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"Good Agricultural Practices of Disaster Risk Management (DRM) and Climate Change Adaptation Measures"

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Introduction

Nepal has unfavorable natural conditions as fragile geology and steep topography make one of the most disaster prone countries in the world. It faces high magnitudes and intensities of a multitude of natural hazards such as flood, landslide, earthquake, fire, hailstorms, and Glacier lake outburst flood (GLOF), cloud burst, drought and epidemics due to global climate change. It constitutes threats to agriculture sector of Nepal. Unusual and erratic rainfall, hot and cold waves in different parts of country had highly affected the agricultural sectors. Increasing trend of extreme climatic events and natural disasters due to climate change/ global warming could under mine the future food security. Both the summer and winter crops are affected by unusual drought, dry spells, floods and hot and cold waved during their growing period. These unusual climatic events are affecting the production and productivity of agricultural crops directly and/or indirectly. Crop and livestock production and aquaculture would be threatened by a combination of various natural and climatic hazards. A number of good agricultural practices and potential technological adaptation options have been developed in Nepal and elsewhere in the agricultural sector.

1. Good Agricultural Practices for DRM and Climate Change Adaptation Options in Cropping Sector.

The term Good Agricultural Practices (GAPs) can be referred to any specific method or practice, which when applied to agriculture, produce results that are in harmony with the values of the proponents of those practices. According to FAO, *"GAPS are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food*

agricultural products, while taking into account economical, social and environmental sustainability". (http://en.wikipedia.org/wiki/Good_agricultural_practices) But the concept of GAPs has been changed in recent year due to rapidly changing agricultural practices, food crisis, global warming, land, soil erosion, degradation, etc. Adopting GAPs reduces the losses caused by natural and climate related disasters. The agricultural technologies or practices differ from eco-system to eco-system, location to location and among the farmer's community, social and economical status of the farmers etc. However, the following GAPs can manage the risk associated with disasters and can reduces the losses caused by present and future climate change in cropping sector of agriculture.

1.1 Growing stress tolerance cultivars, crops, vegetables

- **Rice**
  - Radha 4, Loktantra, Radha 12, Radha 13 Radha 7, Radha 11 and Janaki, for shallow lowland rainfed condition of Terai and foot hills.
  - Ghaiya 1, Ghaiya 2 and Bindeswari for upland rice eco-system.
  - Makawanpur 1 for medium lowland rainfed Terai and foot hills.
  - Sukkha Dhan 1, 2, 3, 4, 5 and 6 being drought tolerant suitable for rainfed area of Terai.
  - Swarna Sub – 1 and Samba Masuli Sub – 1 for submergence tolerance.
  - Taraha – 1 and Hardinath – 2 for alternate wetting and drying and direct seeded rice system
  - Chankdannath 1 and Chandannath 3 as cold tolerant for high hills like Jumla climate
  - Khumal 4, Khumal 6 and Khumal 11 for warm temperate climate like Kathmandu valley and mid hills

- **Wheat**
    - Vijay and Banganga as heat tolerant towards maturity for Terai
    - Bhrikuti, Aditya, Banganga for rainfed condition for Terai
    - Gautam, BL 1473 and NL 297 for late planting in Terai
    - Swargadwari, Danfe, Gaura, Dhaulagiri, Annapurna 1 and Annapurna 3 for warm temperate and temperate climate of hills and high hills
- **Maize:** Extra early varieties Arun 2 and Arun 4
- **Pigeonpea:** Pusa 9 and Pusa 14 for Maize – Pigeonpea system
- **Soybean:** PK 16 for inter cropping with maize
- **Tomato:** Laxmi for rainy season
- **Ckickpea:** Alternate crop for lentil which tolerate more drought condition than lentil
- **Colocasia species of vegetables:** More tolerant to drought.

Hazard context: Drought, rainfed, heat and submergence (rice)

Locations: Terai, lowland area, hills and high hills

Beneficiaries: Small and resource poor farmers.

Benefits: Tolerate the periodic drought and submergence (for rice), thus the yield losses is reduced. Beneficial to all categories of farmers.

