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A REFRESH BOOK OF RANGELAND MANAGEMENT

BY

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1. RANGELAND

INTRODUCTION

Rangelands are vast natural landscapes in the form of grasslands, shrub lands (bushy lands), woodlands, wetlands, and deserts. Types of rangelands include tall grass and short grass prairies, desert grasslands and shrub lands, woodlands, savannas, chaparrals, steppes, and tundras. It is perhaps easier to define rangelands by clearly describing what they are not. Rangelands are not: barren desert, farmland, closed canopy forests, or land covered by solid rock, concrete and/or glaciers.

Types of Rangeland

Prairies are considered part of the temperate grasslands, savannas and shrub lands biome by ecologists, based on similar temperate climates, moderate rainfall, grasses, herbs, and shrubs rather than trees, as the dominant vegetation type.

Grasslands are areas where the vegetation is dominated by grasses and forbs (non-woody plants). Grasslands occur naturally on all continents except Antarctica.

Steppe: The term is used to denote the climate encountered in regions too dry to support a forest, but not dry enough to be a desert.

Pampas are the fertile South American lowlands that include the part of Argentine. The climate is mild, with precipitation of 600 mm, more or less evenly distributed through the year, making the soils appropriate for agriculture. These plains contain unique wildlife because of the different terrains around it.

Shrub land is a plant community characterized by vegetation dominated by shrubs, often also including grasses, herbs and geophytes. Shrub land may either occur naturally or be the result of human activity.

Woodland is a low-dense forest forming open habitats with plenty of sunlight and limited shade. Woodlands may support an understory of shrubs and herbaceous plants including grasses.

Savanna is a grassland ecosystem characterized by the trees being sufficiently small or widely spaced so that the canopy does not close. The open canopy allows sufficient light to reach the ground to support grasses.

Desert (less than 250 mm rainfall per year) is a landscape or region that receives an extremely low amount of precipitation, less than enough to support growth of most plants.

Tundra is a biome where the tree growth is hindered by low temperatures and short growing seasons. The term tundra means treeless mountain tract. In tundra, the vegetation is composed of dwarf shrubs, grasses, mosses, and lichens. Scattered trees grow in some tundra. The eco-tone (or ecological boundary region) between the tundra and the forest is known as the tree line or timber line.

Characteristics of Rangeland

1. Low rainfall/moisture stress
2. Not suitable for agriculture
3. High or low temperature
4. Degraded land (rocky/stony)
5. Shallow soil (low soil fertility)
6. Shorter growing season of the vegetation
7. Prevalence of rain shadow
8. Poor drainage
9. Desert like environmental situation

RANGE ECOSYSTEM OF NEPAL BY GEOGRAPHIC REGIONS/CLIMATIC REGIONS

Collectively, rangelands in Nepal comprise grasslands, pastures, scrubland and forests (MOPE 1998). The rangeland environment supplies forage or vegetation for grazing or browsing livestock. Nepal's rangelands have high biodiversity as they range from subtropical savannahs to temperate grasslands and alpine meadows, and include the cold, arid steppes north of the Himalayas. Nepal's total grassland areas are estimated to cover about 1.75 million hectares, or nearly 12% of Nepal's total land area. About 70% of the rangelands are situated in the western and mid-western regions, and it is estimated that only 37% of rangeland forage is actually available or accessible for livestock (LMP 1993; Pariyar 1998). Based on the physiographic, the range ecosystem of Nepal is categorized into five types:

Tropical rangelands (Approximately extended up to 1000 m)

- Poorly drained clay.
- Dominated by the grasses like *Saccharum*, *Imperata* cylindrical, *Eulaliopsis binata* etc.
- Some grasses are 2 m tall, found in Rapti valley of Chitwan NP and Suklaphanta.
- *Lantana Camera* (banmara) is gradually replacing many palatable species.
- Warm temperature and long dry seasons.
- Level land and dotted trees with low vegetation.
- Dominated by Acacia spp. in river sides and *Shorea*, *Termaniallia* etc on other places.
- Rhino in CNP, Arna in Koshi tappu, S.Deer in Suklaphanta, tiger etc.

Sub-tropical rangelands (Approximately extended from 1000-2000 m)

- Mostly associated with *Pinus roxburghii, schima-castonopsis.*
- More grasses in slopes than in plain area.
- They are heavily grazed and are infested with *Eupatorium adenophorum* (Banmara), *Pteridium aquilinum* (bracken fern), *Urtica parviflora* (Stinging Nettle) and *Artemisia vulgaris.*
- The main forage species are *A. bengalensis, A. nepalensis*, *Imperata cylindrica* etc.
- Barking deer, common leopard etc are found here.

Temperate rangelands (Approximately extended from 2000-3000 m)

- Associated with oak or mixed broad-leafed species such as Quercus or bluepine forests.
- These pasture lands are very important, but due to heavy grazing for many years, less palatable species such as *Arundinella hookeri* are found.

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- In many areas, *Andropogon tristis* has been replaced with less palatable forage species such as *Arundinella hookeri*.
- The common forage species are *Arundinella hookeri*, *Andropogon tristis*, *Poa spp*.
- Low rainfall and low evapo-transpiration
- Very dry seasons e.g lower mustang, humla,jumla.
- Mostly dominated by *pinus spp. and rhododendron spp*. in upper temperate regions.

Sub-alpine rangelands (Approximately extended from 3000-4000m)

- Dominated by Abies spp. and Rhododendron spp. including *betula* and *juniper*.
- *Caragana spp*. are low spiny shrubs rarely exceeding 1.5 m high.
- *Caragana spp*. grow in low rainfall areas (less than 250 mm)e.g mustang.
- Associated with a variety of shrubs.
- The common genera are *Berberis* and *Caragana*.
- Short growing seasons
- Cold temperature with low rainfall with dry seasons.

Alpine rangelands (Approximately extended above 4000 m)

- Lichens, mosses, dwarf plants including *Rhododendron* shrubs and junipers shrubs.
- Snow leopard, musk deer, mountain goats, wild yak etc.
- Cold area with snow
- High mountain region.

Note*: refer Annexes*

FORAGE RESOURCES OF NEPAL: FARM FORESTRY LINKAGE

Nepal has a livestock population of about 6.5 million LU (livestock Unit) and the Nepalese farmers own on an average of 3.3 LU per household. Statistically shows that Nepal has one of the world's highest livestock populations per unit of the cultivated land. However, the productivity per unit of livestock is very low. One of the main constrains in the livestock development in the country is considered to be the lack of animal feed. The major sources of nutrient provided to the ruminants are derived mainly from straws (31%), green grass (30%), fodder tree leaves (12%) and the concentrates (7%).Forest resources has been considered the most important resources. The feed resources in Nepal are given below:

Land types	Availability of Resource
Cropland	• Terrace, raisers, bunds and fallow lands • Crop residue, grass, weeds, leaf fodder • 33% of the total feed stuffs
Rangeland	• Alpine, meadow, steppe, open grazing lands • 30%of the total feed
Forestland	• Leaf fodder and grasses • 20% of the total feed
Wasteland	• Wasteland fodder and grasses • 16% of the total feed

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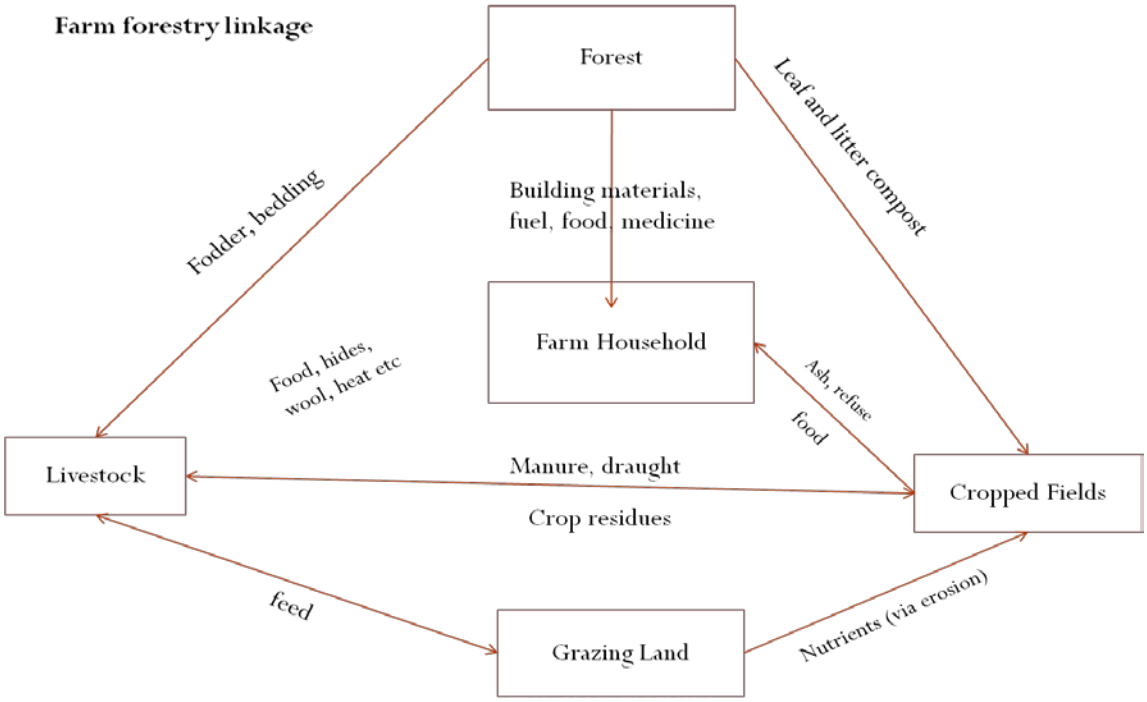
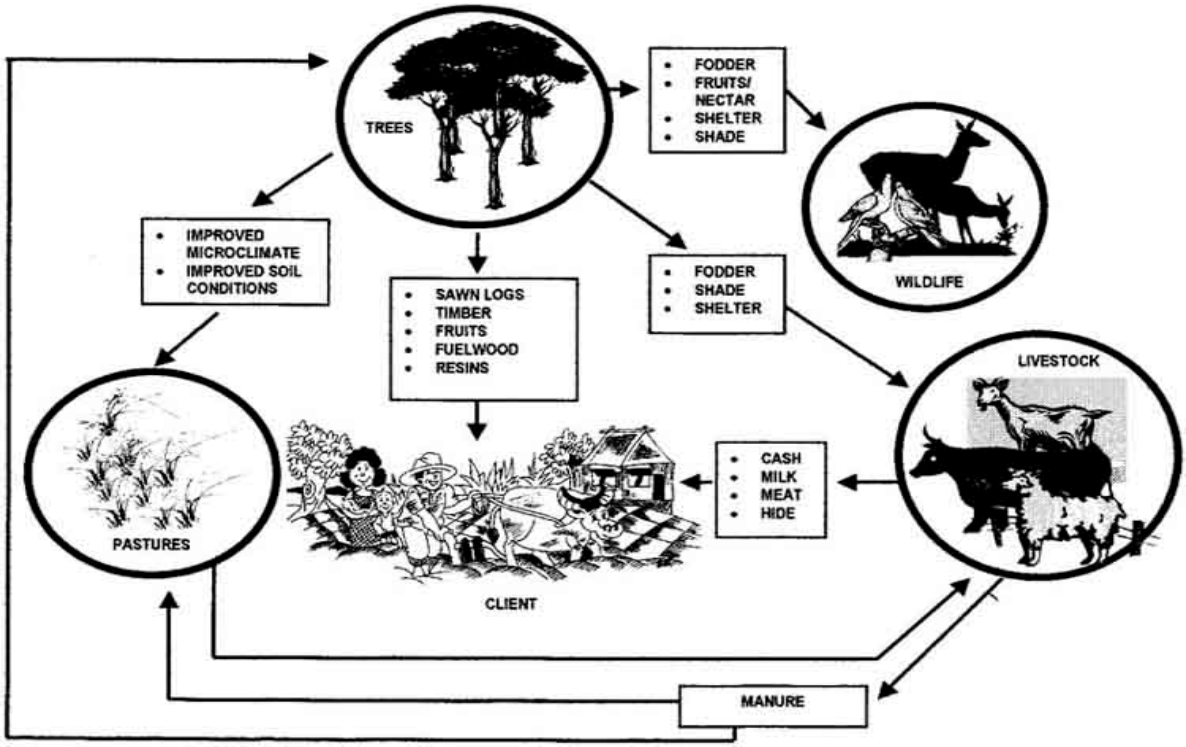


Figure: A model of traditional Nepalese hill farming system



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IMPORTANCE OF LIVESTOCK IN NEPALESE AGRO-ECOSYSTEM

Livestock plays a key role in the overall agricultural production system in the country. More than 80% of the economically active population is engaged in agriculture. From terai to high mountains a strong integrated system of livestock crops forest is in existence. Over 70% farmers of Nepal are based on animals to sustain soil fertility and agriculture production. Sheeps are the major sources of local economy of the mountains people. Livestock provides milk and fibres and their dried manure are the major sources of energy. Some animals are used for trading as well. For e.g horses, donkey, goats, sheeps etc. In Terai animals are used for transportation and land cultivation as well. Major sources of manure come from livestock farm. Livestock contribute 53% to GDP, in Terai 27.6% and Mountains 8.6%. Similarly, wool production, leathers production, meat production etc also contribute a lot etc.

Importance of Livestock

1. Agricultural production: Play key role in agricultural production (Livestock : > 14% of National GDP and >24% of Agriculture GDP (NPC, 1993)
2. Economic importance: Production of milk, meat and wool
3. Cultural importance: Worship for religious purposes
4. Draft power: Pulling carts and carrying goods and things
5. Provides fuel: dried dung and biogas.
6. Recreational values: keeping dogs, cats, rabbit etc in a home.

