Trees for fodder and fuel in Nepal

RIU

Validated RNRRS Output.

In Nepal, farmers are planting trees wherever there's space. More trees mean more animal food and more fuel—both in desperately short supply. Farmers know the advantages of planting trees: less animal feed and firewood needs to be gathered from forests, animal dung can be used as fertiliser rather than for fuel, and trees can be grown on land that's not much use for anything else. In Nepal, farmers now plant trees on banks between rice paddies, on farm boundaries and on poor land. Tree foliage often has much-needed protein—improving milk and meat production. And it's much better than straw, the main food for livestock in the dry season. Plus, many of the trees are leguminous and fix nitrogen in the soil, improving fertility.

Project Ref: **PSP37:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **CAZS-NR, UK**
Source: **Plant Sciences Programme**

Document Contents:

Description

PSP37

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
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UK

Geographical regions included:

Nepal,

Target Audiences for this content:

Crop farmers, Livestock farmers,

A. Description of the research output(s)

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Agroforestry on rice bunds, farm boundaries and marginal lands in low-altitude areas of Nepal.

Enhancing the production of fodder and fuelwood with introduced and indigenous trees and shrubs: *Melia* spp., *Ficus* spp., *Artocarpus lakoocha, Bauhinia longifolia/purpurea and Flemingia* spp., for fodder and fuelwood.

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Plant Sciences Research Programme (PSP)

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RiUP activities.

R6748, R7542, R7122, R8071, R8221

UK
School of the Environment and Natural Resources and CAZS Natural Resources, University of Wales, Bangor, UK

Nepal
Local Initiatives for Biodiversity Research and Development (LI-BIRD), Pokhara
District Agriculture and Development Offices (DADO) Chitwan
District Livestock Service Office (DLSO), Chitwan
Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Chitwan
Tribhuvan University, Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan

*4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? **(max. 400 words)**. This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Using **participatory approaches**, we explored the potential of agroforestry tree species to increase fodder and fuelwood production by utilizing the bunds of rice fields, farm boundaries, and marginal land. Intensification of **agroforestry** (through planting more trees on farm) will increase fodder production on farm thereby contributing to improved **livestock productivity**. Since the availability of fuelwood would be improved, this will also reduce pressure on natural forest for fodder and fuelwood and help maintain a better ecological balance; increase

productivity by reducing the amount of dung burnt as fuel; and help rehabilitate wasteland.

The agroforestry research began in Chitwan and Nawalparasi districts of Nepal in 1997 with the introduction of ***Ficus***, ***Melia***, ***Artocarpus*** and ***Bauhinia*** spp. These are **multipurpose tree species** and their utilities are summarised in Table 1. In recent times, private plantations of *Melia* are becoming more common in the ***terai*** and low hills <1000 m. Similarly, cultivation of fodder trees is also increasing to fulfil **fodder** and **fuelwood** requirements (Singh, 2000).

Subsequently, *Flemingia macrophylla,* a perennial leguminous shrub fodder species was introduced. Because of its' short gestation and smaller canopy this became a fodder species of choice over fodder trees of long gestation. It is high in protein and calcium (Dozowelaa, 1995) and is suitable for hedgerows, planting on rice bunds, marginal areas and farm boundaries. N fixation of Flemingia was reported to be 144 kg ha^{-1} $year^{-1}$ (Muhr, 1999). It is drought tolerant but can survive short periods of water logging (Pandey, 1997). It is an effective **protein supplement** for goats (also Mui et al., 2001) and an effective **dry season browse** (also Skerman, 1977).

Table 1. Use and value of promising introduced and indigenous fodder species tested in participatory research in Chitwan, 1997 to 2006

English/ Nepali Name§	Latin name	Main use	Other uses	Time to first harvest for fodder (years)	Time to first harvest for fuelwood (timber) (years)	Quality of fodder	Quality of fuelwood	Suitable for feeding
Flemingia/ *Bhatamase*	*Flemingia macrophylla F. congesta*	Fodder	Twigs can be used as fuelwood	1	na	Good	Low calorific value	Most preferred by goat, cattle, buffalo
China berry/ *Bakaino*	*Melia azedarach M. composita*	Fuelwood Timber	Fodder, Green manure	2	3 (6-7)	Average	Good	Goat, cattle, buffalo
Rai khanayo	*Ficus cunia F. semicordata*	Fodder	Fuelwood	2-3	na	Good to very good	Good	Cattle, buffalo, goats
Nebharo	*Ficus roxburghii*	Fodder	Fuelwood, Fruit	2-3	na	Excellent	Average	Cattle, buffalo, goats
Badhar	*Ficus glaberrima*	Fodder	Fuelwood, Timber, Fruit	2-3	3 (6-7)	Excellent	Very good	Cattle, buffalo, goats
Tanki	*Artocarpus lakoocha*	Fodder	Fuelwood, Vegetable	2-3	3 (6-7)	Excellent	Very good	Cattle, buffalo, goats

Pakhuri	*Bauhinia longifolia* *B. purpurea*	Fodder	Fuelwood, Timber	2-3 (6-7)	Good	Very Good	Cattle, buffalo, goats

Problem addressed and description of outputs: Livestock plays an important role in Nepalese agricultural systems contributing 32% to the agricultural GDP (MoAC, 1999/2000). There is an annual deficit of 34% dry matter to feed the growing animal population in Nepal (TLDP, 2002). Livestock production is limited due to poor focus on the promotion of suitable indigenous and improved fodder species (Joshi, 1991 and Pandey, 1997) and the development potential of livestock is yet to be properly exploited.

A baseline study conducted in Chitwan and Nawalparasi showed that there is an acute shortage of fodder and forages (Rana et al, 2004). Low quality cereal straw makes up the majority of the animal feed and the overall productivity of animals is sub-optimal.