1.2 Multiple cropping and Cropping System Diversification

Multiple cropping is growing more than one crop on the same field either in combination or in sequence in one year. It is a broad term for growing individual cropping in sequence i. e. sequential cropping or crop rotation and growing crops simultaneously in mixtures i.e.

inter cropping, mixed cropping and relay cropping (Joshi, 2007). Diversification in the traditional system of cropping is essential to cope with the adverse effect of climate change. The choice of different system of cropping and the crops depend on the land type, eco-system of the location, growing season and the availability of the resources. However, in any type of cropping system legumes should be included. A cereal-cereal of rotation or mixture should be avoided. Following the different cropping systems, the adverse effect of climate change can be minimized.

a) Crop combination for crop rotation:

- **Rain-fed upland:** Maize-soybean-fallow, Maixe+upland rice-black gram, Maize/Finger-millet-mustard, Maize+soybean-mustard
- **Rainfed lowland:** Rice-wheat-mungbean, rice/lentil-fallow, rice-chickpea instead of rice-wheat and cowpea-wheat which store 340 mm/180 cm soil moisture compared to maize-wheat (227)

b) Different simultaneous cropping:

- **Row intercropping:** Maize // soybean in 1:2 or 2:4 rows
- **Strip intercropping:** Maize // soybean in 2:4 or 4:6 rows strips
- **Mixed intercropping:** Wheat+rapeseed or mustard, Maize+cowpea, Maize+upland rice, Maize+fingermillet. wheat+peas or chickpea
- **Relay intercropping:** Rice/lentil, Rice/berseem, Maize/fingermillet, Maize/zinger, Maize/pigeonpea, Maize/blackgram, Maize/tomato, Maize/chilly

Hazard context: Drought and rainfed, erosion, depleted soil fertility

Locations: Terai, inner Terai, foot hills and hills

Beneficiaries: Small, medium and large farmers.

Benefits: Improve soil fertility and OM content, increase vegetative cover on soil surface thus decrease soil erodibility, improve infiltration and stability of soil structure, add diversity to farm produce, provide sustainability of production and income stability (risk reduced), increase carbon sequestration into soil.

1.3 Conservation tillage

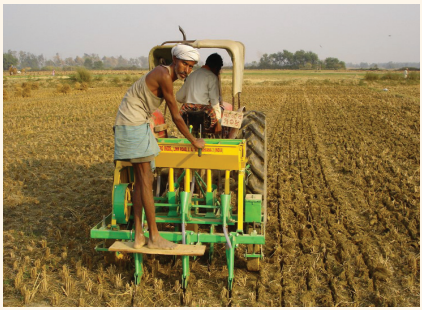
Conservation tillage embraces crop production system involving the management of surface residue with minimal soil disturbance. According to the Conservation Technology Information Center in West Lafayette, Indiana, USA, conservation tillage is defined as: "any tillage or planting system in which at least 30% of the soil surface is covered by plant residue after planting to reduce erosion by water; or where soil erosion by wind is the primary concern, with at least 1120 kg ha^{-1} flat small grain residue on the surface during the critical wind erosion period." http://www.fao.org/ag/ags /AGSE/7mo/69/chapter8.pdf). It varies from soil to soil, crop to crop, and from one agro-ecological region to another.

a) Zero tillage or no-tillage

This is a specialized type of conservation tillage where planting and fertilizer application operation is done in one pass in which the soil and the surface residues are minimally disturbed. It eliminate all preplanting mechanical seedbed preparation except the opening of a narrow small hole in the soil for seed and fertilizer placement to ensure adequate seed and soil contact.

b) Reduced or minimum tillage

In this system, soil disturbance is minimal. Crops are grown with minimum tilling of the lands. Minimum or reduced tillage is not always employed with the same meaning at all circumstances and used in the different contexts of traditional cultivation and mechanized agriculture.



Seeding by Zero-tillage seed drill

Use of Minimum Tillage

c) Ridge tillage

In ridge tillage, the soil is left undisturbed prior to planting but the soil surface is tilled at the time of planting with row cleaners to make the ridge. Crops like maize, peas, vegetable crops, legumes can be grown on the preformed cultivated ridges.

d) Strip tillage

The seedbed is divided into a seedling zone and a soil management zone. The seedling zone is mechanically tilled to optimize the soil and micro climate environment for seed germination and seedling establishment. The inter row area is left undisturbed and protected by mulch.