Some limitation of livestock forming in Nepal

- Laborious Job
- Cultural and religious barrier.
- Needs huge amount of grass land
- Huge amount of initial cost
- Competition with food of human
- Breakout of diseases

Distribution of livestock in Nepal.

- High hills: major source of income. (horse +donkey +chauri+ sheep)
- Mid hills: second major source after cultivation (Cow +buffalo +oxen +goat)
- Terai: Second major source after cultivation. (Buffalo + cow +oxen +goat)

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2. RANGELAND ECOLOGY AND ANIMAL BEHAVIOUR

Introduction:

The removal of leaves or any lives part/s of a plant including leaves by any means by animals grazing or by human intervention is called defoliation. The effects of defoliation may be positive or negative, which are explain below.

a. Plant morphology:
   - Removal of terminal bud and Growth of several lateral buds,
   - Increment of foliage,
   - Thickness of crown
   - Sprouting of roots etc.

b. Plant physiology:
   - Adverse effect on metabolism
   - Damage on photosynthetic tissues
     - ➢ Reduced carbohydrate reserve in the roots
       - o Root growth and forage production.

c. Seed production:
   - Disturbance of entire physiology results
   - ➢ Less seed production
   - ➢ Reduced seed sizes and numbers

d. Vegetative reproduction:
   - Reduces the photosynthesis plant tissues
   - ➢ Hindering food synthesis process.
     - o Reduced size of the rhizomes, bulbs, culms etc.
   - Effect of frequent early grazing affects on rhizomes production.

e. Root system:
   - Reduced photosynthesis decreases nutrient uptake and root size.
   - Hinders water intake capacity.
   - Stop root growths results moisture stress in plants.

f. Soil conditions:
   - Soil compact
     - ➢ Reduces infiltration and increase runoff.
       - o Prohibits normal root development and poor germination.

g. Plant condition:
   - Defoliated plants are susceptible to diseases, insects and rodents.
   - Deteriorates soil moisture conditions
   - Directly affects biodiversity.

PLANT TOLERANCE TO DEFOLIATION

Plant reacts to the defoliation in many ways. Different plants have different ability to tolerate the phenomenon of defoliation. Following factors affect the phenomenon of defoliation.

1. **Species to species:** Deciduous plants have more tolerance capacity than evergreen plants.
2. **Seasons/timing**: in dry seasons (winter) recovery from defoliation is slow.
3. **Frequency:** rate of defoliation is more on particular months.
4. **Intensity:** serious defoliation focused on specific areas or parts.
5. **Cutting height:** recovery process affect by plants cutting height. .g cut Napier grass by leaving 20-30 cm on ground.

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6. Stage of maturity, growth and protein content of the plant. (less Nitrogen more defoliation)
7. Competition of plants for water, nutrients and light (survival under stress).
8. Carbohydrate cycle in the grass: less synthesis of carbohydrate during photosynthesis results more defoliation.
9. Grazing resistance capacity of the plants reduces the probability of defoliation.

(a) **Avoidance mechanisms**: A mechanism in which plant start to produce large no of small tillers, reduced leaf number, leaf blade areas. This reduces the amount of biomass removed by herbivorous and plants stated to avoid by animals.
(b) **Tolerance mechanisms:** A mechanisms in that facilitates re-growth of the plant following defoliation. It increases the no of apical meristem that may contribute growth after defoliation. Plant started to produces reproductive tillers.

GRASSLAND (FACTORS THAT DEFINE GRASSLANDS)
Land area composed by the herbaceous species of grass as the dominant component.

Types: (a) Natural Grassland (b) Artificial grassland

Natural Grassland: The grassland in which the plant communities have perennial grass as dominant species. There may be few or no shrubs at all. However, trees are completely absent. Main factors determining such grassland are: (a) Determined by the extreme climate (b) Low moisture availability (c) Get just enough precipitation (d) Found between desert and forest or at the rain shadow of mountains.

Artificial Grassland: These are the grassland of more recent origin. They have been formed by destroying forest mainly by cutting and fire. These have been maintained largely through grazing animals. Main factors determining such grasslands are:

Climatic factors: Precipitation, Temperature, Humidity
Edaphic factors: physical and chemical properties of soil
Biotic factors: influenced by: Fire, Grazing and land clearing

Category of grassland	Found in
Tropical grasslands	Africa, South America, northern Australia, India
Prairie/steppe	North America, Central Eurasia, South Africa
Temperate grasslands	Europe, North America, Australia, New Zealand, Asia
Tundra	all subarctic grasslands

Grassland categories according to climatic zones (NBS, 2002)

Zone	Remarks
Tropical	Grasslands grazed almost all the year round.
Subtropical	Non-palatable species such as ferns, stinging nettle, and Eupatorium species are becoming dominant because of heavy grazing.
Temperate	Winter grazing for cattle, sheep and goats. Burning to improve grasslands is a common practice, causing increased soil erosion.
Subalpine	Seasonal grazing only because of heavy snow cover in winter. Burning of grasslands at the end of the grazing season and in early spring is common.
Alpine	Grasslands are grazed only during the summer (June - September).

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FACTORS THAT DEFINE GRASSLAND

Stress: It is defined as a Pressure and tension from the defoliation. It is a factor that inhibits growth and production. Plant can survive under stress. Stress is due to: Climate factors, edaphic factors, Topographic factors and biotic factors.

- Climatic factors: it is influence by: Precipitation, Temperature & Humidity
- Edaphic factors: it is influence by: Soil depth, Soil structure, Soil Texture, Soil Moisture & Soil fertility
- Biotic Factors: it is influence by: Fire, Grazing, Land Clearing, land slides

Fire: To the range manager, fire and grazing are the principle tools of rangeland vegetation management. The research has proved that increase in fire frequency decreases the grass productivity. Wild and uncontrolled fire may be devastating to all perennial vegetation. The role of fire is considered to be a little controversial. That is why; in many countries burning of the land is prohibited by laws.

Grazing: Heavy grazing seriously weakens the pressure species particularly, legumes and encourages the weed to develop better. It retarded photosynthesis process resulting in reduced manufacture of food, nutrient uptake and plant vigor.

Lang clearing: Clearing is accomplished mainly for cultivation. It exposes the soil, increase surface runoff, reduces soil permeability, and increases soil erosion leading to the big landslides. If clearing is confined to remove unwanted grass species in the rangeland, it may have some positive impact.

PLANT SUCCESSION AND COMMUNITY COMPOSITION IN RANGE ECOSYSTEM

Plant succession: It is the change of the range vegetation from earlier stage to more developed stage. Therefore, Understanding of succession is basic to range management. Succession begins when an area is made partially or completely devoid of vegetation because of a disturbance. Some common mechanisms of disturbance are fires, wind storms, volcanic eruptions, logging, climate change, severe flooding, disease, and pest infestation. Succession stops when species composition changes no longer occur with time, and this community is said to be a climax community.

Process involve in succession: Colonization, Establishment and Extinction.

TYPES OF SUCCESSION

Primary Succession: It is the establishment of plants on land that has not been previously vegetated. It begins with colonization and establishment of pioneer species. Succession in primary area such as newly formed dunes, deltas etc. It takes long period of time to attain the climax (autogenic succession).

Secondary Succession: It is the invasion of a habitat by plants on land that was previously vegetated. Removal of past vegetation may be caused by natural or human disturbances such as fire, logging, cultivation, or hurricanes, grazing etc. Succession after disturbance imposed on the path of primary succession (allogenic succession).

Progressive succession: It is a succession where the community becomes complex and contains more species and biomass over time.

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Retrogressive succession: It is a succession where the community becomes simplistic and contains fewer species and less biomass over time. Some retrogressive successions are allogenic in nature. For example, the introduction of grazing animals results in degenerated rangeland.

Model in the Succession process

1. The Facilitation Model

- Pioneer species establish a presence on the site of a disturbance.
- They modify a site, for instance, by regenerating the soil with organic material making the area more attractive for invasion by other species.
- Eventually, new species move in, edging out the pioneers.
- This process may repeat itself several times, until the ecosystem reaches the climax stage

2. The Tolerance Model

- All species involved in succession are equally capable of establishing themselves on a recently disturbed site.
- But those capable of attaining a large population size quickly are likely to become dominant
- This model is more akin to natural selection

3. The inhibition Model

- All species have equal opportunity to establish population after a disturbance.
- Some of the early species actually make the site less suitable for the development of other species.
- An example of this is when plant secretes toxins in the soil, thus inhibiting the establishment and growth of other species.

SUCCESSIONAL RESPONSE OF GRAZING

Desirable (Decreaser): Highly productive and palatable species that provide good environmental protection.

Less Desirable (Increaser): Species which are less productive and palatable than desirable species and which provides less environmental protection.

Undesirable (Invader): Species that yield very little, if any, forage that is not particularly palatable. They impair the ecosystem. They can also be noxious.

The terms decreaser, increaser and invader are used in the United States.

Two types of succession are realized due to grazing:

1) **Retrogressive succession**

2) Progressive succession

Retrogression or degeneration is the replacement of a community of plants of higher ecological order with a community of lower ecological order. Disturbance of the stabilized climax through overgrazing or cultivation causes retrogression. Improper grazing management are responsible for this. Too intensive grazing is marked by a disappearance of the preferred plants or those physiologically less resistant to grazing. Vegetation deterioration is followed by soil degradation. The latter begins with loss of organic matter and structure breakdown followed by erosion. If disturbance is compensated or eliminated in time, succession moves back towards climax. When the supply of desirable species becomes limited, the animals then turn to the next most palatable species, which are usually less productive and nourishing and

less desirable in respect to soil and water conservation. While the desirable species are decreasing, these species increase to a point, but with continued overuse, they also weaken and die. These species are termed "increasers" or "less desirable". Only unpalatable species and grazing evasive species can survive such a system of overgrazing and eventually these will invade and they are termed "invaders" or "undesirable". Invaders are less productive than increasers and are of very little value as regards soil and water conservation. Some are excessive consumers of water, giving nothing in return, and livestock refuse to graze.

Stages in vegetative Retrogression induced by grazing

- Physiological Disturbance of Climax plants
- Composition Changes of the Climax cover
- Invasion of New Species
- Disappearance of Climax plants
- Decreased Density of Invaders

Progressive succession:

- Development of vegetation towards climax
- If soil is not disturbed much by overgrazing

GRAZING BEHAVIOUR OF LIVESTOCK AND WILDLIFE

Grazing behavior of animals differ from each other, some examples are given below.

- Goats: prefer browse woody plants then forbs.
- Sheep: prefer forbs then grasses
- Cattles: Prefer grasses
- Horse: selective grazers
- Buffalos: prefer long grass
- Zebra: feeds upper parts of the grasses
- Elephants: clumps of grass, barks, and branches of the tree etc.

PALATABILITY AND PREFERENCE

Palatability is defined as plant characteristic. Palatability can be defined as the relative attractiveness of plants to a feeding animal. The palatability of a plant is determined by a variety of characteristics, such as fiber content, flavor, nutrient and chemical content, and morphological features such as roughness or spines. Different kinds of animals are differentially attracted by a particular species.

Preference refers to the selection of plants by animals. Relative preferences indicate proportional choice among two or more foods. Preference is a combination of learned and genetically programmed.

Palatability and preference have been used as synonyms (Ivins, 1952). Palatability or preference measure in the percentage utilization observed at a particular time or place. 70% utilization of a species commonly is taken to mean both palatability and preference] (e.g. if the plant makes an animal sick, it learns to avoid it). Legumes, such as alfalfa, seem to maintaining their good taste. livestock will always eat the wild white clover first (in between red clover and white clover).Many broadleaves are even more palatable.

Dandelions are extremely tasty and feel very pleasant in the mouth (trendy restaurants use them in salads). They remain palatable for longer periods than grasses or legumes. Younger, less fibrous leaves are preferred. However else can we use our knowledge of palatability and animal preferences to improve pasture management. Ryegrass is very tasty and has a pleasant feel in your mouth during the early stages of maturity.

PREFERENCE INDEX

It is defined as a Utilization Percent/Represent percent. It is not clearly know why certain plants are selected over other. Some plants are eaten by one kind of animals while others plants may be eaten by more than one kind of animals. It depends on species, breed of livestock.

Reason for plant selectivity by animals depends on following factors: (a) Nutrients content: Protein (b) Taste: Salty, bitter, sour, sweet (c) Moisture content: (d)Mineral content: (e) Essential oil: (f) Fiber or lignin content (g) Texture

Rejection level of four animals

Salty: Cattle> sheep> normal goats> pigmy goats
Sour: Cattle> Sheep> normal goats> Pigmy goat
Bitter: Sheep and Cattle> normal and Pigmy goat
Sweet: No rejection thresholds established

Plant use factor may vary according to which affect the preference for range plants by livestock and wild life depends on: (a) Associated species (b) Kind of stock (c) Season (d) Year (e) Past grazing use (f) Undefined local condition (g) Familiarity with plant

FACTORS THAT INFLUENCE FORAGE PALATABILITY

Animal Factors: The animal factors that influence palatability may be partitioned into five major categories: (a) Senses (b) Species or breeds, (c) Individual variations, (d) Previous experience or adaptation (e) Physiological condition.

Plant Factors: Among the numerous plant factors that may at times influence forage palatability to animals are: (a) Species (b) Intra specific variation (c) Chemical composition (d) Morphology or physical traits (e) Succulence or maturation (f) Availability in non-controlled situations, and (g) Form of forage controlled by mechanization.

Environmental Factors: Natural and induced environmental factors frequently influence plant selection by ruminant animals. Among these are:

(1) Plant diseases: (presence or absence is environment dependent),
(2) Soil fertility,
(3) Animal dung,
(4) Feed additives,
(5) Climatic variation,

3. RANGE INVENTORY

Range: Range means broad, open, unfenced areas over which grazing animals roam.

Inventory: To make a systematic list of something.

