Dryland Management Resource Book





Government of Nepal

Ministry of Forests and Environment

Department of Forests and Soil Conservation

Developing Climate Resilient Livelihoods in the Vulnerable Watershed in Nepal (DCRL)

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प्राप्त पत्र संख्या र मितिः
पत्र संख्याः
च. नं.:

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लेख गर्नुहोला ।)
बबरमहल
काठमाडौं, नेपाल

FOREWORD

The geographical diversity, unequal distribution of rain, weak and sensitive land-cover makes dry land management a significant challenge to the sustainable development of Nepal. The impact of dry land and desertification is deteriorating the agro-production capacity, while also directly affecting livelihoods, conservation of biodiversity, stability of water resources, and local prosperity.

In this context, the Department of Forests and Soil Conservation has published a "Dry land Management Resource Booklet" based on its experience, learning and practices from the implementation of the Developing Climate Resilient Livelihoods in the Vulnerable Watersheds in Nepal-DCRL project. This booklet provides an introduction to basic concept and principles of dry land management, while also providing practical tips and guidelines on the technology and institutional growth that can be adopted at the community level.

I believe that this booklet shall become the local government, technical agencies, stakeholder organisations and community practitioners involved in natural resource management. It is also expected to help promote sustainable land management and contribute to climate adaptation, and also strengthen the foundation of long-term food security and consolidate local livelihood.

On this occasion, I would also to extended my heartfelt gratitude, on behalf of the Department, to Dr Prem Prasad Paudel and Agricultural Engineer Dipesh Guragain, who played the role of editors in the development of this booklet, and to all the technical staff, stakeholder agencies, partner organisations--United Nations Development Programme, Global Environmental Facility (GEF), and all other who were directly or indirectly involved in this initiative.

Finally, I would like to extend my best wishes that this "Dry land Management Resource Booklet" provides further inspiration, knowledge and practical support to the stakeholders working in the field of dry land management in Nepal.

Badri Raj Dhungana
Director General

MESSAGE FROM RESIDENT REPRESENTATIVE

United Nations Development Programme

Foreword

Droughts are a frequent challenge in Nepal, often caused by irregular monsoon rainfall and climate variability. The Lower Dudhkoshi watershed, in particular, is highly drought-prone, with households facing increasing water shortages from low rainfall, reduced snowfall, and rising temperatures. With most households relying on rain-fed subsistence agriculture, it is estimated that only 80 percent of them are food secure for three to six months and many depend on traditional wells for drinking water. Climate change further disrupts the hydrological cycle, increasing the frequency and intensity of floods and droughts, which directly threatens lives and livelihoods, especially in mountain communities.

In response to these challenges, UNDP, in partnership with Department of Forests and Soil Conservation, Ministry of Forests and Environment, implemented the GEF/LDCF-funded *Developing Climate Resilient Livelihoods in the Vulnerable Watershed in Nepal (DCRL)* initiative. The project aims to enhance climate resilience through multiple interventions, including water management, soil enrichment, capacity building, and policy and institutional strengthening. It has generated invaluable insights, practical and adaptive solutions, and techniques combining innovative approaches with traditional community knowledge which are particularly relevant for dryland restoration.

The *Dryland Management Resource Book* catalogues the best practices of dryland management identified through the project. It provides an overview of drylands in Nepal, their characteristics, underlying causes of degradation, restoration techniques, and relevant government policies. It is my sincere hope that this book will serve as a resource reference for policy makers, practitioners, professionals, and local communities, enabling them to adapt tested solutions and approaches to their own contexts.

I express my sincere gratitude to the National Project Director, Project Manager, DCRL project team, and all others who contributed for the publication of this pioneer knowledge series.

Kyoko Yokosuka
Resident Representative

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Executive summary

Many parts of Nepal's high mountains, mid-hills, Chure and Tarai are known as dry zones. This book provides practical information on dry land management to farmers, local bodies and stakeholder organisations. Climate change, uneven distribution of rainfall, deforestation, loss of soil fertility and drying up of water resources are the main causes of drought, which have seriously affected farming, animal husbandry and people's lives. There are four types of drought (1) meteorological, (2) water resource, (3) agricultural, and (4) ecological droughts, which are interrelated and cause water scarcity, crop failure, disease and fest infestation, socio-economic crisis and environmental imbalance. In Nepal, the production of major crops such as paddy, wheat, and maize is declining, while many water sources have dried up. This has directly affected the livelihoods and food security of rural farmers.

The basic principles of dry land management are water conservation, soil conservation, agro-forestry systems, appropriate land use and crop planning. Techniques such as rooftop water harvesting, pond construction, drip irrigation, mulching, and use of green manure, crop diversification, planting of drought-tolerant species, afforestation and recovery of degraded land have been found to be effective for drought-affected land management. There are four stages of the drought cycle – normal, alert, emergency and recovery. In normal conditions, water storage and seed collection should be carried out. In the alert stage, preparations should be made for fodder grass/food storage and irrigation. In emergency stage, relief, rescue and health security should be accorded priority. In the recovery stage, emphasis should be laid on sustainable agriculture, afforestation and infrastructure development.

The federal government of Nepal has introduced land, forest, environment, agriculture and watershed management policies, which have provisions to address dry zones. The provincial and local levels are also implementing programs such as pond construction, irrigation technology, fodder grass/vegetable plantation, subsidies and disaster mitigation plans. However, a separate "dry land policy" has not yet been formulated

The following major activities should be carried out for dry zone management:

1. Identification of water sources, springshed management, multi-purpose ponds, rainwater harvesting.
2. Conservation farming, organic fertilizer management, mulching, crop diversification.
3. Degraded land restoration, drought-tolerant species plantation, soil conservation.
4. Food utilization, reduction of evaporation.

Community-focused, science-based and policy-coordinated initiatives are indispensable for successful dry land management. Soil and water conservation, crop diversification, local participation and sustainable planning are the major foundations of farmers' livelihoods, food security and environmental protection.

About the book

This resource book has been prepared to provide information on "Dry Land Management" to social leaders, technicians and farmers in the high hills, mid-hills and Chure regions of Nepal. Global climate change, uneven distribution of rainfall, deterioration in soil productivity, deforestation and drying up of water sources are reducing the productivity of dry land areas. This book specifically explains how dry lands are formed, their characteristics, how they affect people's lives and includes practical techniques to address them such as sustainable use of soil and water, appropriate crop and fodder grass management, water harvesting and promotion of agro-forestry systems. Local examples from the high hills, mid-hills and Chure regions have been included to make the book practical and farmer-friendly.

This book is expected to be used as a field guide by development workers from community-based and non-governmental organizations, government agencies and research institutions involved in the development of agriculture. In addition, it will serve as a reference material for schools, professional institutions and universities. This book provides an overview of the problems and issues facing agriculture in the dry lands of the high mountains, mid hills, Chure and inner Madhesh of Nepal, and includes various initiatives taken by individuals, communities and development organizations to address those problems. It incorporates the experiences and learnings from the Development of Climate Resilient Livelihoods in the Vulnerable Watersheds in Nepal (DCRL) project implemented in the Lower Dudhkoshi watershed area of Khotang and Okhaldhunga districts in collaboration between the Department of Forest and Soil Conservation (DoFSC) and the United Nations Development Programme (UNDP) with financial support from the Global Environment Facility (GEF).

Part 1 Introduction and Concept

Drought is a silent, widespread and all-sides affecting threat. It is caused by a lack of water availability. It has devastating effects on agriculture, animal husbandry, water supply and the environment, and leads to economic losses. Compared to other natural disasters, droughts often begin gradually and without prior warning and can last for a long time over a large territory. Its effects can persist for years even after its end. Recent studies have shown that the increasing frequency and severity of droughts have led to a significant decline in agricultural production in many countries around the world, including the Asian continent.

Dry land management means a sustainable land management system carried out through the use of soil conservation techniques such as soil and water conservation, forest management, rainwater harvesting, manure, mulching, and drought-tolerant species plantation is carried out in areas with low rainfall, water scarcity and low soil moisture, and appropriate use of local resources. Since farming in majority of the areas in Nepal's hills, Chure and high hilly regions are dependent on rain, such type of management ensures appropriate land use, maximum water utilization and helps to increase the income of farmers. It also supports environmental protection and climate adaptation by reducing the problems of soil erosion, drought and land desertification.

1.1. Dry Land

Dry Land refer to lands where rainfall is low, scattered, irregular and unpredictable. According to the UN Convention to Combat Desertification (UNCCD), such areas generally receive only 0 to 600 mm of annual rainfall. These areas often experience long dry seasons, low soil fertility and frequent droughts. Water sources are limited in these areas. Such lands lack irrigation and farming is carried out with complete dependence on rainwater. These areas face problems of gradually decline in production and productivity.

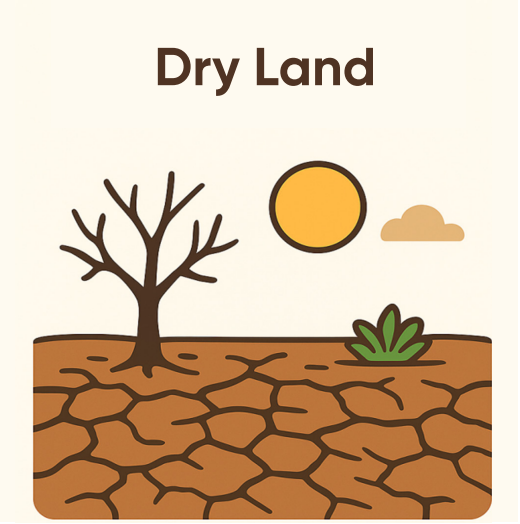

Figure 1: Dry Land

1.2 Dry Land Management

Dry Land management is the sustainable management of water, land and vegetation in areas with low rainfall, dry conditions, rocky soil with low fertility, water scarcity, and low moisture. Its objective is to conserve land productivity, water storage, retaining soil moisture, conserve soil and mitigate the effects of climate change by making the most of limited resources through rainwater harvesting, pasture improvement, forest management and farming systems. This helps in increasing farmers' income, maintaining environmental balance and conserving local resources.

1.3 Characteristics of Dry Land

Drought-affected lands face scarcity of water Due to the low rainfall, there is a high seasonal variation. The land in such areas is often rocky, sandy, barren, and dry, i.e. it lacks nutrients. The ability of such land to absorb water and retain moisture is low. The land is often dry and due to the steep terrain there is a high possibility of inundation and soil erosion. In such areas, trees and plants are mostly scattered, sparse, drought-tolerant thorny shrubs and bushes. The livelihood of the people living in such areas mainly depends on traditional rain-fed agriculture, animal husbandry, and on the forest. Many areas of the high Himalayan region, such as Mustang and Dolpa, and the mid-hills and Chure regions, are dry lands. If these lands are not managed properly, there is a high possibility of desertification.

Figure 2: Struggle for water in dry land

1.4 Types of Drought

Droughts can be classified into four main types based on their nature, characteristics and impact: meteorological drought, hydrological drought, agricultural drought and ecological drought.