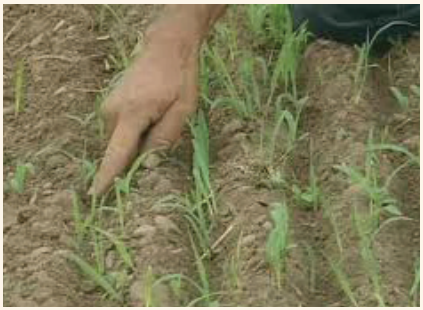
Hazard context: Drought and rainfed, erosion, depleted soil fertility.

Locations: Terai, inner Terai, foot hills and hills

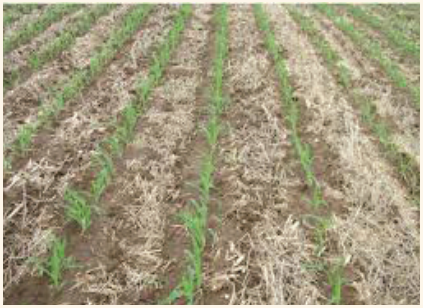
Beneficiaries: Small, medium and large farmers.

Benefits: Efficient weed control, evaporation suppression, and water infiltration enhancement thus increase water storage, lower energy costs per unit production and higher grain yield. In addition, soil organic matter and populations of beneficial insects are maintained.

Soil and nutrients are less likely to be lost from the field and less time and labor is required to prepare the field for planting. Cost of land preparation and irrigation reduced.



Ridge tillage



Strip tillage

1.4 Multi-storied Cropping

In practicing this cropping, the crops underneath the tall trees or horticultural crops withstands the shading effects and provide ideal micro- climatic conditions to all the crops. The crops are citrus, banana, pineapple, turmeric, maize, legumes, vegetable crops, and finger millet for lower altitude and apple, walnut, maize, beans and finger millets in higher altitude.

Hazard context: High intensity rainfall, soil erosion and land slides

Locations: Mountain and hilly area, steep slopes to protect the soil and reduce soil erosion.

Beneficiaries: Small and resource poor farmers.

Benefits: Efficient utilization of resources, soil conservation, and the risk of yield loss is shared among different enterprises. The household income and employment opportunity are increased.

Multi-storied cropping

1.5 Agro-forestry System

Natural calamities like landslides in the hills, flooding in the foothills and the Terai and drought in most of the areas of the country have frequently occurred. Most of all, flooding has become a major cause of land degradation leading to the poor socio-economic conditions and the deterioration of the natural ecosystems. Practicing a number of agro-forestry systems counter the problems of land degradation and meet the demands of the local people for fuelwood, fodder and small timber. Under this system a number of practices are identified which are given below.

a) Agri-silviculture

i) Single crop intercropping: In this system a single agriculture crop species is planted between tree rows at a particular time.

Example : *Delbergai sissoo + Zea mays/Eleusine coracana/ Solanum tuberosum*

ii) Double crop intercropping: This is the technique in which two agriculture crop species are planted along with the rows of single tree species

Example: *Delbergia sissoo +Cajanus cajan+Zea mays/Eleusine coracana/Plaseolus vulgeris*

iii) **Multi tree-crop intercrop**: In this system, different agricultural crops are planted with the tree rows of different species.

Example: *Delbergia sissoo+L. leucocephala+T. grandis+Mangifera indica + Eleusine Coracana./ Zea mays/Solanum Tuberosum/ Sesamum indicum/Fagopyrum spp./Phaseolus vulgeris*

b) Silvi-pasture

Example: *D.sissoo+A.catechu+local grasses*

Hazard context: soil erosion, land slides, land degradation and flooding

Locations: Terai, foot hills and hilly area, sloppy lands, flood prone area of Terai, river side fellow lands, flash flood area

Beneficiaries: Small and resource poor farmers, village communities

Benefits: Efficient utilization of resources, soil conservation, and the risk of yield loss is shared among different enterprises. The household and community income and employment opportunity are increased. The system is suitable for land reclamation. Plantation of Acacia catechu and *Dalbergia sissoo* will be helpful in protecting the land from flash floods. Protect grass lands and planting *Dalbergia sissoo* and *Acacia catechu* result in a change in the vegetation composition leading to increased plant diversity. Availability of fuel wood, fodder, fruits and cereals increases.