Range inventory is the process of gathering and analyzing information of Physical characteristic of range or rangeland and Biological characteristic of range or rangeland. Rangeland information is obtained by observation or from public and private records. Information collected in the inventory is used as a framework to aid in the development of range classification systems. Rangeland Inventory involves collection of range data systematically, evaluation the data scientifically and production a practical, and a workable range management plan under improved management condition. Rangeland inventory includes:

- Classification of rangeland
- Mapping of the vegetation types of the range
- Range improvement process
- Prevailing trend, its production and utilization
- Readiness of the range for the specific purpose
- Season of the range use

PURPOSE OF RANGE INVENTORY

(a) **Ecological classification:** To determine Physical and environmental factors such as precipitation, topography, soil, vegetation
(b) **Range forage inventories**: To determining grazing capacity (domestic or wild animals) and to focus on plant species
(c) **Utilization survey**: To assessing the current grazing pressure and to determining appropriateness of current stocking level or management system
(d) **Condition and Trend analysis**: To judge the adequacy of stocking and management practices which is based on successional and community dynamics concept.
(e) **Multiple use surveys:** To determine the entire biological and physical resource based with the objective of integrating all capabilities.

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(f) **Rangeland appraisals:** To determining economic productivity of a range area.

Range inventory is particularly concerned with the classification of shrubs (tall and low) and herbs (forbs and graminoids), which are forage for livestock and wildlife.

Vegetation inventories: (a) To find out the absolute or relative abundance of plant species

(c) Data quantified by: Numeration, volume or weight

Vegetation inventory range samples consist of: (i) a complete listing of plant species present (ii) shrub transects to measure shrub abundance (iii) Micro-plots to estimate forage production and utilization.

METHODS OF VEGETATION ANALYSIS OR RANGE SPECIES INVENTORY

SPECIES LISTING

The Process of identification and listing of all available species (grasses, grass-like plants, herbs, shrubs and tree of a rangeland is called species listing. It require

- Local people discussion and their experience and investigator experience.
- Survey of the range area.
- Collection of sample plants.
- Identification of all the plant collected.
- You need to do species listing at first.

Format for species listing I

Local Name	English Name	Scientific Name	Symbol
Napier ghas	Napier	Pennisetum purpureum	Pepu
Setaria Ghans	Setaria	Setaria acepa	Seac
Panic Ghans	Green Panic	Penicum maximun	Pama
.....	.....	.....	.....

After species listing in format I, available data need to further divided into several group based on the preference

Format for species listing II

Preference Type	Local Name	English Name	Scientific Name	Symbol
Desirable sp	Napier ghas	Napier	Pennisetum purpureum	Pepu
Intermediate sp	Setaria Ghans	Setaria	Setaria acepa	Seac
Least Desirable Sp	Panic Ghans	Green Panic	Penicum maximun	Pama
Not Desirable Sp	.....	.....	.....	.....

There may be many species of vegetation that cannot be recognized and identified that may be specific to the area under study. They should be brought to the highly specialized person for their identification. Consult with expert of Department of plant resources.

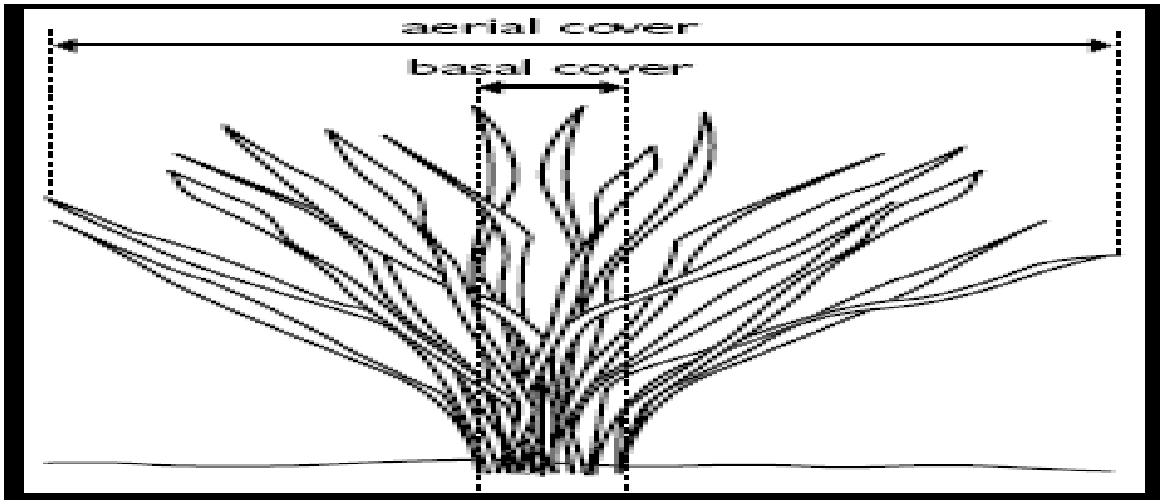
GENERAL OBSERVATION

In this method overall condition of rangeland observed by ocular method. It is highly subjective study of vegetation study. It may vary from observer to observer and required a lot of experience. It aims to make a quick assessment on the species of a grassland site and assess any current or potential threats. As well as providing baseline survey data it will allow the project team to priorities sites for future conservation management.

COVER: Cover is the vertical projection of vegetation from the ground as viewed from above. Two types of cover are recognized for the study.

1. Basal cover is the area where the plant intersects the ground;
2. Aerial cover is the vegetation covering the ground surface above the ground surface. You can visualize aerial cover by considering a bird's-eye view of the vegetation.

It is the indicator of the dominance of a particular species of vegetation in the rangeland and also, the biomass of the vegetation in the rangeland can be estimated. It can be expressed in fraction or percentage.

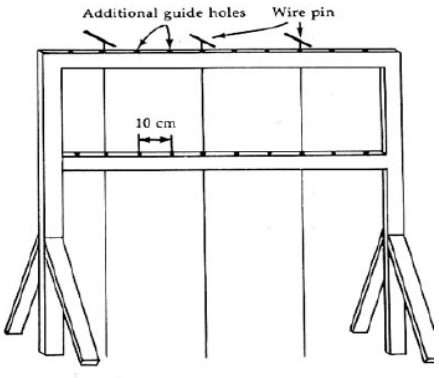


Cover can be estimated by the following method (a) Visual estimation (b) Point method (c) Line interception method

Visual estimation: It is the estimation of a vegetation cover in a particular area based on general visualization. So it required a lot of experience to be close to the correctness. This is also subjective method, may vary with surveyor.

In this method, several circular or rectangular quadrants are used and each of them is estimated individually to have the estimate of overall area.

Point/Frame/Hit method: It Consists of Metallic frame, sliding pins at equal intervals set in vertical position by means of rigid crossbars. The length of pin varies from few inches to a foot depending upon the vegetation. Commonly, frame consists of 10 sliding pins of one ft length.



Procedure:

- Samples are ocular surveyed.
- Vegetation species to be estimated are identified.
- Set frame in field randomly.
- All pins are pulled and each pin is lowered
- Hits by the pins are recorded

Cover %= Mean of all the hits (total hits on a particular vegetation species) X 100

Total number of pin lowered

Drawback of Point/hits method

- Broad leaf plants are hit more
- Blunt pins are likely to overestimate
- Wind movement biasness
- Time consuming

Line interception method: It consists of recording horizontal linear measurement of a particular species or more than a species alone a line.Plant foliage that is intercepted along the line is measured and the total intercepts of the vegetation species to be estimate along the line is the percentage of the ground surface covered by that particular species.

% cover= Distance Intercepted x 100

Total Length

Procedure

- A metallic tape of 100 ft or as required
- Sample area is surveyed.
- Plant species to be estimated and identified.
- Transacts are drawn randomly holding two ends of the tape
- It is stretched at a uniform height
- Plant foliage intercepted by the transact is recorded.

DENSITY

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It is defined as the number of individual species present in unit area. It can be express in fraction or percentage. It is more precise method than the cover method. It involves the actual counting of vegetation species and involves little or no estimation. Generally 2.5 X 2.5 cm plots are used

Density of species

$$= \frac{\text{Total no. of individuals of species}}{\text{Total no. of plots sampled X area of a plot}}$$

FREQUENCY

It is the number of occurrence of a species of vegetation in a particular area. It reflects a good indication of the spatial distribution of a vegetation species over a particular area. It can also be expressed in terms of either fraction or in percentage.

- Frequency of species $= \frac{\text{No. of plots in which species occurs X 100}}{\text{Total no of plots sampled}}$

DETERMINATION OF CARRYING CAPACITY AND GRAZING CAPACITY

Animals Unit (AU/au): It is referred to as a mature buffalo or its equivalent or a mature cow of 1000 Ibs with its calf on the ground up to six months old.

- Number of animals= $\frac{\text{pasture size X pasture yield per acre}}{\text{(Daily intake X average animal weight X days of grazing)}}$

Grazing Capacity:

The maximum animal number that can graze each year on a given area of rangeland for a specific numbers of days of the year without inducing a downward trend of forage biomass production, and forage and soil quality.

Carrying capacity:

The maximum number of individual animals that can survive the greatest period of stress each year on a given land area depending upon the range capability to produce different products and within inducing downward trend of the range condition. Thus, the carrying capacity is the number of individuals an environment can support without significant negative impacts to the given organism and its environment.

Grazing capacity	Carrying capacity
Maximum number of animals that produces the greatest return from a given area of land	Maximum number of individuals that can survive
With out damaging the physical resources	Physical condition with in limitation
GC= Total forage production / Forage requirement/animal/day* 365* area of the grazing land	CC= Total forage production in the rangeland / forage acre requirement/animal AU
Grazing capacity have less animals than carrying capacity.	Carrying capacity includes more than maximum numbers of animals that can survive in the given area.
Term used for rangeland management and	Wide coverage (Tourism, engineering,

livestock management	forestry)
Animal population can increase above the grazing capacity.	Below carrying capacity, populations typically increase, while above, they typically decrease.
Used simply for grazer	Use for game animals such as area of suitable habitat, sufficient foraging area, appropriate cover and a large enough area to cater for social needs (Furstenburg 2002).

LIMITATION OF CARRYING CAPACITY CONCEPT

- Possibilities of Under utilize (lower production year)
- Possibilities of over utilize of the forest resources (higher production year)
- Not suitable when animals to be grazed, its distribution, and the season to use are not obvious.
- It depends on different factors

Dependent factors

- Biomass composition /Vegetation composition
- Palatable species/unpalatable species
- Environment factor (Temp, rainfall, wind,)
- Topographic factors (Slope, Aspect)

RANGE CONDITION CLASSIFICATION FOR NEPAL/ CONCEPT AND DEFINITATION

The production and productivity of rangelands are very low, ranging from 0.12 to 3.2 metric ton (mt) dry matter (DM)/ha. Only 64% of the rangelands are accessible. Most of the rangelands are overstocked and severely grazed out. The estimated carrying capacity ranges from 0.06 to 1.4 livestock units (LU)/ha. The stocking rate on rangelands is very high -up to 37 times the carrying capacity (Pandey, 2008)

The concept of classification of range condition was first develop in USA. It described as the state and health of the range based on what range is naturally capable of producing. The term range condition has a special meaning for the range manager. The condition of the rangeland depends on the seasonal factors. If rains have been frequent and temperature favorable, range are good. Range manager attempts to look beyond the immediate greenness of the herbage. It is the classification of the condition of the rangeland to the potential of a particular area that is capable of producing forage. Range-condition classification is based upon ecological concept of plant succession and climax. Range vegetation can be classified as climatic, edaphic, and biotic factors. The main factors responsible for depletion of range condition are:

- Early grazing
- Over grazing
- Selective grazing
- Invasion by the undesirable species of vegetation and
- Climatic variability

CLASSIFICATION SYSTEM (Criteria for range condition classification).

The criteria for range condition depend on the purpose of classification (Soil Factors, Plant Composition, and Forage value).

SN	Factors	Criteria Description	Classification

1	Soil Type	Depth of soil Soil Erosion Soil Moisture Moisture retention capacity , Soil texture, Soil structure	
2	Vegetation Composition	Vegetation Species Vigor Density Age Litter formation Status of Regeneration and Reproducing capability	
3	Forage Value	Nutritive value of the forage, its palatability and productivity	

Methods of range condition classification

1. Quantitative Climax Approach

This approach is based on the percentage of climax vegetation or species composition. All range plants are grouped in three (Decreaser, Increaser, and Invaders).Commonly called Soil conservation service method. Range condition have been recognized in to (Dyksterihius);

Range Condition	Percent of Climax
Poor	0-25%
Fair	25-50%
Good	50-75%
Excellent	75-100%

2. **USDA Forest Service Method**

Due to the limitation of the Species composition classification which describe above, this method is used. This is based on various factors which determine range condition, these factors have been given rating and marks have been allotted for each.

a) **Soil Condition**

	Characteristic	Point
Class 1	No soil loss, well dispersed accumulation of litter and older litter	Rating 20
Class 2	Soil movement slight, noticed of rill erosion, no accumulation of past litter	Rating 17
Class 3	Soil loss more noticeable, top soil loss, rill marks and poorly dispersed litter	Rating 7
Class 4	Advance stage of erosion, active gullies, exposed plant roots	Rating 0

b**) Density of ground cover**

Density	Rating
0.50 plus	10
0.45	9
0.40	8
0.35	7
0.30	6
0.25	5
0.20	4
0.15	3
0.10	2
Less than 0.10	1

c) **Vegetation Composition and Age**

Class	Characteristics	Rating
1	The perennial herbaceous forage of better quality are abundant. Better quality of forage plant	10
2	The perennial herbaceous forage of better quality are moderately,	7
3	The perennial herbaceous forage of better quality are scarce	5
4	The perennial herbaceous forage of better quality are relices.	1

d**) Plant Vigour**

Class	Characteristics	Rating
1	Palatable plants vigorous, grassess robust with numerous leaves, leaves dark green.	10
2	Palatable plants lacking in vigour. Forage species are shorter, fewer seed stalks,	7
3	Palatable plants lacking in vigour, gresses weak forage plants are nor reproducing	5
4	Palatable plants sickly and weak. Grasses may be pale yellowis in color, seed stalks few and short, no seedling	1

You need to add above A, B, C and D number according the condition and compare your data with the table below to find range condition.