1.4.1 Meteorological Drought

This type of drought is usually caused by fluctuations in rainfall and temperature. There is less than the average annual rainfall for a long period of time. According to the UN Convention to Combat Desertification (UNCCD), such areas usually receive only 0 to 600 mm of annual rainfall. Due to changes in the amount, intensity and timing of rainfall, the water absorption capacity of the land, groundwater recharge and runoff processes are adversely affected. In addition, high temperatures, strong winds, low humidity, lack of clouds and intense sunlight also increase water

evaporation and emission. Its duration determines the intensity of the drought. For example, if an area receives significantly less rainfall than the annual average for several months it is a meteorological drought.

1.4.2 Hydrological Drought

The effect on surface and groundwater resources are clearly evident due to the less than average rainfall. During this type of drought, water sources, wells, ponds, lakes and wetlands are not recharged and dry up i.e. the water level is decreasing. In addition, the flow and volume of water in rivers and streams also decrease significantly.

1.4.3 Agricultural Drought

This type of drought directly affects agricultural activities. The amount of water received through rain and irrigation is not enough for agricultural crops and livestock. There is a lack of moisture in the soil and a shortage or low level of water in reservoirs required for irrigation. This reduces agricultural and livestock production due to the lack of moisture and water for irrigation essential for the vegetation.

1.4.4 Ecological Drought

When the demand for daily economic goods and services is affected due to water scarcity resulting from meteorological, hydrological or agricultural drought, and leading to deterioration of environmental services, socio-economic and ecological services, then it results in ecological drought.

The aforementioned droughts are interrelated. For example, meteorological drought can cause hydrological drought, which can lead to agricultural droughts, and ultimately socio-economic and environmental impacts become visible. This has a negative impact on the socio-economic condition and livelihoods of the people, and the environment. The severity of drought depends on its duration, which varies, making it complex to monitor and manage.

1.5 Basic Principles of Dry Land Management

The major principles of dry land management are integrated management of land and water with community participation to achieve climate adaptation and sustainable livelihoods. This includes conserving soil and water, improving soil fertility, and increasing vegetation cover to maintain agricultural productivity in dry land. Emphasis is laid on maximizing the use of available natural resources through adoption of measures such as mulching to maintain moisture in the soil, rainwater harvesting, soil erosion control, drought-tolerant agro-farming and afforestation. Activities such as sustainable land use planning with community participation, agroforestry, minimum tillage, organic farming and degraded land recovery are important for it. The major objective of these activities is to address the major challenges faced by dry land ecosystems and ensure long-term livelihoods for farmers living in such fragile ecosystems. The basic principles of dry land management are briefly presented below.

Figure 3: Key principles of dry land management

1.5.1 Water Conservation

Water is the most sensitive and important resource in dry land areas, and it is always limited. As rainfall is limited and irregular, every drop of water has to be conserved. To collect and recharge water, techniques such as roof water harvesting of rainwater, digging contour pitches, making small ponds, conservation ponds/run-off water collection ponds and check dams can be adopted. The use of techniques such as low-tillage farming systems, simple drip irrigation and mulching helps to reduce water evaporation and maintains the moisture necessary for crops.

Water sources should be conserved and managed in an integrated manner by conserving water springs and sources and minimizing potential impact on the overall watershed and springshed areas. Such activities shall help ensure the sustainability of water supply for agriculture and domestic purposes.

1.5.2 Soil Conservation and Fertility Management

Landslides and soil nutrient depletion due to wind, run-off rainwater and overgrazing are major problems in drought-hit areas. To prevent this, planting-row improvement, cultivation in contour line, making ridges in contour lines, planting fodder grass in field boundary, and using organic fertilizers such as compost or green manure can be done. Mulching, minimum tillage and appropriate management improves soil moisture content and maintains soil structure and fertility, thereby preventing desertification.

1.5.3 Vegetative and Agro-Forestry Measures

To stabilize the soil and fulfill daily needs such as wood, firewood, fodder grass and fruits, appropriate local plant species, fruit saplings and fodder grass saplings should be planted. Agroforestry systems combine trees, agricultural crops or livestock on the same land. It reduces soil erosion and the risk of climate change by improving biodiversity and promoting greenery. In addition, fodder, grass and drought-tolerant long-rooted trees and plants help reduce evaporation and improve soil moisture.

1.5.4 Proper Land Use and Crop Planning

Land should be used appropriately, considering its condition and soil potential. Forest, fruit trees or grasses can be planted on steep slopes and cereal crops on less slope and flat areas. Crop rotation, mixed cropping, intercropping, and introgression systems should be adopted, and drought-tolerant species should be selected as much as possible. Planning based on soil texture, type and rainfall can ensure good returns and sustainability. Controlling overgrazing and unorganized settlement can increase the further use and productivity of land.

1.5.5 Community Participation and Ownership

Dry land management cannot be successful without the participation of local communities. The people living in these areas are the primary users and common caretakers of land and water resources. Planning, implementation and monitoring should be carried out with the participation of the community, which ensures collective action, cost/benefit sharing and equitable access to and maintenance of completed conservation structures. Local leadership should promote, mainstream, and empower women and marginalized groups in the decision-making process.

1.6 Causes and Effects of Dry Land

According to a recent study conducted in Nepal, the main causes and effects of drought are mainly considered to be as follows.

Figure 4: Causes and Effects of Drought

1.6.1 Climate Change and Drought Frequency

Due to climate change worldwide, the pattern and distribution of rainfall is becoming uneven and uncertain, and the temperature is also gradually increasing. The effects of climate change have also been clearly seen in Nepal in the past few decades. According to the study of meteorological data from 2027 to 2070 BS, the average annual rainfall in Nepal is decreasing about 1.3 mm per year. However, some areas are experiencing unusually high rainfall while some are getting continuous low rainfall. Disasters such as droughts due to prolonged absence of rainfall, sudden heavy rainfall and rise in temperature are gradually increasing.

A study of Nepal's temperature from 2027 to 2070 BS has shown that the annual average temperature rising rate is about 0.056 degree Centigrade per year. In particular, the maximum temperature is increasing rapidly at a rate of about 0.056 degrees Centigrade per year and the minimum temperature increase rate is only 0.002 degrees Centigrade. This indicates that the heat is increasing and the cold is decreasing. This type of rise in temperature has had effects such as reducing soil moisture in dry lands, decline in agricultural production, and increasing damage to forest biodiversity and ecosystems. Due to similar effects, the government of Nepal has declared Madhesh Province as a drought-hit zone in Shrawan 2082 BS (July 2025) due to minimal rainfall and no rain at all. It had directly affected daily life and also had a negative impact on agriculture, animal husbandry, drinking water supply, human health and the environment

1.6.2 Steep slopes and Heavy Rainfall

During heavy monsoon rains in the steep terrain of the high hills, mid-hills and Chure regions of Nepal, the runoff water flows rapidly, which does not allow enough water to be absorbed into the ground, reducing water storage and soil moisture. This leads to surface soil erosion from the traditional hilly farmlands, washing away of fertile soil and the lack of sufficient moisture essential for plant growth.

The rapid flow of runoff water also causes floods and landslides. A study has shown that surface soil erosion in the mid-hill watershed area is up to 11-22 tons/hectare/year. Similarly, it has been found that up to 64 tons/hectare/year of soil has been lost from the Chure-Shiwalik watershed. These facts clearly indicate that in addition to reducing agricultural production, the risk of floods, landslides, inundation and silt has increased in the lower coastal areas.

1.6.3 Insufficient Irrigation and Water Scarcity

The arable lands of the hills, Chure and Tarai of Nepal do not have reliable irrigation facilities all year round. In the dry areas, there are not enough water sources for irrigation. Surface and groundwater sources have dried up due to low rainfall and lack of groundwater recharge.

In drought-affected areas, as irrigation systems remain inactive due to lack of water sources, farmers are forced to rely on rainfall for farming. In the absence of monsoon

and winter rains, the land are left barren, crop failure occurs while the farmers may have to abandon traditional crops such as paddy and legume crop.

1.6.4 Haphazard Infrastructure and Road Construction

Haphazard infrastructure and rural roads construction in the steep terrain of the central hills, using bulldozers without environmental study destroys the soil surface, making the steep hillsides unstable and cemented, and as a result run-off water cannot infiltrate into the ground. Landslides and silt turn the lower coastal areas into swamps, obstructing water flow and drainage.

A study by ICIMOD has shown that approximately 40 million tons of soil was washed away from the Koshi basin area between 2047 and 2067 BS. As a result, the risk of flooding in the lower coastal areas has increased, affecting aquatic life and aquatic ecosystems. Similarly, the indiscriminate use of bulldozers has weakened the slopes and led to landslides, causing damage to agricultural land and access roads, directly affected the community.

1.6.5 Incidence of Pest and Diseases

The increase in temperature and changes in humidity levels create favourable conditions for the disease and pests in crops. Due to the increasing incidence of diseases and pests in traditional indigenous crops, farmers are forced to change crops or use chemical fertilizers and pesticides excessively. This increases both production costs and environmental risks. Study report have shown that there is a risk of losing apple cultivation in Mustang due to new diseases resulting from climate change.

1.6.6 Socio-economic Vulnerability

Due to unequal access to natural resources, more than 50% of marginalized farmers cultivate less than 0.5 hectares of land. This leads to low productivity, food insecurity and extreme poverty, putting their livelihoods at risk. Climate change has also led to a reduction in the availability of labour, with men migrating in search of work and seeking employment opportunities abroad.

Due to limited labour, credit or poor technical services, marginalized farmers are unable to diversify their crops or build water-harvesting structures. Crop failures due to droughts reduce income and employment, and people are forced to migrate. Increasing migration increases the workload of women due to the shortage of male labourers needed for agriculture and reduces overall agricultural productivity. This disrupts the social structure and increases the physical risk of drought.

1.6.7 Deforestation and Overgrazing

Deforestation is increasing in the mid-hills and Chure regions due to migration, encroachment, unplanned settlement and agricultural expansion. Due to insufficient and unsuitable forest cover, the land remains open, which causes water to flow through the surface during rainfall and not be absorbed sufficiently by the soil. Open and excessive grazing leads to the land becoming stiff and devoid of vegetation.

Factors such as stiffness of the land and lack of vegetation contribute to the problems of surface soil erosion, reduction of soil fertility and drying up of water sources. As a result, in addition to creating environmental disasters, the fertility of the land decreases, which leads to the possibility of farmers resorting to deforestation in search of new land for livelihood.

1.7 Condition and impacts of dry areas in Nepal

Figure 5: Impacts of Drought

1.7.1 Condition of Dry Areas

Dry areas in Nepal are found in the high hills, mid-hills, Chure and Bhawar regions. These areas suffer from water scarcity and soil erosion due to irregular rainfall, steep terrain and weak soil structure. According to the report of the National Sample Census of Agriculture Nepal (2021/22), the total area of agricultural land in Nepal is about 2.218 million hectares. Of which, 1.43 million hectares (64.5%) are irrigated land and 07.88 million hectares are dry land. Due to increasing urbanization and land fragmentation, there have been changes in land use in the past few decades. Dry land is mainly found in Koshi, Bagmati, Gandaki and Karnali provinces. Monsoon

rain-based farming is practiced in the high hills, mid-hills and Chure areas, including Karnali and Sudurpaschim provinces due to limited irrigation facilities. The impact of drought on water resources, farming, soil fertility and livelihoods is as follows.