Silvi-pasture and agri-silvi pasture

1.6 Small scale rain water harvesting

Water harvesting is the process of collecting rainfall as runoff from larger catchments for use in a smaller target area (Oweis *et. al.,* 1999). It is of particular importance in semi-arid regions, which are also drought prone. Large scale application of water harvesting measures in drought prone areas may be a strategic tool for reducing the drought risk. Water harvesting, though an age-old practice, is emerging as a new paradigm in water resource development and management. The water collected help in meeting domestic and livestock needs, provide water for supplementary irrigation during drought period, enhance ground water recharge, and reduce storm water discharge and urban floods. In drought prone area rain water harvesting remains an important source of water for irrigation (Kolavalli and Whitaker, 1996). Following are the techniques of rain water harvesting:

a) ***In-situ* rain water harvesting:** Field bunding, counter bunding, ridging, conservation furrows and contour cultivation (Sharma and Smakhtin, 2007) in the sloppy land are the practices to be followed to harvest the rain water. In Terai, constructions of small ditches around the Khet or Bari lands are also practiced.

b) **Run-off water harvesting:** In this system, runoff from upland is collected in the adjoining valley by enclosing as segment with

an earthen bund. During severe drought years, it may be used for getting a successful crop on the stored soil profile moisture.

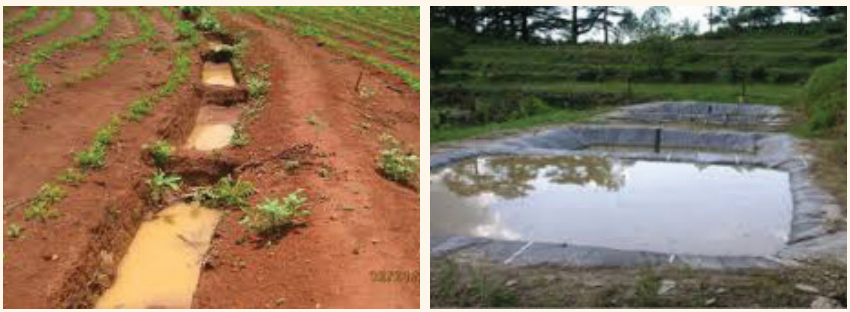
c) **Small ponds:** In this system, rain water or runoff water is collected during the rainy season. The collected water can be used for vegetable farming and drinking water for livestock.

Hazard context: Drought spells.

Locations: Drought prone area, hills, mountains, foot hills and Terai, suitable for deep soil surrounded by some natural catchment zone.

Beneficiaries: Small and medium farmers, local communities,

Benefits: Water availability at the drought spells. Life saving irrigation can be provided to the agricultural crops at drought period.



In-situ water harvesting

1.7 Soil Conservation Practices

a) Contour bunding

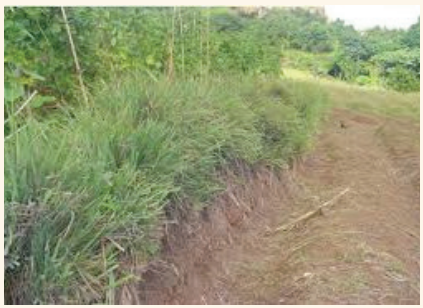
It ensures uniform distribution of water above the bund and therefore, better cultivation possibilities than any other types of bund. As the bunds are at regular interval, they intercept the run-off from attaining erosive velocity and causing erosion. The risk of soil erosion reduced by slowing down the velocity of water in various

places and at various levels in the watershed. The water is thus held on the field for a longer time soaks into the soil used by the crops grown on it.

b) Vegetative barriers

Vegetative barriers are closely spaced plantations- usually a few rows of grasses or herbs – grown along contours for erosion control in sloppy agricultural lands. Khus (*Vittiveria zelanica*), Merker (*Pennisetum purpureum* var. merkeri), a stiff stemmed grass are commonly used for planting. Any local stiff stemmed grass can be planted. They multiply vegetatively and rooted slips are planted during rainy season along the contour.