Fuelwood is the major source of cooking energy. Farmers depend upon their fodder residues, trimmed branches, twigs and fruits of fodder and timber trees around the farm boundary and also twigs of fallen or dead trees collected from the government forest. Most farmers suffer from a shortage of fuel sources (acute in some cases) for cooking. The situation for fodder and fuelwood is similar because farmers have mostly multi-purpose trees. Therefore, it is a matter of having trees or not having them on the farm that determines a household's standing for fodder and fuelwood (Rana et al, 2004).

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	***Technology***	***Service***	***Process or Methodology***	***Policy***	***Other Please specify***
x	*x*	*x*	*x*		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

Indigenous and introduced fodder species that are important from the point of view of supplying fodder and fuelwood are the main commodities upon which this output is being focussed. These are:

1. *Flemingia macrophylla* and *F. congesta*
2. *Melia azedarach and M. composita*
3. *Ficus cunia*
4. *Ficus roxburghii*
5. *Ficus glaberrima*

However, they fit in the main rice-based farming systems of the Nepal *terai* as well in the upland maize or millet-based farming systems prevalent in upland conditions in the hills.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	***High potential***	***Hillsides***	***Forest-Agriculture***	***Peri-urban***	***Land water***	***Tropical moist forest***	***Cross-cutting***
x	*x*	*x*	*x*				

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	***Irrigated***	***Wetland rice based***	***Smallholder rainfed highland***	***Smallholder rainfed dry/cold***	***Dualistic***	***Coastal artisanal fishing***
x	*x*	*x*	*x*		*x*	

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**). Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.*

This approach has manifold benefits to farming systems as a whole. The introduction and promotion of fodder and fuelwood species is important for livestock and dairy enterprises; soil and environmental conservation; human and animal health; increased crop productivity through leguminous fodder species nitrogen fixation; and increased availability of animal manure for crop production.

This output can be combined with outputs from the livestock production programme, for example:

- Cultivation of African Dhaincha and fodder kesari as animal feed in rice fields (R6610),
- Indigenous and biological knowledge integration for improving dry season feeding strategies in hill farms in Nepal (R7637),
- Adoption of planted forages for smallholder dairying in Kenya (R6153, R5732), soil and water conservation (R6621),
- Alternative strategies for small livestock keepers in forest margins (R6774),
- Environmental variability and productivity of semi-arid grazing systems (R6984, R8476).

Similarly it can be combined with some of the outputs from the crop protection programme such as the promotion of crop residues for fodder (R8339, R7346, R8296).

This also has implications for growing crops following rice in the rainfed *rabi* cropping technologies (PSP dossier 35) where soil fertility has been found to be a major limiting factor.

Validation

B. Validation of the research output(s)

***10. How** were the output(s) validated and **who** validated them?*
Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation (max. 500 words).

How and who validated: An evaluation of all fodder and fuel wood crops was conducted across all wealth categories of farmers (Fig. 1) with varying sizes of land holding (Annex 1) (Rana et al, 2004). Validation was done using a similar approach as the participatory variety selection (PVS) used for rice and other crops which was considered effective for the selection and promotion of agro-forestry species (Biggs, 1989).

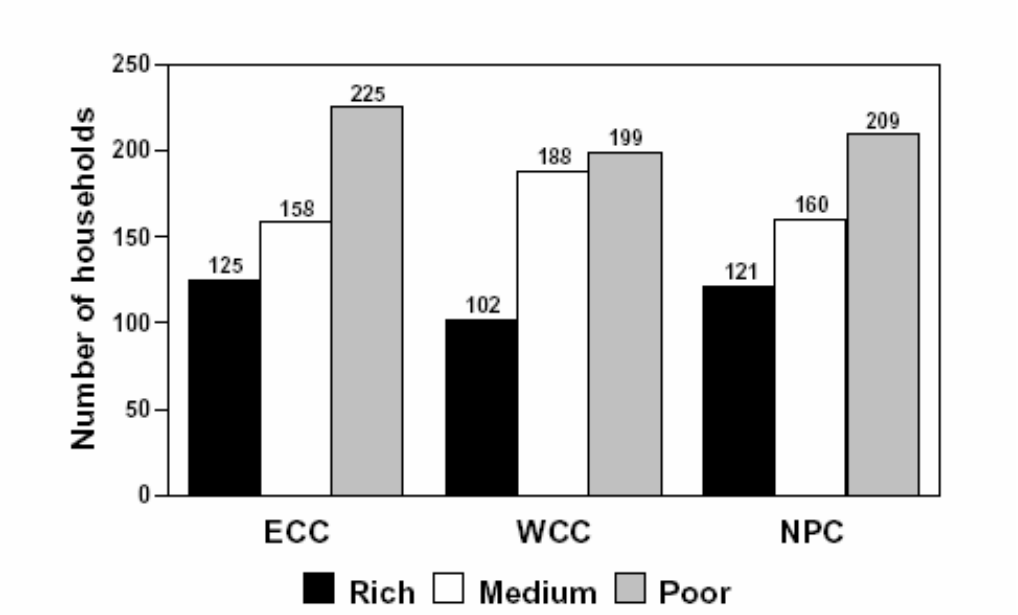

Fig. 1. Households by wealth category in different clusters. The number of respondent was 508 in Eastern Chitwan Cluster (ECC), 489 in Western Chitwan (WCC) and 490 in Nawalparasi cluster (NPC)

Several indigenous fodder species e.g. *Ficus cunia, Ficus semicordata, Ficus roxburghii*, *Ficus glaberrima, Bauhinia longifolia, Artocarpus lakoocha, Melia azedarach and Melia composita* were validated by planting on terrace risers, farm boundaries, field margins and on the rice bunds using farmers' customary agronomic management and growing conditions in Chitwan and Nawalparasi districts from 1999-2003. Subsequently

Flemingia was also validated since 1999 using the same approach and the network. Best accessions of Melia (out of 45 accessions from Terai and mid hills) and other fodder and fuel wood species were scaled up by producing large numbers of seedlings (Appendix 2) through 16 farmers' groups (Table 2) and other networks.