Range condition	Point
Good	Over 40 pts.
Fari	30-40
Poor	15-29

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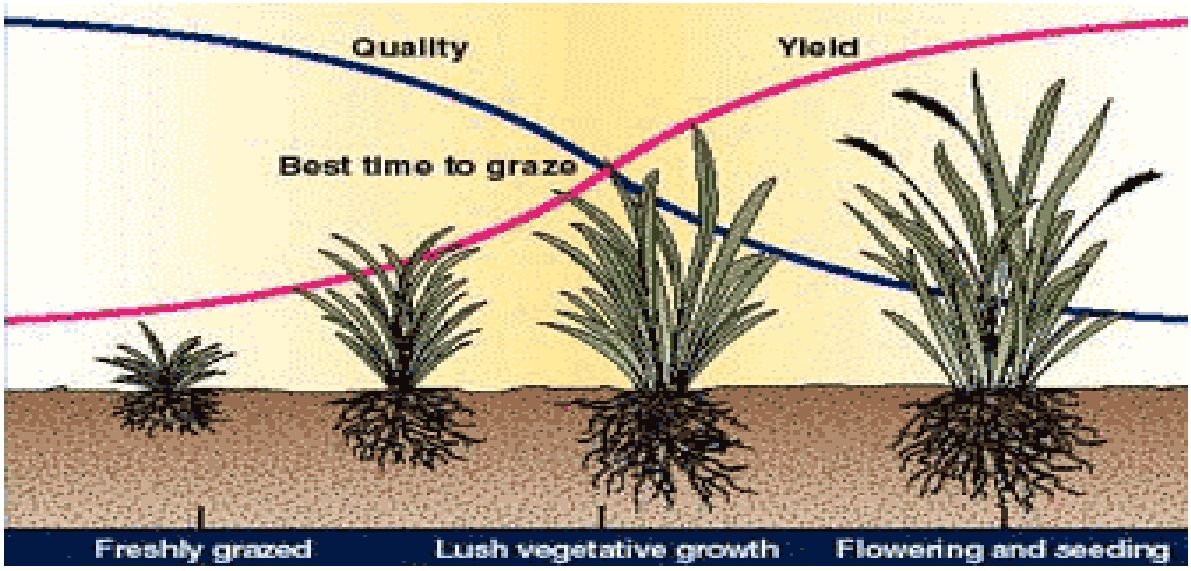
Very Poor	Less than 15

3. Site Potential approach

SN	Range condition	Vegetation type	Percent compositon
1	Excellent	Palatable grass, herbs, forbs, browse	75-100
2	Good	Above species in less amounts	50-75
3	Fair	Above species in lesser amounts	25-50
4	Poor	Above species in very less amounts	0-25

CONDITION TREND ANALYSIS

The nutritive value of the forage change with its growth and maturity. Such as the protein content is higher during earlier stage and biomass increase with the age. Higher nutritive value as well as palatability is realized at the mid of maturity period when the biomass is also at its optimum and advise to fed to animal for maximum benefit. With maturity, the protein as well as the phosphorus content of vegetation decrease and consequently, the carbohydrate content increases. Mature grasses have more fiber content and less palatable. At the same time, the vitamin content is reduced with the age of the plant.



Judging range trend is even more hazardous than judging range conditions, because there are few objective means for assessing trend. We analyze the soil factors and Plant factors for this.

- Soil factors
  - Presence of litter
  - Evidence of soil trampling
  - Presence condition of gullies
- Plant factors

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- Plant vigor
- Seeding establishment
- Degree of percent utilization
- Evidence of past utilization

4. RANGE IMPROVEMENT

Range Improvement: Its aim is based on the ecological principles of competition/succession. It includes

1. Increase production (quality/quantity) of species.
2. Balance species by inducing succession towards desirable direction.
3. Effective utilization of forage production.
4. Increase productivity of range depended animals (both livestock and wildlife)

How to improve rangeland

1. Direct methods: (a) Seedling (b) Controlling undesirable/noxious plants (c) Cultural operation ((weeding, hoeing, pitting, furrowing, fertilizer application, irrigation)
2. Indirect methods (a) Fencing (b) Trail improvement (c) Water availability (d) Effective utilization of the herbage (e) Grazing management

GRAZING PRESFERENCE OF VEGETATION WITH GRAZING ANIMALS

Different animals have different grazing behavior and dietary preference

Types of animals	Grazing preference
Cattle	Less selective and less severe in pasture mainly eat grasses but browse any edible shrubs that appear in path
Buffalo	Long grasses
Sheep	Closer grazer (remove tall grasses from top to bottom, select a diet much more nutrition
Goat	Browse mainly
Horse/donkey	Selective grazer, close to ground ignore browse
Elephant	Clumps of grasses, bark, branches of the tree

Dietary Preference of different type of animals

Types of animals	Dietary Preferences		
	High	Medium	Low
Cattle	Ground grass	Shrubs/Forbs	-
Buffalo	Ground grass	Shrubs/Forbs	-
Sheep	Shrubs/grass	-	-
Goat	Shrubs	Forbs	-

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Horse	Close grass	Forbs	Grass
Deer	Shrubs/Browse	Forbs	Grass

By knowing animals' behaviours range vegetation can be manipulated. So we can combine different types of animals. If we want to control shrubs of the range we can keep goat. For control herbs of the rangeland horse/donkey will be best. Similarly, to utilize both shrubs and grasses: combination of goat and cattle will be best.

Strategies for range improvement

1. Balance the number of animals to be grazed with the carrying capacity of the area.
2. To allow the livestock which are best suited for the existing vegetation.
3. Proper distribution of the grazing animals over the entire grassland.
4. Reseeding the grassland with improved variety of grasses which have a higher yield, and nutritive and more palatable.
5. Application of manure and fertilizer and keeping the area weed- free.
6. Adopting the principles of grazing management and encouraging stall feeding and storage of grasses.
7. Adopting proper soil conservation measures needed for the improvement of the grassland.

GRAZING MANAGEMENT: It consists of wise and skillful manipulation of two basic biological elements: (i) Pasture area (ii) Grazing animals

The principal factors that are under the direct control of the manager includes: (a) Choice of the species (b) Manipulation of agronomic practices (c) Selection of livestock feeding (d) Use of supplementary feeding (e) Choice of the grazing system.

Objective of grazing system: (a) To restore the plant vigour (b) To allow plants to produce seeds (c) To accomplish uniform utilization of forage (d) To maintain animal productivity (e) To maintain ecological stability

GRAZING SYSTEM (TYPES)

(a) Continues Grazing system (b) Rotation Grazing system (c) Deferred grazing system (d) Deferred-Rotation grazing system (e) Controlled Grazing

CONTINUOUS GRAZING SYSTEM

It is extensive grazing in which the stocks are grazed in the same grazing area over a prolonged period of time. After a long period of continuous grazing with high stocking rate pasture deteriorates is the common. It changes the species composition /succession (favourable for thorn like plants). This is common practice in Nepal.

Advantages: (a) Requires less management (b) Capital costs are minimal

Disadvantages:

• Lower forage quality and yields

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• Lower stocking rate and less forage produced per acre

• Uneven pasture use

• Greater forage losses due to trampling

• Animal manure is distributed unevenly

• Weeds and other undesirable plants may be a problem

ROTATIONAL GRAZING SYSTEM

It is an intensive system of grazing in which stocks are grazed in the different area of the rangeland moving from one part to another in rotation. The aim of this system of grazing is to use the grassland when it is young and highly nutritious and then allow an adequate recovery period.

Advantages:

• Can increase forage production and improve pasture condition.

• Allows pastures to rest and allows for forage re growth

• Can provide a longer grazing season, reducing the need for feeding harvested forages

• Better distribution of manure throughout the pasture

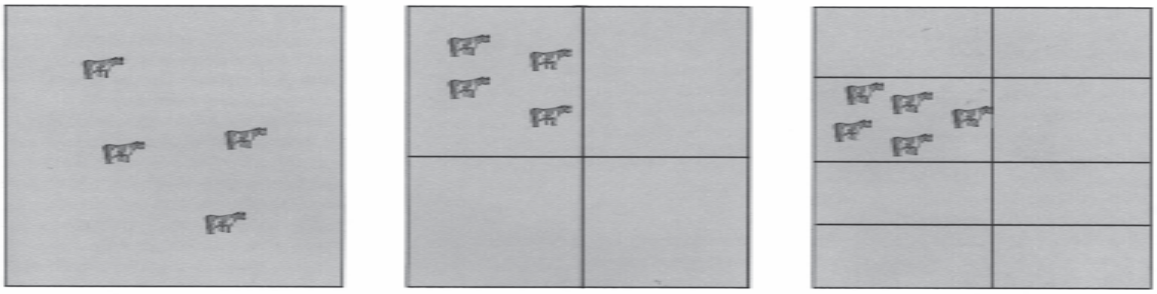
Disadvantages:

• Costs for fencing and water systems can be higher than with continuous grazing

• Forage production and pasture utilization is not as high as intensive rotational grazing systems

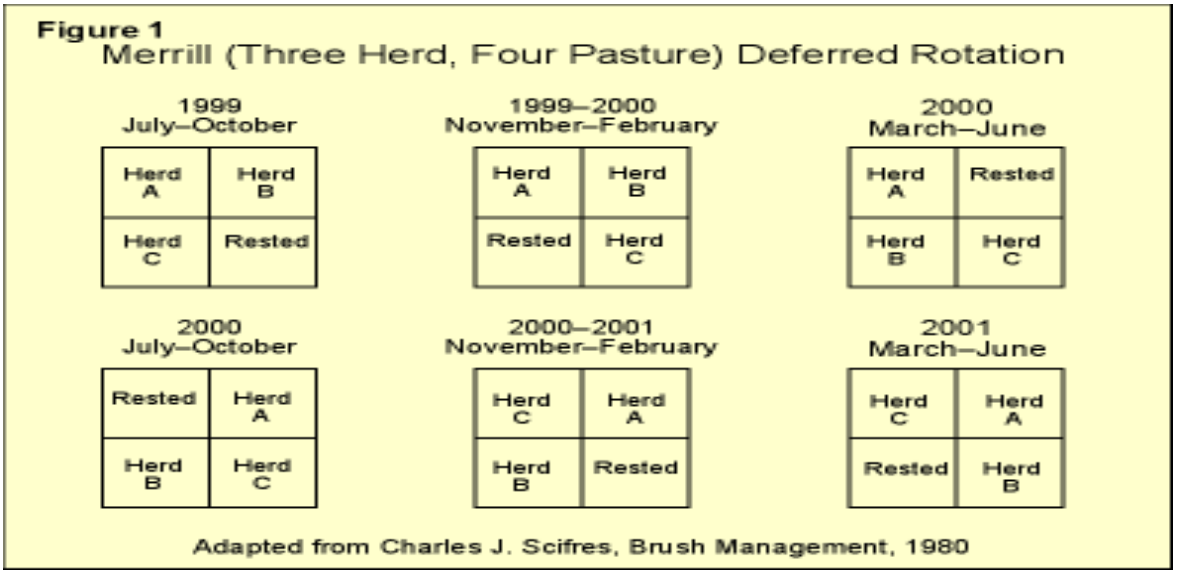
DEFERRED GRAZING SYSTEM

In this system, grazing is delayed until after the most important species have seed, rhizomes, etc for reproduction and propagation. Grazing land vegetation allows to grow fully, root systems are allowed to develop and self sown seeds established. This practice is beneficial for improving degraded pasture and for the conservation of endangered range vegetation.



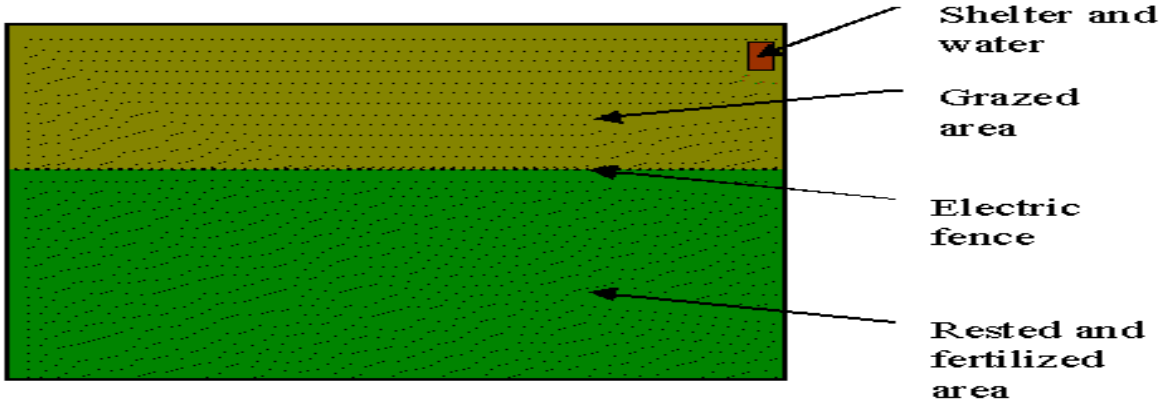
DEFERRED ROTATIONAL GRAZING SYSTEM:

It consists of dividing the grazing land into several compartments, usually three compartments, and the animals are grazed alternatively into two while protecting the third compartment during the growing season. It will allow the palatable species to recoup their vigour. The animals are then allowed to graze the third protected compartment after grass has seeded. Protection of one compartment for once in three years.



STRIP GRAZING SYSTEM:

Strip grazing is more intensive and modified form of rotational grazing. In this case a movable electric fence is placed across the grazing paddock and is moved forward once or twice in a day. This system is applied generally to high productive dairy animals. This will require a small outlay on suitable fencing (ie electric tape which will be highly visible to the horse), plastic stakes which can be moved, and an energiser.