Contour bunding



Vegetative barrier

1.8 Contingent Crop Planning and Management

Contingency crop planning is growing a suitable crop and/or managing the crop management practices in place of normally grown crops according to the aberrant weather condition. There are four major broad scenarios for which contingent planning have to be made. These are:

(i) Delayed onset of monsoon: maximum of 3 weeks from normal date causes delay in planting of rainy/summer season crops.

(ii) Early onset of monsoon and sudden break: causes stress during the crop growth period.

(iii) Early withdrawal of monsoon: causes stress during maturity of rainy season crops.

(iv) Delayed withdrawal or extended monsoon: may damage matured crops at the harvesting time.

(v) Various permutation and combination of above four scenarios: complexities in management of crops.

In rainfed situation, contingency of growing another crop in a place of normally grown crops arises due to delay in onset of monsoon. In contingent crop management, suitable varieties, adoption of proper spacing, application of plant nutrients depending on the number of rainfall events, mid season correction in different management practices and need based pest control are the measures to be followed. This contingent planning reduces the risk of crop failure.

In several parts of Nepal, rainfall starts from June-July and ends in October-November. Drought occurs due to delay in onset of monsoon, prolonged dry spell during the crop season and early cessation of monsoon. During the monsoon, flooding and submergence are another type of disaster the agricultural sector has to face. Contingent cropping or crop planning and management are highly location specific due to variation in amount and distribution of rainfall. Some of these are listed below, which help in reducing the risk of crop failure and/or losses.

- If crops are under severe moisture stress and showing wilting symptoms, spray 2% urea solution along with life saving irrigation, wherever possible.
- In-situ moisture conservation practices should be taken up in maize, commercial crops and orchards under rainfed condition.
- Long dry spell affects crops especially pulses in winter season.

Adopt mechanical weeding and hoeing to keep the crops weed free and creation of soil mulch for moisture conservation in the standing crops.

- Amla based agro forestry systems sustained against drought.
- Under moisture stress condition provide life saving irrigation in different crops if possible.
- Heavy rainfall during September prevail high relative humidity and aggravate fungal diseases different crops. It increased the risk of crop damage. Under this situation follow the following precursory measures.
  - To control rice insects spray carbaryl, malathion or metacid
  - Spray Bavistin @500 g/ha to control sheath blight or sheath rot in rice. For leaf folder, spray monocrotophos (1.5 ml/l)
  - In cucurbits, spray Indofil M-45 @ 2.0 g/litre or carbendazim @ 1.0 g/litre to reduce the risk of crop failure against seedling rot, powdery mildew and downy mildew in vegetable nursery.
  - Spray Mancozeb (0.2%) to control downy mildew in bitter gourd
  - Spray carbaryl @ 4ml/litre to control Pseudo stem weevil in Banana
- If the rainfall is lesser than usual during early growth period, don't undertake intercultural operations in maize and vegetables as it leads to moisture loss. Take up mulching with leaves and grasses for moisture conservation.
- Plantation of horticultural crops and multipurpose trees and adopting in-situ moisture conservation practices as a long term contingency measure wherever possible.
- In-situ green manuring by growing crops like cowpea, horse gram, sunhemp etc.
- Practice scheduled irrigation, with monitoring to plant need and

soil water reserve status to avoid loss by drainage. Practice drip irrigation system in vegetable, horticultural and plantation crops during the shortage of irrigation water.

- Avoid crops with high water requirements in low availability region and period.
- Reduce crop spacing/increase seed rate by 20-25% depending on crops type if rain is delayed or soil moisture is lower than required to establish the appropriate plant population.
- Practice dry seed bed of rice – seedlings best thrive due to drought and under water shortage condition after crop establishment.
- Use more number of rice seedlings (6-8) at transplanting under rainfed condition to avoid and reduce the risk of crop establishment failure.
- If early rain – prefer direct seeding of rice; if normal rain – prefer transplanting of rice and if very late rain – direct seeding of rice or Dapog method of rice nursery to establish the rice crop in rainy season.
- If transplanted rice crop faces moisture stress during reproductive stage give one life saving irrigation (5 cm) wherever possible.
- In case of complete failure of normal rice during October due to severe drought, early sowing of chickpea, mustard and lentil can be done.
- If direct seeded rice upland rice is completely damaged during July due to delayed monsoon or severe drought, the crop may be cut down for supplying straw to cattle. Other crops like finger-millet, green gram, sesame etc can be grown.
- Even if there is no moisture in the soil during October/November, dry sowing of wheat/barley can be done in high hills. When small winter rain or snow is received, it helps in germination of crops.