In this process, in addition to the farmers' groups (Table 2) District Livestock Services Office (DLSO) in Chitwan were actively involved. Subsequently these outputs were also validated by the rice-fallow *rabi* cropping (RRC) project in parts of Jhapa, Sirha, Saptari and Kapilvastu (Fig. 2). These species also provide fuel wood and form an integral part of the farming systems in the hills (Pandey, 1997, Kshatri, 2000) and are gradually being integrated across diverse environments of *terai* farming systems. These outputs were also validated by various GOs, NGOs and special projects in the past (Tables 3 and Appendix 3).

Table 2. Validation of agroforestry outputs by various groups in Chitwan and Nawalparasi districts of Nepal

Name of the group that validated agroforestry outputs	Type of the group with main purpose	District
Drinking water users committee, Nayabelhani	Drinking water	Nawalparasi
Farmer group, Chormara	Agriculture development, multipurpose	Nawalparasi
Farmer group, Abhiwan	Agriculture development, multipurpose	Nawalparasi
Narayani Mahila Milan Center, Amaltari	Agriculture development, multipurpose	Nawalparasi
Swabalamban Bikas Kendra, Bishaltar	Agriculture, rural development, multipurpose	Nawalparasi
Panchakanya dairy, Ratnanagar	Dairy	Chitwan
Jayamangala *Dudh Utpadan Samuha*, Ratnanagar	Dairy	Chitwan
Jayalaxmi dairy, Ratnanagar	Dairy	Chitwan
Shree Indrayani *Gai Bikash Samuha*, Indrapuri, Gitanagar	Dairy	Chitwan
Jan Pragati Krishi Tatha Pasupalan Samuha, Gitanagar	Dairy	Chitwan
Dairy group, Pithuwa, Ratnanagar	Dairy	Chitwan
Biswo Jyoti farmer group, Radhapur	Agriculture development, multipurpose	Chitwan
Farmer group, Parbatipur	Agriculture development, multipurpose	Chitwan
Farmer group, Birendranagar	Agriculture development, multipurpose	Chitwan
Mahila Samuha, Chainpur	Agriculture development, multipurpose	Chitwan
Indrapuri Secondary School, Gitanagar	School	Chitwan

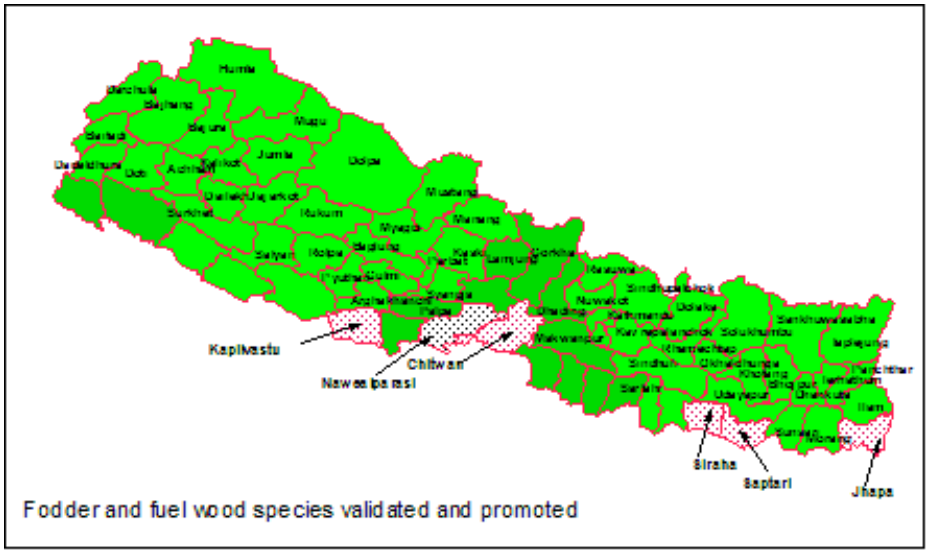

Fig. 2. Districts where indigenous and introduced promising agroforestry species are being validated and promoted in Nepal by I/NGOs

The effects of planting density on the biomass production and its chemical constituents, its palatability to different animals, effects of cutting height and cutting frequency on biomass production were validated by Professionals from IAAS, Tribhuvan University, Rampur and LI-BIRD using two years on-farm trial data at Krishnapur and on-station trial at IAAS, Rampur. From the same trial, two students from IAAS have completed their Masters theses on *Flemingia*.

Farmers' perceptions on the type of land for optimum performance, palatability to different animals and fodder yield were recorded and their perceptions of fodder and fuel wood species becoming integrated into Nepalese farming systems were also collected. Participatory tools such as transact walks, direct observations and household level questionnaires (HLQs) were used for these surveys.

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*11. **Where and when** have the output(s) been validated? Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

Hundreds of farmers validated the performance of indigenous and introduced fodder and fuelwood species across diverse farming systems in wider areas of Nepal through a number of projects, non-government and government organizations (Table 2, Appendix 3).

Current Situation

C. Current situation

*12. **How and by whom** are the outputs currently being used? Please give a brief description **(max. 250 words**).*

Those indigenous and introduced fodder and fuel wood species have been used by thousands of farmers for a variety of reasons in addition to fodder and fuel wood in diverse ecological and environmental conditions (Table 3).

