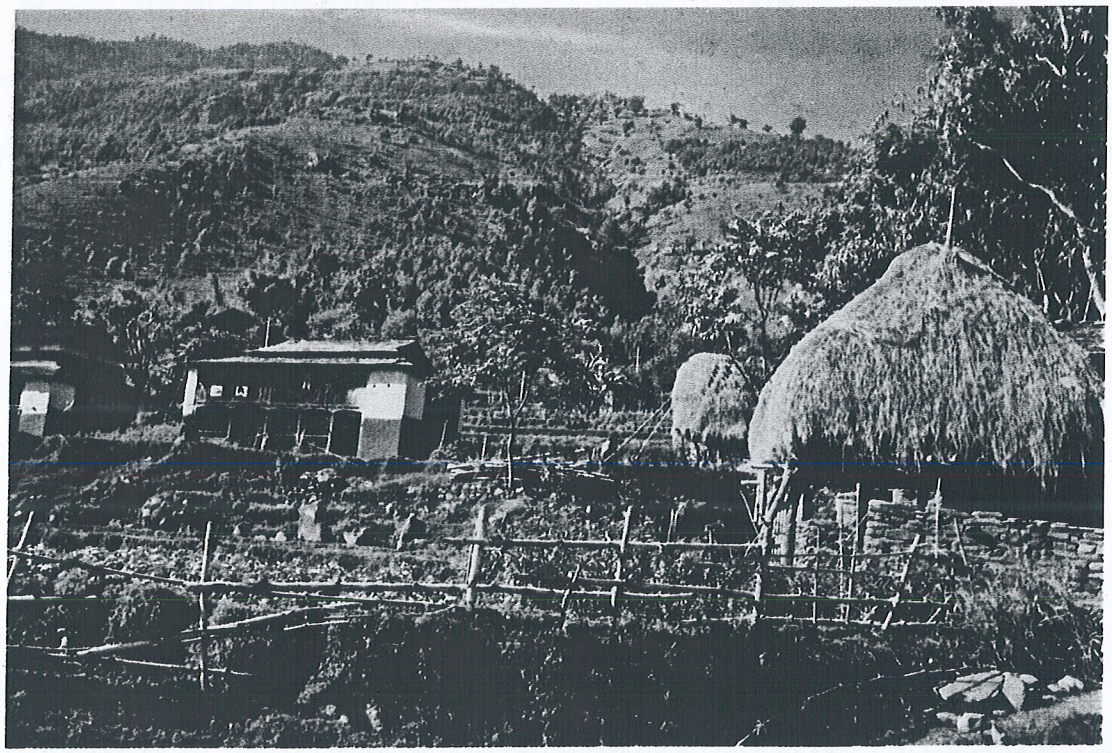
SOME SALIENT INDIGENOUS TECHNOLOGY PRACTICES FOR WATERSHED MANAGEMENT IN NEPAL

Compiled by

D. D. Kandel and M. P. Wagley



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ASIAN WATMANET of the Participatory Watershed Management Training in Asia (PWMTA) Program, Netherlands/FAO(UN), GCP/RAS/161/NET, Kathmandu, Nepal

PWMTA

The Participatory Watershed Management Training in Asia (PWMTA) Program (GCP/RAS/161/NET, FAO/Netherlands) is designed for human resource development in participatory watershed management. It contributes to sustainable use and management of forest, soil, water and other natural resources by enhancing skills and national capabilities to plan, implement, evaluate and monitor participatory watershed rehabilitation programs. This is achieved by regional training, workshops, seminars and national and regional watershed management networking.

Many of the Asian countries are seriously investing in WM today. However, few are providing training in holistic approach to participatory watershed management. PWMTA is assisting the member countries in filling this gap.

ASIAN WATMANET

(ASIAN WATershed MAnagement NETwork)

This is a regional network in participatory watershed management for human resources development (HRD) founded in Nov. 1994. It is sponsored by the PWMTA, GCP/RAS/161/NET program of the FAO(UN)/Netherlands. Its member countries are the participating countries in the PWMTA program. Through HRD, the network is to facilitate people's participation in watershed management at small watershed, village, district and national level, exchange of experiences extensionists, as well as technical, professional, educator and policy maker level, exchange of information among the member countries, and strengthen a movement of GO/NGO/PO/FOs for sustainable natural resources management of the fragile watersheds in the Asian region. It also publishes a quarterly ASIAN WATMANET Newsletter.

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Cover photo: A typical mid hill watershed in Kundula village of Baglung district, Nepal

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Abbreviations

ADB	Asian Development Bank
amsl	Above Mean sea Level
APROSC	Agriculture Projects Services Center
DOI	Department of Irrigation
DSCWM	Department of Soil Conservation and Watershed Management
e.g.	For Example
etc.	Etceteras
FAO	Food and Agriculture Organization
FMIS	Farmer Managed Irrigation System
ft	Feet
FYM	Farm Yard Manure
ha	Hectare
HMG	His Majesty's Government
IAAS	Institute of Agriculture and Animal Sciences
ICIMOD	International Center for Integrated Mountain Development
IHDP	Integrated Hill Development Project
IPM	Integrated Pest Management
ITK	Indigenous Technological Knowledge
ITK/WM	Indigenous Technological Knowledge for Watershed Management
IWM	Integrated Watershed Management
LARC	Lumle Agriculture Research Center
m	Meter
MOA	Ministry of Agriculture
Mt.	Mount
NRM	Natural Resource Management
O & M	Operation and Maintenance
PAC	Pakhribas Agriculture Center
PWMTA	Participatory Watershed Management Training in Asia
RAPA	Regional Office for Asia and the Pacific
UN	United Nation
UNDP	United Nation Development Project
USA	United States of America
VDC	Village Development Committee
WDR	Western Development Region
WECS	Water and Energy Commission Secretariat
WIIAD	Winrock International Institute for Agriculture Development
WM	Watershed Management
WUA	Water Users' Association
WUGs	Water Users Groups

About the authors

Mr. D. D. Kandel is the research officer, Mr. M. P. Wagley is the Director General and Mr. Saroj Man Shrestha is the artist of the Department of Soil Conservation and Watershed Management. (DSCWM), Kathmandu, Nepal, respectively.

Foreword

The Participatory Watershed Management Training in Asia (PWMTA) program GCP/RAS/161/NET recognizes the importance of traditional, local and indigenous technology knowledge (ITK) for watershed management (WM) in tropical Asia as paramount to their sustainable development and conservation. New technologies and practices can be successful if they are well ingrained into the traditional/indigenous knowledge systems. With this background PWMTA commissioned action research studies in its member countries for documenting salient successful ITK for WM in its member countries and held a regional workshop on the same in Beijing, China in Nov., 1997. This document is a result of such a study in Nepal.

Nepalese civilization has evolved around sustainable forest, land and water management since ancient times living in harmony with the mountain ecosystems in a subsistence manner. This can be easily seem in the ancient terrace systems, farmer managed upland supplemental irrigation systems, pasture and live stock management and traditional soil fertility management and the adaptations being made even today by its people for managing their watershed resources better. However, most often the modern development agencies tend to ignore these systems as primitive and less productive rather then building on this sustainable cultural trait of the Nepalese society.

This document has tried to make an effort at highlighting the traditional indigenous systems so that modern watershed development and conservation efforts can be made based on this culture and can be as sustainable as the ancient systems proved to be. The institutional mechanisms implemented to sustain these watershed management systems also have lessons for modern watershed management in Nepal and elsewhere in Asia, hence deserve utmost consideration while designing modern programs of similar nature.

I would like to thank the compilers of this study for their efforts in highlighting the traditional and indigenous knowledge still available with the Nepalese society. Also thanks to the artist Mr. Saroj Man Shrestha for illustrations. I also wish to thank Mr. Ranjan Poudyal of PWMTA, FAO to assist me in the layout of this document and in its final manuscript.

We hope this work will help in rethinking on the whole question of sustainable watershed management in Nepal. It is also to provide a basis for future works by integrating new and recent methods in a culturally sensitive manner so that the present day needs can be met while the watershed management programs continue to remain under the ownership of the people. We look forward to your comments so that future editions can be improved.

February, 1999

Prem N. Sharma
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INTRODUCTION

There is a wide spread need for integrated watershed management (IWM) in Nepal. The country is mountainous, agricultural and endowed with fragile marginal ecosystems. The watershed resources, particularly soils, forests, pastures, water and bio-diversity are in an unstable condition and rapidly being depleted.

Traditionally subsistence agriculture is practised in the country which depends entirely on locally available resources and knowledge base for maintaining the productivity. Most of the rural population lives in the upland watershed areas who still practice their age-old traditional and indigenous technology knowledge (ITK) to manage their natural resources for sustaining their livelihood. The indigenous farming systems as well as the water harvesting and its management depend upon the use of ancient techniques. Local practices of harvesting and utilising herbs, wildlife and plant resources to meet the food, fibre, medicine and income demands use of indigenous techniques and knowledge. In addition, there are many other indigenous knowledge systems and practices being used locally in various sectors like land management, animal husbandry, pasture and range management, agricultural tools, local organisations and their functioning as well as in socio-cultural systems. Hence, indigenous practices that make efficient use of natural resources provide invaluable knowledge that should be used in designing sustainable watershed management plans. Indigenous knowledge and practices are farmer friendly, socially accepted, environmentally sound, economical, based on local resources, and suited to wide range of environmental conditions and farmers' circumstances. However, in the modern development efforts, such practices have often been neglected and overlooked. Also the efforts for understanding and incorporating such ITK for the development of sustainable watershed management (WM) plans are often lacking.

Various organisation and projects have been involved in the IWM sector since many years. Though a number of technologies have been generated and well documented, farmers in Nepal have not adopted most of them. Thus the demonstrations often remain unreplicable. The diverse and complex farming systems, farmers' attitude to avoid unflexible practices, high input cots, labour shortage and external resources based technology in the modern development efforts are the main reasons of poor adaptation, despite many years of demonstration efforts and recommendations. Thus many years of efforts and investment remain futile. On the other hand, farmers possess a great wealth of indigenous knowledge and skills in terms of natural resources management. This offers a great potential for using and expanding local knowledge in watershed management sector. Thus attention need to be focused on it

Farmers in Nepal generally depend on a complex mix of crops, livestock and forest products for their livelihood. They often know more than many qualified professionals about the local resource dynamics within their interdependent, complex and flexible systems. A greater appreciation of indigenous knowledge of these complex systems is also necessary to improve the ability of development agencies and extension services to provide relevant support for the sustainable development and management of the watershed areas. Furthermore, IWM is a dynamic process and factors influencing it are continuously changing. Over the years, farmers have gained experience, skill and knowledge, and found solutions to the management problems by taking series of decisions and implementing them by allocating resources in a manner they considered to be the most effective or efficient. However, they may also have weaknesses, problems and constraints in the face of rapidly increasing population pressure, further marginilazation of marginal people and declining resource base. This is particularly important since increasing human population and shrinking per capita natural resources in the watersheds will require a more efficient use of available land and labour for providing various products that farming families need. This documentation of ITK and practices, their potentialities and constraints would help further strengthen the farmer's existing knowledge and practices for integrated watershed management and development. Also the development agencies will find it useful to integrate this knowledge base in their modern development programs.

METHODOLOGY

This Indigenous Technology Knowledge (ITK) for Watershed Management (WM) study contains more than fifty ideas compiled from farmers over a period of six months. Each idea includes its brief introduction, method to the technique and summarises its advantages and limitations.

During compilation, appreciative inquiry was one of the approaches used to collect primary source information. It was known that farmers possess a great wealth of ITK since generations. To learn this technical information from them repeated field visits were made during which their knowledge, wisdom and expertise were appreciated and slowly in an informal way inquiries on their ITK/WM were made.

Another tool used to get first hand information was through group discussion. This was based on the Participatory Rural Appraisal (PRA) approach. The group actively participated in the discussion, particularly in identifying the advantages and disadvantages of ITK / WM ideas.

During the field visits, personal observations were also made and past field experiences were used to collect the required information. Secondary source of information was a detailed review of over 150 or so articles available on related subjects. This is given under references at the end of this document.

The ideas and comments from a regional workshop on the topic organized by the FAO's PWMTA program in Nov. 97 and national workshop organized on the topic by the DSCWM in Dec. 97 were also incorporated into this document.

INDIGENOUS LOCAL ORGANISATIONS FOR NATURAL RESOURCES MANAGEMENT (NRM)

Rural communities around the world are known to maintain their own indigenous institutions for the NRM (Gilmour and Fisher 1991). In Nepal, there are several informal, yet strong indigenous organisations. Studies have shown that for centuries, these informal indigenous organisations have been effectively managing forests, pastures, water sources (both for irrigation and drinking purposes) and other public properties communally by applying the accumulated knowledge of conservation measures and enforcing the rules and regulations against over exploitation of these resources. Both men and women are involved in such local level indigenous NRM organisations.

These organisations are generally informal and in most instances take the form of "councils" (e.g. water users' group, forest users' group etc.) consisting of representatives from all permanently settled households of a village. The councils decide rules and regulations. Often the councils nominate one or a small number of households in rotation for a specified period (usually one year) to enforce rules and regulations (Rai and Thapa 1993).

Strongest organisations are usually found in

Terai people *Hill people* *Mountain people*

Local people organizing themselves for resources management

many of the farmer managed irrigation systems for operating and managing them. These organisations have evolved through initiative, trust and strong traditions of the community, by enforcing operation and management rules and by enhancing the organisational capabilities.

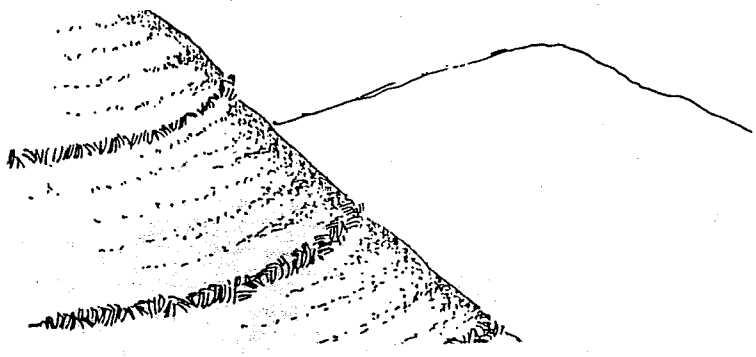
Among the Sherpa of Khumbu, an official known as '*Nawa*' heads the indigenous organisation for pasture and forest management. The position is filled annually on a rotation basis from the village households (Rai and Thapa 1993). Among the Sherpa of Solu, the traditional village headman (*Murmin*) exclusively controls the right to dispense permission for grazing to shepherds (March, 1977). In upper Mustang district, the rules and regulations for pasture management are implemented by the officially designated village leader. According to Rai and Thapa (1993), villagers in lower Mustang, have formed a somewhat formal sheep herders association (*Bheda Goth Samiti*) to decide on the schedule for the use of pasturelands. Among the Tibetan-speaking groups of the northern areas of Nepal, women often make the decisions on pastureland management by themselves, as men are away trading during most of the year.

The advantages of these indigenous institutions (rules, regulations, code of conduct etc.) and organisations are that they insure the participation of the local people in natural resource management thus mobilising local resources, generating employment, facilitating gender balanced participation and manage the watershed resources sustainably. Sometimes they are limited by their informal nature as they are not recognised by the present day modern legal system. Also their record keeping is often oral, their members meet irregularly and they are sometimes misled or exploited by the local elite and officialdom.

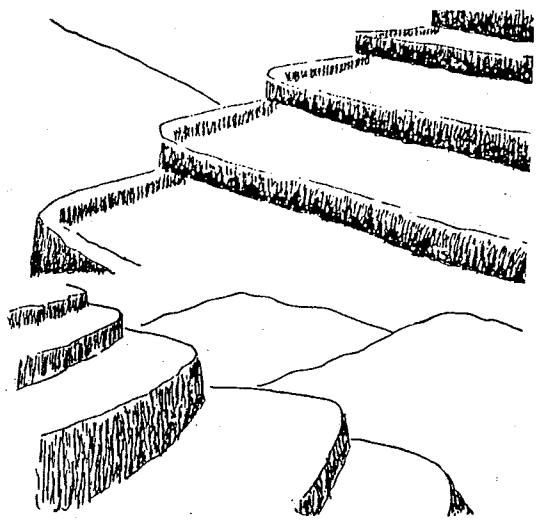
TERRACING: AN ETHNO-ENGINEERING ON–FARM CONSERVATION PRACTICE

Terraces are the most important aspect of upland management in Nepal. These are well integrated into the socio-economic structure of the hill farmers. The dependency on terraces has been increasing among hill farmers due to population growth and subdivision of terraces among family members, and high soil erosion rates from sloping lands. Terraces are being extensively utilised in the mid-hills of Nepal for subsistence agriculture and cash crop production. They are constructed even on lands as narrow as one foot in width (Basnyet, 1989). Existing terraces are the product of several generations' labour and reflect the ingenuity of the Nepalese hill farmers. Very early in the development of stable and permanent agriculture in Nepal, farmers recognised the value of terraces in soil fertility management.