1.7.2 Impact of Drought on Water Resources

Due to the lack of reliable irrigation in about 35% of Nepal's total cultivable land, more than 70% of farming depends on seasonal rainfall. Low rainfall and lack of groundwater recharge and reduced water flow in rivers and streams have increased the shortage of supplementary irrigation in the fields. In addition, the drying up of permanent water sources has also increased the problem of drinking water.

1.7.3 Impact on Crops and Agriculture

Due to dependence on seasonal rainfall-based agriculture, the temporary crop area has decreased by 392 thousand hectares (18.5%) in the last decade, according to the National Sample Census of Agriculture. The decrease in the area and production of drought-tolerant crops such as paddy, maize, wheat and millet is a direct impact of drought. This has a negative impact on food security and the income of farmers.

1.7.4 Impact on Soil Quality

The land in dry areas is often arid, barren and hard, so its water absorption capacity is low. Due to continuous tillage and water shortage, the structure, chemical properties and organic matter of the soil are decreasing. As a result, such land can become barren, dry and devoid of nutrients. In addition, due to surface soil erosion by wind and water, the land in the Himalayas, mid-hills and Chure regions is becoming barren. As a result, the land becomes permanently barren and there is a high possibility of a long-term decline in soil productivity.

1.7.5 Impact on Livelihoods

As the income source of farmers decreases due to the impact of drought on the agricultural sector, young people have been attracted to foreign employment. Due to lack of access to irrigation and modern technology, the cost of production of farmers dependent on dry land increases, which discourages them from farming. This has led to a decline in crop production, increasing food insecurity as well as social and economic inequality.

Part 2 Existing Policies and Programs

The policies of the federal, provincial and local governments have a far-reaching impact on the management of dry lands and the activities of local communities. Timely relevant policies promote sustainable livelihoods, stimulate the economy and encourage people to adapt during a drought. Absence of policies and programs to address droughts can discourage local initiatives, which can lead to resource depletion, poverty and conflict. Policies and programs dedicated to dry land management in Nepal have not yet been formulated. However, some of the provisions related to dry land management are included in the prevailing policies and programs of the federal, provincial and local governments, which are presented below.

2.1 Federal Government Policies and Programs

2.1.1 National Land Policy, 2075

- Prioritizes land classification, sustainable use, soil conservation and development of irrigation.
- Encourages water source conservation and rainwater harvesting to irrigate dry lands.

2.1.2 National Forest Policy, 2075

- Sustainable development of forests and grazing areas in dry lands and inclusion in land use plans.
- Prevent washing away of land and soil erosion by planting forests, grasses and plants.

2.1.3 National Environment Policy, 2076

- Integrated development of water, soil and forest management based on environmental balance.
- Emphasis is placed on soil and water conservation, recharging of water sources and Chure conservation.
- Climate change adaptation and risk reduction programs.

2.1.4 National Agriculture Policy, 2076

- Encourages the use of drought-tolerant agricultural crops, organic fertilizers and modern technology in areas with lack of irrigation.
- Emphasis is placed on development of rainwater harvesting and micro-irrigation systems.

2.1.5 National River Basin Management Strategy, 2080

This includes various strategies, working policies and action plans related to drought management. The most important of these provisions are summarized below.

- To reduce climate-induced land disasters and risks, classify large watersheds based on problems and sensitivity, and identify drought-sensitive watersheds and develop and implement short, medium and long-term adaptation plans in a phase-wise manner.
- To solve the problems of drought-sensitive watersheds, emphasis has been placed on integrated water conservation and management measures such as water storage, springshed conservation, drought-tolerant crops and water demand management.
- To ensure basic water flow by reducing the impact on water resources during droughts, map, identify and document water sources of basin, watersheds/ sub-watersheds for integrated water conservation and management; there is provision for determining environmental water flow and silt limits in rivers and conducting regular monitoring.
- By mapping, classifying and prioritizing basins based on disaster-induced multi-hazards (floods, landslides, droughts), an early warning system can be established in sensitive watersheds and alternative irrigation schedules and livestock grazing management can be implemented through the development of drought monitoring, warnings and early action plans.
- Identify drought-sensitive watersheds in each province and developing an integrated model, activating local-provincial-federal coordination mechanisms, and developing experimental studies and knowledge centers. This has established policy measures for successful drought management practices.
- While conducting all the activities for the management of drought cycles, women, indigenous nationalities, Dalits, marginalized, minorities and underprivileged communities should be given priority and enforce on the basis of social inclusion.

2.1.6 Chure-Terai-Madhesh Conservation Master Plan, 2074

- In the Chure region, priority has been given to community forest management, water source conservation and prevention of soil erosion and river erosion.
- Emphasis has been placed on water recharge structures and bio-engineering techniques.
- Includes the goal of improving dry and damaged land through biological and structural measures.

2.2. Provincial Government's Policies and Programs

No separate policies and programs have been formulated for drought management in all seven provinces, but the policies and programs included in the annual programs and budgets of various ministries are as follows.

2.2.1 Provincial Agriculture and Water Resources Development Program

- Emphasis has been placed on the construction of rainwater harvesting ponds, piped irrigation, and recharge ponds in lands without irrigation facilities.
- Budget invested in fodder grass development programs for sustainable agricultural development in dry areas for pasture management.

2.2.2 Forest and Land Conservation Program

- Use of gabion, mesh wire, afforestation, and bio-engineering techniques to prevent land erosion.
- Encouragement of food grass and fruit plantation in dry lands in Chure and mid-hills.

2.3 Local Level Policies and Programs

2.3.1 Environmental Protection Plan of Rural Municipality/Municipality

- Water source protection, pond construction and rainwater harvesting program.
- Check dams, simple drip irrigation and afforestation to prevent soil erosion.

2.3.2 Agricultural Grant and Technology Transfer Program

- Arrangements have been made to encourage the cultivation of drought-tolerant varieties of agricultural crops and provide subsidies for irrigation technology.
- Provisions have been made to provide training, improved seed distribution, nurseries and organic fertilizers to farmers.

2.3.3 Local Water Sources Conservation and Management Plan

- Grants will be given to build rainwater harvesting structures while protecting taps, wells and springs.
- Plans to build ponds to store water in dry land areas.

2.3.4 Disaster Risk Reduction Plans

- Emergency relief has been provided to reduce the damage caused by drought, landslides and floods.

These policies and programs have given priority to soil-water conservation, water recharge, irrigation facilities, and forest management for dry land management.

Part 3 Basic stages of drought and cycle system

The severity of the impact of drought may vary at different stages of drought depending on the geographical location, rainfall patterns and structure of dry lands. There are four basic stages of drought as presented below.

3.1 Basic Stages of Drought

3.1.1 Normal Stage

In normal conditions of a drought, grasses, plants and crops grow normally. Grasslands are green, crop production is regular, and water sources such as springs, wells, and ponds are regularly supplied with water, and streams and rivers are flowing normally. The community is engaged in regular agricultural and livestock farming activities. In this stage, preparatory work should be done to reduce the risk of potential disaster of drought in dry land areas. For example, farmers can adopt measures such as ponds and dams to collect and conserve rainwater and adopt drip irrigation. Such protective measures can help increase crop production and reduce the risk of droughts that may occur in the near future.

3.1.2 Alert Stage

In the alert stage, rainfall decreases, the ground becomes noticeably dry, and problems with crop germination begin to appear. As the rainfall decreases and water sources gradually dry up, the production of grass in the forests and crops begins to decrease. At this stage, communities should start making various preparations such as storing grain and seeds, managing additional fodder for animals, and checking/maintaining irrigation systems, dams, ponds, etc. Such advance preparations make it easier to manage drought. Local leadership, technicians, and communities should be vigilant during this stage.

3.1.3 Emergency Stage

This stage is a severe and emergency stage of drought. In the emergency stage, due to prolonged lack of rainfall, crops, grass, weeds, and shrubs become extremely dry and begin to wither/burn and gradually extinct. Due to extreme shortage of drinking water and food grains, people and livestock fall victim to severe malnutrition. This stage should include immediate relief, rescue and rescue operations – such as providing human and animal health support, emergency water supply, and providing food to the victims, and animal feed to the livestock. This is a time of crisis and priority should be given to survival, rescue and relief distribution. In such a situation, the federal, provincial and local governments should provide relief and protect the people.

3.1.4 Recovery stage

In this stage of the drought coming to an end, rainfall begins and moisture is maintained, grasses and weeds start to grow, allowing for the plantation of crops. As water sources gradually improve and water begins to flow, long-term

reconstruction and rehabilitation work should be carried out in this stage. To restore the drought-affected areas to greenery, sustainable development plans should be formulated, including soil and water conservation activities and intensive agricultural management activities. Such recovery and stabilization plans benefit the agricultural system and the community, and also help build resilience to droughts likely in the future.

Depending on time, geography, and the ability of the community to cope with the disaster, the different stages of drought disasters may overlap. In particular, marginalized and vulnerable communities, individuals, and regions feel the effects of droughts more quickly than others. If preparedness and timely alertness are observed, the most catastrophic stage of drought such as emergency stage may not have to be faced.