Table 3. Some introduced and indigenous fodder tree species with their range of adaptability and pertinent uses in different physiographic regions of Nepal

Scientific name	Family	Suitable ecological belt and altitude (m)	Pertinent use
Flemingia macrophylla Roxb and Flemingia congesta	Leguminacea	Terai and hills up to 1200	Fodder and fuel wood
Melia azedarach and Melia composita	Meliaceae	Terai and lower hills up to 1000	Fodder, fuel wood, timber and oil from seeds
Ficus cunia and Ficus semicordata	Moraceae	Terai and hills up to 1500	Fodder, fuel wood, fruit
Ficus roxburghii	Moraceae	Terai and hills up to 1500	Fodder, fuel wood, leaves are used for making plates
Ficus glaberrima	Moraceae	Terai and higher hills up to 2000	Fodder and shade
Artocarpus lakoocha	Moraceae	Terai and hills up to 1500	Fodder, timber and edible fruit
Bauhinia longifolia/ purpurea	Fabaceae	Terai and hills up to 1500	Fodder, fuel wood and tool handle

The user's of these outputs are primarily farmers of all the wellbeing category living in rainfed dry and semi-arid environments as well as those living in the HPPSs (Table 2). Recently number academic studies (Masters and PHD) are in progress to look at nutritional status, palatability and acceptability of various fodder species by farm animals.

*13. **Where** are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used **(max. 250 words).***

The outputs are currently being used by thousands of farmers from diverse environmental and geographical areas (Table 4). Users include the socially excluded, marginalised and disadvantaged rural farmers.

Table 4. Districts and watershed regions in Nepal where those outputs are currently using

Fodder species	**Growing districts**	**Growing places**

Flemingia macrophylla and Flemingia congesta	Some villages of Chitwan and Nawalparasi districts	Bunds in rice field, field boundary, marginal areas, hedgerows, fences
Melia azedarach and Melia composita, Ficus cunia, Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia/ purpurea etc.	Gorkha, Lamjung, Syangja, Shivapuri Watershed areas, Tinau Watershed areas, Dang, Salyan, Pyuthan, Rolpa, Rukum, Rasuwa, Nuwakot, Palpa, Ramechhap, Dhadhing, Tanahun, Chitwan, Dolkha, Sindhuli, Makawanpur, Kavre, Taplejung, Sankhuwasva, Sindhupalchok, Manang, Mustang, Humla, Dolpa, Mugu and some other districts from mid and far western development region	Rice bunds are mostly used in agroforestry system with several cereal and legume crops, marginal areas, boundary of field and terrace risers in hilly regions, soil erosion prone areas, pastures and grazing lands in silvopastoral system, plantation in watershed areas, wasteland and denuded forest areas etc.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

LI-BIRD produced more than 12 thousand saplings of different indigenous and introduced agroforestry species and distributed them throughout Chitwan and Nawalparasi districts from1999 to 2003 through several groups (Annex 2 and 3, Table 2).

Traditionally, hill and mountain farming systems have fully integrated multipurpose tree species using field margins, terrace risers, and other waste lands. Several studies on various aspects of more than 57 fodder and forage species had already been done (Pandey, 1997). However, growing trees for livestock feed and fuel wood in the *terai* started after the 1980s. Since then, several efforts have been made by governmental and non-governmental organizations in the *terai*, hill and mountain districts (Table 4, appendix 3) to increase fodder and fuel wood production. Nearly 3 million tonnes of dry matter, 34.7% of total digestible nutrients and 54.3% green fodder are deficient in the country to support the growing animal population (TLDP, 2002)

15. What programmes, platforms, policy, institutional structures exist within the DFID PSA countries to assist with the promotion and/or adoption of the output(s) and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

There are a number of innovation platforms for the scaling up of the outputs, e.g. DLS has its institutional network in all the 75 districts with the presence of trained staff at Service Centre level (covering a population of several thousand people). DLS have been promoting fodder and pasture development by various means such as:

- Promotion of fodder species in Nepal through distribution of vegetative materials of perennial fodder and forage crops
- Distribution of fodder tree seeds and saplings
- Development of silvi-pasture, agro forestry
- Establishment of fodder nursery, fodder seed production resource centres
- Organizing training to the farmers, beneficiaries, technical staffs
- Fodder and pasture seed production, registration of fodder seed producers groups and establishment of Rural Seed Bank
- Quality control of the fodder seed produced

- Assist and facilitation in pricing and marketing of fodder seed and saplings and joint programme implementation with other (I)NGOs, community based organizations and other private sectors etc

The Livelihood Forestry Programme (funded by DFID and that was built on an earlier DFID funded project 'Nepal UK Community Forestry Project' (NUKCFP)) covering over 13, 662 Community Forest Users' Groups involving 1.551, 786 households across 7 districts in the hills of Nepal will be one of the most important innovation platforms for the scaling up of outputs from our agroforestry research.

Leasehold forestry network is also picking up in several of the hilly and some of the terai districts and they encourage planting of fodder and forage crops in such lands. Planting multipurpose trees has been the major objective in all the community forests. Most of the NGOs working in Nepal have agriculture as an integral part of their activities and planting fodder and fuel wood trees is also widely promoted by NGO networks. There is an existing policy environment for the promotion of planting trees. Thus, current government's policy is very helpful and supportive for the dissemination and scaling up of promising indigenous and introduced fodder species.

However, fodder research and scaling up outputs in Nepal in the past have had a number of shortcomings:

- There was a lack of participation from the communities in the research and development (R & D) as result most of the R & D failed to recognize the practical needs of the farmers. Most of the research was the duplication of the already established findings.
- Most of the research and scaling up work lacked the framework of recommendation domains for multi-location trials and were target oriented rather than solving the real problems of farmers
- In most of the cases available resources were concentrated on minor problems
- Lack of clear policy and strategy on forage, fodder and fuel wood research and promotion. Almost all research and promotion work is conducted according to the researcher's interests rather than to meeting the real need

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Current Promotion

D. Current promotion/uptake pathways

*16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion **(max 200 words).***

Several governmental organizations like the Department of Livestock Services (DLS), NARC, Department of Forestry (DOF), Department of Soil Water Conservation (DSWC), Pakhribas Agricultural Centre (PAC), Lumle Agriculture Centre (LAC), IAAS and several NGOs are promoting several promising indigenous and introduced fodder species through different models based on the local need, location, altitude, climatic condition and other socio-economic parameters (Appendix 4).