- Ensure proper drainage for rainy season maize grown in low lands in Terai plains.
- Potato planted in raised bed of 24-31 cm with the row spacing 90-100 cm increased the yield from 32 t/ha to 37.3 t/ha with water productivity of 11.9 t/m3 water with reduced application of water (20.3 cm) compared to farmers local practices.
- Maize and cowpea grown in rotation between 7 years old alleys of *Leucaena leucocephala* shrubs (4m spacing) bind the soil to lessen the surface soil erosion.
- Inclusion of Lucerne in crop rotation in sloppy lands (13% slope) reduces the soil loss due to run-off under intense rainfall.
- Growing of extra short duration pigeonpea variety in shallow low land rice ecosystem if rice planting is not possible due to drought and should follow Pigeonpea-wheat rotation.
- If sugarcane crop faces severe moisture stress during the growth period, dried lower leaves of the standing crops should be used as mulch in the inter-row space of the crops. It will conserve the available soil moisture by reducing surface evaporation and control weeds.
- Under early cessation of monsoon than normal, wheat, lentil, chickpea etc as winter crops should be sown using zero tillage seed drill or minimum tillage without carrying out tillage operation. It will not only save the time for land preparation by conventional method but also obviate further delay in sowing by utilizing available moisture for better plant stand.
- Under late cessation of monsoon than normal, surface seeding of wheat in shallow lowlands and lowlands before or after rice harvest if there is high moisture for land preparation to sow the wheat crop. It will also save the time for land preparation and wheat can be grown in time.
- Spray of 2.5% Urea with 2.5% Murate of Potash will impart

drought tolerant to plants. It should be done where some soil moisture is available.

- Mulching of soil surface with organic materials in vegetable fields is useful under drought condition and water is not available for irrigation.
- If rice transplanting is not possible due to early severe drought maize can be sown in September for fodder purpose wherever feasible. This crop can be harvested in November to facilitate the sowing of winter crops like wheat, lentil and chickpea.
- Growing of low water required vegetable crops like cluster bean, cowpea, lablab bean, radish, peas etc in water scarce condition.
- Enhance cucurbitaceous vegetables by raising nursery in polythene bags followed by transplanting in order to save 2-3 irrigations under less water available condition.
- As the sowing of main winter fodder crops starts in October-November, Berseem and oat can be planted during September if there is light shower to reduce the risk of crop failure due to drought in late crop growth period.
- During drought and post-flood period, fodder and feed for livestock become limited. Sugarcane tops, its dry leaves, sugarcane baggase and press mud can be supplementary for fodder and feed after treatment.
- Further, residues of crops which are not normally fed to livestock, the practice of Total Mixed Ration (TMR) should be practiced and propagated. Such feed materials can be incorporated in TMR to the extent of 10-15%.
- Mineral supplemented through Urea Mineral Block (UMMD) should be given to animals for preventing loss of fertility in case of prolonged drought.
- Growing of drought tolerant grasses like Cenchrus *ciliaris*, *C. seligerus*, *Lasirius sindicus* in marginal lands improves the

waste land productivity under prolonged drought.

- Growing of perennial Napier grass along agriculture bunds in rainfed and drought prone areas especially in mid-hills' sloppy lands under agro-forestry system will not only yield surplus fodder during prolonged dry spell but also protect crops from wild animal predation.
- In-situ moisture conservation by creating micro-water harvesting catchment to direct surface flow into tree basis under water deficient condition
- In tea and coffee plantation crops, in-situ soil moisture conservation by trenching, contour or field bunding and gully plugging may be taken as the measures for minimizing the impact of deficient rainfall.
- High incidence of diseases like *Haemorrhagic septicaemia* (HS) and *Enterotoxaemia* (ET) in cattle and buffalo and PPR in sheep are likely to occur after post flood. Suitable immediate vaccination program should be put in the place to reduce the risk of damages of the animals.
- Large scale de-worming need to be carried for severe worm infestation after occurrence of flood due to muddy water and non-availability of clean and safe drinking water.
- Livestock should be protected from cold waves by managing proper shelter during winter season. Animal shed should be prevented from dampness as it aggravates the respiratory problems because of severe cold environmental condition.
- Provide proper shelter to livestock to protect from heat waves during summer (April-May). Also, sprinkle the shed during peak summer to prevent heat stress and production loss and make available of cold clean drinking water throughout the day.
- In June-July if there is heavy rain or thunderstorm protect the animals and prevent water logging condition in the shed by

providing the drainage.