There are a great number of terrace types in Nepal, each reflecting the physical and socio-economic attributes of the village lands on which they occur. Irrigated rice terraces are flat and dyked (*bunded*), rainfed terraces tend to be gently outward or sideways sloping so as to join the terraces at different levels. Terraces



Outward sloping terraces in uplands

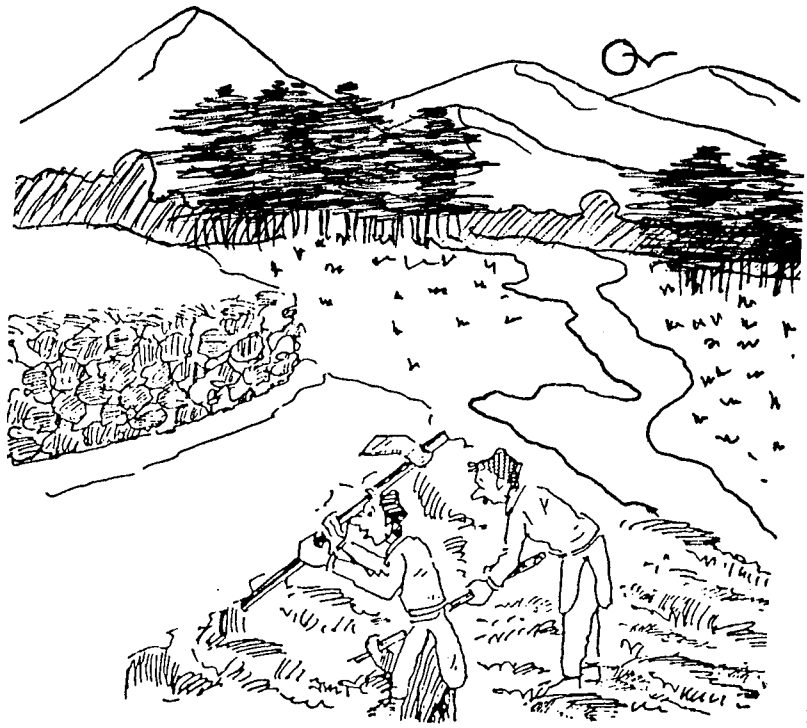


Level bench terraces in irrigated lands

range from perfectly groomed, flat fields with substantial, vertical rock-lined risers to a simple row of banana trees and a small pile of stones cast off the field along the contour lines. Regardless of their surface form, they generally reflect the local soil conditions, regional climatic conditions, cropping preferences. Local productivity and profitability of the farming systems develops on them.

Risers connect terraces. Terrace risers are stone-lined, vegetated, or purposely cut to bare soil. Extremely stony soils will have stone-lined risers. Most terrace risers are vegetated either naturally or planted with improved grasses to provide significant quantities of fodder. The slope and height of risers are different for outward sloping and level bench terraces. Risers of outward sloping terraces are higher and are more inclined to aid stabilization. Although maintaining a riser with a slope means reduction of cultivable land, farmers maintain a riser with a slope to protect fertile topsoil and fertilizer. It is easier for farmers to scrape a higher riser with a slope than one without slope. Level terrace risers' height is generally smaller and they are scraped vertically.

Farmers themselves design and construct the terraces using locally available materials such as boulders, stones, clods and soil. Cutting and filling to produce a series of steps normally construct these terraces. This breaks the slope length and allows water to infiltrate slowly into the soil thereby reducing velocity of the surface runoff. Farmers' family members mostly provide the required labour. Existing terraces are the efforts of several generations' labour. Farmers often build these terraces over a period of five-years. During this construction phase, they first build the riser using soil clods or stones in pre-monsoon season and allow grasses to grow on it during monsoon so that it gets stabilised. The same process is repeated every year and a few meters are added to the terrace lengthwise. Slowly terracing is advanced across the slope following the contour line as far as possible.



Terrace building in progress

In areas of Palpa, Gulmi and Salyan, farmers have developed less commonly seen sloping terraces to suit the local soil and slope conditions (Carson 1992). Contours are planted with bananas and a range of fodder trees. Maize is grown on cultivated patches. Farmers also convert outward sloping terraces to level bench terraces in order to increase cultivable area, add to its agricultural productivity and reduce its soil erodability. Basnyet (1989) reports that during 1975, farmers of Kakani in Nuwakot district converted larger outward sloping terraces into smaller ones of about one foot in width to reduce riser height so that soil erosion would diminish. However, new terraces are not being commonly built today in Nepal. Rather thousands of hectares of abandoned terraces can be seen throughout the country. This is a direct result of decline in their soil fertility since there are not enough nutrients available to meet all the needs of the farmer in his presently more intensive cropping system.

The terraces reduce soil erosion substantially by reducing the velocity of over land flow and trapping sediment from upstream areas, provide ease in tillage and other agronomic practices, maintain soil fertility if bio materials are recycled back, intercept runoff and retain soil and water, thus conserving soil moisture. However, in the initial period the terraces do disturb the top soils thus the productivity in the first few years is reduced. The cultivable land is reduced due to risers, and they need intensive labour and investment for construction. The riser requires regular maintenance and increases labour input. Terraces are not suitable for shallow and slipping upland soils and unstable mountain terrain as they have a low return on investment in poor soil areas.

INDIGENOUS JYAPOO METHOD OF SOIL MANAGEMENT

Jyapoo way of soil management, that differs significantly from other farming communities, is the best soil management practice in Nepal. Jyapoo farmers rarely keep cattle and they do not use oxen/ bullocks to plough fields. They perform tillage operation by using a set of simple tools, mainly crooked hoes developed by them to meet and fit their needs. They use black clay, compost and human excrement as the traditional source of manure.

Jyapoo farmers use simple, but effective soil management techniques. No machinery, ploughs, or draft animals are employed. They use only a few tools to assist their labour. The tools include crooked digging hoe, large digging hoe, small digging hoe, spud digging hoe, soil pulveriser and sickle. Jyapoo farmers do not leave land fallow. They are much more efficient than other farmers in using land and adapting cropping systems. They even crop on corners and bunds. The moment they harvest a crop, they start preparing soil for sowing next crop. Jyapoo farmers prepare soil using deep digging and turning method. The male members of the family do digging and clods are broken and pulverised by the women folk. If soil is moist, it is allowed to dry for a day or two. As soil is prepared, any pebbles, crop residues and weeds are removed. Compost and manure are added and mixed during this process. Principal sources of organic manure are chicken manure, human excrement, discarded vegetables, rice straw, weeds, household waste, and ash. Waste materials are collected, stored in backyard or fields, piled up and mixed together to facilitate decomposing. They often apply lime and urea for quicker rotting. When the compost is ready, it is covered with plastic sheets or other materials to prevent nutrient leaching.

Jyapoo farmer tilling his field

This method of soil management is simple and effective. It is environmentally sound and economical. It requires minimum tillage, prevents soil erosion, maintains soil fertility and prepares good soil tilth. The only limitation of this method of soil management is its intensive and time consuming labour requirements as the soil is tilled manually.

INDIGENOUS SOIL FERTILITY MANAGEMENT TECHNIQUES

Use of Farm Yard Manure/Compost

Farm Yard Manure (FYM)/Compost is the most important soil additive applied by the Nepalese farmers to manage fertility. Next to almost every house in the hills, a FYM/compost pile will be found. Indigenous methods of FYM preparation and utilisation have been developed over several centuries. This is a mix of dung, urine, forest litter, and agricultural and household wastes, including ash from cooking fires.

Farmers prepare compost in many different ways (in a pit, above ground, in a field, near cattle shed, etc.) depending on various socio-economic and biophysical factors. Composting involves the decomposition of plant and animal wastes. In the inner Himalayan region, farmers prepare FYM by a unique system. Animal sheds are constructed in the courtyard of the houses to make compost by utilising household wastes, human excreta, wood ash, animal dung and urine. Bedding materials are added every week to keep animal sheds dry. The whole process of FYM preparation and storage takes place in the animal shed. In some areas, it is allowed to remain in animal sheds for almost one year; while in others, once the compost is relatively decomposed, lower layers are taken out and transported to the distant fields during slack

periods. In the mid-hills, bedding materials are either spread in animal shed or get incorporated with animal dung and urine.

Left over animal feed, forage, forest litter, and crop residues are the most common form of bedding materials which include rice straw, maize stocks, straws of millet and wheat, residues from leguminous crops and left over tree fodder. Leaves of Uttis (*Alnus nepalensis*), Chilaune (*Schima wallichii*), Dhurselo, Katus (*Castanopsis spp.*), Asuro (*Adhatoda vasica*) and Sal (*Shorea robusta*) are used as bedding materials during different seasons (Sthapit et al., 1988; Subedi et al., 1989; Joshi et al., 1995). Regarding the quality of bedding materials, leaves of *Alnus spp.* are considered to be the best. In some places, partially decomposed leaf litters are brought from the forest to increase the compost output. In some locations such as Marpha, animals are moved from one place to another within the animal shed to accomplish a uniform spread of dung and urine and for the better trampling of bedding materials (Joshi et al., 1995).

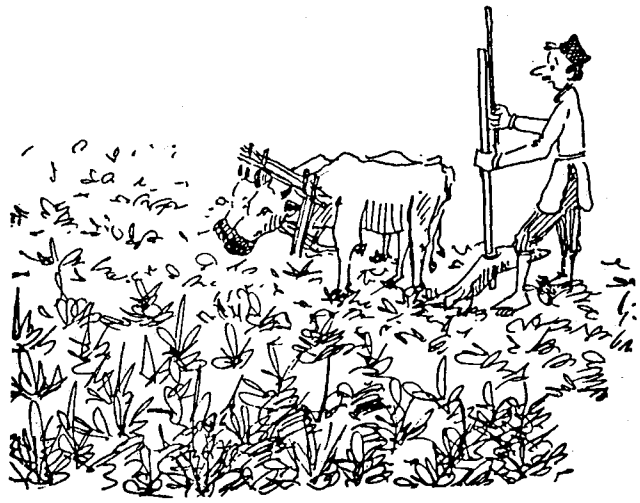
The major part of FYM/compost is used on upland (*bari lands*) i.e. near to the homestead for crops such as maize, finger millet, vegetables and mustard. These crops get priority for manuring as they assure food supply. FYM/compost application to irrigated lands is limited. The time gap between FYM/compost application to the field and subsequent incorporation varies from a few days up to three weeks, depending upon the distance of the land from the homestead. The majority of compost is applied during dry season (December to February). The rate of use of FYM/compost range from 0 to 58 tons per hectare but is most commonly between 0 and 23 tons per hectare for paddy and 20 to 28 tons per hectare for maize crops (Suwal et al., 1991).

Farm yard manure can easily be made with the locally available resources. It is environmentally sound and economical. It increases organic matter content and nutrients in the soil. The FYM in addition to retaining soil fertility, increases infiltration rate and soil moisture holding capacity and improves soil structure. It however takes long time to make a completely decomposed compost under traditional conditions and requires large quantity of bio-mass/plant materials and labour. The FYM can not be effectively used in the weed-infested areas.

Green Manuring

The use of green manure plays an integral role in the farmers' overall fertility management strategies. Green manure is used extensively in nursery seedbed preparation in many parts of Nepal. Many common, locally available species, such as *Artemesia valgaris, Vigna umbellata, Sesbania species, Cassia toda, Albizzia species* and a number of grasses are traditionally used by Nepalese farmers as green manure.

Green manuring species are not intermixed with the soil, rather the application is in the form of mulching, especially after the sowing of vegetable seeds. This is, however, not common in field crops and fruit tree cultivation. Green leaves, twigs or whole plants of different species are used as green manure. The common plant species used as green manure are Asuro (*Adhatoda vasica*), Titepati (*Artemisia vulgaris*), Dhurselo, Budhdhairo (*Albizzia species*). Grasses like Dhaincha (*Sesbania species*), sesame (*Seasmum indicum*) and Pumpkin (*Cucurbita melanosperma*) are also used for green manuring. In the high hills and inner Himalayas, titepati and unyu (a kind of fern) are used as green manuring species. In the middle hills, the partially decomposed leaves of different broad-leafed species are also used.



Green manuring by plowing with mouldboard plow

The use of green manure provides organic matter to the soil. It improves the soil's physical condition when used as mulch or when incorporated into the soil and protects newly sown seeds and seedlings from birds and insects. Its production however, requires large quantities of plant material. Usually plants used as green manure have less fodder value.

In-situ Manuring

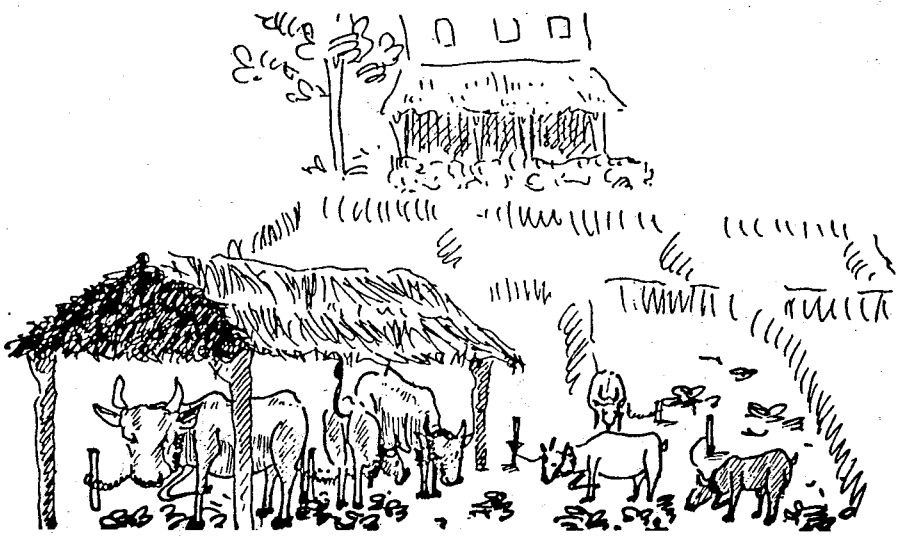
In-situ manuring is the practice of manuring fields by gathering the animals directly on the field. Animals grazing an area leave behind their manure and urine. This is a common traditional practice in the mid and high hills of Nepal (Sthapit ,1987; Subedi et al., 1998).

In-Situ Manuring by Keeping Animals on Uplands

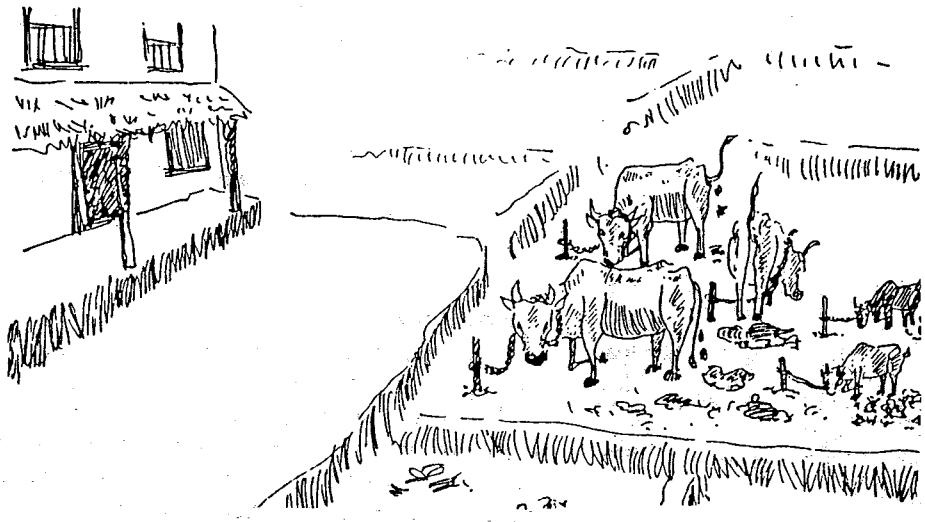
This practice is common in the uplands (bari) of middle and high hills where cropping intensity is relatively low. Animals are moved from one place to another in rotation in order to manure the entire lands. Depending on the season and location, animals are kept in the temporary sheds or kept in the open field (in most of the cases) overnight. Farmers have reported that urine and dung of a buffalo gathered for three days in one spot of land is equal to heavy application of compost .This is commonly done in October/November i. e. after the harvest of finger millet and before planting winter crops (usually wheat or barley). The practice is repeated in March/April before maize or millet planting. Animals are moved from one place to another after every two or three nights so as to manure the entire field. Certain pieces of land are intensively manured by keeping animals for a longer period where land is available for about two to three months after the harvest of the first crop. This is done by constructing temporary sheds (*Goths*) in the fallow lands, and animals are kept in these sheds for a few weeks at a time moving from one place to another to manure the entire area. Some farmers also keep animals under the canopy of fruit trees for a period of one to three nights to manure the orchards.

In-situ Manuring by Using Migratory Flocks of Sheep and Goats

The flocks of sheep and goats graze on the alpine pasture > 3000 m altitude from May to November. In winter, the flocks descend to the lower areas around 1000 m altitude to feed on crop residues and grasses, and manure the fields. The downward movement of the flocks in October/November is called 'Udhouli' and they start to return back and move upward in March/April, which is called 'Ubhouli'. By May/June, they enter the highland pasture areas again. There is a very high demand for such flocks in the higher altitude areas in Nepal. In high altitude areas of Kaski and Lamjung districts alone, there are about 70 to 80 flocks of migratory sheep and goats with animals' number ranging from 200 to 500 in each flock .



In-situ manuring by keeping animals making temporary sheds in uplands



In-situ manuring by keeping animals in open upland fields

The bari lands under maize/finger millet-barley cropping pattern are manured twice a year after the millet harvest in October/November and after the barley harvest in March/April. When the flocks are kept overnight on a person's land other than those of the flock owners, the land owner has to pay the shepherd in cash or kind (usually food grains) for every night of the stay. This is taken as the cost of manuring the land.