A survey was conducted in October 2006 using FGD and/or HLQ to assess the adoption and preference of various fodder species distributed by LI-BIRD from 1999-2003. The summary of the findings of this study are

summarized in Table 5 (also see Appendix 5).

Table 5. Overall ranking of the fodder species promoted in the project area

Species	Rank	Reason
Ficus cunia	1	Best preferred fodder by all animal species. Best quality fuel wood. More than three harvests a year.
Artocarpus lakoocha	2	Best quality fodder, preferred to feed lactating cattle and buffalo. Its intake increased milk production, lactose and fat in the milk. Good firewood. Preferred by all animals.
Bauhinia longifolia/purpurea	3	Best quality fodder, preferred to feed lactating cattle and buffalo. Its intake increased milk production, lactose and fat in the milk. Good firewood. Preferred by all animals.
Ficus roxburghii	4	Good quality fodder
Melia azedarach/composita	5	Good fodder for goat, timber, good quality firewood
Ficus glaberrima	6	Good quality fodder, fuel wood, timber
Flemingia macrophylla/congesta	7	Fodder preferred mostly by goats

17. What are the current barriers preventing or slowing the adoption of the output(s)? Cover here institutional issues, those relating to policy, marketing, infrastructure, social exclusion etc. ***(max 200 words)****.*

Institutional and policy issues:

- An objective assessment and documentation of fodder and pasture research and development is lacking (Pandey, 1997) which restricts implementation by planners, policy makers, professionals and farmers attempting to facilitate livestock development in the country.
- Limited scientific research to understand the minimum husbandry practices, e.g. planting density, frequency of cutting, nutritive value, digestibility etc.
- Lack of understanding regarding the priority setting for fodder and fuel wood species in terms of livelihoods of poor people.

Marketing, infrastructure and social exclusion:

- *Conventional thinking:* Conventionally farmers think that livestock thrive on grazing and crop by-products and no additional fodder and feed is needed.
- *Subsistence farming:* Majority of farmers depend on small land holdings for their subsistence food crops production and thus are reluctant to grow fodder crops which do not give an immediate and direct return
- *Invasion/protection of pastureland:* Community pasturelands and fodder species are considered common property. There is a lack of responsibility for the protection and improvement of such lands and species. Most of the community pasturelands are over grazed and are deteriorating. In recent years

stocking and utilisation of such lands are increasing especially around the vicinity of villages.

- *Poor people's participation:* there is a lack of awareness and education amongst the farmers towards pastureland management, fodder production and means to maintain productivity. Most of the programmes and activities in the past failed mainly because of a lack of inclusion of such groups in project activities.
- *Fodder species:* A legume component in pasturelands, and improved perennial legume fodder species are lacking, which are important for quality feed as well as to improve soil fertility. Moreover, local species tend to be slow-maturing.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues ***(max 200 words).***

According to Pariyar, D., Dhaubhadel T. S., Chemjong P.B., and Upreti C.R., (eds) 1995 for wider promotion and rapid adoption of fodder and fuel wood species in Nepal the following barriers need to be changed:

- Government should give a high priority to fodder improvement / development, either through the introduction of improved species or the promotion of promising indigenous species
- Research on appropriate fodder, forage and fuel wood species for specific agro-ecological zones and land use systems needs to be given top priority involving all the important stakeholders.
- In hilly areas soil acidity has reached an alarming level. There is therefore a need to introduce acid tolerant indigenous or improved fodder species for soil amelioration, both by governmental and non-governmental organizations
- Seed shortages are a major constraint in fodder species' development and promotion
- An inventory of the nutritional content of different feeds and fodder should be maintained

19. What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? ***(max 300 words).***

Using Rogers (2003) diffusion of information as a framework for the lessons learnt:

1. The relative advantage of a technology compared to what it is replacing;
This is generally high (see Table 1) and farmers generally agree on the reasons why they prefer a new species.

2. The compatibility of the technology with existing systems and ways of doing things, which is closely related to culture;
The compatibility with farmers is high as they are used to experimentation in their own fields.

3. The complexity of the technology in terms of what people need to learn to make it work;
The complexity is low for farmers and introduction of new fodder species do not require changes in management practices.

4. The observability of a technology in terms of how easy it is to demonstrate and observe performance;
The observability is high for most traits such as yield, palatability, cattle preference etc.

5. The trialability of a technology in terms of how easy it is to test it before deciding to adopt.

The trialability is high if seeds/seedlings are available with appropriate extension materials.

The most important lesson is that the process should be one of Participatory Agro-forestry Species Evaluation (PASE)

Impacts On Poverty

E. Impacts on poverty to date

20. Where have poverty impact studies on this output or cluster of outputs taken place? Please list studies here.

Devkota, K.P., Tripathi M., Chaudhary M., Gurung M., Poudel H., and Gyawali S. (2006). Final Technical Report of R8071-Participatory Plant Breeding in High Potential Production Systems-Validating PPB products, testing different breeding methods and scaling up of new rice varieties. Available at www.dfid-psp.org

Dhakal, P. (2002). An Evaluation of the Participatory Tree Selection Approach and Adoption of Agroforestry Practices within the Terai Region of Nepal, Using Participatory Methods. Masters thesis, University of Wales, Bangor.

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21. Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) ***(max. 500 words):***

What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;
For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;

Indicate the number of people who have realised a positive impact on their livelihood;
Using whatever appropriate indicator was used detail what was the average percentage increase recorded

Fodder and firewood species are an integral part of rural livelihoods in Nepal (Figure 2). They dominate not only the landscape but also the way people live. Fuel wood provides 75% of the total energy consumed in the country and more than 40% of fodder for livestock is extracted from fodder species (MPFS 1988). Besides, they play a dynamic role in protecting the fragile mountain ecosystems and maintaining diverse and complex ecosystems of the country (Thomson 1995).