CONTROLLED GRAZING

In this system the number of animals that are allowed to graze per unit area of rangeland is fixed in accordance with the carrying capacity of rangeland.

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Choosing a grazing system: Continuous grazing does, however, have the benefit of low capital investment, since few fencing and watering facilities are required. Because livestock are seldom moved from pasture to pasture, management decisions are simple. Rotational (or controlled) grazing, on the other hand, increases pounds of animal production per acre.

FIRE AS A MANAGEMENT TOOL (controlled burning):

The controlled burning is recognized practice in the management of rangelands. But the practice has great diversity of opinions and has become a controversial subject. In range management controlled burning has defined as the "Planned application and confinement of fire to preselected wild land area." Many studies have revealed that the judicious use of fire has great role in range management but too frequent and unseasonal burning, especially if not followed by good management practices is harmful for the rangelands.

Objectives and importance:

1. To remove unutilized material of previous years and to stimulate growth of new vegetation.
2. To remove unwanted species (thorny, noxious) in more effective and economical way thus to increase the growth of preferred grasses.
3. In tropical areas the grasslands are bunt to induce early spring growth of grasses.
4. To produce ash for fertilization. (Burnt material increases the fertility of the soil.)
5. To produce quality and quantity of forage for livestock (The crude protein % in the herbage increased after burning. (Smith,1960))
6. To control undesirable animals and insects such as ticks and reptiles.

a. Fire removes old, steamy and fibrous growth which would not be eaten by animals.
b. Fire burns litter which suppresses the desirable species.
c. It helps to obtain the desirable species composition.
d. High temperature of the fire imitates the sprouting as result new tillers formed even in the dry season.
e. It facilitates the movement of livestock by controlling/destroying the bushes.
f. It controls pests and pathogens and increases the soil ph.

Some results of burning in the grassland:

a. The root and shoot production in *Dichanthium* grassland of Varansi has increased after burning (Pandey, 1971).
b. Total annual net production of 2480g/m^2 on plots burned twice in a year as compared to 1325g/m^2 for unburned plots
c. Nitrogen content of soil has also increased rapidly in burned grassland.
d. Changes the vegetative composition in some area in some extends.

Summery, burning is a valuable tool in the management of rangelands. But at the same time it has an adverse effect also. Each individual area has to be analyzed critically before the practice of burning is adopted. The results obtained in one area should not be made a basis for the application in similar areas. It should always be practiced with great care and should be regulated in respect of frequency, intensity and time of burning.

CONTROL OF WEEDS

To improve the rangeland we have to control and eradicate the unwanted weeds. The invasion of grazing lands by the weed reduces the carrying capacity of the range land. The weeds have and adverse effects on the forage production of the area as they compete with main crop for water, soil nutrients, light and space. The poisonous weeds and shrubs may be injurious to the grazing livestock if these are grazed during the

period of scarcity or accidently eaten by them, when mixed with the main crops it reduces the forage value of the crop.

Methods of weeds control:

1. **Cultural control:** The establishment of competitive and desirable vegetations prevents or slows down the invasion by weeds which are the key component of successful weeds management.
2. **Biological Control:** Living agents are used to control the unwanted weeds. Such agents may be useful insects, bacteria or may be grazing animals.
3. **Mechanical control:** The process of eradicating the weeds manually by restoring to hand pulling, hoeing, tilling or by mowing (grubbing). Tractor may be used also.
4. **Chemical control:** In the chemical method, the use is made of herbicides and weedicides for the eradication of weeds and unwanted plants. The methods are quite effective and have certain advantages than other methods. The herbicides can be used in the immediate vicinity of the weeds. Some of the herbicides clear the area covered by weeds permanently. This increase forage yield of the range lands. It is easier in application and less expensive. Herbicides should be: economical, easy in handling, sure result, and non toxic to animals

   Herbicide is a chemical that kills the plants. The chemicals employed can be classified into:
   (a) **Selective herbicides (b) Non-selective herbicides.**

(a) Selective herbicides are those which are effective in killing only certain weeds or broad leaved plants when provided with a given dosage and may not affect the growth of grasses and certain other plants. it can be applied directly to the foliage part of the growing plants.
(b) Non-selective herbicides are those which kill the above ground parts of most of the plants that are treated.

To destroy the roots of perennial weeds, trans-located herbicides may be used which move with in the plants. Some of the trans-located herbicides are: carbine, 2 methyl-4chlorophenoxy acetic acid. Name of some herbicides are: TCA (Trichloracetic acid) and 2, 4 DB (2, 4-dichlorophenoxyacetic acid.

Note: Invasive species such as *Lantanma Camera, Mikania Macarantha* (in CNP) Water hyacinth (in lakes) are common in Nepal.

5. GRAZING MANAGEMENT

INDIFENEOUS HEARDING SYSTEM OF NEPAL

Livestock rearing in the area depends upon the overall farming system of the area. Herding system is governed by factors as cropping intensity, Availability and proximity of forest resource, Animal Species and productive stage, Labour availability, Animal population per household. Farming systems at different altitude are different upon the temperature, irrigation, and other interrelated factors and will vary**.**

Common herding system in Nepal (a) Transhumance system (b) Sedentary System (c) Stall Feeding

TRANSHUMANCE SYSTEM

This system is adopted in the high Himalayan area where the herds of animals migrate from one place to another throughout the year. Herdsmen settle at about 2500 m elevation and this system applicable in where sedentary animal husbandry is not possible due to snowfall and shortage of grazing areas. All the herbage remains under snow for about six months in a year. Therefore, as soon as temperature rises, animals start ascending to the high elevations in March for grazing and they start moving down in August and reach at 2000m elevation. Herds of animal migrate from one place to another throughout the year. In this system alpine pasture utilizes during monsoon and crop stubble of the fallow land utilize during winter.

During upward and downward migration, the undergrowth in the forest region is the major forage source. The ruminant animals involved in this system are; Yak, Sheep, goat, and cattle. But in some area buffaloes are also included. The pure breed yak can not come down below 3000m elevation, they either have to go to Tibet for grazing while all the grass land remain under snow in Nepal, or remains in Nepal under starving condition. Owners go to see their herd once a while and offer some corn bread, which does not help even for maintenance. Other animals while on the way to lower elevations graze on the crop stubble of arable field and lopped branches of *Quercus* and *Castonopsis*.

SENDENTARY SYSTEM

Ruminant livestock make daily grazing and return evening. The main grazing area during the summer is the scrubland and community grazing area around the village. The sedentary population consists of working oxen, dry buffaloes and small number of cattle.

STALL FEEDING SYSTEM

This type of animals rearing is found mostly in the area with intensive cultivation and availability of crop residues are abundantly in addition to tree leaves and other grass and weeds are available. Mostly the high value animal like milking buffalos and exotic or crossbreed animals are kept under this system.

TRANSHUMANCE SHEEP HEARDING SYSTEM

This system is followed in the High hill and Himalayan areas (Mustang, Dolpa, Jumla and Humla). Animals are moved to different area throughout the year. The flock migrates from lower hills (south) to the high alpine pasture and back again based on climatic condition. Supplemented with 40-50 gm salt/head/week .This is one of oldest system evolved when animals were domesticated. In migratory flocks, sheep and goat are run together, with the goats acting as the lead animals. Baruwal and Bhyanglung sheep, Sinhal goat are the principal breeds in this system.

In Transhimalayan area Chyangra “Mountain goat” also form the considerable number in herd composition.2 or more shepherds accompanied by Tibetan mastiff dogs look each migratory flock. Animals are not owned by single individual and belong to several owners. Shepherds may be owners as well as hired.

Socio-economic factors influencing Livestock Population and Structure: Geographical region along with socioeconomic issues play an importance role in livestock population and structure. Pastoralism has a long history in the northern region. Geographical region along with socioeconomic issues play an importance role in lives. Horses are the fulcrum of society and one of the most significance measures of wealth in Himalayan area. Villager of the Himalayan offset their income and low-yielding field by keeping domestic livestock. The number and kinds of animals kept by residents vary with Village to village, House to house. It also depends on Community wealth, Individuals family income and Available rangeland and forage resources.

Death from cold and starvation during harsh winter is common for the livestock in the Himalayan area. In the last twenty years, however the number of horses kept by the people of Mustang has continued to increase due to income generated by tourism trade (@ Nrs 400 to 1000/day) but current development of road network can decrease these source of income. Goats (Capra hircus) are common in all Mustang as a domestic animals. Goats, sheep and yak are reared for their meat, milk, skin and wool and carry salt from Tibet. Mules, donkey, yak cow cross breeds: Ploughing and Transporting. Their dried dung is an important fuel, used all over Tibet, and is often the only fuel available on the high treeless Tibetan plateau. Yak milk is often processed to a cheese called *chhurpi* in Tibetan and Nepali languages

Constraints in herding systems:

1. Excessive Population Depending on Limited Natural Resources: Lack of Forage resource and water for livestock

2. Severe Forage Deficit: Availability of feed and fodder during the winter and early summer is a major constraint
3. Disease and their effects: (a) High incidence of disease and parasitism is common (b) Poor nutrition

© Mostly disease and parasite are endemic to Nepal (d) Many more yet to be diagnosed (e) Approx 90% death or mortality occurs due to starvation and 10% due to accidents and disease.

4. Labour availability: (a) High labour requirement and minimum Net return (b) The size of the herds depends upon the labor availability. (c) One herder can take care of approx 500 heads. (d) Sheep and goats are generally looked after by either children or by old people incapable for doing other operations.
5.Poor productivity potential of indigenous animals: (a) Low milk production (b) Low meat production/body size (c) Quantity and quality of wool low (d) Long calving interval (e) Late sexual maturity
6. Poor marketing Structure: (a) For livestock and it's byproducts (b) Hat Bazaar System: Weekly system (c) No competitive market (d) Middleman control
7. Poor Transportation and Communication: Narrow trails and bridges to pasture
8. Lack of specialized industries.
9. Climate change: Changes resulting in disaster such as floods, landslides can also have devasting effect on local rangeland and create the situation difficult for trans-humance herding.
10. Livestock depredation: Snow leopard, bears,

CULTURAL AND RELIGIOUS TABOOS

Most villagers in SPNP in Dolpa are Buddhists and have strict religious beliefs against the killing of animals. Certain places are considered sacred where animal entry is not allowed: movement of human and livestock restricted in Himalayan pick after crops are cultivate; beliefs to be the homes of gods and goddesses.

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6. FORAGE MANAGEMNT IN CONTEXT OF COMMUNITY FORESTRY

INTRODUCTION

In Nepal more than 80% of the population derives their livelihood from agriculture. Existing farming systems are traditional, labour intensive and complex in nature. Livestock husbandry, forestry and arable cropping are inter-dependent, being part of same system. Average land holding of the farmer in the country is around 0.5 ha which can barely meet staple food that required for the families. The situation continues to deteriorate, stressed by continues reduction in size of landholding, shortage of traditional forms of forest litter and animals litter linked with declining crop yield. Under these conditions, in particular the poor have become increasingly dependent on exploiting governmental/communal forest areas to sustain their animals, on which they depend for their survival.

Over the past 30 years, human population and animal population in the country continue to increase faster than forage resource can be developed.

Cause of resource decline in Nepal

- Increase in LS population
- Resettlement programme
- Timber export to India (past and present)
- Shifting cultivation
- Development project
- Encroachment on resources
- Illegal harvesting and selling etc.

Under present condition, more than 50% of farmer's fodder requirements are derived from forest (Paudel &Tiwari; 1992). Forest Act 1993 and Regulation 1995 provide opportunity for increasing user involvement, responsible, accountable for fodder, bedding and litter.

Forest based Concept for Forage Development: Community Forestry, Leasehold Forestry concept are currently towards forage development established during the 1990s and 1970s respectively. The community forestry concepts supports livestock development indirectly by increasing the supply of animals bedding, fodder trees resources and indigenous grasses. No planned attempts to promote improve fodder cultivation and utilization from the understory of the forestland.

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In leasehold Forestry: it mostly focuses on fodder (trees, shrubs and pasture). Each farm family gains access to approx.1 ha of forestland for improve fodder production.

Forage and Pasture Intervention on Community Forestry

1. Protection from Grazing to Facilitate the Natural Regeneration of Indigenous and Naturalized Exotic Fodder and Pasture Species (Paudel &Tiwari 19920) reported that simple protection of CF of 19.2 ha had produced 24 m of grass in dry matter basis and had a potentially to produce 30 m grass along with 100mt of wood biomass annually.
2. Strategic Use of Exotic Fodder and Pasture Species: (Legumes and some grass which required low and medium fertility).

   Stylo (*Stylosanthes guinensis*), molasses grass (*Melinins minutiflora*) are successful in warmer climate. White clover (*Trifolium repens*), cocksfoot (*Dactylis glomerata*) and or Perennial grass (*Lolium perenne*) has shown limited potential in cooler climates
3. Multipurpose/Fodder Tree Plantation and Silvi-pasture: Nitrogen fixing plan should be promoted in plantation area: pasture as a under story.
4. Broom Grass, Bamboo and Nigalo Plantation: Broom (*Tyosanaleana maxima*), bamboo (*Dendrocalamus spp*) and nigalo (*Arundanaria spp*):

   These include soil conservation, to provide fodder during scarce period, and to increase household income by providing raw material to village based cottage industries and selling brooms in nearby markets.

OVERSTORY/UNDERSTORY VEGETATION MANAGEMENT

Light intensity determines the forage production in forest and may largely determine the species present in natural condition. In dense stand of most conifer: few plants will grow on the forest floor.