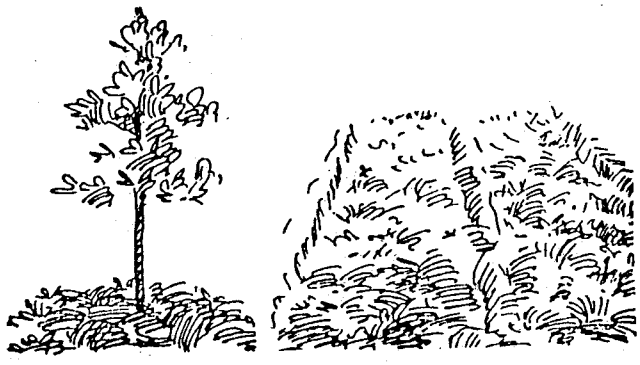
The animals are kept in dry lands only. If they are kept on khet (irrigated) lands e.g. after harvesting rice, they fall sick due to the wet conditions.

In-situ manuring by using migratory flocks of sheep and goats in high hills

Mulching

Mulching is considered to be the cheapest soil conservation measure. This practice is commonly used in areas subject to drought and weed infestation. The choice of mulch depends on locally available materials.

Mulch materials are collected and spread over the soil surface between rows of crops or around the trunks of trees. Mulching is also done in seedbeds and potato fields. Farmers use weeds, fallen leaves, crop residues, fodder leftovers and twigs (Ghaseuta) for mulching. Leaves and twigs of Asuro (*Adhatoda basica*) and Budhdhairo are chopped and used as mulches. Similarly crop residues, such as husk of soybean (*Glycine max*), black gram (*Phaseolus mungo*), niger (*Guizotia abbysinica*) are also used as mulch. The rotten thatch is considered very high value material as far as mulching is considered.



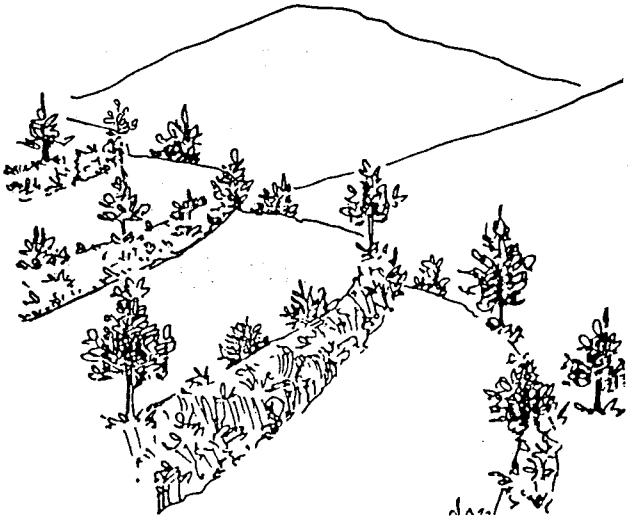
Mulching

method is not applicable while on steep lands it is difficult to spread the mulch.

Use of Nitrogen Fixing Plants

Leguminous crops are an important plant species in mountain farming systems. These are included either as mixed crops, inter-crops, planted on rice bunds or under orchards. The commonly grown grain legumes in the hills and mountains are soybean (*Glycine max*), black gram (*Phaseolus mungo*), lentil (*Lens esculentus*), ricebean (*Vigna umbellata*), runner beans (*Dolichos lablab*), peas (*Pisum sativum*), and cowpea (*Vigna unguiculata*). Although level of contribution of grain legumes in overall fertility management system may not be very high, the practice is consistently found across the hills and mountain areas (Joshi et al., 1994, 1995).

On bari (uplands) land, farmers have long been planting leguminous shrubs that provide high protein fodder for their cattle (Pandey, 1991). Soybeans and lentils are often planted in association with grain crops. Well-drained bunds within the rice fields support soybeans. The use of such plants improves soil fertility by fixing atmospheric nitrogen and thus increases the productivity of the overall system.



Nitrogen Fixing Plants on Terrace Risers and Dykes

Crop Rotation

Indigenous crop rotation includes growing different kinds of crops on the same parcel of land with in the same year or in different years. The indigenous crop rotation systems followed by the farmers is one of the most important crop management practices that have a significant effect on the soil fertility

maintenance and soil moisture regime (Sthapit et al., 1988; Joshi et al., 1995).

Various crop species are grown in sequence, one after another, in the same part of the field. These cropping patterns vary from year to year. A typical crop rotation is rice-beans-maize-cowpea. Mustard or potato follows maize in some parcels during one year while the same parcels are planted with ricebean next year. Growing linseeds, lintels and chickpeas after rice in irrigated (*khet*) land in different years are other practices. Rotation is also followed between vegetables and other field crop to better utilise soil fertility and soil moisture regimes.

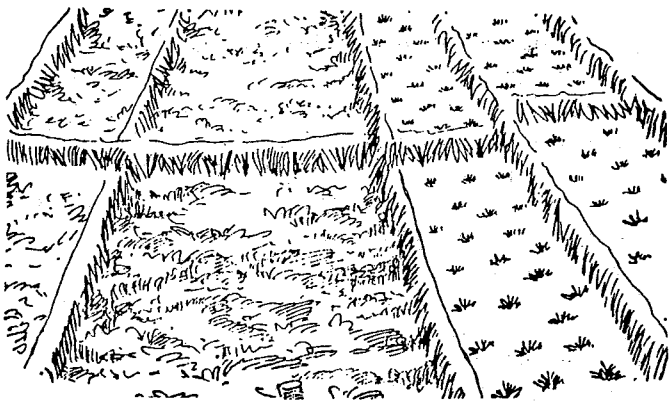
Crop rotation.

This crop management practice insures that plant nutrients and soil moisture are used rationally. Crop rotation improves the soil fertility, and sustains and diversifies crop production. Pests and diseases are also controlled by this practice.

Fallowing

Most soils when given a break from crop production, have their fertility renewed. For majority of the Nepalese farmers, fallowing as a method of soil fertility management ended many years ago due to need for intensive cultivation to meet house hold needs. However, many farmers fallow a portion of their upland fields. These are usually lands that are remote and marginalized (Carson, 1992).

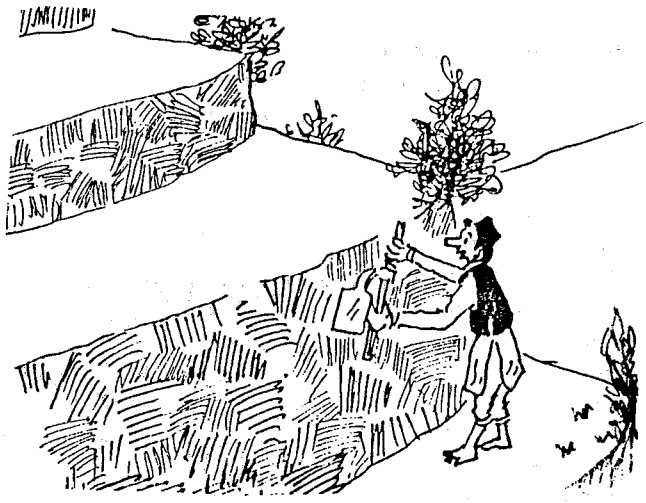
There are no general guidelines followed by farmers as to when and how the land should be fallowed. In many instances, cultivated land is abandoned temporarily, when its fertility becomes too low and crop yields do not justify further tillage efforts. In some cases, Khar (*Cymbopogon microtheca*) is used extensively on fallow land, producing a useful product from land that has been seriously degraded.



Fallowed and cultivated parts of the land

Terrace Riser Slicing

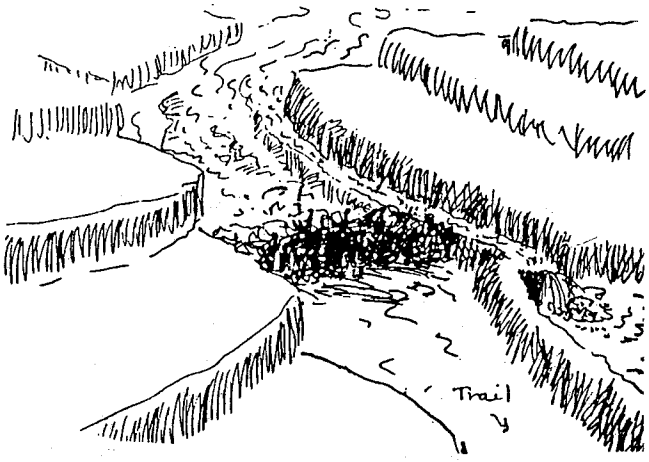
As part of their overall soil fertility and terrace management system, farmers slice terrace risers and deposit the sliced material on the field below. The risers for level bench terraces are scraped once a year and for outward sloping terraces once every two years (Basnyet, 1989). Farmers do this to control weeds on terraces that would otherwise compete with crops. The practice controls rodents, rats and insects. It also provides small but significant amount of organic matter to the field below from the sliced vegetative materials. Scraping of risers also reduces the consumption of fertilisers and provides an additional layer of weathered soil on terraces. This also leads to the substitution of soil loss, widens the lowest terrace, narrows the uppermost terrace and used does maintenance of any breaks in the risers. Terraces in low land irrigated areas are sliced while transplanting rice and upland terraces are sliced during winter, generally before maize plantation.



Slicing of terrace risers

Trapping Flood Water for Fertigation

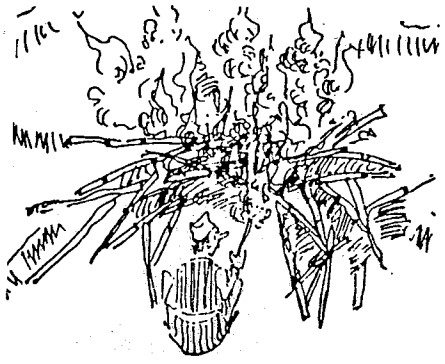
Trapping flood waters from the first monsoon rain for the purpose of manuring irrigated lands is common in the mid-hills (Joshi et al., 1995). Paddy farmers frequently divert sediment-laden runoff water to their fields to take advantage of nutrients in the sediments. Farmers make small channels or ditches on the upland soil surface using simple agricultural tools like spade, hoe etc. to divert the floodwater. Many farmers take advantage of local surface runoff even for their upland crops. Local interceptor ditches on the upper side of terraced fields collect sediment-laden water and divert it to the farmers' fields. Fertigation (application of fertiliser with irrigation water) is also realised from this activity. As far as possible, farmers divert the surface runoff coming from forest and pasturelands. Farmers even divert runoff water from the village roads.



Diverting flood water to terraces by making earthen dam across the trail

Burning of Trash

In the mid-hills and inner Himalayan region, farmers collect the stubble of maize/millet, left over of wheat straw, dried weeds, other trash and burn them. They report that burning of trash has two important functions: Firstly, it enhances soil fertility, and secondly it improves the general cleanliness of the farmland, which reduces the infestation of rodents and insects. This is normally done during dry period.



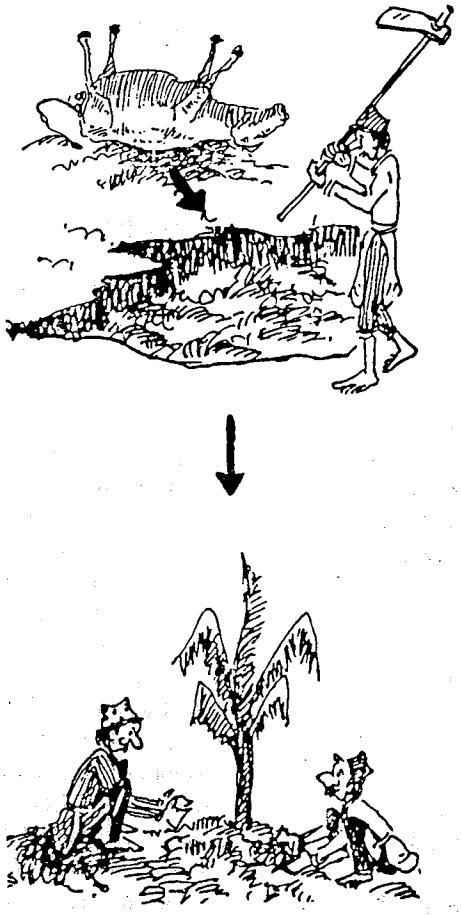
Burning of trash , other agriculture residues & waste in uplands

Use of Forest Soil and Black Soil

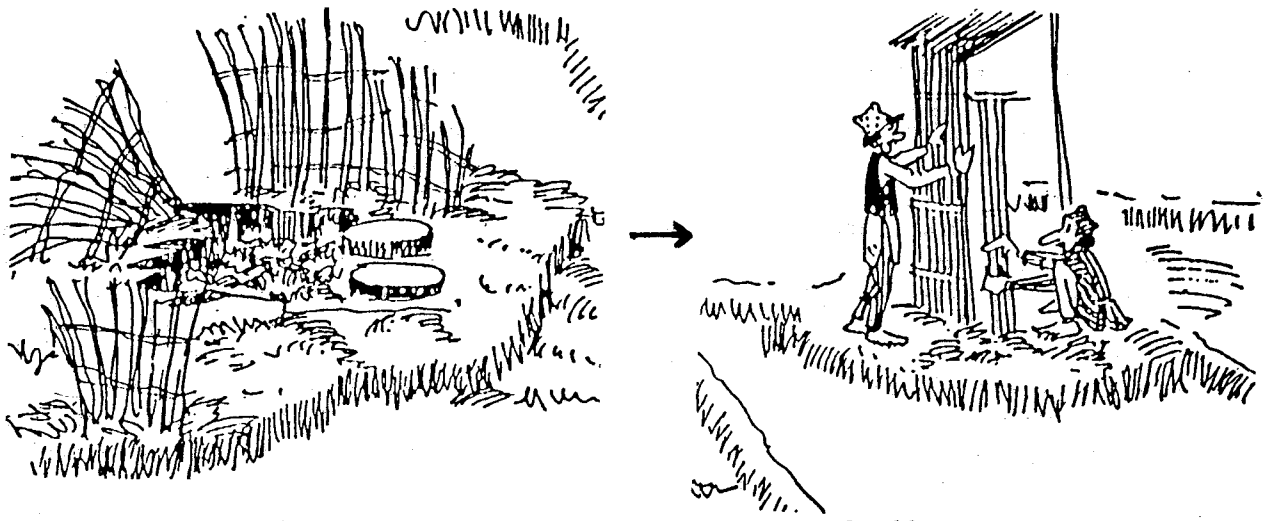
Farmers incorporate forest topsoil either directly in the field or as bedding material. This will improve the fertility status and soil texture. The use of black, charcoal-like soil as bedding material is quite common around Muktinath area and other villages of Mustang district. The use of small fragments of soft slate or charcoal like sedimentary rock as bedding material is a peculiar feature of Kagbeni village in Mustang.

Burying of Dead Animals and Mobile Toilets

Farmers from different part of the mid hills report that they bury dead animals and use toilets as an integral part of soil fertility management. Farmers are aware of the importance of animal carcasses and bones in soil fertility maintenance. After burying the dead animal, fruit trees are planted on top.



Planting a banana tree over buried dead animal



Building a new toilet by demolishing and moving the old one

Temporary mobile toilets are made of locally available materials by simply digging pits. When one pit is full, they dig another in nearby place and within few years, the entire bari land will be covered. This will serve the purpose of toilet and at the same time supply nutrients to the field.

INDIGENOUS WATER RESOURCES MANAGEMENT SYSTEMS

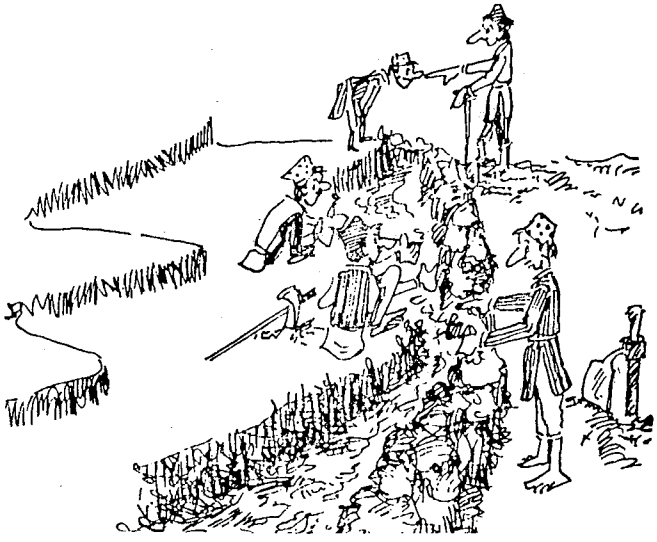
Rainfall water, surface water from small streams (*Khola*) and sub-surface water from springs (*Mul*) are the common sources of water in the hills. These water sources are used for supplying drinking water, for operating water mills (*Pani Ghatta*), water turbines and indigenous farmer managed irrigation systems (FMIS). According to Dhakal (1993), in Kharkhola basin of Gorkha alone, there are three water mills, one water turbine and thirty-two indigenous FMIS operating from Kharkhola water source. These water sources have been managed by local communities through their indigenous knowledge and skills for generations while no new upland irrigation systems have been installed by any official agencies so far.

Farmer Managed Irrigation Engineering Practice

Farmer Managed Irrigation Systems (FMIS) include 75% of the total irrigated area (0.9 million ha) in Nepal. About 70 % of irrigation development in the Terai consisting of 1,700 systems and 90 % in the hills consisting of 15,000 systems have been developed and managed by farmers themselves. Some of them are in operation for over 250 years. The Surtana irrigation system of East Chitwon with a command area of about 350 ha. was constructed by the Tharus (an ethnic group of Nepal) and is in use for generations. The Lothar irrigation system which commands an area of 800 ha. was built in 1971 by the higher caste farmers who had migrated to Chitwon from the hills. The feeling of ownership of the FMIS makes these systems sustainable for generations. Most FMIS have a strong farmers' organisation for operating and managing the systems. These are indigenous and called Water Users' Groups (WUGs). Their activities concern with water, physical structures and organisation to manage them. Water needs to be acquired, allocated, distributed, delivered and if in excess, drained. Physical structures need to be designed, constructed, operated and maintained. Farmers' organisation plays an important role in managing water and physical structures including decision making, resource mobilisation, operations and maintenance (O & M), communication and conflict resolution.