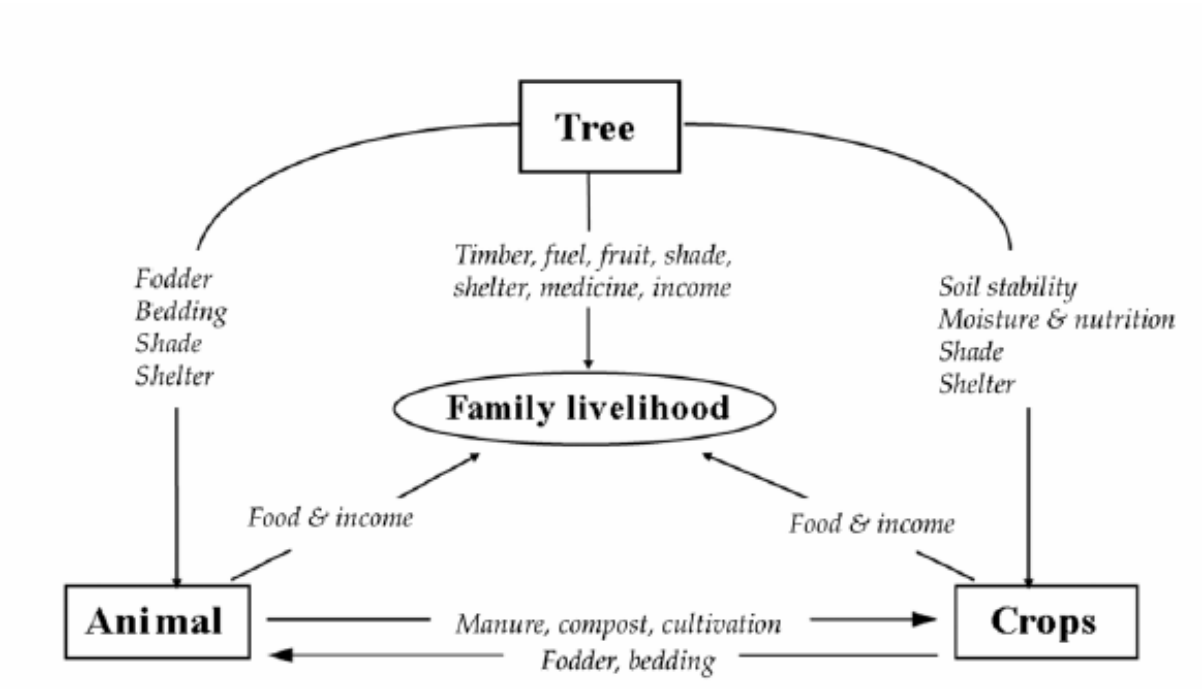

Fig. 2. Nepal's tree-animal-crop farming system

Although specific impact assessments of interventions on fodders and fuel wood is yet to be conducted, there are several reports on the impact of agroforestry on livelihood and poverty. With the increased adoption of agroforestry in various regions of country there is a positive impact on poverty and various aspects of livelihoods like increased fodder, fuel wood and timber supply. There is an increased awareness among the farming communities on the quality of fodder etc. and ultimately an improved educational, health, income and food security situation. There is an overall positive impact on environmental conservation and reduced soil erosion. The agroforestry approach addresses **livelihood resources** which comprise natural resources, human resources, social resources, financial resources and physical resources. The outcome addresses **poverty** indices like vulnerability, income, powerlessness, physical weakness and isolation as:

Physical assets	The forest resource is improving under farmer's cultivation and management

Vulnerability context	The agro-forestry species act as a buffer for the poor people, providing both food and income sources during lean periods, seasonally and in bad years.
Transforming structures and processes	The Forest Act provides an opportunity to legitimize farmers and communities use of the agro-forestry species i.e. it provides legal access. Socially marginalized people have most to gain from this system in community decision making i.e. it offers the opportunity for influence.
Livelihood strategies	Improved fodder supply increases livestock production and productivity, increased firewood supply, increased supply of fruit, bio-fencing, improved supply of medicinal herb etc.
Influence and Access	Can be strengthened through an empowerment process at many levels, among many stakeholders - boosting self-confidence, competencies, leadership in the farming communities

The framework is derived basically from three important theoretical elements namely ***the concept of empowerment, capacity building and sustainable rural livelihood.***

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

- Directly, the outputs address the problems of land degradation by seeking to deliver the fodder requirement for livestock thorough increased productivity of quality fodder. Indirectly, the emphasis on increasing fodder production and stall-feeding of farm animals is environmentally beneficial.
- Reduce the pressure on natural forests for fodder and fuel wood which positively contributes to environmental protection.
- More cattle dung will be available for manuring as a result of the increased availability of fuel wood.
- Use of a greater number of species (particularly encouraging the planting of indigenous species) and the intensification of land cover reduces soil erosion and land slides. This further contributes to biodiversity enhancement by relieving pressure on adjacent forest and conservation areas (native species biodiversity).
- Species diversification will help reduce crop loss due to pests and diseases and thereby reduce the use of pesticides. Introduction of new species always increased on-farm diversity as farmers adopt different species for different niches.
- The better disease and pest resistance of new species can reduce the use of water and soil polluting agro-chemicals. Reduced use of pesticides and insecticides will also reduce the risk to human life will help

maintain a balanced pest-predator cycle.

