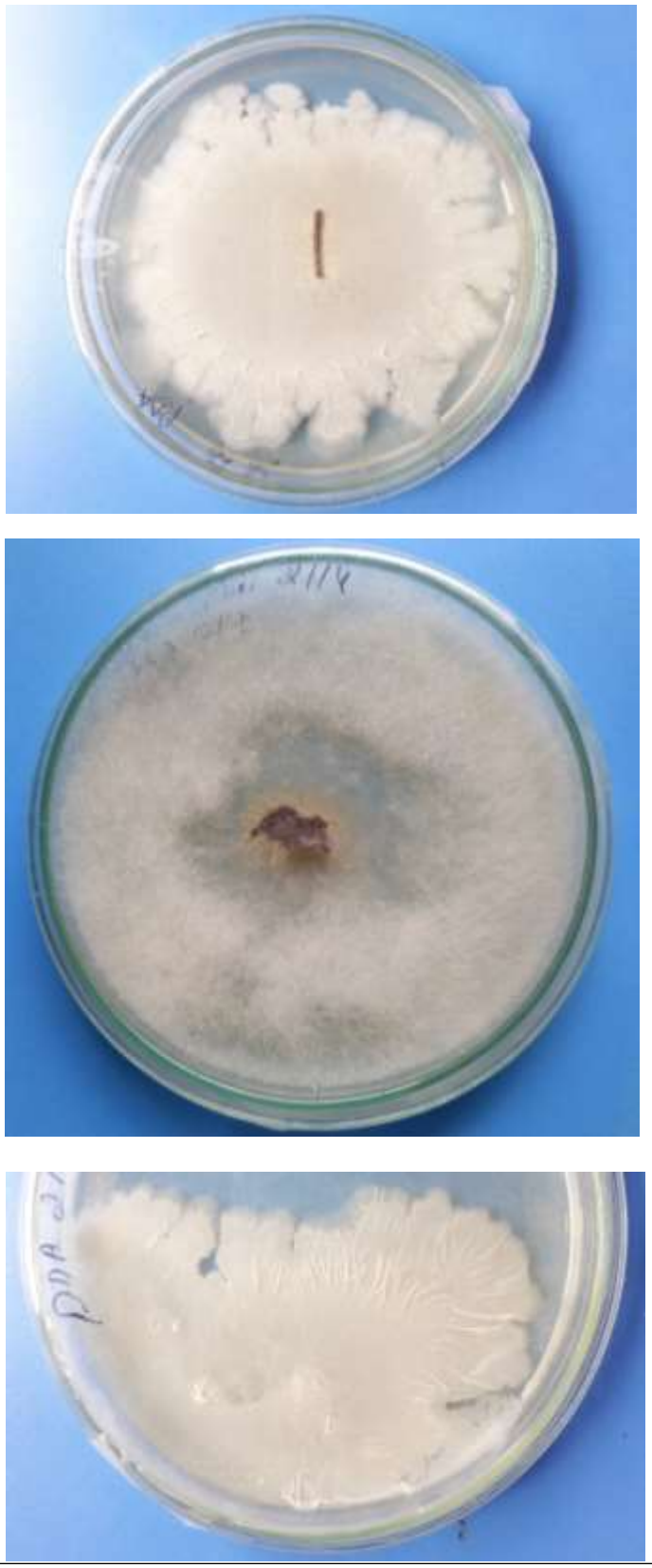


Figure 16: Isolation of fungi on PDA media

Figure 17: LPCB staining image of isolated fungi under inverted light microscope

Figure 18: Wet mount microscopic image of isolated fungi

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Annex

List of the activities performed:

1. Discussion with experts and concerned government officials prior to the filed survey in Kathmandu
2. Meeting with District Agriculture Development Office and Irrigation Sub Division Office in Jomsom
3. Household Survey in Synag and Jongputak
4. Field Survey
5. Laboratory test
6. Preparation of Report

List of the personnel visited during the field survey:

1. Uddav Khadka, MSc Biotechnology, MA
2. Tilak Thapa, MSc Zoology
3. Arun Simkhada, MSc Biotechnology
4. Rajkumar Dulal, MSc Environmental Science

स्याऊ खेतीमा संलग्न किसानको लागि तयार गरिएको प्रश्नावलीको नमूनाः

१. नामः २. उमेरः

३. परिवार संख्याः

४. स्याऊ खेतीः छ / छैन ५. अन्य बालीः

५. यदि छ भनेः (क) क्षेत्रफल
(ख) बार्षिक आम्दानी
(ग) मुख्य समस्याहरुः

६. मुख्य रोगहरुः

७. सिंचाईको अबस्थाः

८. भण्डारणः

९. ढुवानीको अबस्थाः

१०. बजार भाऊः

११. पछिल्लो ५ बर्षको कुल बार्षिक उत्पादन र आम्दानीः

१२. स्याउजन्य उत्पादन र आम्दानीः

१३. घरयासी खपत

१४. खेर गएको नबिकेको

१५. पानी र हिउँ पर्ने मात्रा र बारम्बरताः

१६. नयाँ रोजन्य किराहरुको अबस्थाः

१७. स्याऊ उत्पादनको अबस्था