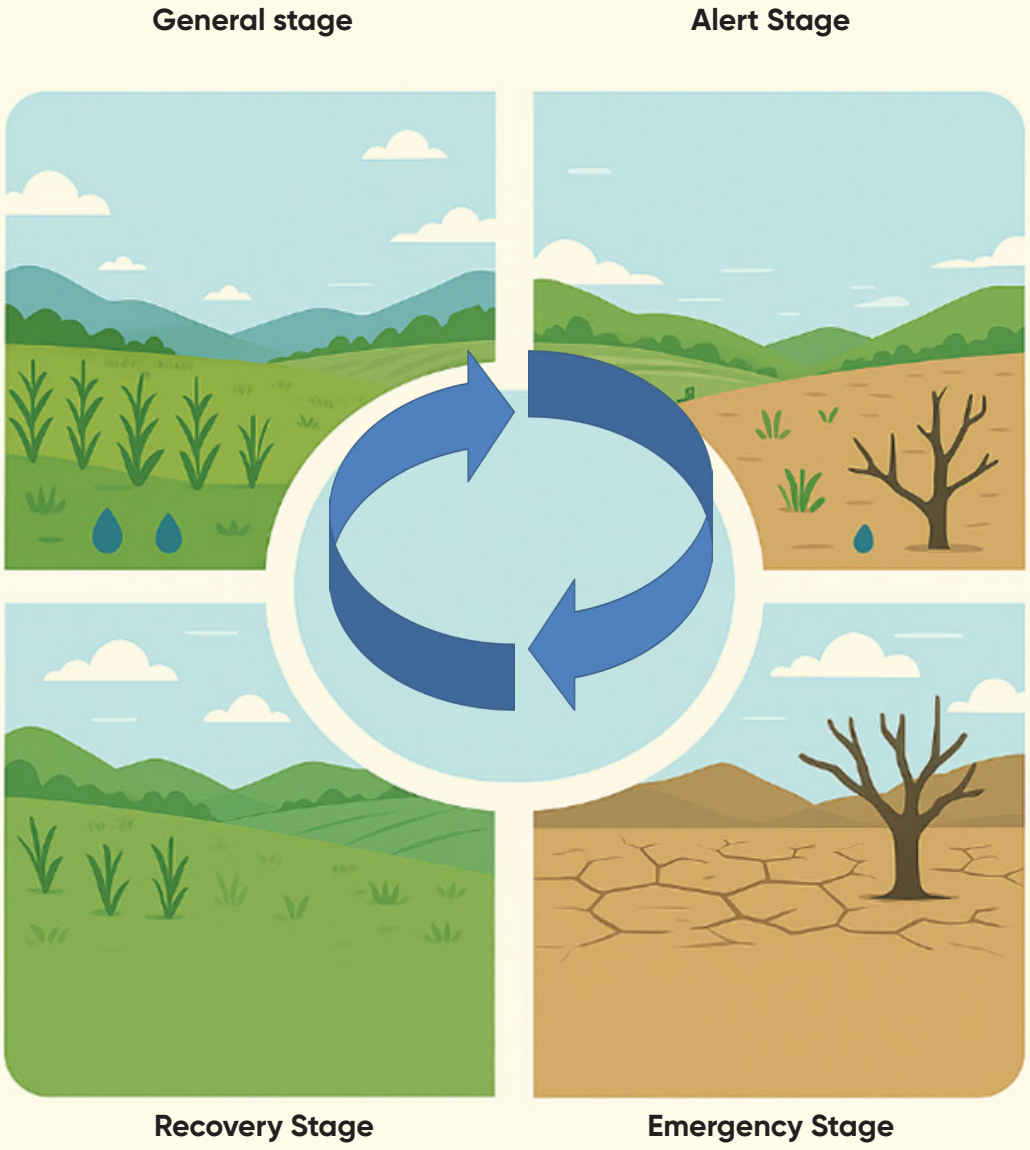

Figure 6: Stages of the Drought Cycle

Figure 7: Work Division in Drought Cycle Management

3.2 Management of Drought Cycles

Local communities, farmers and stakeholder agencies have adopted various strategies to cope with the different stages of drought. If these stages are understood and planned with the active participation of the community while formulating various activities for the successful management of dry lands, drought management becomes easier, effective and durable. For convenience, the functions and responsibilities of the local community and external agencies are presented below.

3.2.1 Activities to be carried by local communities to manage drought

The activities to be carried out by farmers in drought-hit areas during each stage of the drought cycle vary from one place to another. The activities to be carried out by them depend on income, availability of resources, local traditions and skills. The activities that farmers living in drought-hit areas should do during different stages of drought are presented below.

Normal Situation:

In this situation, farmers can do the following activities according to the local circumstances:

- Planting different intercrops to take advantage of the soil moisture and reduce the period between two crops.
- Storing seeds to save seeds in case of no rainfall and if that is not possible, organizing joint seed storage at the community level.
- Carry out activities that potentially do not require water to increase alternative sources of income, such as collecting khoto or resin, making ropes, mats and bamboo handicrafts and selling them.

Alert Stage

- Planting drought-tolerant or early-maturing varieties of cereals such as maize, millet, *chino*, barley, *uwa* and soybean.
- Since it is uncertain to plant the next crop in drought-hit areas, not sell the crop immediately after harvest and store it for the future.
- Drying, freezing or packaging fodder grass, potatoes, fruits and vegetables for the near future drought period.
- Selling livestock, poultry, sheep and goats.
- Providing irrigation at critical stages of crop growth (Deficit irrigation Management)

Emergency Stage

Farmers can adopt the following strategies to cope with this stage.

- Changing food habits and reducing the amount of food in all meals.
- Reducing the use of animal-based foods (milk, curd, ghee, meat, etc.).
- Making proper use of their fixed assets and tools.
- Moving to suitable moist areas.
- If cash is available, purchase food grains from those who have reserves.
- Reducing the size of their gardens to reduce water use.
- Appeal to local, provincial, federal governments, non-governmental organizations, and donor agencies to support rescue and relief efforts.

Recovery Stage

To face this stage, farmers can adopt the following methods:

- Planting early maturing crops.
- Emphasizing the use of local seeds.
- Arranging for oxen or other animals for tillage, and avoiding the use of large machinery for tillage as much as possible.
- Arranging for labour exchange (barter) with other farmers.
- Working in cities or getting help from relatives.
- Preparing the land for plantation by applying additional fertilizer to the fields and tilling the land.
- Land preparation should start with more fertile land, which is better for farming.

Women, children, and the elderly are especially at risk from drought. The number of weak, sick, and emaciated livestock that do not produce as a result of previous droughts increases.

3.2.2 Role of government and non-government agencies in managing leveling

To manage drought-affected areas, government and non-government agencies should prepare their plans and activities based on the drought cycle. When determining such activities, the benefits and impacts of such activities should be seriously reviewed and activities with less negative impacts should be prioritized.

General Stage

At this stage, stakeholders should focus on preparedness for potential droughts. Its main objective is to develop the capacity of local people to cope with the effects of potential drought. This should include the following initiatives:

- Building necessary structures for proper management and use of water sources with the involvement of the community.
- Analyzing community capacity related to drought and drought risks.
- Working with communities to plan for how to quickly respond to disasters, mobilize necessary resources, and provide assistance.
- Developing the capacity of communities and local levels and integrating drought-related plans into local disaster risk reduction strategic action plans and district development plans and submitting them to the provincial and federal governments and coordinating to ensure funds for it.
- Coordinate to arrange term insurance for crop and livestock protection.

Alert Stage

During this stage, government and non-government agencies should take the following actions to minimize the impact of potential future droughts.

- Arrange medicines and treatments for emergency diseases related to human health, such as diarrhea, fever, etc.
- Activities related to animal health such as arranging nutritious feed, water, medicines and treatment.
- Coordinate with livestock keepers by arranging transportation or identifying buyers to sell animals.
- Make relief distribution work fast, easy and convenient and arrange for food storage in remote areas.

Emergency Stage

During the emergency stage, government and non-government agencies should focus on rescue and relief efforts for the affected communities. The decision on where, how and for whom to carry out rescue and relief efforts should be made in consultation with the affected communities.

- First, provide supplementary food to vulnerable groups such as children, pregnant women, the elderly, and the people with disabilities.

- During severe emergencies, provide food and water to all affected communities.
- Repair wells, taps, and irrigation dams and ensure spare parts for water pumps.
- Provide health services.

Recovery Stage

During this stage, government and non-government agencies should focus on the following activities to help local people restore their livelihoods:

- Provide breeding animals to restore empty cattle sheds.
- Reconstruct irrigation dams and water wells and taps.
- Provide food for work to local people.
- Provide seeds to poor and marginalized farmers.
- Implement long-term plans to develop local infrastructure related to water, forests, land, people and animals.

Part 4 Major Activities of Dry Land Management

4.1 Water Conservation and Management

An average 80 % of Nepal's annual monsoon rainfall takes place around four months (JJAS average annual rainfall is about 1,472 mm) in a year. Hence, besides the monsoon, rainwater should be harvested and used in drought-prone areas during the winter period also by adopting various technologies suitable for the particular location. Water source conservation and management are very important for dry land management. For this, rainwater harvesting should be carried out and used through in-situ conservation, and water sources should be identified, protected and managed. To utilize rainwater in agriculture, site-appropriate techniques such as plowing along the contour lines to retain water, mulching, digging water absorption ditches, building vegetative dams and small check dams should be used. Similarly, site-appropriate structures for rainwater harvesting, use and groundwater recharge should be built, such as tanks to collect rainwater from the rooftop of houses, small plastic or concrete ponds in farmland and aquatic recharge ponds.

In addition, natural sources of water should be identified, mapped and managed. The amount of water in the source should be increased by constructing water recharge structures, fencing and carrying out afforestation in the micro-watershed areas of the springs. The collected water should be utilized optimally by using technologies like simple drip or sprinkler irrigation. Various recent studies have confirmed that the use of these technologies has been successful in various municipalities of Khotang, Okhaldhunga and Kavre districts. Therefore, where rainfall is very limited during the monsoon and where rainfall uncertainty is increasing due to climate change, a combination of local water collection-storage-recharge as well as efficient and effective irrigation will make reactivate drinking water, animal husbandry and agriculture in the dry areas. The major activities that can be carried out for water resource management in dry lands are presented below

4.1.1 Water Source Inventory and Mapping

Definition

Since water sources are scarce in drought-affected areas, they need to be identified and mapped. While identifying and mapping water sources, it is necessary to collect detail and updated information about their condition, and the information and reports should be reviewed in a timely manner.

Figure 8: Spending time on fetching water

Objective

Since water sources are associated with the livelihood of humans and other animals and species, it is necessary to identify them and maintained updated information and data related to them. This function plays a special role in drought-affected area management; as the information maintained in this manner not only acts as an indicator for drought but also provides guidance on how to properly utilize water resources during a drought.

Implementation Process

Identification of water sources and springs can be conducted at the local level by conducting field visits and using information and technology (such as GIS, GPS, RS, etc.). While collecting and entering data and information accordingly, it should be done with the direct involvement of the local community and beneficiaries as much as possible. A report should be prepared about the identified water sources and kept safe.

Care

A copy of the report thus prepared should be kept safely at the local level agency (municipality or ward). This will facilitate future water source identification activities and also help in preparing a water quantity and quality management plan.

4.1.2 Springshed management

Figure 9: Locally preserved water source

Definition

The concept of springshed management has been developed because water, contrary to the principle of watershed, can also be transferred between watersheds according to underground water sources and land structure. Springshed is the area of recharge where water enters the ground to provide water to a source and the storage layer (aquifer) where water accumulates. Springshed management is a participatory overall process carried out to protect and revive groundwater sources including springs. It involves using scientific and local knowledge to identify springshed areas, understand soil water and socio-economic conditions, take measures to absorb rainwater into the ground, and create an effective management system to ensure long-term water security.

Objective

Springshed management activities such as springshed mapping, identification of water recharge areas, and water source protection and management activities contribute to both quantity and quality of water. Restoring dried up water sources and preserving drying-up springs can help reduce the impact of drought-related disasters.

Implementation Process

Springshed management activities include site selection and preliminary study, social surveys, water-soil and rock mapping (hydrogeological mapping), and community-based aquatic recharge. This can be achieved by constructing structures such as trenches, ponds, and small check dams. Other activities include farming measures such as planting trees in contour line, mulching, building institutional capacity, encouraging collaboration between two or more parties, and carrying out regular measurement and assessment of the quantity and quality of water in the source.

Care

The responsibility for the protection, management and regular maintenance of water sources will rest with the local community and local level people's representatives.