Making a channel head diversion

Farmers design and construct all the structures in the irrigation system using simple and indigenous technologies and locally available materials, such as boulders, stones, branches, sand, soil and wood. In erosion prone zones along the canal alignments, locally available bushes and bamboo are planted for slope and gully stabilisation. Hollowed out logs are used as conduits for transporting water across gullies. In steep cliffs, farmers make channel by cutting rocks with the help of chisel and scaffolding support of bamboo. All the farmers who use water from the system organise themselves and form WUGs, regardless of the community, ethnicity and other variables. These may be either formal or informal. In the systems operated and managed by informal user groups, there are no documented rules and regulations. However, all users contribute labour and materials as needed for repair and O & M of the system. Most of the O & M work is carried out through mutual consensus of the user households. If some users fail to make necessary contributions when needed, fines and penalties are imposed as decided by the WUG.



O & M activities along the channel

In order to allocate and distribute water to all members of the irrigation system, it is compulsory for all the WUGs to submit their cultivation plan to the water users' committee (WUC) well in advance. Upon receipt of cultivation plan, the committee schedules plantation date for all users on rotational basis. All users are then notified according to the schedule. Water is mainly used for plantation in daytime and for irrigating of already transplanted fields at night. Users are required to observe the set rules to insure equitable sharing of water at all times.

Irrigation systems require maintenance and cleaning at least two to three times a year. The indigenous WUCs are entrusted with overall O & M responsibility. Users are required to work according to the decision of the committee and established norms. The major annual repair and maintenance work is done prior to monsoon rice plantation. Labour for repair and maintenance is the main input in all the systems, irrespective of their size. Mobilised labour is used for the collection of construction materials and construction work. In some cases during monsoon season, watchmen are hired to patrol the main canal and intake everyday to repair small leaks in the intake and canal, and to alert users if major damage such as land slides occurs requiring emergency maintenance work. Resources (cash and kind) are also raised from the beneficiaries according to their land holding size in the command area, and the fund thus raised is used to pay the watchmen. In small irrigation systems, the O & M responsibility moves from one user to another on a predetermined rotational basis. In FMIS, conflicts over water use are not uncommon. There are normally two types of water use conflicts: between water users of different systems and among water users within a system. However such conflicts are settled locally by WUC members and neighbours through mutual understanding and consent. Committee members and farmer leaders who have a proven ability to convince the disputants have a strong role in arbitrating the disputes. The conflict resolution measures include compromise and financial and social sanctions imposed upon the offenders according to the established rules.

Indigenous Knowledge in Irrigation Systems Management (Shukla and Khanal, 1997):

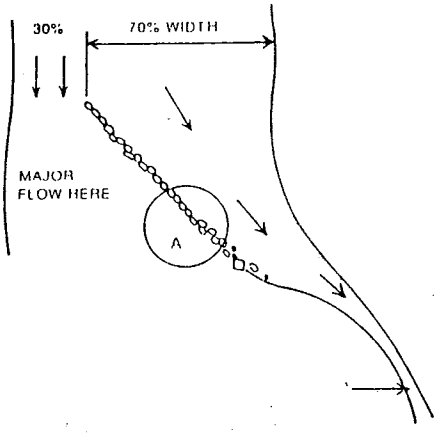
Irrigation management in Nepal is probably as old or even older than rice terraces carved by the Nepalese farmers. It is believed that about 75% of irrigation development in the country is by (Poudel, 1992). Many of the FMIS in Nepal originated during 18th and 19th century and first half of 20th century. These systems are still functioning very well hence best examples of sustainable water resource management systems. Raj Kulo at Argali in Palpa District is for example, believed to have been developed by Mani Mukund Sen, a ruler of the then state of Palpa about 400 years ago (Benjamin, 1994). Chhattis Mauja Irrigation System in Rupendehi District irrigating 3500 ha of land was developed by Tharu inhabitants over 150 years ago (Yoder, 1994). One may site hundreds of similar examples from all over the country. These systems were developed during the period of difficulty in transportation and communication when concepts of modern engineering

principals and materials were not available to the people. Still these systems furnish some of the finest examples of irrigation acquisition, delivery and use.

Strong indigenous knowledge system is available for design, construction, operation and governance of FMIS in Nepal. These knowledge systems are time tested: tried, modified and tried again and are dynamic: changed over time in response to the stresses of social, economic and ecological forces.

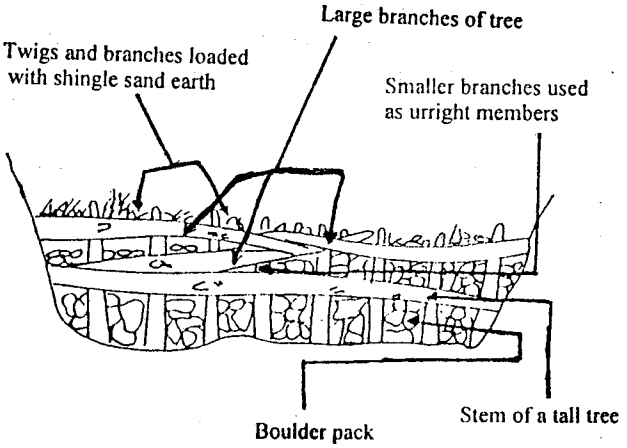
Irrigation Acquisition

In most FMIS in Nepal, temporary and semi-permanent type over flow weirs are found to be performing satisfactorily. The farmers seem to be knowledgeable about the characteristics of flow, making the temporary and semi-permanent weirs more viable in mountain streams having intermittent peak flow and low base flow.



Orientation of brushwood diversion weir across a stream

Brushwood temporary weir is the most common diversion structure found in the FMIS. These are built using locally available materials like boulders, brushwood, grasses, tree branches, wooden piles and stakes. They have to be repaired or replaced at least once annually and in many streams the farmers have to be continuously on alert and mobilise labour to replace or repair the weir. The farmers are also knowledgeable on stability concerns of brushwood weir. The weir is never laid across the stream at right angle to the river axis but is inclined to flow and a portion of stream is left uncrossed by the weir. Therefore the weir is less likely to be damaged by normal stream flow. In streams having small catchments even a temporary diversion structure may last several seasons. Their stability is insured by making the base width large. One would also appreciate the farmers' rationale of selecting sites for the construction of diversion structure in the FMIS. In most cases the intake is found to be located in a narrow section of stream. Obviously a diversion weir would be reasonably stable and cost effective if the weir length is short.



A brush wood diversion weir

Water Delivery System

In the hills usually a number of FMIS originating from the same stream and running parallel to each other are observed. This may appear illogical to build several small canals resulting to more loss of land in digging, however this may have definite merit from ecological considerations. Instead of one large system on an unstable hill slope prone to landslide and soil erosion, a number of systems at different levels insure less disturbance of soil and less chances of damage to the system. Parallel canals also serve as waterways, draining the seepage of upper canal by the lower canal, across the slope. Two or more parallel canals originating from the same point in the stream are common.

Where overhanging rocks make it difficult to construct a canal or a narrow ridge make it necessary to dig a long canal, tunnels are often dug by the farmers. There are examples where tunnels as long as 50m to 150m have been dug by the farmers by local means and resources. *Agris* are the group of people found in Baglung and Dhading Districts specialised in tunnel making in the hills of Nepal. They use varieties of techniques and materials to break the rocks. For breaking hard rocks, except inside the tunnel, they heat the rocks by lighting a fire which are then cooled by pouring water. This causes cracks to develop in the rock. They also locally manufacture gunpowder from charcoal of chillies, sulphur and soda, which is used in blasting the rocks. Inside the tunnel, they work with chisel and hammer (Yoder et. al., 1987; Pradhan, 1989). Mathar Irrigation System in Nawalparasi District and Chherlung in Palpa District have very long tunnels made by the *Agris*.

In many FMIS, use of proportioning water division structures are observed to divide water into

two or more parts. Usually such division corresponds to water share of a farmer or a group of farmers served by the branching canals. The proportioning device locally called "*Sancho*" or "*Jhyal*" is usually made of wooden blocks with rectangular notches. The farmers also seem to be concerned with the magnitude of losses in their irrigation system. Though most FMIS have unlined canals, frequently examples of efforts to line whole or part of the canal through locally available materials are observed. Use of slates on the canal bed and side is found in many of the FMIS in the hills of Nepal. Other measures to minimise the losses include management of aquatic plants and grasses growing on the inside face of canal section. When the grasses grow too long they are cut but never uprooted. The binding effect of grasses not only prevents bank erosion but also make the unlined canals fairly leak proof.

Irrigation Governance

Traditionally FMIS in Nepal have been made and managed on a self-help basis. Effective governance and organisation has been key to successful irrigation management in most FMIS. Rules defined by Ostrom (1992) in-use as irrigation institution governing the irrigation system shape the human interaction by permitting, forbidding and requiring some actions or outcomes. One may come across diverse forms of rules in use for defining membership in the system, water allocation, distribution, resource mobilisation, conflict management and fines and sanctions. These rules-in-use are tied to terrain, community mixes and flow regime in the system. In most FMIS, prompt decision making and effective enforcement of rules through prompt communication are found to ensure high decree of compliance to the decisions. Diverse forms of organisation and rules in use in the FMIS furnish many success stories of collective action and self-governance in irrigation management. The crafting of rules and organisation has been possible through long experiences of the farmers tailored to local needs.

Drinking Water Sources Management Systems

In many parts of Nepal, water is brought either from piped taps, springs or wells. Hill farmers wash themselves and their clothes at the water source itself. Amount of water consumed for drinking, cooking, and for feeding livestock depends on the season of a year, whether it is a dry period (March to June), monsoon period (July to September), or winter (October to February). Normally, women folk walk to the sources to fetch water. The time required to collect water from the sources varies during different months and seasons. During rainy season, new springs emerge due to monsoon rain (locally called *Asare pani*), and this reduces travel time required for collecting water for household and livestock consumption. However in other seasons, most of their time is spent in fetching water only.

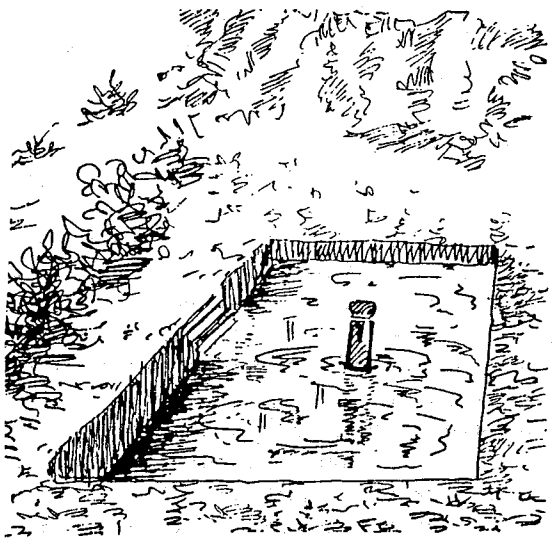
Farmers protect springs from flooding and encroachment of livestock. They maintain water sources by using locally available materials and technology. Locally available materials like stones, wood, bamboo, soil, etc. are mobilised. All the households collecting water from that source participate in protection and maintenance work. In some instances, an intake is constructed at the source and polythene pipes are laid to bring the water as near as possible to the village. All households contribute money to purchase pipes. Transportation, earthwork and pipe lining work are done by local people themselves. Every household participates in such work and those who fail to participate have to pay compensation.

Women folk fetching drinking water from a natural water source

This system has a low investment as locally available resources are mobilised, and protection and maintenance is done by local people. The water is tasty and rich in minerals. However, if the water source is polluted and/or flooded during monsoon it could be quite unhygienic. Regular maintenance is required and during winter and pre-monsoon period drying up of the source occurs. Conflict could arise between upper and lower caste people over water use.

Farm Pond: An Indigenous Water Harvesting Technique

We can see small to medium sized century-old ponds scattered all over the hills in Nepal. These are the farm ponds. Normally such ponds are built in the public land on the initiatives of the local people themselves. They are to collect surface runoff during monsoon for various uses in the lean period. It is found that people generally relate such ponds with religion. In Phulout, Doti district, there is a pond of about 250 m^2 in size built at the top of the village by the local community with a god's name more than 200 years ago. This pond collects surface runoff from the upstream forest area and the collected water can be used for irrigating the farmlands of the whole village (reported by farmer Mr Dev Singh Khadka, Doti). Another such pond in Khadka Chour, Baglung district is with a log (*Maulo*) at the centre of the pond-representing god of water. The people have a religious belief that the god of water lives in the pond and therefore the pond should be kept clean or else the god would be angered and instil a water shortage (source farmer Mr Bhumiswor Sapkota and his 84- year old mother, Baglung). A similar pond in Bela, Kavre Palanchowk district, called "*Deuti Than Ko Pokhari*" is about 150 m^2 in size and is more than 150 years old (source farmer Mr Uddhav Pathak and his 96-year old father). This pond catches surface runoff from agricultural land and trails. The up-slope side of the pond is open with Bar (*Ficus bengalensis*)and Pipal (*Ficus religiosa*) trees and the down-slope side has earthen embankment made by the local people (Personal observation of DD Kandel).



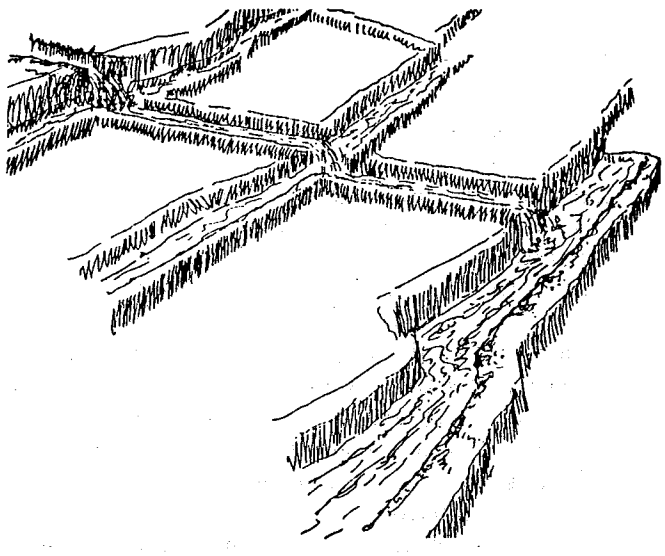
Harvesting surface runoff by building farm pond with sacred log installed at the center

Farmers harvest rain water (collect and store) for use in dry period for different purposes. People build ponds for the collection of monsoon rain and temporarily store runoff water from different sources. Farmers participate in the pond construction work. They do all the earth and masonry works themselves. Local construction materials like stones, sand etc. are collected and transported to the site. Water in the pond is used for drinking purposes for livestock, for wallowing buffaloes and for irrigating vegetable and winter crops. Farmers also build smaller ponds to collect monsoon runoff water to irrigate vegetable crops during dry period. They also try to optimise on water use so that water is available throughout the growing period.

Farm ponds are a low cost investment and are easy to construct. Their construction promotes conservation by trapping eroded soil with surface runoff, gives protection from drought and increases food production. Local people mobilise in a community for common good.

Diversion Channels

Terraces in the hills are maintained by using indigenous water management practices. Farmers have been managing soil and water by making arrangements for the safe disposal of excess water. In general, farmers make diversion channels at the toes of the risers. Water collects at the toe and flows on it until it reaches a waterway or falls on to lower terrace. Generally, diversion ditches are constructed along the contour lines and across slopes in order to intercept surface runoff and divert it to suitable outlets.



Safe disposal of surplus surface runoff through a diversion channel

However, for a wide terrace, they are made perpendicular to the toe at appropriate locations, and this is done according to the rational decisions of farmers who have years of practical experience. In Kavre district, ditches are found along the slope in wider terraces that eventually feed other ditches constructed across the slope. Dykes built at the edge of the terrace block this water and reduce its velocity. Drainage is managed by farmers. Any obstruction to the waterway is removed.

This method controls surface runoff and its erosive power; prevents rill formation and controls the advancement of already existing gullies. Regular maintenance is however required and some loss of cultivation area happens.

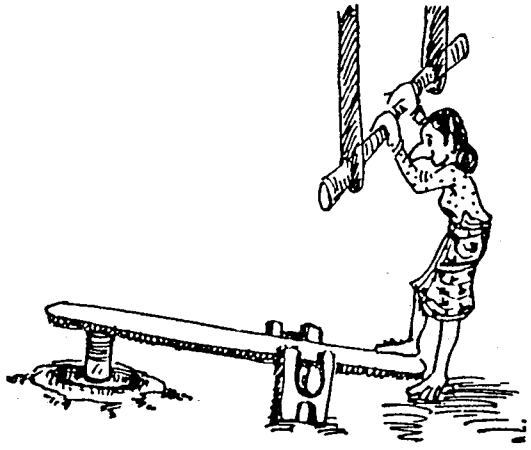
INDIGENOUS MILLING AND GRINDING TECHNIQUES

A hill women farmers' major time used to be spent on fetching water, fuel wood and grinding of flour. As in the case of water resource management and fuel wood, farmers have tried to reduce this time consumption in grinding by Indigenous grinding/milling techniques, which are still widespread in Nepal. There are various traditional techniques for processing cereals, oil seeds and spices with hand or foot driven devices. The most common methods are grinding wheat, maize and millet with hand-operated quern (*Janto*); dehulling rice with foot-operated pounder (*Dhiki*) and extracting oil with manually operated oil-expeller/crusher. Schnitzer and Melzer (1983) reports that in Nepal, only about a quarter of cereal grain produced is processed in rice mills and only 10 percent of wheat is ground in modern flour mills. Shrestha (1981) mentions that in the principal oil seed cultivation areas (Chitwon, Bara, Parsa, Rautahat, Morang and Saptary districts), there exist small oil-crushers driven by men or animals side by side with the power-driven large oil mills. There are also oxen-driven mills in the Terai part of Nepal.