- During February to March, if there are no greens for feeding the animals due to prolonged winter drought; add vitamin supplements in the concentrate mixture to overcome vitamin deficiency in lactating animals.
- Aquaculture practices can be practiced to utilize the left over water in low lying areas and ditches after floods by rearing short-duration fishes.
- Post-flood contingency plan for crops
  - Plant short duration pulse crops like pigeonpea and black gram in mid and upland
  - Grow vegetables like cucurbits, brinjal, tomato etc

  -Grow maize, cowpea and napier etc for fodder
- Plant short duration oil seed crops like toria, early potato, gram, sunflower etc as per the farmers need

1.9 Adaptation Measures and Strategies of Climate Change Impact in Agriculture

Adaptation includes policies, strategies, program, plans and activities that help people and ecosystems reduce the vulnerability to the adverse impacts of climate change and minimize the costs of climate related disasters. It aims is to reduce the climate-related vulnerability and empower the farm community to effectively cope with current climatic variability and to adapt the unexpected consequences of climate change. To develop coherent adaptation program, main factors causing vulnerability of climate change should be understood. Lesser awareness of policy makers on the serious impact of climate change on development as well as unavailability of legal and regulatory framework for managing effect and risks of climate change in the short, medium and long term are the important factors causing the level of vulnerability to

climate change. In view point of reducing the impacts of climate change and its variability, the adaptation measures and strategies should be considered from local level to national level. For this, short to long term adaptation strategies with multi-sectoral approach should be made.

Short-term adaptation measures (1-2 years):

The evidences of climate change have been observed in many agro-ecological zones of the country. The effect of variable weather change patterns across the locations, geographic regions and ago-ecological zones necessitate to initiate the immediate action in order to address problems related to drought, floods and landslides for food security. It is imperative to follow a multi-sectoral approach given the nature of climate change.

- Rehabilitation and networking of existing irrigation system and promotion of rain water harvesting technology in order to prevent crop failures caused by drought in drought prone areas thus reduces drought risk and increased planting index,
- Strengthen existing community based early warning flood prevention systems to reduce the crop losses from water inundation and promotion of runoff harvesting as well as building water storage systems during periods of intense rains,
- Use of more heat and drought tolerant crop/varieties in rainfed areas where precipitation and increased temperature poses the risk of crop failure,
- Develop and promote resource conservation agriculture technology as minimum tillage and zero tillage practices for rice, wheat, maize and legumes to reduce carbon and water loss from soil, particularly in the Terai and hill region,
- Application of soil conservation practices particularly in the hilly and mountain areas,

- Limiting practices of mono-cropping to reduce vulnerability of farmers to weather-related events,
- Identification, documentation, demonstration and extension of existing available climate resilient production technologies,
- Provision of good quality seeds to vulnerable groups and of appropriate varieties by agro-ecological region,
- Promotion of multi-tree-crop intercropping, agr-silvipasture, silvi-pasture and multi-storied cropping wherever possible,
- Use faster growing fish species in vulnerable area,
- Revitalizing research and extension programs in the areas of institution, human resources, methodologies and supporting facilities for extension activities,
- Development of strong extension and communication system to deliver the climate resilient technologies at community level,
- Promote available post-harvest practices to manage climate related risks proactively.
- Promote crop diversification programs like multiple and mixed cropping systems which gives better insurance averting the risk of crop failure with diversified income source and natural resources conservations;
- Broaden extension services and research programs to help farmers introduce new adaptive technologies and farming practices related to crop production

Medium-term adaptation measures (4-5 years):