4.1.3 Multipurpose Conservation Pond

Definition

A structure constructed in the upper or middle part of a farm to collect surface run-off water from the rainfall and use it for irrigation, animal husbandry and domestic purposes is called a conservation pond. Depending on the purpose of the construction of a conservation or farm pond, it can be made using stones, soil, plastic or cement and sand.

Figure 10: View of multipurpose pond

Function and area of use

In Nepal, monsoon rainfall is basically limited to only four months in a year and at other times there is negligible rainfall. In addition, since 65% of the farming in high-hills, mid-hills, Chure and Tarai areas are dependent on rain, it is very relevant to construct such conservation ponds. Such ponds have been found to be very useful for collecting rainwater and using it for irrigation and other household purposes during the dry season. The water stored in this way helps to increase the production and thereby income of farmers as it provides irrigation facilities during the dry season.

The Developing Climate Resilient Livelihood in the vulnerable Watershed in Nepal (DCRL) Project, implemented in Okhaldhunga and Khotang districts, has constructed multi-purpose conservation ponds to collect surface water, recharge ponds to recharge groundwater, and ditches in contour line at various local levels. Studies have shown that it has helped to restore water sources, such as wells and ponds by flowing water into the water sources and has increased the water content in the springs. In brief, conservation ponds are a low-cost technology for collecting and saving run-off rainwater for later reuse in the fields.

Advantages

- Since it provides water during the dry season, it is a reliable source of irrigation. This ensures both the continuity of farming and increased production.
- After receiving sufficient water from the ponds, farmers can diversify their crops by growing valuable cash crops, vegetables, and fruits rather than traditional grown cereal crops, and that increases the income of the farmers.
- Apart from irrigation, pond water can also be used for domestic purpose and for animal husbandry. Additional income can be made through fish farming in such ponds.
- Collecting surface runoff water helps in recharging groundwater and surface soil erosion is minimized with lower runoff flow. Collecting dry and unexpected rainfall water helps in maintaining environmental balance.

Figure 11: Conservation pond for multipurpose uses of water

Disadvantages and limitations

- Digging a pond and building a dam costs labour and money. Initially, purchasing plastic also costs money.
- Some part of the farmland has to be set aside for the pond, which reduces cultivable land.
- In dry areas, when the temperature is high, the water in the pond evaporates. If the dam and its walls are not properly constructed, water leakage can also happen. According to a study by ICIMOD, in three months 58.82 cm of water was found to have evaporated from (artificial) ponds made of cement, and the amount of water collected in plastic ponds decreased by 19-25 %.
- The still water in the pond may increase mosquitoes and other insects around the pond and the risk of spreading of diseases such as dengue and malaria can increase.

Construction process

Figure 12: Pond for water recharge

1. Selection of location Generally, a suitable location should be selected for the pond by identifying the area where run-off water flows. As far as possible, low-sloped land should be selected above the farmland. It would be appropriate to find a place where the soil is soft or greasy that can be dug out easily. Rocky areas with little soil are not suitable.

2. Drawing and cleaning of the area The selected location should be cleared of bushes and weeds and the outline of the pond's boundaries should be drawn. Its shape can be rectangular or square depending on the location. For example, a pond dug 10.5 m x 3 m x 4 m deep (≈126 cubic meters) with a volume of 20 mm of water collected can be used to irrigate crops planted in an area of about 0.5 hectares.

3. Digging and building dam First, a place should be identified for placing a drain or pipe to draw water into the pond. Then a pond of the specified size should be dug. The slope should be maintained in a ratio of 3 1 so that the side walls of the pond do not collapse. If the soil is very loose, the bottom and walls of the pond should be covered with compacted soil. If the purpose is water recharge, the lower part (bed) of the pond should be left as it is. In cases where the soil in the pond cannot sufficiently prevent leakage, it is appropriate to use plastic sheets on the bottom and sides or to build a cement structure.

4. Inlet and outlet system An inlet (drain, pipe) should be made to draw water into the pond. Overflow drains/water drainage should be arranged to prevent the dam from breaking when the pond is full (of water).

5. Conservation and maintenance To strengthen the pond's banks, the soil around it should be stiffened and to prevent soil erosion it should be covered with grass-mud patch and grass should be planted. To reduce evaporation, shade-giving trees and plants should be planted around the pond. The bottom grass and sand should be removed and cleaned regularly. It is better to fence the area to protect children and animals from accidents.

4.1.4 Drip irrigation

Definition

Simple drip irrigation is an effective water management system that delivers water and nutrients slowly (drop by drop) directly to the roots of plants through nozzle and nipple. This avoids the possibility of water evaporation or water going waste, the required moisture in the soil is maintained, and production increases significantly by reducing unnecessary plants and shrubs. Therefore, the use of drip irrigation helps to save water for agriculture and kitchen gardening and provides plant-friendly irrigation.

Objective

Since drought-hit areas lack water sources and its quantity, crop production is not as expected. Hence, such irrigation technologies help to increase land productivity.

Figure 13: Drip irrigation system

Implementation process

For simple drip irrigation used in dry land, the main pipes are laid based on the amount of water for irrigation and the area of land to be irrigated, holes are drilled in them and installed, so that the water gradually reaches the roots of the plants. Its main components are the main pipe, side/branch pipes, water pumps, water filters and related tools. The installation process starts with planning, in which the distribution system of pipes and lines is determined according to the size of the land and the distance between the plants. Then the pump is connected to the main pipe and arrangements are made to prevent waste through filters. The main pipe is laid in the field and holes are prepared at the necessary places to connect the branch pipes according to the structure of the land. Rubber washers and connectors are placed in the holes to connect the branch pipes. The branch pipes are placed close to the roots of the plants, in which water gradually reaches the roots of the plants through the small holes made on the pipes. The head of the pipe at the end of the pipe line is shut to prevent water loss.

Maintenance

The system is tested to check for leakage, whether the water reaches the roots equally, and if necessary, necessary improvements are made to the entire system or any part of it.

4.1.5 Rainwater Harvesting and Reuse

Definition

Rainwater harvesting is the process of collecting rainwater from the roof of a house or building through a drain or pipe, after removing the first-flush and then collecting it in a tank for later use or recharging it in the ground. This technology provides additional water for domestic use, animal husbandry, irrigation or recharge in drought-hit areas. Studies conducted by ICIMOD in Gulmi, Arghakhanchi, Kavre, Surkhet,

Figure 14: Multipurpose use of rainwater

Gorkha and Kathmandu in Nepal have shown that rainwater harvesting can provide quality water at the household level in places where there is a shortage of water.

Objective

Rainwater harvesting is the process of collecting, storing and using rainwater during the rainy season, which is particularly useful in areas with water scarcity and frequent droughts. In dry areas where rainfall is irregular and concentrated in short periods, it helps to mitigate the impact of drought by providing water for irrigation, livestock and domestic use. It is a key component of Integrated Watershed Management Programme (IWMP) and climate resilient development, which contributes to groundwater recharge, sustainable livelihoods and long-term water security in communities. Rainwater harvesting has positive effects on irrigation, soil moisture, increased productivity and activities such as forestry and animal husbandry. It also enables villages and communities to cope with the impacts of climate change.

Implementation

Suitable locations for rainwater harvesting are semi-arid and arid areas with rain-fed agricultural land, steep slopes, schools, community buildings and areas with high groundwater use. The structures are of two types for example, In-Situ Contour Bund made in locations with rainfall, in farm dam, and deep fields; and Ex-situ ponds (10 x 10 x 3 m), percolation tanks (0.1-0.5 ha capacity), check dam and roof structures (5,000-50,000 litres) made in separation locations of rainfall and collection point. While designing, land availability, land ownership, land slope, rainfall and purpose are evaluated. Materials can be earth, brick walls or HDPE lining. Water use is prioritized for drinking, for livestock and crops. In addition, rainwater harvesting becomes more effective when linking with mulching, soil and water conservation, micro-irrigation system and environment-friendly farming system.

Working procedure

For this, the water going into the tank is filtered after separating the first-flush water and when the tank is full, the excess water is absorbed into the ground through the recharge pit. The quality of the water should be maintained by installing a mosquito net in the overflow pipe of the tank, cleaning it, and adopting measures such as chlorination or boiling. This technology can be used in all locations from cities to villages, hills to mid-hills to lowlands for domestic drinking water, schools/health centres, hotels/offices, small irrigation, and animal husbandry and for groundwater recharge.

Figure 15: Rainwater harvesting in Ferrocement Tank and use

Advantages

- Water can be collected during the rainy season and used in the dry/inter-seasonal months. The experience of Gulmi, Gorkha and Dhulikhel in Kavre has shown that it has made a significant contribution to household water use.
- By storing the excess water in a water recharge pit or trench, the moisture in the ground is retained and the water level in springs and wells increases, helping to make the source sustainable. It also reduces floods and runoff flow in urban streams and roads.
- In most areas of Nepal where rainfall is low, it can be implemented at low cost by changing the size according to the location.

Limitations

In rain-shadow areas with less than 200 mm of rainfall per year (such as the Mustang across the high Himalayas), water from the roof may be insufficient for household needs only. For this, other options such as surface springs or wells, etc. can be used to supplement water, using solar energy pumps. For this, the first step is to regularly clean the wastewater holding tank and filter, and boiling or chlorinating it according to the World Health Organization standards for drinking water.

4.1.6 Water Recharge Structures

While identifying the springshed of the water source, the water recharge area is also classified, and therefore the aquatic recharge structures constructed in such areas increase the volume of water. As water flow takes place from a high-pressure area to a low-pressure area, such structures should be built in the upper coastal area of the water source. The structures constructed in this way collect run-off water, thus reducing the impact of drought as well as flood-induced disasters. Due to increasing urbanization, the ground water sources are also decreasing as the land is unable to absorb water. As a result, the quality as well as the quantity of water are decreasing, so it is necessary to build recharge structures.

4.1.6.1 Contour Trench

Definition

Contour Trench is a long but shallow and wide ditch or channel dug at the same height, i.e. parallel to the contour, to control the surface flow of water in hilly terrain and help the water absorb into the ground. This technique is a natural structure that prevents water, soil and manure from flowing away and going waste, which helps to slow down the speed of the run-off water flowing from above during rainfall, collect it

Figure 16: Contour trench

and gradually absorb it into the soil. In other words, these channels, like a dam, stop the rainwater for some time and help it penetrate into dry land. In simple terms, it is like a belt tied around the waist of a mountain that prevents soil and water from flowing down at a rapid rate.

Function

This structure mainly works in three ways. First, it stops the run-off water, slows it down and collects it into a pit. Second, the water collected in the pit is gradually absorbed into the ground, increases moisture and recharges the groundwater, increasing the level and quantity of water in water sources, spring and wells. As a result, during the dry season, the groundwater sources do not dry up and water is available for domestic use and irrigation. Third, it does not allow the fertile soil of the surface to wash away and reduces the problems of sudden floods and accumulation of sediment in the fields and villages downstream. Thus, it protects against both drought and floods.