Heliophytes: Plants that thrive best in bright light or full sunshine are known as sun plants

Skiophytes: Those that are shade tolerant, as shade pants

SECONDARY GROWTH FOREST

It is found beneath the primary layer of trees and are less dominant. It consists of herbs, shrubs and small trees. It's determined by the amount of available light and moisture. They may attain prominence when the canopy is not too dense. The pasture yield decrease as the tree canopy increases. The establishment of pasture-tree combination system (Silvo pastoral system) is an ideal use practice in this.

Saccharum under the Leucaena leucocephala or Cynoden dactylon under the Acacia nilotica

PLANTATION FOREST

Dry tropical*: Acacia catechu, A. nilotica, Albizia lebbek, Azadarichta indica, Leucaena leucocephala, Melia azadarichta, Bauhinia variegata.*

Moist Tropical: *A. Catechu, Adina cardifolia, Anthocephalus chinensis, Morus alba, Syzygium cumini, Terminalia chebula, Melia azadarich, Ficus religiosa*

Sub Tropical: *Alnus nepalensis, Bauhinia racemosa, Ficus religiosa, Mallotus philippinesis, Toona ciliata,*

Temperate: Populus ciliata, Quercus floribunda, Q. glauca

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Multiple uses of forest grazing land: Multiple uses means management of the grazing land for the variety of purposes likes: Forage production, Wildlife management, Fuel wood production, Timber production, Litter production, Eco-tourism and Medicinal herb production

The relation between the components in multiple uses could be: Competitive, Complementary AND Supplementary

FODDER PRODUCTION FROM GARAZING LAND

It supports both wildlife and domestic animals. It should be based on overstory/understory concept. The species selected should have the following criteria: Well recovering species, Longer producing, Compatible with tree, Soil stabilizing, Shade tolerant

As many as 33 tree species are lopped for tree fodder in the central Himalayan at an elevation of 300 – 3100 m. Tree leaf fodder is available between Oct- July.

FODDER

FOR TERAI			FOR MIDHILLS		
SN	Botanical Name	Nepali Name	SN	Botanical Name	Nepali Name
1	*Albizzia procera*	Seto siris	4	*Brassiopsis hainla*	Chuletro
2	*Dalbergia sissoo*	Sisau	5	*Castanopsis tribuloides*	Musure katus
3	*Ficus semicordata*	Khanyu	6	*morus alba*	Kimbu
4	*Gmelina arborea*	Gamari	7	*Saurauria nepalensis*	Gogan\Tingur
5	*Grevia optiva*	Bhimal	8	*Albizzia odratissima*	-
6	*Acacia nilotica*	Babul	9	*Erythrina arborescens*	Phaledo
7	*Leuceana leucocephala*	Ipilipil	10	*Ficus roxburghii*	Nimaro
8	*Litsea monopetala*	Kutmero	11	*Ficus nimarolis*	Dudhilo
9	*Michelia champaca*	Champ	FOR HIGH MOUNTAIN		
10	*Sesbania grandiflra*	Dhaincha	SN	Botanical Name	Nepali Name
11	*Terminali alata*	Asna	1	*Celtis australis*	Khari
12	*Zizyphus jujube*	Bayer	2	*Quercus lamellose*	Thulo phalant
13	*Ficus nimarolis*	Dudhilo	3	*Q.leucotricphora*	Sano banjh
14	*Azadirahta indica*	Neem	4	*Q. semecarpofolia*	Khasru
FOR MIDHILLS			5	*Salix babylonica*	
SN	*Botanical Name*	Nepali Name	6	*Taxsus baccata*	Lauth salla
1	*Artocarpus lakoocha*	Badhar	7	*Populus ciliate*	Banghe kath
2	*Bauhinia purpurea*	Tanki	8	*Brassiopsis glomerulata*	Kalo chuletro
3	*Bauhinia variegate*	Koiralo	9	*Quercus lanata*	Thulo banjh

FUELWOOD AND TIMBER PRODUCTION

It brings nutrients from sub-surface to make it available to the companion crops. Deeper rooting species pumps minerals up from deeper soil layers to the surface. Some times considered by experts as 'Wishful-thinking' especially for phosphorus. But fast growing forage species could well extract all the available nutrients in the topsoil in the first years of production. Many forage species grows well under low soil-PH. From the mineral point of view, the non-fertilizer, option is not enhancing the sustainability of the intervention on the long run. Species selected should have following character apart from the general character of fuel wood and fodder: (a) Compatible with grass (b) Deep rooted (c) Light Shading

FUELWOOD

FOR TERAI			FOR MIDHILLS		
SN	Botanical Name	Nepali Name	SN	Botanical Name	Nepali Name

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1	*Acacia nilotica*	Babool	1	*Aesculus indica*	Kandar
2	*Acacia auricoloformis*		2	*Albizzia lebbeck*	Kalo siris
3	*Anogeissus latifolia*	Banjhi	3	*Alnus nepalensis*	Utis
4	*Terminali tomentosa*	Asna	4	*Betula alnoides*	Bhojpatra
5	*Eucalyptus camaldulensis*	Masala	5	*Eurya acuminata*	Jhingane
6	*Gmelina arborea*	Gamari	6	*Bauhinia variegata*	Koiralo
7	*Largerstroemia parviflora*	Bot dhangero	7	*Castanopsis indica*	Katus
8	*Azadiracta indica*	Neem	8	*Quercus lanata*	Thulo banjh
9	*Dalbergia sissoo*	Sisau	FOR HIGH MOUNTAIN		
10	*Bauhinia variegata*	Koiralo	1	*Betula utilis*	Bojpatra
11	*Albizzia lebbeck*	Kalo siris	2	*Betula alnoides*	-
12	*Adina cordifolia*	Haldu	3	*Juniperus spp.*	-
13	*Bombax ceiba*	Simal	4	*Quercus lanata*	Thulo banjh

TIMBER

FOR TERAI			FOR MIDHILLS		
SN	*Botanical Name*	Nepali Name	SN	Botanical Name	Nepali Name
1	*Shorea robusta*	Sal	4	*Castanopsis indica*	Katus
2	*Tectona grandis*	Teak	5	*Cedrus deodara*	Deodar
3	*Terminalia alata*	Asna	6	*Cryptomeria japonica*	Dhupi salla
4	*Dalbergia sissoo*	Sisau	7	*Pinus roxburghii*	Kote salla
5	*Dalbergia latifolia*	Satisal	8	*Quercus lemellosa*	Thulo phalant
6	*Acrocarpus fraxinifolius*	-	9	*Toona ciliate*	Tooni
7	*Eucalytus camaldulensis*	-	FOR HIGH MOUNTAIN		
8	*Gmelina arborea*	Gamari	1	*Abies pindrow*	Gobre salla
9	*Albizzia lebbeck*	Kalo siris	2	*Abies spectibilis*	Talis patra
10	*Albizzia procera*	Seto siris	3	*Cedrus deodara*	Drodar
11	*Largerstromia parviflora*	Bot dhangero	4	*Cupressus torulosa*	Raj salla
FOR MIDHILLS			5	*Juglans regia*	Okhar
SN	*Botanical Name*	Nepali Name	6	*Pinus wallichiana*	Gobre salla
1	*Exbucklandia populnia*	Pipal	7	*Quercus floribunda*	Thinke
2	*Aesculus indica*	Kandar	8	*Q. semecarpifolia*	Khasru
3	*Betula alnoids*	Bhjpatra	9	*Aesculus indica*	Kandar

LITTER COLLECTION

Leaf Litter collection is another important component of Nepalese farming system. At present; 50% of the litters produced are removed2.3 mt Litter and manure are applied per hectare of cultivated land. The practices of collecting litter seriously interrupt the nutrient cycle. The quantity of manure production by livestock are depends on (stall feeding; no of livestock, and amount of bedding materials). The use of litter will be further increase to replace chemical fertilizer. Criteria of species for the little production have

- Easily decomposable leaves
- No other effect on cultivated land (Pine needle)

In Cool climates: coniferous forest: decomposition of litter is very slowly where as in the Warm, moist: rapidly decomposition takes places.

Mor	Moder	Mull

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Typical for slow humification	Typical for moderately slow humification	Typical for fast humification
No mixing with mineral soil	Mixing with mineral soil	Intense mixing with mineral soil forming clay-human complexes
Presences of fungi, low biotic activity	Residues of small insects, medium biotic activity	Present of earth worms
C/N Ration >20	C/N ration 10-20	C/N Ratio < 12
PH 3.5-4.5	Ph 5	PH 5-7
Erica, Rhododendron, coniferous spp	Deciduous tree	Grass and Crop residues

7. FORAGE MANAGEMENT IN CONTEXT OF THE FARMING SYSTEM

INTRODUCTION

Different forage development program in Nepal are already well accepted. E.g. use of the winter annuals oats/berseem and improvement of communal cut and carry area with Stylo and molasses grass. *Leucaena* is widely grown, although management is sub optional.

STRATEGY

Emphasis should be promoting more strategy options and introducing a wider range of genetic materials, whilst allowing well established activities. Strategies and species need to be continually refined, and the ranking of importance of strategies will continually change. Strategies should be focus on use of leguminous species because of their roles in livestock nutrition and in stabilizing cropping systems. Species recommendations should continually change, in the light of local experience and availability of new genetic materials. Species recommended should mostly well adopt to low soil fertility. In the cut and carry system large quantity of nutrients are removed from the soil, and eventually these must be replaced

by the addition of organic or inorganic fertilizer. Generally use mixture to reduce risk of failure. And we need to familiarize farmers with the alternatives species.

Key strategy for implementation of forage development

- Over sowing: for the more production of forage, available land (Communal grazing areas, roadsides, landslides) should be sown with forage species.
- Forage should be raise on terrace risers
- Leguminous forage/cover crops should be promoted under citrus and other trees
- Under sowing/ relay cropping of forage legumes in annual crops such as finger millet will be effective
- Hedgerows of multi-purpose tree legumes should be promoted.
- Communal cut and carry plots should be develop.
- Intensive individuals cut and carry plots should be established.

TERRACE AND BUND TMPROVEMENTT

1. Planting should be started on the upper terrace and should be continued to the edge of the field in downhill terraces.
2. As far as possible fallowing should be avoided.
3. All the operations should be done across the slope.
4. Minimum tillage and relay cropping should be practiced.
5. Over grazing should be avoided and maximum crop residue should be left to keep the ground well covered.
6. Safe disposal of water. Planted grass in waterways.
7. Manures and fertilizers should be applied.
8. Bunds are relatively on lower slope and should be protected by seeding or planting grasses.

UTILIZATION OF NON-AGRICULTURAL INCLUSIONS (Gullies, Kharbari)

In the small gullies, at the head of a gully, grasses and other herbaceous cover often hold the top few centimeters of the soil with a mass of fibrous roots. Woody plants and tap root species hold a thicker layer of soil than do the grasses.

Gullies that are deeper than 0.5 m and that are growing both upstream and downstream need control measures at these critical points. A series of small dams are used to control gullies or large flows. Dams may be constructed from materials available at the site. After sedimentation and filling to a stable extent, extensive planting with suitable species.

In case of *Kharbari*, if it contains some palatable species, these should be used for grazing for animals, if not, the land under *Kharbari* should be cleared and reseeding with palatable grasses and forage may be done.

FODDER TREE IMPROVEMENTS

In Nepal, there is long tradition of using fodder tree leaves during winter and dry summer period, particularly in the hills of Nepal whether it comes from farm land or from forests. Farmers have traditionally protected or planted tree seedling for fodder available place and in marginal land. In Nepal more than 130 species of trees used as fodder and it plays an importance role in livestock husbandry.

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Advantage: (a) Natural preservation (b) Multiple species: trough out the years (c) Use of Marginal land

Disadvantage: (a) Late producer (b) Production less per unit area as compare to ground fodder (c) Mostly single or two time harvesting system (d) Shading effects on crops

Improvement options:

- Planting only selective species
- More focus on legume and NFT species
- Can withstand multi harvesting
- Focus on hedgerows species: produce more forage per unit area.
- Manage lopping operation/practices

IMPROVEMENT OF CROP RESIDUES MANAGEMENT

In Nepal Mostly green grass are available from June to September so crop byproducts plays very important role.

Crop By products	Quantity (000 ton)	Percent
Rice straws	4400	59.8
Maize Stover	1800	22.4
Wheat straw	1200	14.3
Millet straw	240	3.0
Barley straw	43	0.5
Total	9843	

In general crop by products are inferior in quantity. They contain high fiber low protein.

How to improve quality: (a) Treating with urea (b) Ammonia treatment (c) Maize Stover ensiling (d) Urine treatment

These treatments increase the protein% and palatability. For the improved use of the byproduct it can be used by supplementing with high quality forage like berseem, stylo etc.

Problem associate with crop byproduct improvement in Farmers Level: (a) Lack of technical know how (b) Cost factor (c) Limited response to animals (d) Lack of extension

PROPER FEEDING TECHNIQUES

In general good quality forage meets all the requirement of the animals. Feed requirement differ with stage of production. Producing animals needs extra nutrition over maintenance. When the animals loose their condition some concentrate need to be provided such as grains, cakes etc. Some time additional salt and bone meal improve the condition of animals and feed intake. Vet licks or mineral blocks are available commercially in the market for mineral supplement.

Supplement feeding required for: (a) Young animals (b) Pregnant animals (b) Meat/Milking animals

Supplement feeds: Protein, fats, vitamins, minerals

Concentrates feeding time: (a) Winter: scarcity of grains and fodder (b) Summer: inaccessible season Concentrates: Rice bran, Whet grain, Barley bran, Maize bran, Oil seed cakes

HAY (PARAL) AND SILAGE PRODUCTION

Hay is grass, legumes or other herbaceous plants that have been cut, dried, and stored for use as animal fodder, particularly for grazing livestock. It is also fed to pets such as rabbits and pigs. Hay is fed

when or where there is not enough pasture or rangeland due to weather (such as during the winter) or It is also fed during times when an animal is unable to access pasture, such as when animals are kept in a stable or barn.