Pounder (Dhiki)

This is a traditional foot-operated device mainly used for de-hulling rice. Dhiki consists of a long wooden pounder. One end of this pounder is equipped with a mortar and the other end is linked with two wooden supports. By pressing and releasing the supported end with foot, the mortar can be raised and lowered respectively. The tip of the mortar is, in some cases, made of metal. The spot where mortar strikes is made of flat wood with a hole in it. Rice and millet are fed in this hole and processed by pounding the pounder with foot. Two persons are required to operate the pounder: One for pounding and another for feeding and separating processed products. This is normally operated by women.

The Dhiki is a simple and a low-cost device. It can be made of locally available materials and skills and can process small quantities when required. The nutrient content in cereals is not lost during processing. Farmers believe that rice processed with pounder is tastier and contains more vitamins than the one processed by the mills. Since family labour is involved there is no extra cost in processing. The device is reliable and easily accessible.



A lady milling rice with Dhiki

The process is labour intensive and time consuming in fact it is drudgery. Since it is a women-specific job, it increases their already existing load and the work could be very boring and arduous.

Quern (Janto)

Janto has been traditionally used for grinding grain crops like wheat, maize and millet. Many farmers in the hills, have to rely on Janto to meet their requirements of flour. Janto consists of two circular grinding stones one above another. Lower stone is fixed on floor and has a wooden peg or metal rod fixed at the centre to guide upper stone. Upper stone has a round hole at the centre and a handle at the edge. The guide in lower stone fits in to the hole in upper stone when one rests on top of the other. The upper stone is rotated in horizontal plane manually holding it by the handle. Grinding surfaces of the stones are made rough by making little notches using a chisel. Grain is fed by hand through the round hole in upper stone. When upper stone is rotated, grains are ground by friction and flour is collected around the lower fixed

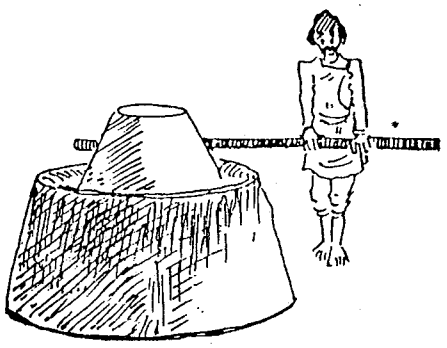
stone. Feeding is done by one hand and Janto is operated by another hand. Janto operation, by tradition, is the responsibility of women folk. Women perform this operation mostly during night when they finish their daily household chores or early morning. It is still drudgery in absence of better options.

A lady grinding corn with Janto

Janto can grind a small amount of grain to meet daily requirements of a family. Farmers prefer not to store flour due to infestation by insects, damage by rodents and humidity. This device can be run throughout the year and does not depend on water or fuel. Cost is considerably reduced as family labour is involved and entails no transportation or waiting at the mills. Like the Dhiki, the Janto is labour intensive, time consuming and the grinding efficiency is low. Its use also increases the workload for the women folk.

Oil-expeller (Kol)

Kol is a traditional device used by rural people to extract oil from mustard and other oil seeds. This is generally men-operated but sometime driven by animals also. However, the traditional Kol method of oil extracting has luckily almost disappeared (Jantzen, 1989), owing to the existence of more efficient water mills and other modern mills. This too was drudgery on the men and animal but it worked well.



A farmer extracting oil from mustard by crushing in the Kol

The oil cake (a by-product) can be a good feed for livestock. It is more economical as the money otherwise paid to the mill owner is saved. There is no transportation cost and waiting at the mills. This method of extraction however has a low efficiency. It is labour intensive and time consuming.

Water Mill (Ghatta)

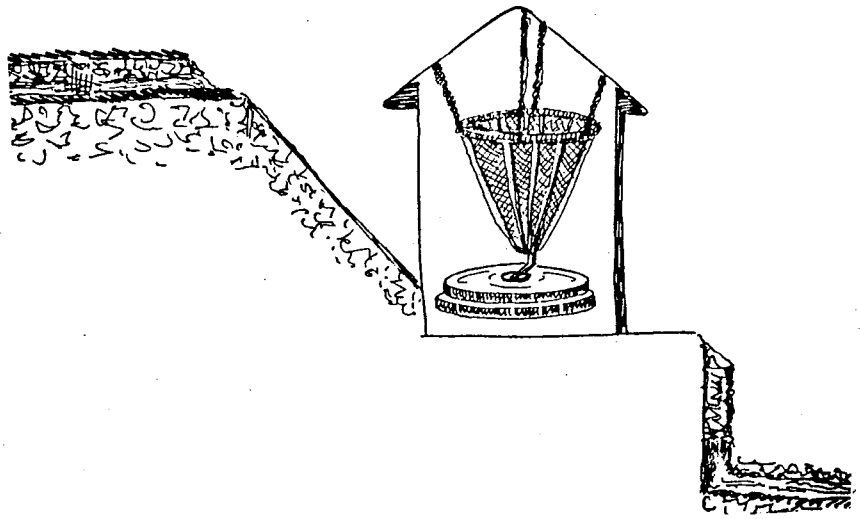
Traditional vertical axis water wheel (Ghatta) has been in use in Nepal for centuries. Ghatta is made entirely of local materials and widely used for agricultural processing in the hills of Nepal. Though in very small scale, nowadays ghatta has been used for electricity generation also. It is estimated that there are about 25000 ghattas functioning in Nepal. Ghattas are installed at the riverbank in valleys inside the huts with thatched roofs. Streams that drive these mills are channelled down the mountainside based on traditional irrigation techniques and the water head of 3 to 5 m is maintained to drive mill. After driving a mill, these watercourses usually form the beginning (head) of a terrace irrigation system, at the end of which another mill can be driven, if there is sufficient head of water. If mills and irrigation system are linked, mill-owner and farmers both participate in maintaining diversion (stone-brush mixed earthen dam) and channels.

The Ghatta technology

Stream is diverted into channels with piled up stones and brushwood weirs. Normally, the diversions are rebuilt after every monsoon floods. A few metres before the mill inlet, there will be a screen or grill which will keep solid and floating materials out of mill. Last part of channel leads into a chute inclined at an angle of about 45-degree. Water flowing down the chute accelerates until it strikes turbine blades. These blades consist of flat or slightly curved pieces of board which are set at an average angle of 45 degree. Usually there will be 6 to 14 blades in a turbine. The centrepiece of turbine is the massive wooden boss and a forged steel tip serves as a trunnion. The grinding mechanism consists of two millstones placed one above another. Upper millstone can be raised and lowered. Lower millstone rests on mill floor and is provided with a bamboo bearing inserted into a centrally drilled hole.

When millstones wear down and their weight becomes no longer sufficient for effective grinding, they are redressed by making little notches on the surface using a chisel. Material to be ground is fed in to conic hopper which has a adjustable feeding spout made of wood or bamboo at the lower outlet. Grains fall into the eye of millstone in a regular succession with the aid of an agitator. Flour is collected around the

stone in a square box. Grinding capacity of such ghattas varies between 100 to 250 kg a day.

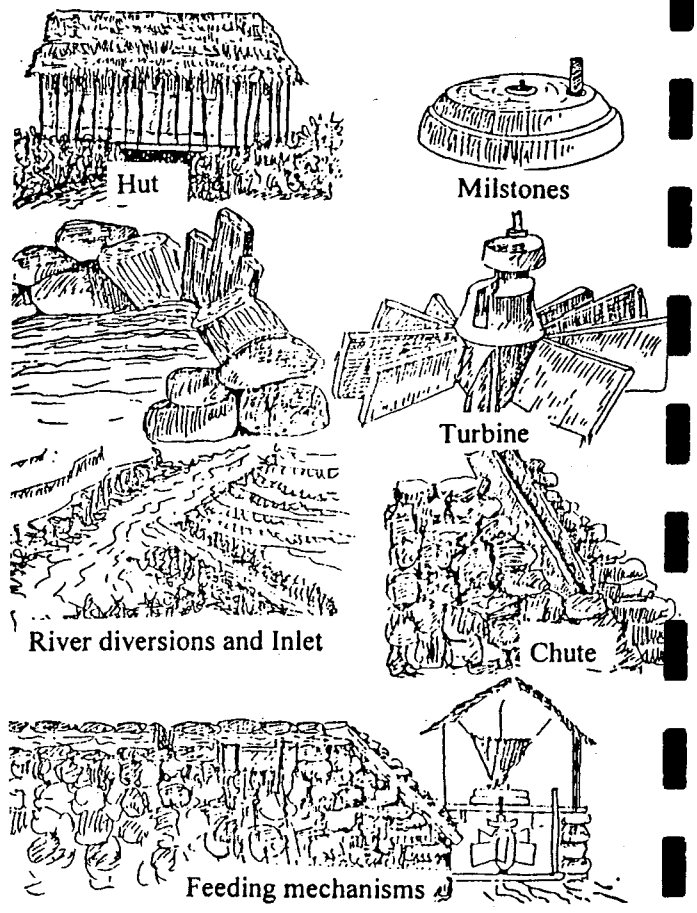


Cross-section of a Ghatta plant.

Ghattas are most commonly used in Nepal for processing agricultural products by milling, hulling and oil expelling. Ghattas operate only when there is demand from users. This demand depends on agricultural season and ghatta operating time is also made flexible accordingly. Although milling functions are spread throughout the year, many ghattas close completely for up to four months because of lack of water or after damage to intakes or canals. For example: the Yagya Rice Mill in Khaireni, Gulmi district was established in 1967. Present owner is the third owner and he has been operating this mill since 1977. This mill operates an oil expeller, a grinder and husker as well as the generator. The owner carries out minor repairs himself. During peak seasons for each crop (wheat, rice and mustard), mill is opened from 7 am to 6 p.m. and the rest of the year it operates for about four hours each day. Milling charges are accepted in cash or kind. Electricity is also generated and supplied to 103 households. Electricity is supplied only at night from 7- 11 PM during summer and 5-11 PM during winters.

The Ghatta is environmentally sound, socially and economically acceptable, made of locally available materials and can be installed by local craftsman. Water can be used for milling and irrigation simultaneously and electricity can be generated for local use. It has higher extraction efficiency compared to traditional manual milling technique, at the same time it is time and labour savings and generates income. The milled products contain bran as well as husk that can be used as livestock feed. It changes the traditional division of labour due to the shift in agro-processing responsibility from women to men. As a result women are relieved of their drudgery and save time. Relief from drudgery by manual pounding (dhiki/janto) of grain improves women's health.

However some of the limitations include increased labour for transportation, more travel time and waiting at the mill, low output from electricity generation, and not suitable for small amounts of grain processing. Seasonal fluctuations in water flow effect the grinding. Regular maintenance of diversion channels and milling mechanism adds labour. Competition between mill owner and irrigated farmers over water use is also seen. The milling provides highly polished products of rice, which contains less vitamin. Also since most payments are made in kind it becomes relatively expensive to the farmers.



Accessories of Ghatta technology.

INDIGENOUS KNOWLEDGE ON FOREST MANAGEMENT

Communal Forest Management System

Communal forest is defined as forests with restricted access or distribution of benefits to sociologically discrete parts of a community. It is a common resource for a specific group (e.g. clan or cluster of family) but not for the community as a whole (Messerschmidt, 1992). Communal forests still exist in Lachowk Village of Kaski District, in the Western Development Region of Nepal. Lachowk villagers have been managing communal forests by using their knowledge, skills, ideas and experiences since time immemorial. A number of castes such as Thakuri, Ranabhat, Paudel and Adhikari have been practising communal forestry since Talukdar system. These forests were received from the then government by their ancestors either as gift or salary. In Lachowk village, forest management system was initiated by villagers when there was a severe scarcity of forest products.

Indigenous communal forest management system has been operating since past two generations. Each clan forest has its own management systems with distinctive rules and regulations to run the system (Bhandari and Pokharel, 1993). Villagers have been protecting forests by appointing watchers and paying them in kind or cash as salaries. Users' committee appoints required number of watchers from among users. Responsibilities of watchers include controlling illegal cutting and patrolling the forest. Villagers harvest forest products once a year, or sometimes in alternate years, on rational basis depending upon forest condition. They remove less valuable trees (kukath), hollow trees (dhodro), top dying trees (mathi sukeko), cut thorny bushes and lop lower branches of healthy trees during harvesting period which is locally known as *Godne* (weeding). Harvesting period varies from January to March especially during slack agricultural season. Small timbers for making agriculture tools and firewood are the major forest products. These products are available only for the members of a particular caste or clan who formally manage the forest.

Forests are open for dry fuel wood collection throughout the year provided no axe or sickle is used. However, in the Adhikari clan forest, bushes have been distributed among users for their exclusive use. Owners are free to carry axe or sickle and are also allow to cut bushes any time provided they do not touch others' bushes. Besides user group members, only Kamis (blacksmith) are allowed to harvest the forests. Such benefits go only to those Kamis who maintain and make agricultural tools (e.g. sickle, axe etc.) for the community.

Managing communal forest

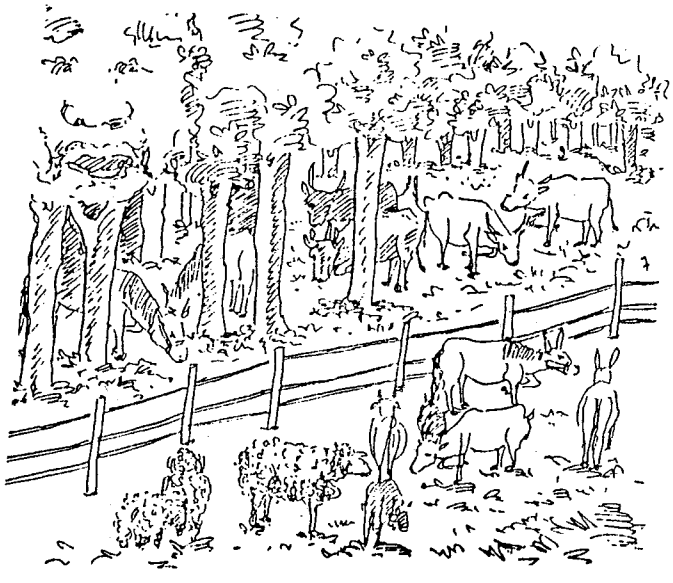
Committee asks users to send one member from each household during harvesting period. Forest products, thus harvested, are collected at one place and distributed. Standard measures, such as ten feet long rope, are used, to distribute green fuel wood among users. In Thakuri clan forest, green fuel wood is distributed according to bijan share. In Ranabhat and Adhikari clan forests, products are equally distributed among users. In Poudel clan forest, green firewood is distributed equally among users by using standard ten feet long measuring rope. However, the devotion and dedication of persons in the protection of forest is also considered at distribution time. Poudel clan forest committee has established this rule in order to get more people's involvement in forest protection activities.

Local people's participation in forest protection is guaranteed for which local organisations and resources are mobilised. The forest management practice guarantees equitable distribution of forest products, controls free grazing and promotes greenery. However, the access is restricted to a specific group or clan or cluster of families only since the forest resources are not for the community as a whole. Some times the forest resources are not properly utilised.

Forest Management in Mountain Areas

In many hill areas of Nepal, local people have gradually developed their own arrangements for protecting and regulating access to forest resources (Fisher, 1991; Khatri-Chhetri, 1993; Prasai et al., 1987; Tamang, 1990b). Review of literature indicates that indigenous forest management systems are diverse and community specific in the mountains. Many studies on indigenous forest management systems represent mid-hills and only a few studies represent Mountain areas (Furer-Haimendorf, 1975 and 1984; Messerschmidth, 1984; Gilmour, 1989; Metz, 1990). Khatri-Chhetri (1993) reports that farmers in Jomsom VDC in Mustang perceive forests as community forests, though legally they are all owned by the government. Access is controlled by local committees and forests are protected and utilised in different ways.

Indigenous forest management practices include protection and utilisation of forest products and organisational framework for implementing these activities. Khatri-Chhetri (1993) reports that in Jomsom VDC of Mustang, a committee is formed to manage equitable distribution of water and forest resources. Committee includes *Mukhiyas* (village head man), *Bhaladmi* (a morally respected person) from each ward and few *Katuwals* (messengers cum general assistants). *Mukhiya* and *bhaladmi* are normally elected for two years and they do not receive any remuneration for their services. *Katuwals* are selected from each household in turn for a period of one year and paid either by cash or by mana-pathi (one mana = about 055 litre, 8 mana = one pathi = 4.5 litres) system as fixed by the community. Committee imposes fines for breaches in rules and regulations. Violators are fined which is enforced by fear of social boycott or sanctions.



Forest management in mountain areas.

In Ghasa, Mustang farmers close to degraded areas of forests allow for regeneration (Messerschmidt, 1984). Grazing by sheep and goats are forbidden whereas cattle, horses, mules and buffalo are allowed. In Jomsom VDC, goats and donkeys are not allowed to graze. There is a traditional belief among the Thakali community that if donkeys are allowed to graze in forest, the god will be offended and landslides will occur. Cutting of live trees and branches for fodder, fuel wood or timber without a permit of the committee is prohibited, but collection of leaf litter, dead branches and short dry logs (less than 3 ft long) are allowed.