Suitable areas for application

This technology is particularly useful in drought-affected mid-hill with up to 20-30% slopes, thin soil, areas with short but intense rainfall, and the upper part of farmland. It has also been found to be very effective in the Chure/Bhawar region for collecting rapidly flowing run-off rainwater, absorbing water into the ground, and recharging groundwater. Digging trenches in community forests and private pastures, and planting grass/plants in the soil piled up at the top of the trenches has also been found to increase forest regeneration and grass production. The Developing Climate Resilient Livelihood (DCRL) Project constructed contour trenches using community labour and local materials in Okhaldhunga and Khotang districts, which have been very effective in increasing soil moisture, recharging groundwater, and controlling soil erosion.

Benefits

- Stopping the flow of run-off water helps to retain soil and nutrients in the field.
- Retains moisture in the soil and make it available to plants, increasing yields and increases the chances of crop survival during dry periods.
- When run-off water collected in the trenches penetrates the soil, the water from the wells/springs can be stored for a long time.
- It reduces the risk of landslides and silt accumulation in the lower coastal areas.
- Planting grass/shrubs/trees on the banks of the trenches provides fodder and fuel wood, as well as maintains environmental cleanliness.

Disadvantages

- Community coordination is required as digging trenches is labour-intensive and time-consuming act.

- If proper outlet is not ensured the trenches can collapse during heavy rainfall.
- If sand the soil that comes along with run-off water is not cleaned regularly, the trench fills up and its capacity decreases.
- When digging a trench in agricultural land, the area occupied by the trench can make it difficult to plow or use machinery to cultivate.

Construction steps

a) Selecting the site to design a contour line

- First, a slope land of 20-30% should be selected. With the help of a technician, a contour line should be determined using a simple (A)-frame or water tube. The A-frame should be placed from top to bottom on the sloping land and the place where the height of both legs is equal should be marked.

b) Size of the contour line trench

- Generally, depending on the slope of the land and the type of soil, the width of the trench should be 30-45 cm, and the depth should be 45-60 cm. It is better to divide a long trench into sections of 10-20 meters and keep a small spill/break between each section.
- The soil extracted while digging the trench should be piled up like a small dam at the bottom and grass should be planted on it.

c) Contour trench distance determination

- Depending on the slope of the land, the distance between the two trenches may vary, such as 10-12 m for a 5-10% slope, 6-8 m for a 10-20% slope, and 4-6 m for a 20-30% slope. It is appropriate to dig at a gap of about 10-12 m. The technician should make adjustments based on the local geographical conditions.

d) Run-off water inlet and outlet system

- Surface runoff water from the top should be drained directly into the trench and small channels should be made to allow it to flow from one section to another.

e) Maintenance

- All ditches should be inspected every year before the onset of the rainy season and after heavy rains. Ditches that are filled or collapsed should be cleaned, repaired and rebuilt. This is a regular task to be carried out by the community members together.

f) Limitations

- In large dry areas with very low rainfall, the water to fill the trench may not be sufficient.
- On very steep terrain (>30-40%) a long trench may become unstable and cause landslides.

- In sandy and shallow areas, the run-off water can be absorbed immediately, but since the ditch is likely to collapse in such places, the construction of support dams or the use of mulching is necessary.
- Since the effectiveness of the contour pitch decreases within 1-2 years, community participation is required for regular maintenance.

4.1.6.2 Water recharge pond/water holes

Definition

Water holes are natural or man-made pit, where rain and runoff water are collected. It increases the groundwater source and also provides drinking water for livestock.

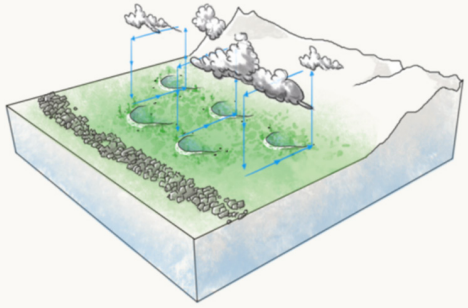

Figure 17: Hydrological system of water holes

Objective

The main objective of constructing waterholes is to collect the excess water that flows during the rainy season into the groundwater source, so that the water sources do not dry up during the dry season and can also be discharged as needed. The water collected in this way also protects the existence of plants and animals.

Figure 18: Water recharge pond

Implementation process

Suitable locations for constructing waterholes are in or near forests, public lands, farmlands, and bushy areas, where the soil layer is thin, the water flow is moderate and rainfall is irregular, and is not frequented by wildlife and cattle. The shape of the pond is round, oval, rectangular, or square, and its size varies according to the conditions of the construction site it can be made small (5 m x 5 m x 1.5 m deep), medium (10 m x 10 m x 2 m deep), or even larger. For the stability of the constructed waterholes, the side slope is kept at 1 1 to 1.5 1. A dam (bund) is built at the bottom to stop the water and an inlet channel is used to bring water from the surrounding slope land.

Such waterholes constructed for water recharge are not very deep and are constructed with gravel at the bottom and stone walls at the surrounding walls. In case water has to be filled, red clay can be pasted at the bottom and if necessary, a thick layer of soil or stones are also stamped in places where water leaks. The construction process includes selecting a suitable location, digging the waterhole, building a dam around it, constructing an inlet to bring water, building a fence if necessary, and controlling soil erosion by planting grass or plants around the pond.

4.2 On-Farm Conservation and Management

4.2.1 Conservation Farming

Definition

Conservation farming is a farming system that prioritizes minimum tillage, preservation of permanent soil cover, and promotion of crop diversity. It helps in soil and water conservation, reducing soil erosion, and increasing fertility and productivity. Sustainable production is possible by increasing the utilization of water and fertilizer through biological activities on and within the soil and increased biodiversity. It depends on three major aspects species diversity, permanent soil cover, and minimum tillage. Special attention is focused on tillage, crop systems, and fertilizer management in this exercise.

Objective

There are three main reasons for tilling a field, to loosen the soil, prevent weeds, and mix fertilizer into the soil. But when these three tasks can be done without tillage, sustainability can be maintained with little use of resources and equipment. Therefore, conserving soil, water and organic matter using conservation farming systems and maintaining production and income through low-cost technologies is a major activity of dry land management.

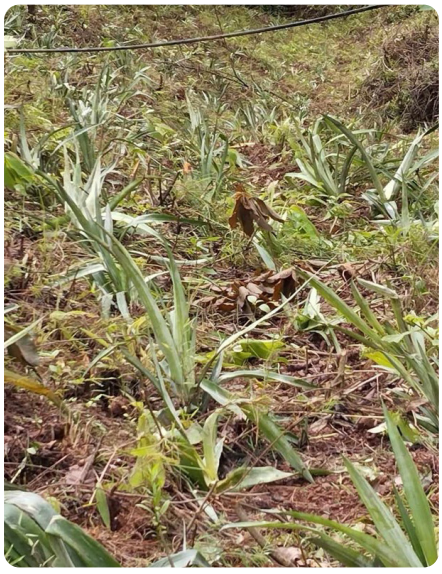

Figure 19: Conservation farming

Figure 20: Planting walnut, turmeric and ginger through conservation farming

Implementation process

For conservation farming, techniques such as conservation tillage and minimum tillage can be implemented by selecting individual or farmers' group fields. Prioritizing local participation in planning, implementation, conservation and benefit sharing increases the effectiveness of this act. This activity includes the use of green manure, measures to reduce the impact of tillage, and crop diversification.

Care

Since unwanted weeds and plants can grow excessively during this type of farming, weeding should be done from time to time. Through such conservation, it is also possible to providing grazing for cattle and livestock as well. However, the grazing of livestock should be completely stopped during the crops growing and harvesting stage.

4.2.2 Soil fertility improvement

Figure 21: Sample of fertile soil

Various practices and measures need to be adopted to bring long-term stability in the yield potential of cultivable soil through sustainable soil management. Soil is the source of food element of almost all living organisms, only its proper management ensures that the necessary minerals reach the crops and there is no toxicity. This management aims to improve the production of small farmers and marginalized groups in the agricultural sector by providing them with access to technology and resources, and establishing market linkages.

Under sustainable soil management, practices such as soil testing, soil erosion control, use of cover crops, compost manure, organic manure, and green manure and agroforestry systems are practiced to improve soil health and increase fertility and utility. Methods for proper use of available water, such as rainwater harvesting, drip irrigation systems and use of mulching, and reducing the use of chemical fertilizers and giving priority to compost manure can be implemented in such programs. Farmers can be attracted towards sustainable soil management through practical policies and incentives, and contribution can be made to sustainable agriculture through knowledge management, exchange of experiences and capacity development.

4.2.3 Cattleshed improvement

Since dung and urine are the main sources of manure, their conservation is very important. In particular, since urine often flows and goes to waste, it is necessary to use a suitable structure and a shed to collect it. In traditional sheds, due to the lack of proper management of urine, food elements are often go to waste. When making manure, dung, urine and waste should be mixed and systematically decomposed, for which a good structure of the shed and pit is necessary. Manure improvement means creating a comfortable habitat for cattle such as cows, buffaloes, sheep, goats, pigs, etc. and preparing a structure where dung and urine can be easily collected. Urine can be collected by creating a slope

Figure 22: Improvement of shed for collecting manure and urine

in the floor of the shed, constructing a urine drainage channel and a collection tank. Urine management is also possible by stone paving or compacted soil.

There are many benefits that can be derived from the use of manure. It helps in saving money on imported fertilizers by providing the same amount of nitrogen and potassium as obtained from urea and potash. Disease and pest management and micronutrient supplements can be achieved by preparing organic pesticides from animal urine, which reduces the use of chemical fertilizers and pesticides, and reduces production costs. In addition, clean shed improves animal health and increases milk production. Manure is also useful in irrigation, while it increases the amount of methane in biogas production. Overall, both biological and economic benefits can be obtained in agricultural production by improving the quality of manure.

4.2.4 Compost Manure

Definition

Organic fertilizer prepared by mixing plant-based products from home, farm and gardens such as straw, leaves, hay, straw, weeds, household organic waste and excrement from cowsheds, etc., together with supplementary materials such as lime and decomposing them by bacteria in controlled humidity and air is called compost manure. .

Figure 23: Pit for making organic manure/green manure

Function

It improves the physical structure of the soil and increases its water absorption capacity. It improves soil fertility by increasing nitrogen, phosphorus, potash and other micronutrients essential for plant growth. It keeps the acidity of the soil under control and activates beneficial microorganisms. Therefore, compost fertilizer is very useful for drought management.

Area of use

All farmers in the dry regions of Nepal, including the hills, tarai, and Chure, can widely use compost manure in their fields, gardens, vegetable and fruit farms, and in dry land management. It can be used especially in grain crops such as paddy, wheat, and corn, and in legumes and oilseeds, vegetables, fruit gardens, dry rocky land, kitchen gardens, and community forest nursery. It can be used in households with cowsheds, community compost centers, village/municipal level waste management programs, and semi-irrigated lands where irrigation is lacking. Combinations such as “compost+ mulch + low tillage + rainwater harvesting in fields” are very effective in drought management.

Advantages

a. Improves soil structure and helps retain moisture by increasing water absorption capacity. This allows drought-resistant crops to be grown.

b. Provides long-term supply of nutrients and reduces consumption and dependence on chemical fertilizers.

c. Uses local resources and labour.

d. Promotes organic farming.