- Drying of the grass at right stage of maturity for the further use.
- Reduce moisture down to 15-20%
- Protect it from rain, reduce the possibility of loosing leaves of dried grass.
- Utilize instead of green forage when such green forages are not available and it equally good as green grass.

Good quality of Hay: The quality of hey depends on the species, time of harvest and freedom from moulds and bacteria.

- Should have sufficient leaves
- Mixed hay of legume and grass are better than grass only.
- Harvest forage immediately after flowering started (10% flowering), earlier quantity is less and later than this the quality is poor.
- It should be green in color (dry in shade)
- No fungus/ moldy growth
- Soft and nutritious
- Should able to store for long period.

Types of hay

1. Legume hay: Made from legumes: more nutritious
2. Non-legume hay: hay made without legume
3. Mixed hay; contains both legume and grasses

Suitable species to make hay: Any grass and legume which can be easily dried quicker, like oats, *cynodon*, *berseem*, *Pennisetum*, *Heteropogan*

SILAGE: It is defined as the product obtained by packing fresh fodder in a suitable container and allowing it to ferment under anaerobic condition with out undergoing much loss of nutrients. It can be storage for more than a year. Quality of silage depends upon time of harvesting, type of forage, storage. Good quality silage is usually greenish or yellowish brown in color and with pleasant aroma.

Advantage

- Can be store without reducing the quality
- Less space required
- Control weed problem
- There are may ways of silage making
    - Pit silage
    - Tower silage
    - Plastic bag silage
        - Pit silage is more common in Nepal, in small farming system. Pit should be narrower in bottom than in the top for better compaction.
- Types of grass: Any forage can be use for silage but it should have around 60-65% moisture content.
- Forage like maize, bajra, sorghum makes good silage.
- Silage can be made by mixing legume and grasses. But in general grass can easily preserve as silage than the legumes.

Method of silage making

- Harvest crop at suitable time
- Reduce the moisture % of forage into 60-65%
- Chop it into pieces of 2-2.5''
- Place plastic sheet at the bottom of pit to check the contamination with soil.
- Place the chopped forages and continue compaction for removal of air
- Continue up to 1 foot above ground level
- Cover with plastic again and plaster with mud.
- Temperature ensiled place will be 30-38 ^{0c}
- Take care not to allow airs and water in the silage pit.

In North America, Australia, North-Western Europe, and frequently in New Zealand, silage is placed in large heaps on the ground and rolled by tractor to push out the air, then wrapped in plastic covers held by recycled tires.

Good quality silage: Soft, smelling like curd, green or dark

- Lab test for silage quality

Characters	Good silage	Bad silage
PH	4.1	5.4
Lactic acid	8.5	1
Acetic acid	2.5	3
Butyric Acid	0	3.5
Ammonium nitrate	1.9	4

Silage can be feed after 3 months of ensiling. It should be started to feed from one part of pit and cover after every use. Some time the animals may not like it so it should be fed slowly to adopt the animals.

Hay is grass, legumes or other herbaceous plants that have been cut, dried, and stored for use as animal fodder, particularly for grazing livestock such as cattle, horses, goats, and sheep. Hay is also fed to pets such as rabbits and guinea pigs. Pigs may be fed hay, but they do not digest it as efficiently as more fully herbivorous animals.

Hay is fed when or where there is not enough pasture or rangeland on which to graze an animal, when grazing is unavailable due to weather (such as during the winter) or when lush (green) pasture by itself is too rich for the health of the animal. It is also fed during times when an animal is unable to access pasture, such as when animals are kept in a stable. Good quality hay is green and not too coarse, and includes plant heads and leaves as well as stems. This is fresh grass/alfalfa hay, newly baled.

Commonly used plants for hay include mixtures of grasses such as ryegrass (Lolium species), timothy, brome, fescue, Bermuda grass, orchard grass, and other species, depending on region. Hay may also include legumes, such as alfalfa (lucerne) and clovers (red, white and subterranean). Other pasture forbs are also sometimes a part of the mix, though other than legumes, which ideally are cut pre-bloom, forbs are not necessarily desired. Certain forbs are toxic to some animals.

Oat, barley, and wheat plant materials are occasionally cut green and made into hay for animal fodder; however they are more usually used in the form of straw, a harvest byproduct where the stems and dead leaves are baled after the grain has been harvested and threshed. Straw is used mainly for animal bedding. Although straw is also used as fodder, particularly as a source of dietary fiber, it has lower nutritional value than hay.

It is the leaf and seed material in the hay that determines its quality. Farmers try to harvest hay at the point when the seed heads are not quite ripe and the leaf is at its maximum when the grass is mowed in the

field. The cut material is allowed to dry so that the bulk of the moisture is removed but the leafy material is still robust enough to be picked up from the ground by machinery and processed into storage in bales, stacks or pits. Poor quality hay is dry, bleached out and coarse-stemmed. Sometimes, hay stored outdoors will look like this on the outside but still be green inside the bale. A dried, bleached or coarse bale is still edible and provides some nutritional value as long as it is dry and not moldy, dusty, or rotting.

Hay is very sensitive to weather conditions, particularly when it is harvested. In drought conditions, both seed and leaf production are stunted, making hay that has a high ratio of dry coarse stems that have very low nutritional values. If the weather is too wet, the cut hay may spoil in the field before it can be baled. The hay may also develop rot and mold after being baled, creating the potential for toxins to form in the feed, which could make the animals sick. It also has to be stored in a manner to prevent it from getting wet. Mold and spoilage reduce nutritional value and may cause illness in animals. The successful harvest of maximum yields of high-quality hay is entirely dependent on the coincident occurrence of optimum crop, field, and weather conditions. When this occurs, there may be a period of intense activity on the hay farm while harvest proceeds until weather conditions become unfavorable.

Silage is fermented, high-moisture fodder that can be fed to ruminants (cud-chewing animals like cattle and sheep) or used as a bio-fuel feedstock for anaerobic digesters. It is fermented and stored in a process called ensiling or silaging, and is usually made from grass crops, including corn (maize), sorghum or other cereals, using the entire green plant (not just the grain). Silage can be made from many field crops, and special terms may be used depending on type (oatlage for oats, haylage for alfalfa – but see below for the different British use of the term haylage). Silage is made either by placing cut green vegetation in a silo, by piling it in a large heap covered with plastic sheet, or by wrapping large bales in plastic film.

Silage must be made from plant material with suitable moisture content, about 50% to 60%, depending on the means of storage, the degree of compression, and the amount of water that will be lost in storage. For corn (maize), harvest begins when the whole-plant moisture is at a suitable level. For pasture-type crops, the grass is mowed and allowed to wilt for a day or so until the moisture content drops to a suitable level.

The plant material is collected, chopped into pieces about 0.5 in (1.3 cm) long and packed. In the early days of mechanized agriculture, stalks were cut and collected manually using a knife and horse drawn wagon, and fed into a stationary machine called”silo filler" that would chop the stalks and blow them up a narrow tube to the top of a tower silo. Current technology uses mechanical forage harvesters that collect and chop the plant material, and deposit it in trucks or wagons. These forage harvesters can be either tractor-drawn or self-propelled. Harvesters blow the silage into the wagon via a chute at the rear or side of the machine. Silage may also be emptied into a bagger, which puts the silage into a large plastic bag that is laid out on the ground.

In North America, Australia, North-Western Europe, and frequently in New Zealand, silage is placed in large heaps on the ground and rolled by tractor to push out the air, then wrapped in plastic covers held down by re-used tires or tire ring walls.

Fermentation: Before starting the anaerobic stage there is an aerobic phase in which the trapped oxygen is utilized. After finishing that oxygen, the anaerobic phase starts. Silage undergoes anaerobic fermentation, which starts about 48 hours after the silo is filled. In the past, the fermentation was conducted by indigenous microorganisms, but, today, some bulk silage is inoculated with specific microorganisms to speed fermentation or improve the resulting silage. The process converts sugars to acids and exhausts any oxygen present in the crop material. Fermentation is essentially complete after about two weeks. Silage inoculants contain one or more strains of lactic acid bacteria, and the most common is Lactobacillus

plantarum. Other bacteria used in inoculants include *Lactobacillus buchneri, Enterococcus faecium and Pediococcus species.*

Pollution and waste: The fermentation process of silo or pit silage releases liquid. Silo effluent contains nitric acid (HNO_3), which is corrosive. It can also contaminate water courses unless collected and treated – the high nutrient content can lead to eutrophication (growth of bacterial or algal blooms).

Plastic sheeting used for sealing pit or baled silage needs proper disposal, and in some areas there are recycling schemes for it.

Storing silage: Silage must be firmly packed to minimize the oxygen content, or it will spoil. Four major stages silage goes through in a silo:

- Presealing, which, after the first few days after filling a silo, enables some respiration and some dry matter (DM) loss, but stops
- Fermentation, which occurs over a few weeks; pH drops; there is more DM loss, but hemicelluous is broken down; aerobic respiration stops
- Infiltration, which enables some oxygen infiltration, allowing for limited microbial respiration; available carbohydrates (CHOs) are lost as heat and gas
- Emptying, which exposes surface, causing additional loss; rate of loss increases.

Anaerobic digestion: Silage is a useful feedstock for anaerobic digestion. Here silage can be fed into anaerobic digesters to produce biogas that, in turn, can be used to generate electricity and heat.

Safety: Silos are hazardous, and deaths occur in the process of filling and maintaining them. There is a risk of injury by machinery or from falls. When a silo is filled, fine dust particles in the air can become explosive because of their large aggregate surface area. Also, fermentation presents respiratory hazards. The ensiling process produces "silo gas" during the early stages of the fermentation process. Silage gas contains nitric oxide (NO), which will react with oxygen (O_2) in the air to form nitrogen dioxide (NO_2), which is toxic.[5] Lack of oxygen inside the silo can cause asphyxiation. Molds that grow when air reaches cured silage can cause toxic organic dust syndrome. Silage bales are heavy, and can fall, roll or overbalance machinery. Collapsing silage from large bunker silos has caused deaths. Silage itself poses no special danger.

Nutrition: The ensiled product retains a much larger proportion of its nutrients than if the crop had been dried and stored as hay or Stover. Bulk silage is commonly fed to dairy cattle, while baled silage tends to be used for beef cattle, sheep and horses. Since silage goes through a fermentation process, energy is used by fermentative bacteria to produce volatile fatty acids (VFA), such as acetate, propionate, lactate, and butyrate, which preserve the forage. The result is that the silage is lower in energy than the original forage, since the fermentative bacteria use some of the carbohydrates to produce VFA. Thus, the ensiling process preserves forages, but does not improve the quality or the nutrient value.

8. INTEGRATED FORGAE RERSOURCE MANAGEMENT

INTEGRATION OF FARM, FOREST AND LIVESTOCK SYSTEM

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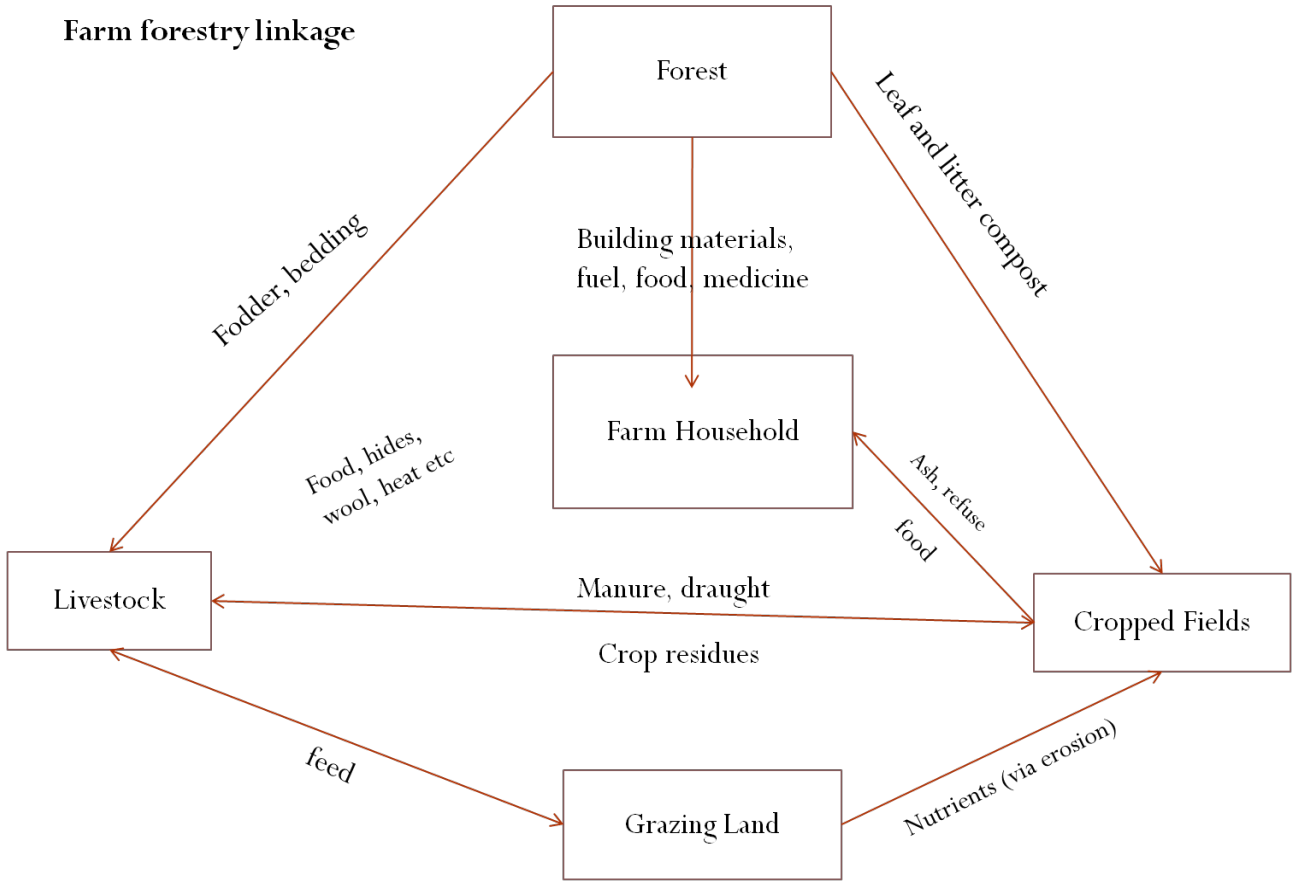
Important linkage exists between forestry and farming. Forestry support agriculture and livestock husbandry. It is importance to understand this linkage in the context of forestry development and to future forestry activities to fulfill the needs of the local people.