- Leguminous species like Flemingia have better nitrogen use efficiency and nitrogen fixing capacity, thereby reducing the need for chemical fertilisers which are an important pollutant and their synthetic production is a significant contributor to global warming (Gibbon, 2005).
- Increased fodder supply will increase livestock production and result in an increased supply of meat, milk etc. and have a direct impact on human health.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Any adverse environmental impact is unlikely in the present case as the promising indigenous and improved local are scale neutral and do not require any special cultural, management and production inputs.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 100 words)***

Yes. The outputs are directly related to the management of soil and water, which are some of the first few factors affecting crop production immediately in the event of climate changes and natural disasters. Better management of soil and water minimising soil and nutrient losses and increasing soil fertility increases resilience of soil against adverse effects of climate change and natural disasters like flood and landslides. Increased farmer's knowledge and promotion of adoption of agroforestry species greatly increases the capacity of poor farmers to cope with the effects of climate change and natural disasters.

Increased species diversification is a means of coping with climate change. For example, promotion of drought tolerant agro-forestry species like Flemingia reduces the risks from drought. Similarly, insect and disease tolerant species reduce the risk against disease and pest epidemics and also reduces the risk of adverse weather (high winds, hail, and floods) thus increasing the resilience of farmers to cope with variation.

Annex

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Annex 1. Land holding information by wealth categories within clusters in Chitwan and Nawalparasi.

Variables	*Khet*	*Bari*	p-value for Khet only
ECC			
Rich	1.19 ± 0.06 (125)	0.24 ± 0.04 (46)	0.000
Medium	0.54 ± 0.03 (155)	0.09 ± 0.02 (43)	
Poor	0.029 ± 0.02 (169)	0.05 ± 0.01 (56)	
WCC			
Rich	2.10±0.16 (99)	0.44±0.12 (12)	0.000
Medium	0.80±0.03 (187)	0.50±0.14 (11)	
Poor	0.41±0.02 (171)	0.16±0.05 (13)	
NPC			
Rich	0.96±0.0.08 (116)	0.29±0.05 (40)	0.000
Medium	0.54±0.03 (154)	0.19±0.02 (55)	
Poor	0.30±0.02 (154)	0.13±0.01 (64)	

Annex 2. Different indigenous and introduced agro forestry species distributed through various dairy groups, other farmers groups and individual farmers in Chitwan and Nawalparasi districts during 1999 to 2003

Year	Species	No. of farmers		Total participants	Number of seedlings		Total no. of seedlings
		Trial	IRD		Trial	IRD	
1999	*Melia azedarach*	84	-	84	1563	-	1563
	Ficus cunia	46	-	46	95	-	95
	Bauhinia longifolia	87	-	87	677	-	677
	Leucaena leucocephala	14	-	14	46	-	46
	Artocarpus lakoocha	2	-	2	3	-	3

	Total	233	-	233	2384	-	2384
2000	*Melia azedarach*	14	23	37	700	250	950
	Ficus roxburghii	-	13	13	-	25	25
	Artocarpus lakoocha	-	10	10	-	20	20
	Ficus cunia	-	15	15	-	29	29
	Flemingia macrophylla	16	-	16	320	-	320
	Total	30	61	91	1020	324	1344
2001	*Melia azedarach*	50	3	53	491	12	503
	Ficus cunia	-	177	177	-	272	272
	Artocarpus lakoocha	-	101	101	-	154	154
	Ficus roxburghii	-	72	72	-	78	78
	Ficus glaberrima	-	117	117	-	146	146
	Bauhinia longifolia	-	143	143	-	296	296
	Tejpatta	-	18	18	-	18	18
	Gogon	-	16	16	-	16	16
	Flemingia	58	33	91	580	95	675
	Total	108	680	788	1071	1087	2185
2003	*Ficus cunia*	-	-	-	-	2250	2250
	Ficus roxburghii	-	-	-	-	1775	1775
	Flemingia	-	-	-	-	2350	2350
	Mendola	-	-	-	-	575	575
	Total	-	-	-	-	6950	6950
Grand total		371	741	1112	4475	8361	12863

Appendix 3. Where (region and farming system) and when the outputs were validated and with whom

Fodder species	**Who and where**	**When**	**Farmers**	**System**
Flemingia macrophylla and *Flemingia congesta*	Several village development committees (VDCs) of Chitwan and Nawalparasi districts	1999-2003	Hundreds of Low, medium and high resource farmers	High potential, rainfed and irrigated rice bunds

Melia azedarach and *Melia composita,*	Gorkha, Lamjung, Tanahun, Syangja, Palpa etc, by Resource Conservation and Utilization Project (RCUP)	1980	Low resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
Ficus cunia and *Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia etc.*	Shivapuri Watershed areas by Shivapuri Watershed Management and Fuel wood Plantation Project	1985-1990	Low resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	Tinau Watershed areas by Tinau Watershed Project	1981-1990	Low resource farmers	Semi arid, hillside, smallholder rainfed dry/cold
	Dang, Salyan, Pyuthan, Rolpa, Rukum by Rapti Development Project	1987-1995	Low, medium and high resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	Rasuwa and Nuwakot by Rasuwa-Nuwakot Rural Development Project	1986-1990	Low, medium and high resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	Palpa by HELVETAS/GTZ	1989-1994	Low resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	ICIMOD is testing and validating in several mid and hill districts	Continuing since several years	Low, medium and high resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	Sindhupalchok, Ramechhap, Dhadhing, Tanahun, Chitwan, Dolkha, Sindhuli, Makawanpur, Kavre by Hills Leasehold Forestry and Forage Development Project (HLFFDP)	1993-	Low, medium and high resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	High altitude Himalayan districts Taplejung, Sankhuwasva, Dolkha, Sindhupalchok, Gorkha, Manang, Mustang, Humla, Dolpa and Mugu through Northern Belt Pasture Development Program (NBPDP)	1980-1990	Low resource farmers Thousands	Semi arid, hillside, smallholder rainfed dry/cold
	Mid and far western development region through Third Livestock Development Project (TLDP)	1996 to date	Low, medium and high resource farmers Thousands	High potential, semi arid, hillside, smallholder rainfed dry/cold