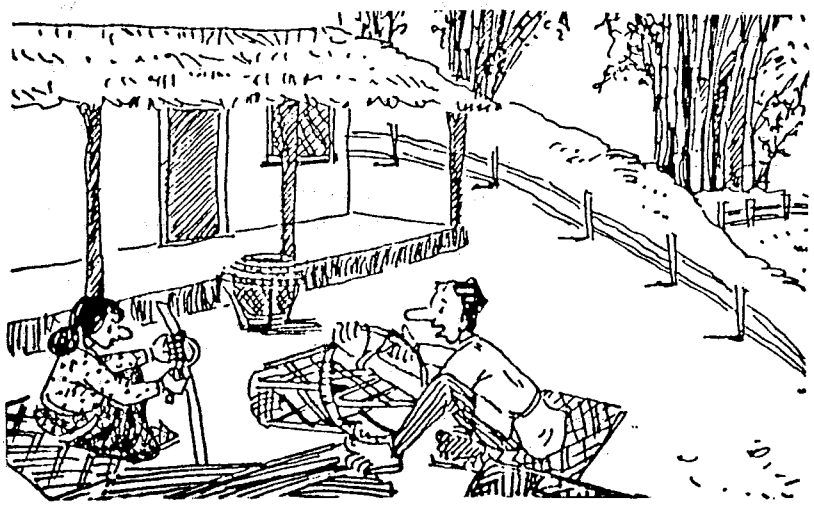
The system helps manage mountain watersheds, encourages community participation in common property management, controls free grazing, protects forest resources and promotes greenery. However, while local forest resources are managed sensibly, existing practices concentrate only on restricting access to forest products without involving any sort of silviculture practices for the optimal use of forest resources. Prevailing indigenous practices have been inadequate in mountain areas owing to very low regenerative capacity of forest, unfavourable climatic conditions, and a rapid increase in fuel wood demand.

Natural Bamboo Resources Management Technology

Bamboo is one of the most useful plants in Nepal for over 12,000 years (Poudyal, 1992). Filkins (1992) states that it is one of the most useful plants to the largest number of people in the world. Bamboo has been extensively used in about 200 different ways in basket making, construction, food, fodder, firewood, fieldwork, fences, and so forth. Shrestha and Tiwari (1992) and Upadhya (1991) report that bamboo is one of the fastest growing plants and its foliage is a popular fodder during dry season in many parts of Nepal. A study in the hill district of Dhankuta and Terai district of Morang in Eastern Nepal shows that farmers in rural areas use bamboo to fence their Aangan (yard in front of main house) and backyard of the houses, for partitioning walls as well as roofing the houses, and also as fuelwood and fodder (Das and Seeley, 1996). Similar uses of bamboo can be seen in Baglung and Parbat districts also.

Bamboo helps in soil and water conservation also. It is one of the most suitable plants for soil conservation along riverbanks, roadsides, periphery of landslides, gullies, gully heads and other areas prone to erosion. Rural people have planted bamboo in such erosion prone areas (Poudyal, 1993). People also generate cash income by selling bamboo products like *doko/dalo* (baskets), *mandro* (mattresses), *nanglo* (shallow flat trays), *bhukari* (storage structure) etc. or bamboo clumps directly. These bamboo based

products are used for different purposes in day-to-day life such as for carrying goods, grain storage structures, mattresses for drying grains, and so forth. Bamboo is also used for scaffolding, fencing, as construction materials for houses and its tender shoots are used as vegetables.



Bamboo basketry: Income generating source for the small holder.

People in Nepal have developed their own indigenous methods of managing natural bamboo resources for many centuries, depending on their requirements. Bamboo shoots start sprouting with rainy season and harvesting is banned during this sprouting season. Some shoots may, however be harvested for use as vegetables and making pickles. Grazing is controlled during this season (Poudyal, 1993). Dead stumps, fallen branches, vines and shrubs or any other dry woody materials are removed from clumps during dry season. Farmers excavate rhizomes of a young bamboo located at the periphery and trim above a few branching nodes. This is then transplanted for propagation. Villagers harvest bamboo in October/November (*Kartik*) and during dry season. In this season, moisture content of bamboo is lower than in rainy season, thus making bamboo lighter in weight. During dry season, it is easier to season and sun-dry the bamboo clumps. People harvest bamboo by cutting at its base. They believe that its rhizome will produce new shoots in the next sprouting season if cut in this way.

Moisture in bamboo wall contains starch, sugar etc. and termites feed on this. So to protect bamboo from borers, villagers have adopted the following methods: a) Bamboo is stored directly above fire place for smoke seasoning. In this, bamboo is cut into short lengths, bundled, and then hung above fire place. People believe that bamboo seasoned by this method will be more durable. b) Freshly harvested bamboo is immersed in a pool of water for about three days so that starch contained moisture will be flushed out of bamboo. It is, then dried in sun. c) People harvest bamboo on the dark night of *Kartik*. As they believe that bamboo harvested on "no-moon day" of *Kartik* will not be attacked by borers.

Bamboo is smooth, clean, straight, hollow, light, hard, strong, pliable, elastic and it bends and splits. With these great many natural qualities, it can be used for many different ways. Harvesting cycle is short because of its fast growth and short maturation period. It regenerates naturally. It is easy to transport and handle. Network of underground rhizomes bind and stabilise soil, thus controlling erosion. It can be used in hundreds of ways using simple technology. It is a fuel and timber for smallholders and generates cash income for others. Tender shoots can be used as vegetable for human and leaves as fodder for animal. However, it is highly susceptible to borers attack, has a negative effect on crops at its peripheral areas, occupies considerable space and dries out soil around them. So smallholder can not afford to grow it at the expense of food crops.

Indigenous Knowledge on Farm Tree Plantation

Fodder trees plantation in bari land (uplands around houses) is the age-old practice in Nepal. Knowledge of tree plantation has been transmitted from one generation to next, and new ideas and skills are added in every generation. Farmers learn from their ancestral experiences. Farmers' knowledge on appropriate tree species, their propagation, management and tree-crop interaction is crucial to ensure maximum complementarity and least competition between various components on farm. Studies show that tree species that exist on private lands are usually not the relics of natural forest, but have been planted quite independently of any inputs by the Government agencies or NGOs (Carter, 1991; Carter and Gilmour, 1989; Messerschmidt, 1984; Robinson and Neupane, 1988; Rusten, 1989).

Fodder trees are mostly found planted on the sides and dykes of plots and around the homestead. According to farmers, seedling plantation should be done at the beginning of monsoon. Farmers argue that if plantation is done at the first monsoon rain, root develops at its beginning itself and plant growth will be much better during the first monsoon. While planting, farmers prefer large seedlings to the normally available seedling in nurseries. Farmers

believe that large seedlings grow faster and in a short time, attain height that is out of the browsing reach of livestock. Some indigenous plantation techniques practised by farmers in Nepal, are as follows:

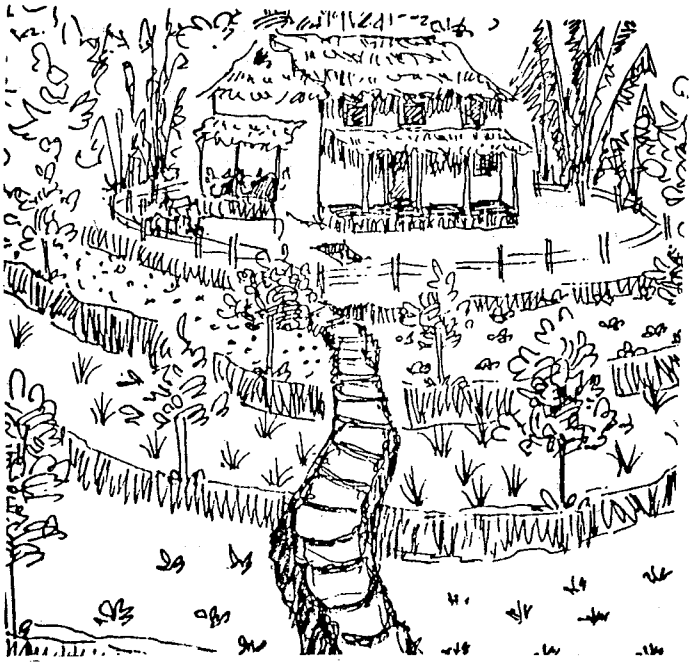
1. Many studies show that farmers mostly look on the trees that originated in situ. Tree species from in-situ natural regeneration are preferred and protected. Trees originated from in-situ or surrounding land or forest areas are collected and planted.
2. Planted as cuttings. Farmers prepare propagule by wood cutting (Devkota et al., 1995). Wood cutting is a very common practice and one of the traditional techniques not known to professionals (Pandey, 1982; Robinson and Khatri-Chhetri, 1990).
3. Sown as seed in beds or moist areas and transplanted.
4. Planted after rooting by air-layering (Robinson and Khatri-Chhetri, 1990).

The local methods of tree propagation are simple, low cost, well adapted to local conditions, and use locally available resources. They help supply fuelwood and fodder as well as conserve soil and reduce soil erosion.

Agroforestry Systems

Farmers in Nepal have developed complex agroforestry systems on their private lands. Studies indicate that farmers have a wealth of knowledge about tree species, their uses, and the way in which they can be manipulated to their best advantage in any particular situation. Farmers have been actively promoting trees on their farms owing to decreasing availability of required forest products and the increased demand for fodder.

Pandey (1982) estimated that in the hills, about 30 % of total feed is supplied by fodder trees for farm animals. Gatenby et al. (1989) reported that about 60 % of feed given to buffaloes in the Koshi hills is tree fodder. Shrestha and Tiwari (1992) reported that more than 170 tree species are used for fodder out of which 30 are used extensively.



Agro-forestry system

According to Sharma (1985), about 70 varieties of fodder trees are used as feed for ruminants. Similarly, Robinson and Thompson (1989) reported that over 100 species of trees and shrubs are being used for fodder in Nepal. The commonly grown fodder trees are locally called: Badahar (*Artocarpus lakoocha*), Tanki (*Bauhinia purpurea*), Kavro (*Ficus lacor)*), Khanyo (*Fecus semicordata*), Koiralo (*Bauhinia varegate*), Ipil-ipil (*Leucena leucocephala)*, Bakaino (*Melia azedarch*), Dabdabe (*Garuga pinnata*), Dumri (Ficus glomerata), Gidari (*Premna integrifolia*) , Khamari (*Gmelina arboria*), Kimbu (*Morus alba*), Kutmiro (*Litsea monopetala*), Nimaro (*Ficus auriculata*), and so forth (Baral et al,. 1988; Karki and Gold, 1992; Devkota et al., 1995; Pandey and Neupane, 1995). It is reported that Badahar is the most preferred species by farmers followed by Khanyo and Kavro. While giving preferences for fodder species, farmers consider the following factors- 1) foliage production, 2) fast growth, 3) nutritive value, 4) multi-purpose uses, 5) side effect on agricultural crops, 6) palatability and dryness of fodder, 7) disease resistance, 8) milk and fat production, 9) ease in lopping, 10) time and frequency of lopping, and 11) suitability for plantation on dykes (bunds) and marginal lands (Devkota et al., 1995; Pandey and Neupane, 1995).

Farmers grow 15 to 20 fodder trees per farm depending on farm size and livestock number (Pandey and Neupane, 1995). Farmers have given peculiar Nepalese words to represent different fodder types such as *Chiso* (wet), *Obano* (dry), *Garmi* (hot), *Sardi* (cold), *Rogi* (unhealthy) and *Nirogi* (healthy). According to farmers' classification, fodder like Badahar, Tanki, Dabdabe, Kalo Gindari (*Premna bengalensis*), Koiralo, Kutmero and Kavro are grouped as *obano*, and Khamari, Nimaro, Dumri and Bakaino are grouped as *chiso* fodder. *Chiso* fodder is often considered to be of poor quality and usually mixed with straw or other *obano* fodder while feeding livestock. These fodder, if fed alone, choke and cause livestock to produce watery dung (Rusten and Gold, 1991). On the other hand, the farmers' experience is that *obano* fodder

are the best and have the following advantages: a) lead to the production of firm and relatively dry dung without causing constipation, b) improve livestock health, and c) contribute to higher production of milk and fat both in quantity and quality.

Farmers lop fodder trees, generally in lean period during winter. However, there exists a wide variation with respect to the time and frequency of lopping (Pandey, 1982; Pandey and Neupane, 1995; Pokharel et al., 1995). Owing to the shortage of fodder during lean period, farmers also make concentrates with the ingredients like rice bran, maize grits, mustard cake, pumpkin, etc. for feeding animals. Pandey and Neupane (1995) report that farmers of Baglung and Parbat districts pay up to Rs. 500 (exchange rate US$ 1 = NRs. 67 in Jan., 1999) for one clump of bamboo per year for leaf fodder, whereas farmers of Lamjung, Tanahu and Kaski districts either do not feed bamboo at all or feed only a little to ruminants only as they believe that bamboo causes abortion and reduces production.

The farm tree plantation makes agricultural production system more sustainable by supplying fodder and fuel wood. It helps stop destruction of forest resource base, improves soil and nutrient recycling, and promotes soil conservation. It also generates income for cash-strapped farm families and reduces risk of crop failure by diversifying land use and farm produce. Thus it environmentally sound and culturally accepted by farmers. The techniques used are relatively simple, inexpensive and lie within the capacity of small farmers. However, if not designed properly, it can have adverse competitive effect on agricultural crops.

Indigenous Pasture Management Systems in High-Altitude Areas

Pasture lands are defined as those communal areas that are exclusively set aside for grazing of domestic animals, with their access and use-managed and regulated primarily by local communities (Rai and Thapa, 1993). Most pasture lands in Nepal are public land areas. High altitude stock-farmers have developed effective indigenous pasture management systems to suit the existing conditions of local pasture lands. Many researchers have reported different types of indigenous pasture management systems in operation in Nepal (Furer-Haimendorf, 1954; McDougal, 1979; Messerschmidt, 1974; 1987, 1990a; Molnar, 1981; Sherpa, 1988). Among different regions and communities in the country, there are different types of indigenous pasture management practices. The herders have evolved complex arrangements to protect and regulate access to pasture lands. Local community level organisations define rights, promulgate rules and enforce sanctions relating to pasture management (Rai and Thapa, 1993). However, indigenous knowledge for pasture management varies from group to group and from area to area, depending on particular local conditions, particular responses to problems, and extent of geographical and social isolation from adjoining groups (Rai and Thapa, 1993). Some indigenous practices for pasture management that are popular among high altitude herders of Nepal are given below.

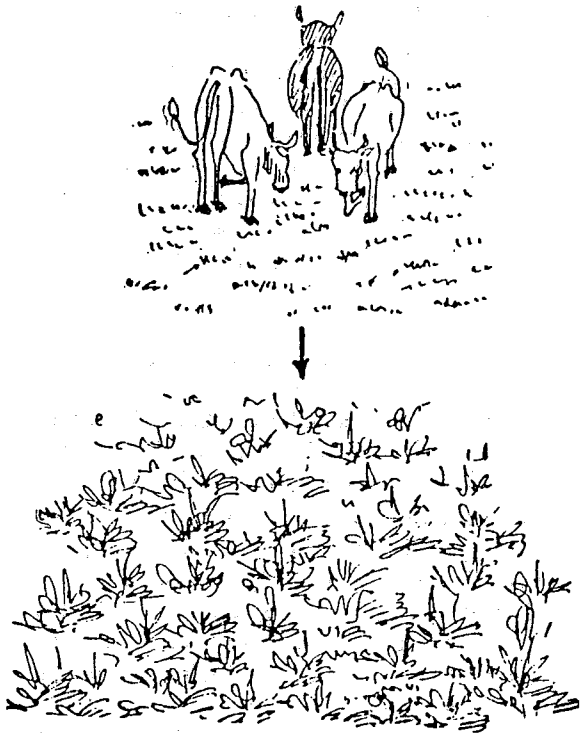
Pasture Management by Religious Beliefs

Indigenous knowledge systems are often embedded in religious belief and ritual. In Khumbu, the Sherpa practice of ceremonially imposing restrictions on access to grazing in particular pasture areas for specified periods, in a way protects critical winter grazing lands for the duration of growing season (Brower,1987, 1990). Similarly, Fisher et al. (1989) reported that villagers in Sindhupalchowk region observe a land-related propitiatory land worshipping ritual (*Bhumi Puja*) to signal the beginning and end of access to pasture lands.

Gurung (1987) reported that Magar herders of Tara village move their livestock towards high pastures only after they perform a ritual called "*bansorakni*". Following the ritual, all heads of households in the village come together to make various decisions on natural resources use for the coming year. Villagers occasionally set aside areas of privately owned cultivated lands for return to pasture, which is sometimes carried out, according to Dhungel (1987), in the memory of dead by performing a ceremony called "broadcasting of salt" (*Nun chharne*).

Pasture Management by Seasonal Restrictions

One popular form of indigenous pasture land management is by severe restrictions imposed on certain pasture areas according to local conditions. Fodder and forage are extracted from different sources (pasture land, forests, crop residues and fodder trees on cultivated lands) at different times in the year. Grazing is generally carried out during monsoon months (June-September), and fodder is collected from forest during monsoon and spring (January to March). As the fodder availability is most limited during the winter (November to January), residues are fed to animals during these fodder deficit months (Riley, 1991). In Thuli Kharka (Solokhumbu), access to certain pasture lands is restricted during winter months when large amount of fodder is needed (Gibbon et al., 1988). The grazing right system in high altitude forest on Chyo Chyo Lekh (Sindhupalchowk) excludes human and livestock activities for most part of the year (Schmidt-Vogt, 1988) for recovery.