Some common integrated systems

1. Silvo-agriculture: Tree+ Agriculture crop
2. Agrosilviculture: Agriculture+ Trees
3. Silvopastoral: Trees+ grazing land (Pasture)
4. Spatial arrangement:
    1. Border or boundary planting: line fences, wind breaks
    2. Alternate row and alternative strips: alley or hedgerow cropping
    3. Random mixing: no specific arrangement
    4. Home garden

PLANNING THE ANNUAL FORAGE BUGET

Annual forage budget is the input-output relationship for particular forage crop. A forage budget includes all the variable resources per unit area (Ha), cost, the expected output, grass returns and net returns etc.

Budget sheet

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S.N	Particulars	Unit	Amount
A	Land preparation		
1	Tractor fuel cost for ploughing and leveling		
2	Land preparation may be done by bullock drawn plow		
3	Human labor for removing stubbles, weeds etc		
B	Manure and fertilizers		
	Farmyard manure/compost		
	Urea		
	Others		
	Labour for fertilizer application		
C	Seed sowing		
	Seed		
	Labour for seed sowing		
D	Irrigation		
E	Insect control		
	Insecticide		
	Human labour		
F	Weed control		
	Herbicide		
	Human labour		
G	Human labour for cutting and grazing		
	Total cost		
Supposes Total production: 30 ton green grass/ha and selling at 0.5 paisa/kg Gross benefit: Rs 15000 Net benefit= Gross benefit – Total Cost			

BOTTLENECKS TO IMPLEMENTATION OF FORAGE RESOURCES DEVELOPMENT

It is generally claimed that ruminants are the best way to accumulate capital and are important for the maintenance of crop production. The common premise is that ruminant production and productivity is low and that is mainly due to shortage of feed. Very litter importance is given in the government programme to resolve these issues.

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Bottlenecks

1) Policy Issues

I. Lack of coherent policy on rangeland management
II. Responsibility split into different agencies
    I. Forestry
    II. Agriculture
III. Lack of co-ordination between agencies

2) Management Issues

IV. Negligence on indigenous knowledge while formulating plans.
V. Poor state of knowledge on scientific management

3) Technological issues

I. Most of the research activities carried out in the past have been a failure to recognize the need of the farmer and country
II. Most of the researches are either a duplication of the pervious finding of focused on sophisticated study that is less applicable in the existing situation.
III. Lack of available technology on grazing management, stocking rate etc related to the local situation.
IV. Lack of exposure to the modern management techniques
V. Lack of suitable propagation materials
VI. Poor linkage between extensionist, researcher and farmers.

4) Institutional Issues

- Low capacity of NGOs, GOs and CBOs and private institutions
- No defined role of the above mentioned organizations

5) Socio- economic Issues

- Poor understanding of local priorities, situation and interests.
- Roles of WPDM groups are not well recognized

6) Others

- Difficult accessibility
- Population pressure
- Low productive animals
- Marketing of animals product
- Lack of extension education to the farmers
- Lack of trained manpower in this field
- Infrastructure and incentives

POLICY RECOMMENDATION TO OVERCOME LIMITATION

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Any activities, which try to address the above problem, may have significance positive impact to resolve the existing bottleneck to implement the forage development problem in the country. We should have Collaborative works

- on technology development,
  - rangeland management,
  - Human resource development
  - Socio-economic studies
- Should develop Rangeland database
- Policy should be Bottom up
- Alternative feeds and fodder resources
- Management of grazing areas
  - Rangeland management plans
  - Improvement of grazing area by scientific inputs.
  - Imposition of adequate rational fees
  - Improvement of herbage resource along the migratory routes
  - Introduction of alternative system of hortisilvipasture, wherever feasible.
- Capacity building of institutions
- Proper attention to incorporate gender prospective
- Establishing strong resource centers for range/pastureland

Policy recommendation:

1. Community forest management
2. Improved stove management
3. Improved irrigation and hydro facilities
4. Improved grazing system
5. Winter forage resource management
6. Improved animals husbandry
7. Alternative income generating activities
8. Tourism management plan including trekking permit limitation
9. Coordinate with local labour
10. Restricted fuel wood use (trekking, camping)
11. Sustainable forest management.

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GLOSSARY

- **Range:** Natural and uncultivated grassland, shrub land and forest land that produces forage for grazing and browsing livestock and wildlife.
- **Forage:** Herbaceous palatable plants mostly used as grazing.
- **Fodder**: Herbaceous palatable plants mostly used by cut and carry system.
- **Herbage**: Both palatable and non-palatable fodder and forage.
- **Browse:** Palatable leaves or shoots/twig.
- **Range analysis**: The critical study of range classes in individual form.
- **Defoliation:** Removal of leaves or live parts of plant.
- **Range ecosystem:** interaction between biotic and a biotic components of rangeland.
- **Range science:** it deals with the use of rangeland to obtain return of the resources benefit to meet the needs and desire of the people in a sustainable way.
- **Forbs:** Plants with solid, non-woody stem, usually, broadleaf with netted venations.

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Plant species found in the rangelands of Nepal

RANGELAND	PLANT SPECIES
Tropical (Terai)	*Ageratum conyzoides, Artemesia vulgaris, Arthraxon sikkimensis, Arundinella nepalensis, Bothriochloa glabra, Bothriochloa intermedia, Brachiaria villosa, Chrysopogon aciculatus, Cissus repens, Cymbopogon pendulus, Cynodon dactylon, Cyperus difformis, Desmodium heterocarpon, Desmostachys bipinnata, Digitaria longiflora, Eragrostiella nardoides, Eragrostis atrovirens, Eragrostis nigra, Eragrostis pilosa, Eragrostis unioloides, Hackelochloa granularis, Heteropogon contortus, Hymenachne pseudointerrupta, Imperata cylindrica, Ischaemum rugosum, Narenga porphyrocoma, Neyraudia reynaudiana, Panicum notatum, Paspalidium flavidum, Paspalum conjugatum, Paspalum scrobiculatum, Phragmites karka, Pogonatherum paniceum, Rotala indica, Saccharum arundinaceum, Saccharum spontaneum, Sacciolepis indica, Setaria pallidefusca, Sporobolus diander, Trudax procumbens, Vetiveria zizaniodes.*
Subtropical	*Ageratum conyzoides, Agrostis pilosula, Anaphallis busua, Apluda mutica, Apocopis paleacea, Artemisia vulgaris, Arthraxon sikkimensis, Arundinella bengalensis, Arundinella nepalensis, Arundinella setosa, Bothriochloa intermedia, Bothriochloa pertusa, Brachiaria ramosa, Brachiaria villosa, Campanula cana, Capillipedium assimile, Capillipedium parviflorum, Carex alopecuroides, Cheilanthus grisea, Chrysopogon aciculatus, Chrysopogon fulvus, Chrysopogon gryllus, Cymbopogon jawarancusa, Cymbopogon pendulus, Cymbopogon stracheyi, Cynodon dactylon, Cynogolossum zeylanicum, Cyperus niveus, Cyperus rotundus, Desmodium heterocarpon, Desmodium microphyllum, Digitaria longiflora, Digitaria setigera, Dimeria fuscescens, Dryopteris fillix-mass, Elephantopus scaber, Eleusine indica, Eragrostiella nardoides, Eragrostis atrovirens, Eragrostis nigra, Eragrostis pilosa, Eragrostis unioloides, Eulalia mollis, Eulaliopsis binata, Eupatorium adenophorum, Euphorbia thymifolia, Gonostegia hirta, Heteropogon contortus, Heteropogon contortus, Imperata cylindrica, Isachne globosa, Ischaemum rugosum, Justicia procumbens, Laggera alata, Micromeria biflora, Paspalidium flavidum, Paspalum distichum, Paspalum scrobiculatum, Pennisetum pedicellatum, Perotis hordeiformis, Phyllanthus parvifolius, Pogonatherum paniceum, Rotala indica, Saccharum spontaneum, Sacciolepis indica, Schizachyrium brevifolium, Setaria pallidefusca, Sida*

	rhombifolia, Sporobolus fertilis, Thysanolaena maxima.
Temperate	*Agrostis myriantha, Agrostis gigantea, Agrostis micrantha, Agrostis munroana, Agrostis pilosula, Anaphalis triplinervis, Andropogon munroi, Apluda mutica, Apocopis paleacea, Artemisia dubia, Arthraxon sikkimensis, Arundinella birmanica, Arundinella hookeri, Arundinella nepalensis, Arundinella setosa, Berberis aristata, Berberis asiatica, Bothriochloa intermedia, Bothriochloa ischaemum, Brachypodium sylvaticum, Bromus nepalensis, Calamagrostis emodensis, Calamagrostis epigejos, Calamagrostis pseudophragmites, Capillipedium assimile, Chrysopogon gryllus, Colquhounia coccinea, Cotoneaster microphyllus, Cymbopogon distans, Cymbopogon pendulus, Cymbopogon schoenanthus, Dactylis glomerata, Danthonia cumminsii, Deschampsia caespitosa, Desmodium elegans, Deyeuxia scabrescens, Digitaria longiflora, Elymus canaliculatus, Elymus semicostatus, Elymus thomsonii, Eragrostis nigra, Erianthus longesetosus, Eulalia mollis, Eulaliopsis binata, Festuca gigantea, Festuca leptopogon, Festuca modesta, Festuca ovina, Festuca rubra, Festuca wallichiana, Glyceria tonglensis, Hackelochloa granularis, Helictorichon virescens, Helictotrichon asperum, Helictotrichon virescens, Imperata cylindrica, Koeleria cristata, Miscanthus nepalensis, Muhlenbergia duthieana, Muhlenbergia himalayensis, Muhlenbergia huegelii, Oryzopsis lateralis, Pennisetum flaccidum, Phleum alpinum, Poa alpina, Poa angustifolia, Poa annua, Poa pagophila, Poa pratensis, Pogonantherum crinitum, Pteridium acquilinum, Rosa brunonii, Schizachyrium delavayi, Setaria pallidefusca, Stipa roylei, Themeda anathera, Themeda quadrivalvis, Themeda triandra, Trisetum clarkei, Trisetum spicatum*.
Sub-alpine	*Agrostis inaequiglumis, Agrostis pilosula, Anthoxanthum hookeri, Artemisia stricta, Bromus grandis, Bromus himalaicus, Calamagrostis pseudophragmites, Calamagrostis emodensis, Chrysopogon gryllus, Cymbopogon schoenanthus, Danthonia cumminsii, Deyeuxia scabrescens, Duthiea nepalensis, Elymus canaliculatus, Elymus dahuricus, Elymus nutans, Elymus schrenkianus, Elymus sibiricus, Festuca leptopogon, Festuca ovina, Festuca polycolea, Helictotrichon virescens, Koeleria cristata, Pennisetum flaccidum, Poa alpigena, Poa ludens, Stellarea chamaejasme, Stipa consanguinea, Stipa duthiei, Stipa royleii, Stipa sibirica, Stipa staintonii, Trigonella emodi, Trisetum spicatum*.
Alpine	*Androsace delavayi, Aster stracheyi, Bistorta vivipara, Carex atrofusca, Cortia depressa, Gernium donianum, Kobresia nelpalensis, Kobresia caricina, Kobresia duthei, Kobresia kanaii, Nardostachys grandiflora, Picrorhiza scrophulariiflora, Poa pagophila, Potentilla peduncularis, Rheum moocroftianum, Saussurea gossypiphora, Swertia multicaulis*.
Steppe	*Agrostis pilosula, Andropogon munroi, Aristida adscensionis, Arthraxon submuticus, Arundinella setosa, Berberis angulosa, Berberis concinna, Bothriochloa intermedia, Bothriochloa pertusa, Bromus grandis, Bromus himalaicus, Bromusporphyranthos, Calamagrostis emodensis, Calamagrostis garhwalensis, Calamagrostis pseudophragmites, Caragana brevifolia, Caragana versicolor, Carex atrata, Cerastostigna ulicinun, Chrysopogon gryllus, Cymbopogon schoenanthus, Cymbopogon strachey, Cymbopogon stracheyi, Danthomia cumminsii, Danthonia cachemyriana, Deyeuxia holciformis, Deyeuxia pulchella, Deyeuxia scabrescens, Elymus canaliculatus, Elymus dahuricus, Elymus schrenkianus, Elymus semicostatus, Eulalia mollis, Festuca ovina, Fimbristylis complanata, Helictotrichon virescens, Indigofera cylindracea, Juniperus indica, Juniperus squamata, Kobresia macrantha,*

Kobresia seticulnis, Koeleria crista, Koeleria cristata, Lespedeza juncea, Medicago falcata, Melica jacquemontii, Melica scaberrima, Oryzopsis lateralis, Pennisetum flaccidum, Poa alpigena, Poa pagophila, Poa poophagorum, Poa pratensis, Potentilla fructicosa, Rhododendron anthopogon, Rhododendron lepitodum, Rhododendron nivale, Rosa sericea, Stipa moocroftiana, Stipa sibirica, Themeda roylei, Themeda triandra, Trisetum aeneum.

Sources: Whyte (1968), Field & Pandey (1968), Stainton (1972), Pariyar & Shrestha (1984), Miller (1987), Archer (1990).

THE END

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