Kapilvastu, Sirha, Saptari, Jhapa	2002-2005	RRC project implemented by FORWARD and CAZS NR	Rainfed dry, semi-arid Hundreds of farmers

Appendix 4. Various models for the scaling up of fodder and fuel wood species in Nepal

Where is promotion taking place	Who is promoting	Scale of promotion
Traditional Model (Model-1): Fodder trees plantation in the terrace and risers, a common traditional practice in the rural areas. Depending upon the altitude, adaptability and palatability fodder saplings are being selected and transplanted. Basically, top stratum constitutes fodder trees, the second strata with bushes and the ground is covered with grasses and legumes. Through this process and in those areas *Ficus cunia, Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia/ purpurea* etc are promoting.	Over 75 different fodder tree species are available at domestication in Nepal. **Elevation** determines the type of plants.	Very high
Model –2: Slope Agricultural Land Technology (SALT) which is basically a contour hedgerow inter-cropping. Through this process *Flemingia macrophylla Roxb, Flemingia congesta, Melia azedarach, Melia composita* etc are promoting.	International Centre for Integrated Mountain Development (ICIMOD) has established a number of demonstration plots in mid hills of Nepal.	Medium
Model –3: Fodder, monoculture and combination of legume and grasses (Oat+Vetch or Oat and cowpea). Through this process and in those areas *Flemingia macrophylla Roxb and Flemingia congesta* etc are promoting.	About a decade old practice in farmer's field. It is getting popular in Nepal. Several INGOs and government organizations are focussing in this method.	High

Model – 4: Modified use of bonds, terrace risers for forage production in the mid hills. Alternative rows of legumes and grasses which include *Flemingia macrophylla Roxb, Flemingia congesta, Ficus cunia, Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia/ purpurea, Melia azedarach, Melia composita* etc. Thus in such areas those fodder species are promoting.	Newly advanced model being tested by the Hills Leasehold Forestry and Forage Development Project. Several other Several INGOs and government organizations are focussing in this method.	Very high
Model-5: Use of un-reclaimed and fallow land for grass and legume forage production. For example, forage legume and grasses under mango orchard. Through this process and in those areas *Flemingia macrophylla Roxb, Flemingia congesta* etc are promoting.	Helen Keller International working in Siraha district of Nepal and several INGOs are focussing in this method.	Medium to low
Model –6: Use of roadsides and land under electric high-tension line by plantation of appropriate fodder shrubs and grass and legumes. In those areas *Ficus cunia, Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia/ purpurea, Melia azedarach, Melia composita* etc are promoting.	Under testing by the Department of Livestock Services and other INGOs are also testing and promoting through this method.	High

Model – 7: Selection of naturally established grasses and legumes, weeding of obnoxious plants and makes the high altitude pasturelands accessible. Through this process and in those areas *Ficus cunia, Ficus semicordata, Ficus roxburghii, Ficus glaberrima, Artocarpus lakoocha, Bauhinia longifolia/ purpurea* etc are promoting.	Northern Belt Pasture Development Project and other INGOs are promoting through this method.	Medium to low

Appendix 5. Farmer's adoption and preference of those fodder species in 2006 in various villages of Chitwan and Nawalparasi

Farmers group	Survey method	Species preferred by farmers
A. Nawalparasi		
1. Drinking Water Users Committee, Nayabelhani	FGD	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have been growing at least one tree of each fodder species distributed. *Flemingia* is not spreading because cattle and buffalo did not prefer its fodder.
2. Narayani Mahila Milan Center, Amaltari	HLQ	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have at least one tree of each fodder species received. There is heavy demand of sapling of all species except *Flemingia* in this village.
3. Swabalamban Bikas Kendra, Bishaltar	FGD	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have at least one tree of each fodder species received. *Flemingia* is not much spreading because cattle and buffalo did not prefer its fodder and there is heavy rat infestation in the *Flemingia* field.
B. Chitwan		
I. Dairy groups		
1. Panchakanya Dairy, Ratnanagar	FGD	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have at least one tree of each fodder species received. There is heavy demand of sapling of all species. *Flemingia* is not much spreading because there is heavy rat infestation in the *Flemingia* field. Some of the saplings of *Ficus cunia, Artocarpus lakoocha* and *Bauhinia longifolia/ purpurea* are spreading outside villages as well.

2. Jayamangala Dudh Utpadan Samuha, Ratnanagar	FGD	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have at least one tree of each fodder species received. Demand of *Ficus cunia* is very high.
3. Jayalaxmi Dairy, Pithuwa 3, Ratnanagar	FGD	Most of the distributed species are preferred and scaled up by the farmers. Almost all households have at least one tree of each fodder species received. Some of the saplings of *Ficus cunia, Artocarpus lakoocha* and *Bauhinia longifolia/ purpurea* are spreading outside villages as well.
II. Other farmers groups		
1. Biswo Jyoti Farmer Group, Radhapur	FGD /HLQ	Most of the distributed species are preferred and scaled up by the farmers. *Ficus cunia, Artocarpus lakoocha* and *Bauhinia longifolia/ purpurea* are mostly preferred for lactating cattle and buffalo and upon their feeding milk production, lactose and fat increased. Among them *Ficus cunia* is the most preferred. *Flemingia* is also spreading a bit around the bunds of cannel and marginal land.
III. School		
1. Indrapuri Secondary School, Gitanagar	Personal inquiry with a teacher	Now all the plantation of *Melia* in this school in good condition and are now using for fodder for goat and fuel wood by the neighbouring communities
IV. Individual farmers, Gitanagar	HLQ	*Flemingia* is preferred mostly by the goat rearing farmers. Cultivating in dry and marginal land.