Disadvantages

a. Requires more labour and time.

b. The amount of nutrients is less than that of chemical fertilizers, so a large amount is required.

c. If not managed well, it can cause odour or insect problems.

Limitations

It is difficult to produce in large quantity, difficult to reach it to the market and the immediate effect is less visible than chemical fertilizers. If left open in the field for many days, nutrients can evaporate and be damaged.

Steps for preparation

1. Collect plant-based products such as straw, leaves, grass, straw, weeds, household organic waste, and excrement from the cowshed.
2. Dig a 5 m long, 2 m wide and 1 m deep pit in a shady place where water does not stagnate and pour the aforementioned materials in layers.
3. Place dry and wet ingredients in an order, sprinkling cow dung or water on each layer.
4. Cover in a way to allow air circulation.
5. Turn over after 30-45 days.
6. Let it mature to dark brown/black colour and odourless manure is ready in 3-4 months.

4.2.5 Mulching

The technique of covering the soil surface in the field with grass, leaves, plastic, straw, animal dung, dust-soil or other materials is called mulching. Mulching is a simple but very effective agricultural practice. It conserves soil moisture, controls weeds, controls soil temperature and improves soil health in dry and drought-affected areas.

Figure 24: Vegetable cultivation by mulching

It is a technique similar to covering the field floor with a cloth that protects crops from the sun and drought. It reduces soil evaporation by 30-70%, protects the roots from extreme effects of temperature, and increases drought tolerance by increasing soil structure and microbial activity, which ultimately increases crop production and water use.

Area of application

This technology can be used in vegetable farming (tomato, cauliflower, cucumber, chilly, gourd, etc.), orchard and fruit farming (banana, mango, orange, etc.), rice fields, gardens, plantation sites and nurseries. It can be used especially in drought-affected areas and places where moisture needs to be preserved after the rains.

Method of use

It is very easy to use. First, the field should be cleaned by removing weeds, grass, and stones. After planting the saplings or seeds in the ground, mulching materials (straw, plastic, leaves, etc.) should be spread. Generally, mulch should be placed around the crop in a thickness of 5-10 cm. It is necessary to make holes for water to penetrate or for the seedlings to emerge and we should check the condition of the mulch from time to time.

Limitations

Its limitations are as follows. For example, materials may not always be available, if applied improperly it may lead to disease or pest infestation, plastic mulch is difficult to reuse/dispose of, and waterlogging may be a problem in areas with heavy rainfall.

4.2.6 Crop Diversification

Definition

Crop diversification for dry land management is a strategy of growing different types of crops rather than a single crop, in a time-cycle manner. It increases resilience to drought and climate change, improves soil health, increases water use efficiency, increases farmer income, and provides nutritional diversity.

Figure 25: Crop diversification model

This includes using different species of crops, crop rotation, intercropping, and agroforestry practices. In this way, a single type of farming (monocropping) can be transformed into a diverse and productive system. As the changing rainfall pattern due to climate change is having an adverse impact on the agricultural sector, it is necessary to identify crops that can produce even in dry conditions.

Objective

The traditional crop rotation system plays an important role in preserving soil fertility and ensuring production even in dry conditions. Including deep-rooted mustard and gurans in the rotation, as per the location in Tarai, hill, and high hill regions of Nepal, increases the water absorption and water retention capacity of the soil. In addition, rotating crops such as paddy, which require a lot of water, with drought-resistant crops such as maize and millet save water.

Similarly, nitrogen-fixing leguminous crops such as lentils, chickpeas, or beans provide natural nutrients to the soil, which reduces the need for chemical fertilizers. Crops such as buckwheat planted during dry periods and plants that can be used as organic fertilizers help prevent soil erosion and increase organic matter in the soil. Increasing the amount of organic matter in the soil means that the soil can store more water, hence adopting these measures according to the local terrain, rainfall pattern, soil type, altitude and traditional knowledge can significantly improve the drought-resistance ability of Nepali farmers.

4.3 Degraded Land Rehabilitation

As natural disasters deteriorate the productivity and cause damage to the land, it is necessary to rehabilitate the degraded land. By minimizing the impact of drought-affected areas by using biological and structural measures for rehabilitation of degraded land, the drought disaster will also be reduced and it will also provide a ray of hope for the people living in such areas.

4.3.1 Agroforestry System

Definition

Agroforestry is a strategy for combining agriculture, animal husbandry and forestry activities on a single unit of land to improve the productivity of the land and the environment, in addition to increasing the income of local people. This technique is particularly useful in balancing water storage, soil conservation, recycle of nutrients and livelihoods in dry land areas.

Objective

It will integrate agriculture, animal husbandry and forestry activities in the agroforestry system, thereby increasing productivity, enhancing food security, creating employment and livelihood opportunities, conserving biodiversity and protecting dry land, mitigating the adverse effects of climate change, and making a positive contribution to the utilization of barren and other marginalized lands.

Figure 26: Agroforestry system

Functions

Other main functions of this system are (1) Preventing soil erosion by acting as a cover for the land, (2) Increasing water absorption by the land by enhancing groundwater recharge, (3) Maintaining biodiversity, (4) Providing wood, firewood, fruits, fodder grass and straw litter etc., (5) Protecting the crop from frost, heat and drought, (6) Ensure daily additional income of the household. It is the major way to increase groundwater recharge and drought tolerance in dry areas.

Scope

This system can be used in high hills, mid hills and Chure regions. It can be used especially around homesteads, deep ditches of farmlands, border of fields, springshed areas, pastures and riparian buffer region. In addition, it can be used in community forests, grazing areas and degraded lands.

Advantages

It conserves the soil and reduces soil erosion. By absorbing rainwater into the ground, moisture in the ground is maintained during the dry season. It improves the circulation of nutrients that have leaked to the lower levels of the soil and brings them to the surface, as well as improves the environment. It provides households with fruits, fodder grass, wood, fuel and small cash crops (fruits, nursery materials), thereby increasing their income sources. This leads to diversification of ecological and socio-economic risks. This technology is effective for climate resilience as it can be easily linked to small farmer groups, cooperatives and ward-level community plans.

Disadvantages

Initially, agricultural production may decrease due to competition between tree saplings and agricultural crops for light, space, moisture and nutrients. Since it occupies some land, the area for farming decreases. Initial investment (nursery, maintenance) and care costs are incurred. Poor variety selection or incorrect spacing can negatively affect production. These risks can be minimized through selection of geographically appropriate varieties, proper management and market management.

Limitations

In dry lands, the chances of survival and growth of new plants may be low due to very low water availability. Irrigation may be required for initial growth of plants. Marginalized farmers with limited land area may not be able to plant trees for a long time. Lack of access to technical services such as nursery, training, water resource management, and grants may limit the scale-up of the program.

Implementation Process

Site Assessment

With the active participation of local farmers, sites such as homesteads, field banks, farm boundaries, springshed area, kharbari and watersheds should be selected based on soil type, slope, climate, and water availability.

Figure 27: Plantation for the expansion of agroforestry system,

Consultation with Communities and Farmers

Priorities should be determined based on local needs, traditions, and culture through group discussions with communities and farmers. A list of species to be planted should be prepared based on the purpose of such as growing fruits, for timber, firewood, fodder, animal husbandry and grazing etc.

Species selection

Native, multipurpose, soil quality improving, drought-tolerant, fast growing (surviving) species should be selected. According to the various purposes of agroforestry system, the following species can be selected

- Fodder grass Badahar, Koiralo, Tanki, Gideri, Nimaro, Raikhanyu, Dabdabe, Sirish, Chuletro, Kutmiro, Ipil, Kimbu, Kabro, Bedulo, Bhimal, etc.
- Firewood Uttis, Bakaino, Sirish, Chilaune, Masala, Mauwa, etc.
- Wood Sisau, Chanp, Salla, Chilaune, Tik etc.
- Multi-purpose Chiuri, Lapsi, Amla, Bel, Kimbu, Timur and Bamboo etc.
- Green manure Asuro, Sirish, Khiro, Bakaino, Dhaicha, Simli, Sajiwan etc.
- Organic fodder Asuro, Simali, Phaledo, Nilakanda, Bamboo, Nigalo etc.

Water management

While planting trees in dry areas, a check dam should be built on the banks of the ditch to collect rainwater. If possible, small ponds can also be built at suitable places to collect run-off water.

Nursery and plant quality

Source and availability of quality seeds and multi-year plants from local nurseries should be ensured. If quality saplings are not available, it is necessary to establish nursery at the local level for plant production, increase the adaptability of plants (hardening) and monitor diseases and pests and select healthy plants.

Digging pit and plantation

The distance between the pit and the saplings generally varies according to the purpose, topography, land ownership, forest species and type of crop. Generally, for fruit, fodder grass and wood-based plants, a pit of 45 x 30 x 30 cm should be

dug at a distance of 5 to 7 meters. The distance between two plants may also vary depending on the type of crop. As much as possible, fertile soil or compost should be placed in the pit. Generally, plantation should be done at the beginning of the monsoon. While planting trees in dry areas, the pit should be slightly sloped towards the wall, leaving some part of the soil unfilled and covered with a mulch.

Conservation and Care

Irrigation during dry periods, fire prevention and protection from livestock should be done through fencing and collective care. Regular records should be maintained of the survival rate of the planted seedlings, their growth rate, the impact on crop production and the community's response, and if necessary, plants and crops should be readjusted.

Markets and Value Chains (Market Linkages)

For the sale and distribution of forest and agricultural products such as fruits, fodder grass, pulses, grains and vegetables, it is necessary to find a smooth market through cooperatives/groups. Training should be conducted on value addition such as making dried fruits, fruit jams, juices, etc. and plans should be made for product storage. This ensures long-term investment of the farmers.

4.3.2 Conservation Plantation

Conservation plantation is the practice of planting trees, shrubs, and grasses based on moisture and conservation of the soil to improve water resources, promote greenery, and protect against land degradation. Its main objective is to conserve land, soil, and water in dry lands and stabilize ecosystems. It involves planting drought-tolerant species in a variety of ways and adopting soil and water conservation techniques. In dry lands, it often focuses on water conservation, soil conservation, and increasing greenery.

Function

It acts as a surface cover on the ground and reduces landslides and soil erosion caused by raindrops. It helps in recharging groundwater by increasing the process of rainwater absorption in the ground. It strengthens the slope land. It provides wood, firewood and fodder for cattle. It also helps in purifying the air and creating a source of income for rural families.

Scope

This technology can be used in private farms, community forests, gorge and landslide-prone areas, embankments and river banks, steep sides of roads, public places and pastures. Drought-tolerant native species should be selected and planted according to the altitude, soil type and rainfall pattern of the drought-affected area.

Suitable planting techniques

1. Horizontal Platform or Benches

In dry areas and slopes where loose soil falls and moisture is lacking, a trench should be dug and the soil should be leveled and the seedlings should be planted after putting fertile soil in it. In this way, the run-off rainwater is collected in the trench. Due to this, the moisture in the soil remains, which makes it easy for the seedlings to germinate and grow. This method is suitable in very dry areas, areas with little rainfall and places where there is a lot of rainfall in a short period of time.