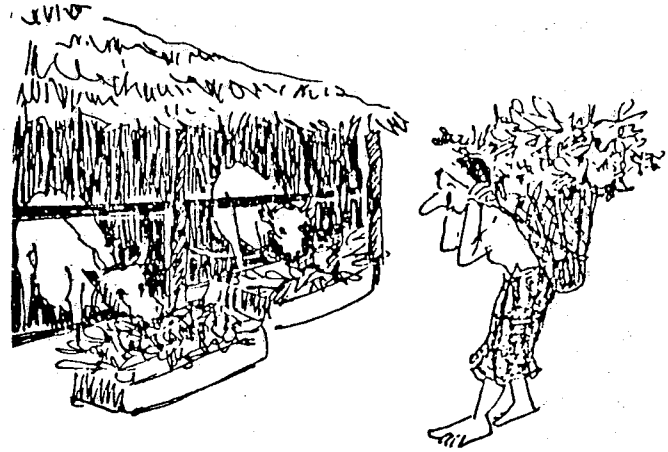
Rotational grazing practice

Pasture Management by Rotational Grazing

Herders of the Northern areas of Nepal follow a rotational grazing, whereby the animals are regularly moved from one pasture area to another. Herders realise that such a rotational grazing protects the pasture lands from overgrazing and increases forage production (Rai and Thapa, 1993). Badoux (1959) reported that rotational grazing is a popular means of pasture management in the higher regions of Nepal. In the Rhodung (Solukhumbu) area herds followed a well established pasture rotation.

Pasture Management by Harvesting Indigenous Grasses and Legumes

Local herding communities have managed and harvested indigenous grasses and legumes for centuries. The hay and browse collection practice was a popular traditional practice among herders in the Northern regions of Nepal (Rai and Thapa, 1993) where the Yak herders harvest native grass for feeding livestock in the winter (Dutt, 1985). Similarly, the Shrepas of Mt. Everest region maintain native hay meadows at elevations up to 4,500 m amsl. The Thakali of Mustang make hay from the grass that grows along the edge of the fields which is generally *Pennisetum flaccidum*. Villages in upper Mustang raise a native legume, *Medicago falcata*, for supplemental winter feed.



Stall feeding system

Pasture Management by Setting Fire

Another indigenous technique of pasture management is to set fire to the pasture areas during the dry season (Alirol, 1979; Gurung, 1987). Farmers believe that burning clears dead organic matter, promotes the re-growth of green matter, and eradicates parasites (Niamir, 1990). The carrying capacity of local pasture areas is also considered by the local communities. In Dolpa area, the herding households maintain only as many animals as quantity of winter fodder can feed (Sherchan, Riley and Yoshida, 1990).

Setting fire on pasture land

The practice has organisational measures and social control mechanisms, which minimise the risk and maximise the benefits and a scientifically sound techniques of pasture management. The rotational grazing practice increases forage production. However, the system is very complex and relatively weak in biological conservation. Soon after the fires, rains also cause soil erosion.

INDIGENOUS KNOWLEDGE ON INTEGRATED PEST MANAGEMENT

Farmers in Nepal have been using their own indigenous knowledge and practices to protect agricultural crops, and other plants from pest and diseases. These knowledge and skills have been the result of years of observation, experience, trial and error imposed by the need to survive with the available resources under various stressful and unfavourable environmental conditions. According to Gyawali (1993), more than 50 species of plants and indigenous techniques have been used in Nepal to help protect field crops and reduce pest damage losses in stored grains successfully. Farmers express that harvesting during dark moon period minimises insect/pest infestation. The parts of Neem (*Azadirachta indica*), Marigold (*Tagetes erecta*), Titepati (*Artemesja vulgaris*), etc. are also used against pests. Many farmers are also using crop residues and stubble for pest control through mulching. Litsinger and Ruhendi (1984) report that the use of rice stubble and straw mulching suppresses pest in cowpea (*Vigna unguiculata*). All these indigenous technologies are socially accepted, economical and environment friendly.

Crop Insect/Pest Management

Use of Local Variety and their Mixtures

In the hills, farmers still use local varieties in spite of government efforts to promote and introduce improved varieties. According to farmers, local varieties have field tolerance to diseases and pests and have ability to produce even under water stress during the growing season. To quote an example from the hills, some farmers experience was that the introduced improved varieties of tomato suddenly collapsed and failed to produce fruit due to late blight disease, where as local varieties survived and produced smaller, round and cherry type fruits satisfactorily (Budathoki et al., 1993). Farmers also minimise the spread of disease by planting a mixture of crop varieties. They express that when garlic, onion, carrot, ginger, coriander, etc. are inter-planted with other vegetables, the attacks by feeding and sucking insects are reduced (Pandey, 1993).

While all these are low, simple and familiar practice to farmers, use locally available seeds and seedlings and minimise risk of failure, most production systems are low in productivity.

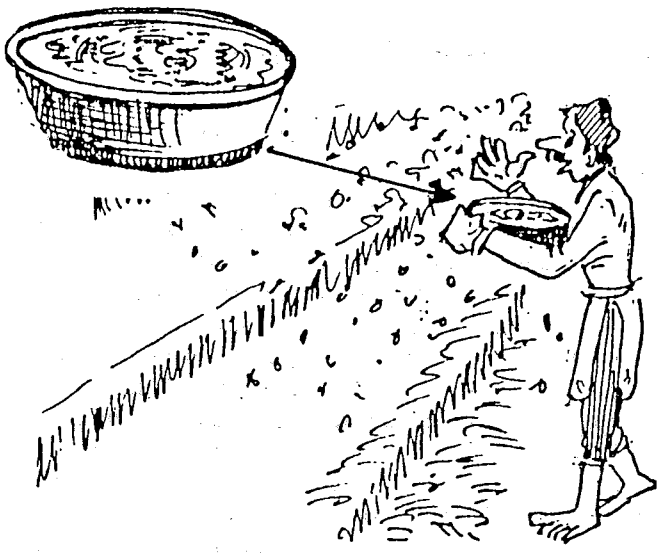
Application of Ash

Farmers apply ash from wood, rice husk, straw, maize stubble, and cobs, cow dung cake and other farm yard products to protect vegetable crops from small sucking insects like aphids on cowpea, cabbage and cauliflower. Gyawali (1993), Budathoki et al. (1993) reported that application of fine wood ash early in the morning to protect leafy vegetables and winter beans is a common practice. Farmers claim that using this method, damage caused by aphids can be avoided to a large extent. The reasons may be that ash applied early in the morning soaks in to the dew and forms a layer on the leaf surface. Small insects get trapped, suffocate below this layer and are possibly killed. The second reason may be the physical disturbance to insects feeding on plants due to the presence of a layer of ash. It also controls insect pests like maggots, cucumber beetles and leaf miner (Raymundo and Alcajar, 1983a) and also effective against mildew (Rankin 1985), odium and rust.

Farmer applying ash in a field.

Cow Dung Slurry

In rural areas, fresh cow dung is frequently used for house cleaning. Fresh dung is mixed with water to make a slurry, which is then applied, to the ground floor and walls of a house. Some farmers apply this slurry to threshing floors also. This serves as a disinfectant against pathogens like bacteria and fungus as well as an insect repellent for housefly and mosquitoes. Farmers believe that the use of cow dung slurry can protect crops from aphid attack and also act as a repellent to cutting and biting insects and animals (Budathoki et al., 1993). According to Gyawali (1993), farmers apply cow dung slurry to standing crops like rice, wheat, garlic and cabbage to protect them from insects, and from damage by freely grazing animals (cattle, goats and sheep).



Application of cow dung slurry and cattle urine in a field.

Cattle Urine

Farmers believe that cattle urine is very effective as a pesticide for kitchen garden plants. They report that use of diluted urine on plants and seedlings keeps crops clean and relatively free from many diseases and insect/pests, especially the Brassica species. Lohar and Budathoki (1992) reported that cattle urine applied on board leaf mustard (*Brassica compstris*) has significantly reduced powdery mildew diseases. Cattle urine has also been successfully used against thrips, mites and fungal diseases (Peries, 1986), aphids and caterpillars (Rankin, 1985), and viral diseases.

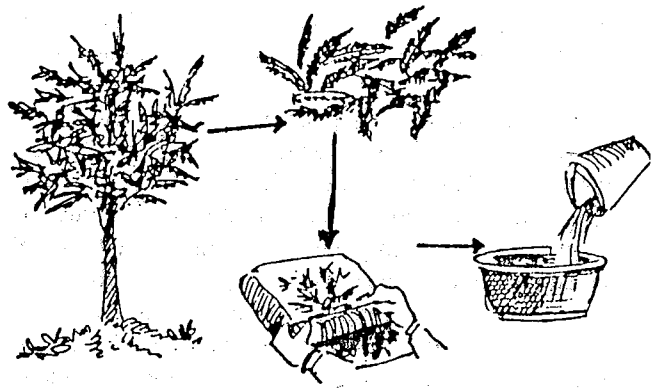
Neem (Azadirachta indica)

The use of Neem extract, its seeds or leaves or any other part of the plant as pesticide has been known for hundreds of year. The leaves, stems and fruits of Neem trees are generally used against pests. The different parts of Neem trees can combat rice pests and diamond black moths (Saxena, 1984; Saxena et al., 1981; 1988). Farmers report that use of Neem effectively controls the potato tuber moth in stored potatoes. As mentioned by Stoll (1987), there is a long list of insect pests and diseases that can be controlled and prevented by Neem. Neem trees are grown much more widely in semi-arid and light soil regions. It grows fast and within a few years starts bearing fruits. It has not become a crop for agro-forestry systems as yet. During drought when most crops fail, Neem tree survives well and in fact its leaves are used as stress fodder for livestock. There is no other crop that is so sturdy, requires so little inputs and yet offers so much economic gains.

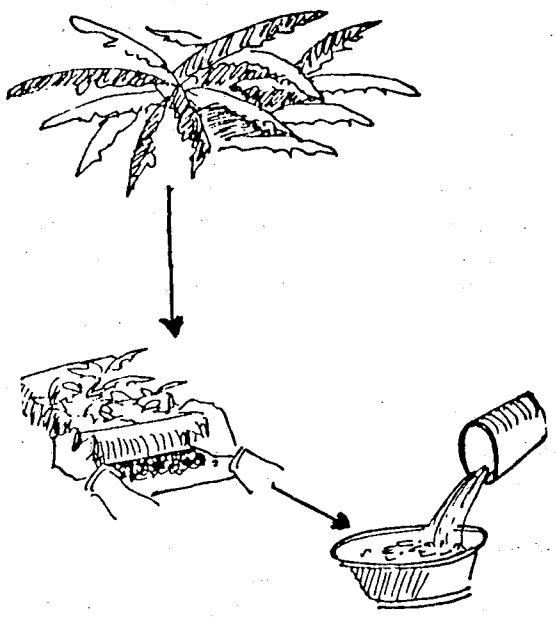
It is a herbal medicine, can grow on marginal and wastelands and each and every part of it (root, stem, bark, leaves and seeds) is useful in one way or the other. However it is not a preferred fodder and its wood quality is not good for timber.

Tobacco

It is reported that tobacco can both prevent and control many insects, pests and diseases of crops and vegetable plants. It can control insects such as caterpillars, beetles, stem borers, leaf miners, aphids, thrips and those which hibernate in soils like cutworms (Conacher, 1980), diseases like kasahui fungus of potato (Harve, 1981) and rust in beans. It also prevents leaf curl virus. According to Pandey (1993), tobacco leaf extract and washing soap solution are sprayed against smaller sucking insects such as aphids.



Making pesticides from Neem tree



Making pesticides from tobacco leaves

Gyanwali (1993) reports that tobacco decoction is used for insect pest control in vegetable crops. Farmers in rural areas use *hukka* (smoking water pipe) in which tobacco leaves are ignited and then the smoke is drawn through the water. This water is then used against some sucking insects/pests such as aphids, hoppers, mites and lepidopterous larvae. Farmers have, particularly utilised this indigenous technique for the suppression of insects/pests associated with vegetables. For larger areas, farmers soak the dried tobacco leaves in water for one or two days and then the decoction is applied to crops using local brooms made of grasses.

Use of Plant Extracts

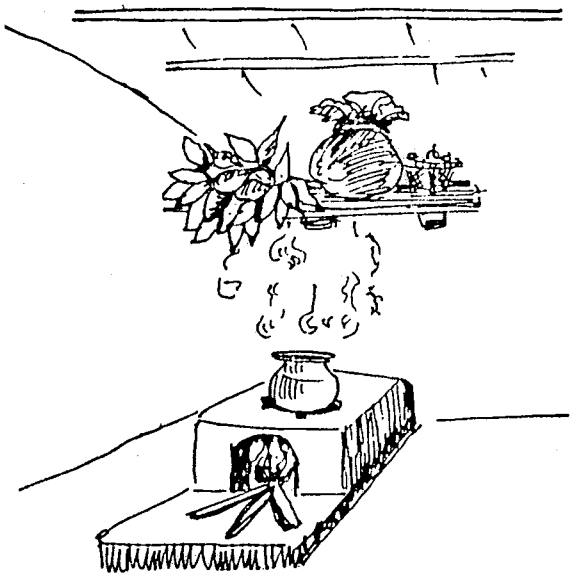
Farmers use the extracts of plant parts and fruits to control a wide variety of insects, pests and diseases. It is reported that the extract prepared from the parts of Sisnu (*Urtica species*) plants and fruits of Timur (*Zanthoxylum armatum*) plants is used to control many kinds of chewing, biting and cutting insects, like the larvae of cabbage butterfly, hairy caterpillars, red ants and termites (Budathoki et al., 1993). Garlic clove extract and kerosene are used for caterpillars, cut worms and aphids. Leaf and leafy extracts of china berry (*Melia azadaracht*) are also used to protect against various kinds of insects. According to Pandey (1993), about 5 to 10 parts berries or leaves are soaked overnight in water, then they are ground and the paste is mixed in 100 parts water and used as spray. The dry leaves that fall on to the field also work as a natural insect killer and repellent. Most vegetable producing areas in the Kathmandu valley have china berry trees on the bordering bunds of the fields.

Insect/Pest Management in Grain Storage

Grain Storage near Kitchen

The majority of farmers in the mid-hills and high mountains have developed a traditional package of practices for storage. Cereals and other food grains are stored in places where the smoke of burning fuel wood penetrates. This smoke produces carbon dioxide (CO_2) and carbon monoxide (CO) gases that suppress the infestation of insects/pests in the seeds (Gyawali, 1993). Farmers' experience is that places where these gases do not penetrate are vulnerable to pest infestation. This indigenous technology has saved millions of dollars worth of pesticides required to protect food grains in rural areas of Nepal.

The practice is low cost appropriate technology, good for seed storage and represents best use of kitchen smoke. However, the practice is not effective and possible for large storage.



Storing grain above the fire place in the kitchen

Grain Storage with Neem(Azadirachta indica) /Tulasi (Ocimum basilicum) Leaves

In rural Nepal, grains are also stored with the leaves of Neem or Tulasi (*Ocimum basilicum*). After spreading the leaves from top of the storage structures, it is closed. The smell of these leaves keeps the insects/pests away from the structures.

Grain Storage with Wood Ash

Farmers believe that the wood ash is effective in controlling pests in stored grain. It is specifically used in seed storage. The ash is mixed with grains and sometimes applied on top of the stored grains based on the extent of infestation, quantity of grain and storage structures. The method is very economic and used locally available materials. The seeds and grains do not get chemically contaminated and the ash can be easily separated from grains. However it is good for small capacity storage so that fuel wood required is not too large.

INDIGENOUS VEGETABLE PRODUCTION SYSTEMS

Indigenous Knowledge on Local Vegetables

Nepalese farmers grow most of their household vegetable requirement themselves. Budathoki et al. (1993) reported that in the hills of Western Development Region (WDR) in Nepal, farmers cultivate 34 species of local vegetables. Local vegetables have been adapted to the local conditions and their management developed by the people. They can easily tolerate unfavourable situations such as prolonged drought or rain, disease and pest outbreaks, poor soil fertility, etc. better than improved vegetables. Consequently, local vegetables never fail completely.

Almost all the locally cultivated vegetables are either herbal or climbers. In low and mid-hills, fruits are the most commonly used plant parts whereas in high hills, green leafy vegetables constitute the majority. Hill farmers also consume dried seeds of legumes as vegetables. They have developed techniques of lengthening the storage life of local vegetables in order to ensure supplies during periods of scarcity. The practices used include sun drying (dried vegetables locally called sinki, maseura i.e. mixture of pulses etc.), or ensiling followed by drying (gundruk i.e. dried vegetables) of vegetables such as broad leaf mustard, radish, colocasia, bittergourd, tomato and sun-drying of legume seeds. Vegetables are also pickled for off-season as well as normal seasonal use.

Making Gundruk and Maseura from local vegetables

These vegetables are very suitable for subsistence hill farmers as they have minimal risks of failure. Also they fit the Nepalese hill cropping systems (mixed, inter and relay cropping) well. The seeds and seedlings are locally available since due to high cost of transportation in the mountains it is very difficult to get seeds that are not produced locally. These vegetables have multiple use and are disease tolerant, pest resistant as well as can withstand the other unfavourable conditions. However their productivity is lower.

Buk Method of Potato Farming in the High Hills

Potato is primary staple food for people of the high hills. In areas above 1,800 m elevation in Ramechhap, Dolakha, Solukhumbu, Okhaldhunga and Khotang districts as well as neighbouring regions, farming is mostly fallow-based, and farmers cultivate potatoes on natural slopes on a four to six years fallow cycle, using the "buk" method (Dhakal, 1993). Local variety red potato grows successfully under this practice. Farmers have discovered through experience that it has a high resistance to insects, high yielding, and good storage qualities in comparison with other varieties. Some farmers mention that this variety is resistant to drought and some diseases and that it has good cooking qualities.