To implement appropriate adaptation measures in the medium term making the agriculture sector more resilient to climate change, capacities and knowledge on the part of farmers and communities is lacking in Nepal. Tackling climate change impact is lacking due to technical, human resource and financial capacity at all

levels, including community and institutional level. Medium-term measures are related to necessary investments oriented toward mainstreaming climate change in agricultural policy, capacity building, and program formulation as well as building a strategy. The gap exists in translating the climate information products into impact outlooks, alternative management relevant to farmers and communities and establishing strategies for communicating the information products. The following measures and strategies have to follow:

- Implementing climate change adaptation strategies outlined in different agriculture policies and frameworks to promote resilience and sustainable development,
- Capacity building programs at government level aimed at enhancing knowledge and understanding of the key challenges of climate change in crop production,
- Enhance knowledge, innovation and good practices and training and general education for climate change adaptation for the rural population considering the gender to help improve their knowledge on adaptive farming practices,
- Formulation and implementation of the strategy of agricultural research and development institutions to help them address identified adaptation needs and priorities, while at the same time considering the financial and human resources investments necessary for this; possible creation of a special Climate Change Adaptation Cell where ever required,
- Strengthening of present crop monitoring system in order to better monitor crops, livestock and fisheries and to provide early warning information to the farmers,
- Development and implementation of early warning systems for flood prevention in affected areas,
- Promotion of crop diversification with crops suitable to local

conditions within appropriate regions,

- Provision of support for daily, weekly and seasonal climate outlooks by making available to the farm community,
- There is a need to radically depart from reliance on rain-fed food production through heavy utilization of irrigation. There is therefore the need for adequate provision of irrigation and drainage infrastructures which could be regarded as crucial for climate change adaptation,
- Development of plans for short-term measures to adapt to water shortages and thus mitigate drought,
- Documentation and utilization of indigenous knowledge on coping climate change impact and
- Development of strategy, plan and program for Climate Smart Agriculture in all sub-sectors (crop, livestock, horticulture and fisheries/aquaculture).

Long-term adaptation measures (10-15 years):

The adaptation measures outline below should be incorporated into a longer-term national agricultural response policy in order to improve crop productivity adapting to future projected climate change. Limited investment in research and development, and extension services further constrains agriculture resilience. Thus, for the long-terms, the main measures should be concentrated on institutional capacity building and reformation, including strengthening of research and development institutions with programs aimed both at local and national level and financial resource mobilization on climate change issues.

- Increased investment aiming at strengthening research and development institutions for developing climate resilient and climate change adaptive agricultural technologies and its communication at the community level,
- Develop new crop varieties and breeds resistant to heat, drought,

new pests and diseases,

- Promotion of studies to identify areas of opportunity in the different agro-ecological regions of the country in terms of soil and water conservation,
- Elaborating risk maps for the different agro-ecological regions of the country,
- Continuous promotion of contingency planning at all level in all sub-sectors,
- Identification and promotion of risk sharing and transfer mechanism at community level,
- Strengthening local capacity to cope with the climate change impact in agricultural production and deal with vulnerability and uncertainty by developing regular monitoring, vulnerability assessment and reporting mechanism,
- Strategies to promote public and private awareness and participation in climate change adaptation in agriculture,
- Strengthen the related institution to develop climate-forecasting and early warning systems for reducing hazards in the agriculture and effective distribution of information to farmers,
- Introduction of weather-indexing crop insurance system by integrating micro-finance programs,
- Implement aquaculture insurance policy,
- Selective breeding and genetic improvement for higher temperature tolerance in livestock and fisheries/aquaculture,
- Programs to establish crop insurance covering losses due to flooding and drought,
- Increased investments for rehabilitation and construction of efficient irrigation schemes,
- Develop interactive communication for transfer of technologies

to farmers about climate change and its impacts on crop production,

- Developing continuous regional and international collaboration and coordination in terms of information sharing on adaptive farming practices and new farming technologies to help cope with vulnerabilities,
- Diversifying the livelihood strategy to include income from other farming and non-farming activities,
- Program and investment to establish seed bank at community level for seed security and crop/variety diversity at the time seed scarcity,
- Vulnerability study on the effect of future climate change on crop production using different decision support tools,
- Action plan on Integrated Ecosystem based fisheries/aquaculture management, and
- Assessment of future scenario of climate change impact on fisheries and aquaculture using different tools especially models.

For Further Information

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