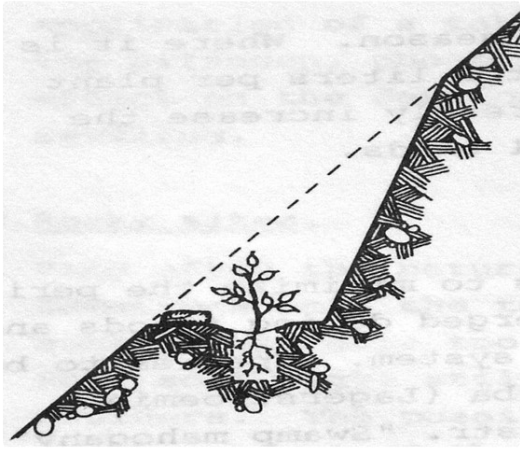

Figure 28: Planting on Horizontal Platform or Bench

2. Planting on Basin Pits

It is a plantation done in dry and arid land by digging half-moon shaped pits. Its main purpose is to collect the rainwater that flows away during the rain and make it available to the plants. It helps in absorbing water and maintaining moisture in the soil. In this, half-moon-shaped pits should be dug as shown in the picture above and the plants should be planted at a distance of 2 meters.

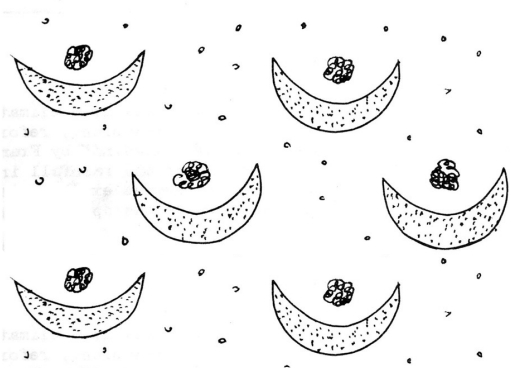

Figure 29: Plantation in Basin Pits

3. Contour Plantation

This is plantation carried out in pits dug in a contour line on dry, sloping land with low moisture and nutrients. Its main purpose is to prevent soil from flowing from above and collect run-off water for the plants. In this, pits of 45-60 cm. width and 60 cm. depth should be dug at a distance of 3 meters as shown in the picture and the plants should be planted.

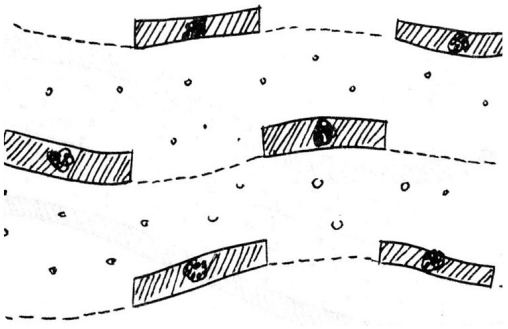

Figure 30: Contour Trench Plantation

4. Strip Plantation

This type of plantation can be done in places where tall shrubs and bushes are planted to supply wood, firewood and fodder grass. In this technique, strips should be made at a distance of 3 meters on the contour line. The distance between two plants depends on the purpose of the plantation. If the commercial production of fast-growing species is to be

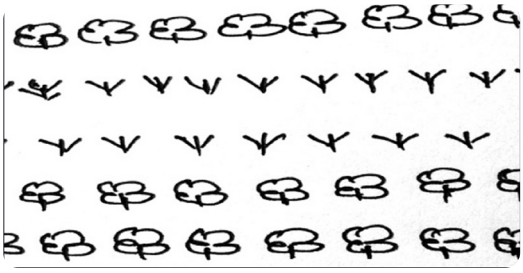

Figure 31: Strip Plantation

done, the distance should be closer than normal. Generally, the plants should be planted in pits measuring 45 x 30 x 30 cm at a distance of 2 x 2 meters. However, in cities or on roads, the distance between two plants can also be kept from 3 to 5 meters. Generally, the roots of the tree can spread as far as the spread of its branches.

Steps of plantation

- Plantation sites should be identified with the participation of local communities/farmers, especially on slopes, ridges or dry barren areas.
- Multipurpose species should be selected based on the interest of local farmers, soil type and quality, climate, altitude and slope, etc.
- While selecting the species, local/native species should be given priority for plantation.
- Shrubs and bushes should be removed and cleaned from the plantation site 1-2 months before the plantation and security (fence, enclosure) should be arranged as required.
- The digging of the pit should be done 15 days before the plantation using local tools such as a spade, a shovel, a rake, etc.
- The selected healthy saplings should be transported from the nursery to the plantation site by vehicles or people (in a bamboo carry-basket) and the saplings should be kept in the shade.
- The plantation method depends on the type of plant. For example, plastic bag plants or root-shoot cut plants or grafted plants with soil-free roots.
- Before planting, the polybag containing the plant should be cut with a sharp knife or blade and the plastic bag should be removed without affecting the soil around the roots of the plant and the plant should be planted upright.
- The pit should be filled with soil around the plant and firmly pressed with the feet.
- After the planting of the sapling in dry areas is completed, to maintain moisture, the soil around the plant should be slightly lower than the surrounding soil surface.
- The plantation site should be regularly tilled and protected from grazing and fire.

Other things to consider

- While selecting species, local/native species should be given priority for plantation.
- For dry, loose soil and places where stones fall regularly, trees that can take root from stems and branches such as lahare pipal, simili, khirro, phaledo, bains, kimbu, davdabe, etc. are suitable.

- For dry and rocky places, phaledo, amla, chilaune, sallo, ketuki, khirro, davdabe, etc. are suitable.
- For places with dry soil, amla, bayar, ketuki, khayar, sisau, bakaino, babul, simali, kalo shirrish, khirro, etc. are suitable.
- For the fodder grass, Kutmiro, Phaledo, Tanki, Koiralo, Khanyu, Rai Khanyu, Kavro, Pakuri, Badhar, Dudhilo etc. can be planted.
- When planting in very steep and adverse areas, it is better to plant the saplings with roots in the soil wherever a suitable place is found rather than at regular distances.
- When planting cuttings, cow dung mixed with soil should be applied to the tops to prevent it from drying.
- For the restoration of damaged land, the legumes should be planted in combination with other plant species.

Limitations

Natural limitations such as very steep/rocky land, salinity, environmental heat or heavy rainfall in a short period of time can cause damage. In addition, lack of financial resources, lack of technical knowledge and lack of market access can also make it difficult to complete the plantation work. Policy support, community involvement and long-term monitoring are essential for success.

4.3.3 Drought-tolerant species

Definition

Drought-tolerant plants are plants that can survive for long periods without water and grow well even in conditions of water scarcity. Such plants have developed special physical and biological abilities, such as thick leaves to minimize transpiration, thorny leaves, waxy layers on the leaves, as well as deep roots exploring water inside the soil. Once well grown up, such species can survive for long periods of time in dry conditions with little or no additional water.

Figure 32: Plants growing in arid areas

Objective

The main indicator of the restoration of degraded land is the availability of trees in that area, so the species and methods of agricultural and forestry cultivation in that area should be identified.

Implementation Process

When cultivating in drought-affected areas, fast-growing and fast-returns giving species should be selected. For example, corn yields less in places with low water and high temperatures, while junelo can give the expected yield even with less

water. In this way, soil structure and locally proven species should be given priority when selecting species. If agro-forestry system of drought-tolerant species can be developed, it can be developed as a source of income for local communities.

During implementation, it is necessary to disseminate information through new partnerships and networks, training for technical and financial support, and exchange local and external expertise. If agroforestry and natural resource management can move forward in a coordinated manner to solve the challenges of climate change, population growth, and dry land problems, this method can become the basis for sustainable development.

Agricultural plants	millet, sunflower, drought-tolerant maize (Rampur yellow), paddy (Ghaiya), and wheat (Banganga) varieties, quinoa, barley, uwa, gahat, gram, beans, soybean, etc.
Forest plants	amla, chilaune, sallo, ketuki, lahare pipal, simali, khirro, phaledo, dabdabe, bayar, khayar, sisau, bakaino, kalo shirish, etc.

Care

Although the conservation and care of such drought-tolerant species requires less time and resources, the process of identifying appropriate species and selecting plantation methods is important and sensitive.

4.3.4 Soil Conservation Measures

Definition

Soil conservation activities in dry lands means arable land and crop management practices that prevent soil erosion and maintain soil fertility. For example, the use of cover crops, conservation tillage, and integrated soil fertility management practices increase soil productivity by maintaining the biological, physical, and chemical properties of the soil.

Figure 33: Benefits of Sustainable Soil Management through Soil Conservation

Objective

Emphasis should be placed on techniques that maintain soil moisture and reduce erosion to restore degraded land in drought-affected areas. For this, techniques such contour farming, strip farming, agroforestry and mulching are useful. In addition, structural measures for soil conservation and watershed management – such as

check dams, pond construction, planting drought-tolerant crops – help improve soil fertility and productivity.

Implementation process

Soil conservation techniques include cultivation on contour line, which controls water and wind flow and reduces soil erosion by planting crops according to the slope of the land. In strip farming, alternating grass or nearby-growing crops with the main crop reduces the flow of water or wind that causes soil erosion. Cover cropping protects the soil from wind and water erosion and balances organic matter in the soil. Mulching helps to retain moisture in the soil and reduce unwanted weeds. In structural measures, the construction of ponds and canals controls water and wind flow, while check dams slows down the speed of water and recharges the water. In agroforestry systems, the productivity of the land can be increased and the environmental balance can be maintained by combining multipurpose plants and crops.

4.3.5 Degraded Land Management

Degraded land management programs are conducted with the aim of restoring environmental services in dry areas and improving the livelihoods of local communities. Such programs use sustainable land management techniques, including proper management of groundwater and soil, community-based conservation, and site and context specific appropriate technologies for community-based conservation.

Figure 34: Sample of degraded land management

For example, soil fertility can be improved by keeping crop residues on arable land, mulching, and using manure and compost. Sustainable land management is achieved by reducing the number of livestock in the barn, adopting controlled grazing systems, and planting drought-tolerant species in forest areas and water efficient irrigation systems.

These programs focus on land restoration, preventing deforestation, strengthening protected areas, and sustainable management of water resources. In addition, policy mechanisms, economic incentives, and capacity development measures should be adopted to make such programs effective. Overall, the management of degraded lands aims to increase climate resilience, maintain environmental balance, and contribute to the long-term prosperity of local communities.

4.4 Other Activities

4.4.1 Utilization of food that go waste

- Utilization of food by drying, freezing or other methods (gundruk, radish pieces, sukuti, etc.),
- Emphasize on consumption plant-based foods over animal-based foods.
- Store dry grass, straw, silage, etc. for animal feed.

Figure 35: Food utilization measures

4.4.2 Measures to prevent evaporation

- Maintaining land use
- Prioritizing multipurpose uses of water
- Using artificial mulching (plastic sheets)

Figure 36: Use of plastic to reduce evaporation

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