Buk method of plot preparation starts in November, seeds are sown in January/February, and harvesting is done in July/August. First, farmers slice the vegetated (by local weeds) soil and place it in to piles (known as buks). Usually four to eight piles are formed. Dubo (*Cynodon dactylon*) serves as the best vegetative ground cover for making buks. Piles of dried surface soil slices are then burnt using a piece of dried cow dung to help ignite fire. Then, individual potato seeds are sown into the piles and are left to mature without addition of any organic matter or fertiliser. Farmers use their own source of seeds that are stored locally. Seeds can be successfully stored for a year using local method of keeping them on simple slatted shelves or on the floor. Farmers usually grow several plots of potato together and then move to another area after one harvest. As plots are planted on a group basis, there will be no problems of fencing or protecting them from animals or people. Generally, male farmers do the slicing of land and women farmers collect slices into piles, burn them and sow the seeds. Labour exchange (Perma) system is quite common but sometimes labour is hired and paid in cash or kind (Dhaka, 1993).

No additional manure is required. Nutrients are recovered during fallow period. Chemical fertilisers, insecticides and pesticides are not used. Also inter-cultural operations are not necessary. It is also a model of social fencing. As groups of people

plant in an area, they co-operate with each other to protect the plots. Fallow period serves the purpose of rotation. The practice of burning prevents soil borne diseases. Family members usually fulfil labour requirement. The potatoes so harvested are tasty, disease free and have good cooking and storage qualities as well as produces high vigour seeds. The potatoes receive a good price (in areas accessible by roads) due to their popularity. However, open and intensive grazing by livestock on buk farming plots hinder growth of surface vegetation required to for buk preparation. Thus requiring a longer fallow period. Since harvesting is done in July/August (peak rainy season), potatoes can get spoilt easily.

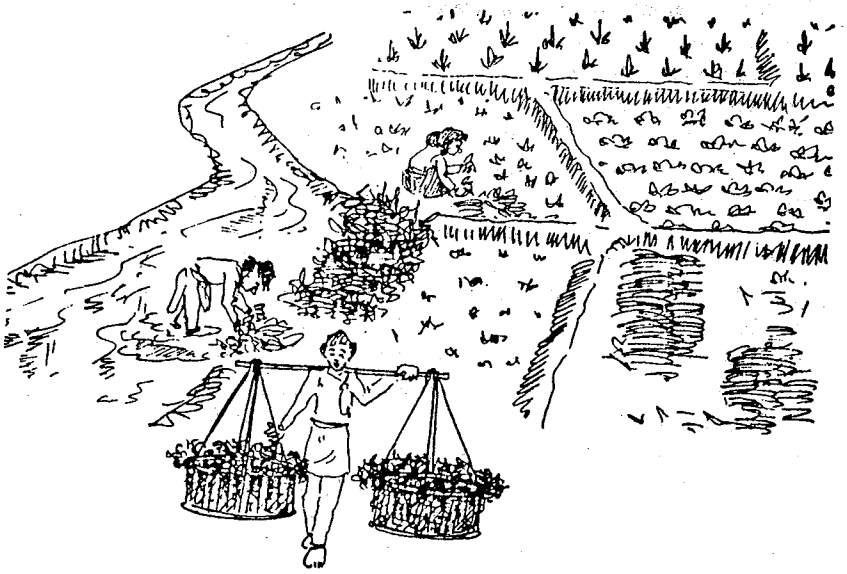
Preparing buks and planting potatoes

Jyapoo Method of Vegetable Production

Jyapoos are a farming community in the Kathmandu valley, well known for their skills in vegetable production. They have developed sustainable indigenous methods of vegetable production many years before the introduction of modern agricultural planning and technologies in Nepal (Pandey 1994). They supplement their agriculture production with other traditional activities. They weave and wear their own homespun cloth. They make their own pots and bricks. Methods developed by Jyapoo farmers are not the result of one year or even one decade. Techniques were developed, refined, and adapted through the centuries. Knowledge and wisdom has accumulated from the experiences of scores of Jyapoo farming families.

Jyapoos usually have only 1000 to 1500 m^2 of land per family and produce almost all types of vegetables. They maximise production by mix-cropping several vegetables concurrently. Relay cropping, inter-cropping, and meadow cropping are other very common practices of Jyapoo farming. Indigenous vegetable production techniques of Jyapoos include heavy use of compost, raised soil ridges, and deep drainage furrows. Jyapoo farmers divide field into smaller sunken plots and sub-plots by making sunken and raised beds. Width of beds varies from 1-1.5 m. Beds and ridges are made across the field length. Traditionally, they use human excrement as an important source of organic manure for vegetables. Another traditional source of organic matter for the Jyapoos is the black-clay that is dug out from beneath the fields and spread over the cultivated surface. Jyapoos believe that good compost nourishes and protects crops from disease and pest attack.

Jyapoo farmers maintain and produce seeds for their own use. Most Jyapoo seed stocks are quite superior to the stocks developed by the national institutes and the government firms (Pandey, 1994). However, they do not produce vegetable seeds for commercial purposes. They express that when raising a good seedling is half of the cultivation work. They locate seed beds for nursery as close to their home as possible. They prefer short duration vegetable varieties and plant field bunds with coriander. They harvest vegetables based on crop parts to be used for consumption as per crop type. Vegetables after being harvested, are cleaned by removing diseased, rotten, and unusable parts. Leafy green vegetables are



Jyapoo farmer carrying vegetables in Kharpan for marketing

trimmed, bundled and each bundle is tied with a moistened straw. Vegetable bundles are then piled into a pair of baskets suspended on a pole with the support of ropes and carried to market hanging across the shoulders. These hanging baskets (locally called Kharpan) are the traditional carriers of Jyapoo farmers.

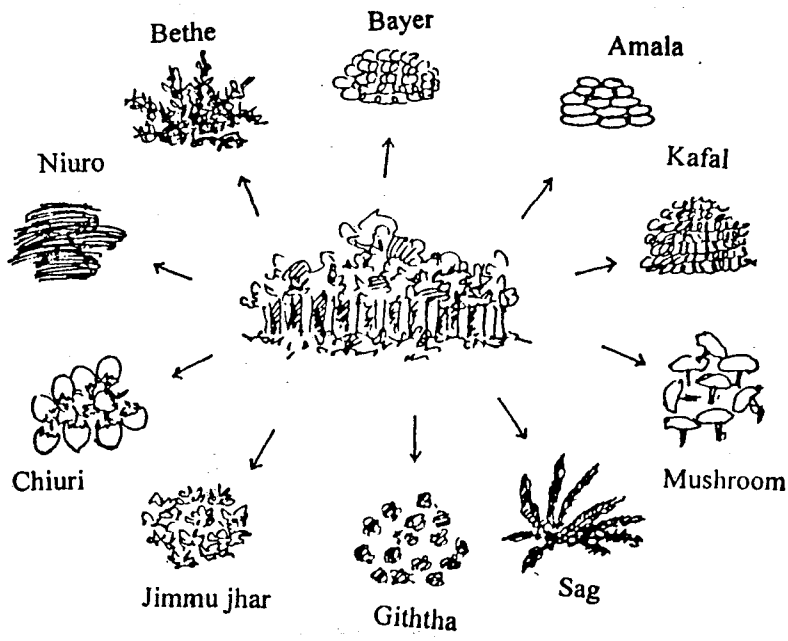
The method minimise the risk of crop failure, maintains soil fertility and prevents disease and insect spread. It employ family labour while transportation by Kharpan minimises the risk of bruising and spoiling fresh vegetables. Self sufficiency in terms of seed, compost, tools, labour, transport and marketing is hell mark of the Jyapoos. The production system is very sustainable and generates high income. However, the use of fresh night soil as manure is dangerous to human health.

Wild Ethno-vegetables and Fruits

Wild plants have been sources of food and medicine from the dawn of human civilisation. The improved and better varieties of today's fruits, vegetables and crops have been derived from indigenous knowledge and technologies of ancient village people on wild plants. People have been using wild plant sources during months of food scarcity. These indigenous wild plants are eaten in different ways depending upon the locality and community (Manandhar, 1989). In the hills of Nepal, many wild plants are used as food, vegetables, fruits, medicines, pickles and spices. The plant parts used are rhizome, root, tuber, leaves, tender twigs and bark. Budathoki et al. (1993) report that hill people in Western Development Region (WDR) consume about 60 species of wild plants as vegetables. Most of the wild vegetable plants are herbaceous, and their tender shoots and leaves are eaten.

Numerous wild vegetables are also being consumed by different ethnic groups in the Terai region of Nepal. The Tharu and Chepang communities in Chitwon are engaged in collection and use of these vegetables (Adhikari et al., 1995). It is reported that people from Meghauli and Kabilas VDC in Chitwon have been using 93 different wild vegetables for consumption. A study in Saktikhor VDC of Chitwon shows that Chiuri is the most preferred tree species by Chepang and contributes greatly in the lives of farm families. However in poor groups, Gittha and Bhyakur contributes the most. Women and children have greater role in wild vegetable collection, preparation and selling. The local names of some of the wild vegetables and fruits are listed in the foot note[1] (Source: Farmers Mr Bhagi Rath Kandel and Mr Yam Prasad Sapkota of Baglung and Chitwon Districts, respectively).

The leaves and tender shoots begin to grow in the spring season. Harvesting starts from February/March (Phalgun) in the lower hills and continues up to August/September (Bhadra) in the high hills. The frequency, time and quantity of harvest depend on the altitude. According to Budathoki et al. (1993), in lower hills (1000 to 1800 m amsl), wild species used as vegetables are found around the



Wild vegetables and fruits

[1] *Vegetables:* *Baanko, Ban Fapar, Ban Tarul, Bethe, Bhyakur, Giththa, Gholtapre, Hal-hale, Jhuse Karela, Jibre Sag, Jimmu Jhar, Karkalo, Kukur Dainu, Kurilo, Lahare Sag, Latte Sag, Lunde Sag, Nimaro, Niuro, Patke Chyau (Mushroom), Pindalu Colocossia), Siplican, Sisnu, Simal Tarul, Sital Chini, Tama (Bamboo shoot), Timilo, Tusa (Nigalo shoot), etc.*

Fruits: *Amala, Ainselu, Ban Kera, Barro, Bayer, Chiuri, Chutro, Gol Kankri, Imili, Jyamuna, Kafal (Kyun / Haade Kafal), Katus, Khanyo, Kusum, Kyamuna, Labsi, Narkat, etc.*

Pickles: *Amala, Bayer, Chulthe Amilo, Imili, Kavro, Koiralo, Labsi, Pudina, Tama, etc.*

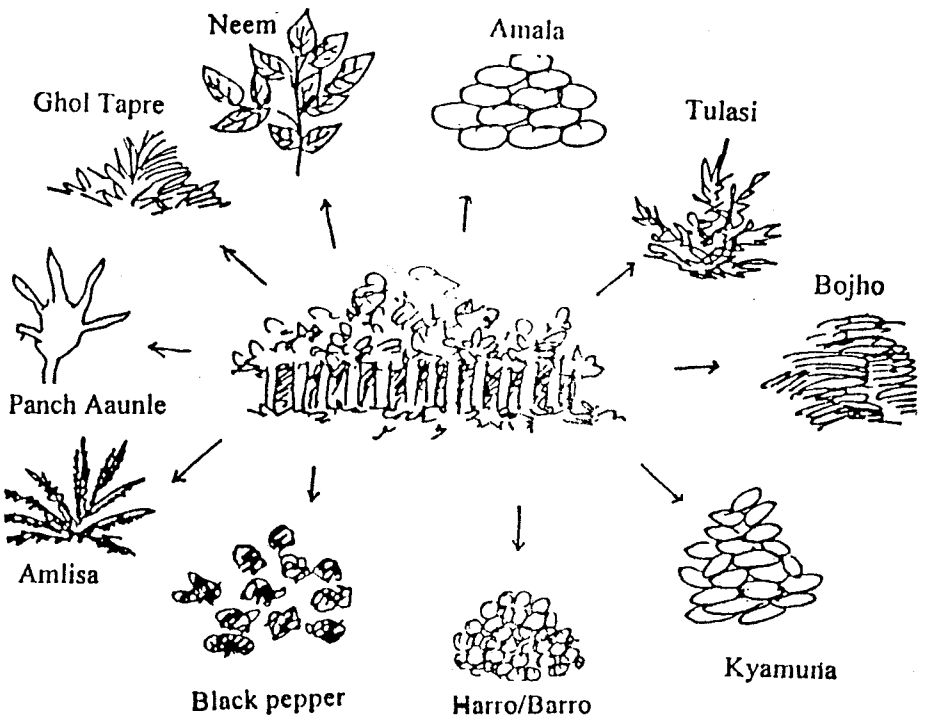
villages and people frequently harvest them as they walk between their fields and home. In mid-hills (2000 to 2400 m amsl), wild species are harvested less frequently as they are farther from the village. Farmers harvest these species about twice a season in bulk. In high hills (above 3000 m amsl), plants are usually harvested once a year. Farmers go in groups to the areas and stay there for one or two days for harvesting. These vegetables are collected in large quantity, cured and used over a longer period of time.

The wild plans supply seasonal food materials to humans and some of them also have medicinal values. Thus they act as alternatives to commercial vegetables and fruits which are easily available, tasty, cheap, fresh and nutritive. In addition they generate income for the poor people with out doing any agricultural operations except harvesting.

INDIGENOUS KNOWLEDGE ON MEDICINAL WILD PLANTS

Use of wild plants as medicine goes back to the Hindu epic Ramayana era. In one of the best known incidents in this epic, Hanuman (the white monkey god) is sent to find a rare Himalayan medicinal plant with healing properties to cure Lakshman, Lord Ram's brother who has been wounded by a magical spear in a battle. Unable to identify the plant, Hanuman wrenches out a whole chunk of mountain (known as Sumeru) and carries it back. Lakshman is saved. This clearly indicates that people have been depending on wild plants for curing ailments since the dawn of history. They are the ones who collected and compiled information on the use of these plants and developed herbal medicines from which many of our present day pharmacopoeias grew.

Rural people through their indigenous knowledge and experiences have discovered that many wild plants have medicinal values and they have been using such plants in their day-to-day lives. Medicinal plants can save lives, livelihoods and cultures. Medicinal plants are mostly taken internally by drinking concoction or eating fresh or cooked plant parts. They are also used externally as bath, wound wash or applied as ointment, plaster or poultice. Some medicinal uses of few plants found in the upland watersheds of Nepal are given below:



Wild medicinal plants

Kera ko Ganu (Banana, Musa paradisica) - Juice extract of root is used against 'garmi' (body heat).

Bodo or Bojho (Acorus calamus)- The root is fried on fire and used against dry cough.

Lasun (Garlic Pear) - Leaves of garlic pear are bitter in taste and used as a medicine for stomach problems. Its bark promotes appetite and is beneficial in curing stomach ache.

Ghol Tapre- Juice made out of its leaves mixed with the juice of Tulasi and Neem leaves and the root of Amliso and Siru is used against fever and typhoid.

Harro (terminalia chebula) – Barro (terminalia bellerica)- Fruits dry-fried on fire are used against cough.

Jai Patri- This is fried with clear butter (ghee) and used against cold and loose motion for children.

Jai Phal- Jai Phal crushed and mixed with Ginger, Black Pepper and Timur is drunk with hot milk against common cold.

Koiralo (Bauhinia variegata)- Juice of

Koiralo flowers is used to treat dysentery and diarrhoea.

Kyamuna- Juice extract from the bark of Kyamuna is used against sinus.

Neem(Azadirachta indica)-

- Right from the ancient time, the twigs of Neem have been in use as tooth brush.
- Juice of Neem leaves mixed with salt and black pepper is drunk to kill intestinal worms.
- Juice of Neem leaves and oil extract from Neem seed are used to cure skin diseases.
- Juice of Neem leaves mixed with honey is drunk against jaundice.
- Juice of Neem and Titepati leaves is used against skin diseases.
- Drinking juice of Neem leaves cures fever, malaria, diarrhoea and dysentery.
- Neem seed oil is used against sprains, tooth ache, ear ache and bronchitis.
- Ointment made of mixing juice of Neem and Amala with ghee controls skin diseases.
- Ointment made of Neem seed oil is used against venereal and skin diseases.

Panhele- Juice extract from its root is used against stomach pain.

Raye Timur (Zanthoxylum armatum) - Soup of Raye Timur, Jimmu, Garlic and Turmeric is used for gastric problems.

Sajiwan (Jatropha curcas)- Its extract is used against mud borne diseases in the finger gaps of hands and legs during rainy season, particularly during paddy cultivation time.

Sattuwa (Paris polyphylla)- Juice extract from root is used against poison and gas formation.

Sil Timur (Litsea citrata)-Soup of Sil Timur is used against diarrhoea and gas formation.

Sisnu (Urtica sp.)-

- A decoction of leaves is useful for curing Gonorrhoea.
- Juice is esteemed as medicine for eye troubles.
- The leaf juice mixed with curd is used to treat blood dysentery and the bark is used to treat gout (Manandhar, 1989).

Sital Chini (Moringa oleifera)- Dried seeds are drunk with plain water against high blood pressure.

Surti (Tobacco)- Juice extract from its leaves is used against skin diseases and blood sucking insects like mice, leeches etc.

Tulasi (Ocimum basilicum)-Tulasi leaves are used against ear ache and fever. It is also a mosquito repellent.

All these medicinal plans generally do not have side effects if used in right quantity, they are economical, fresh and locally available. Further collation of indigenous knowledge (IK) of medicinal plants can help to distinguish between true medicinal knowledge and superstition. However many of the rare species are depleting rapidly.

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