Transfer of Technology Model

Bamboo Green Feed for Livestock

(This transfer of technology model is an outcome of the IFAD-EU-funded South-South knowledge transfer strategies for scaling up pro-poor bamboo livelihoods, income generation and employment creation, and environmental management in Africa (Phase II) Project in Tanzania, Madagascar and Ethiopia.)

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INBAR, the International Bamboo and Rattan Organisation, is an intergovernmental organisation bringing together some 44 countries for the promotion of the ecosystem benefits and values of bamboo and rattan.

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Foreword

Rearing livestock in traditional production systems is an engine for the rural economy. It ensures the livelihoods and food security of millions of rural households. Bamboo leaves and twigs are nutrient-rich fodder; the inclusion of bamboo charcoal and vinegar additives as dietary supplementation can replace antibiotics to improve growth performance, increase the feed intake and feed conversion efficiency, raise the quality of meat and reduce the incidence of diseases and the mortality rates of livestock. The increasing global demand for organic, healthier animal meat and dairy products requires organic feed and forage. Bamboo is an organic feed resource that offers medicinal properties for livestock. A single clump of bamboo can be useful for a small rural homestead, which uses farm-raised feed ingredients and pasture forage to provide nutrients for its livestock.

The agro-pastoral based rural economy in Africa needs quality feed and fodder to manage its valuable livestock in rural areas during the winter and dry season. The incidence of climate change is reducing the size of grazing areas. Consequently, rural households are often forced to sell their livestock and later fall into poverty. Bamboo is a grass family plant. Bamboo leaves can be used as feed and fodder as a buffer stock to mitigate the risks for livestock-rearing households in the region.

This technical manual, *Bamboo Green Feed for Livestock*, is based on secondary sources and the primary field experiments of INBAR's IFAD-EU funded south-south knowledge transfer strategies to scale up pro-poor bamboo livelihoods, generate income, create employment and manage the environment in Africa as part of the Phase II project in Tanzania, Madagascar and Ethiopia to be disseminated as a knowledge product on bamboo as feed, fodder and forage for livestock.

Dr. Hans Friederich
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Acknowledgements

The livestock sector is a complex and integral component of agriculture. Animals are used for ploughing, planting, weeding and transporting people, food and other commodities; they also help women and children carry water and firewood. Millions of rural people rear livestock using traditional production systems to support their livelihoods and provide household food security.

This sector is now undergoing change at a rapid pace. The surging demand for food and products derived from animals has led to structural changes; commercial livestock production and its associated food chains have evolved to meet this demand. Bamboo is a perennial grass and may well reduce the stress of feed crop production. In addition to providing feed and forage, an increase in bamboo will contribute to soil, water and biodiversity conservation.

This technical manual, *Bamboo Green Feed for Livestock*, is based on secondary sources of information and primary field experiments. It describes the nutrients provided by bamboo leaves and current methods of harvesting bamboo leaves. It also elaborates on the benefits of bamboo extracts as additives in livestock feed and provides simple methods of making bamboo charcoal. Bamboo by-products – charcoal, vinegar and extracts – are particularly important as they provide many benefits as additives, and they are easy to make in both homestead and commercial production systems. It is hoped that this information, substantiated by observations and research, will encourage the addition of bamboo to the diets of livestock in many countries. This report also offers policy-makers and other stakeholders an argument to move forward with bamboo, as a feed and forage resource, to improve livestock production systems, enhance livelihoods, use wastelands to reduce biodiversity losses and also mitigate climate.

We offer special thanks to the FIFANMOR (Centre de Development Rural et de Recherche Appliquée) and PROSPERER (Support Micro-Enterprise Programme Poles Rural and Regional Economies) teams of Madagascar for conducting joint research on the suitability of local bamboo species as a feed and fodder for dairy cattle in Madagascar. The experimental field evidence data have been used to prepare this manual.

It is our immense pleasure to express sincere gratitude to Dr. Fu Jinhe, Tesfaye Hunde, Fiker Assefa, Wondimagegn Bekele, Biruk Kebede and Zerihun Tsigaye of INBAR, East Africa Regional Office, Addis Ababa, Ethiopia, for their enormous support and cooperation.

We owe our heartiest thanks to Bedilu Kilfe, National Coordinator of Ethiopia, Njaka Rajaonarison, National Coordinator of Madagascar and Donald D. Kibhuti, National Coordinator of Tanzania (INBAR, South-south Phase-II project) for providing endless field support and cooperation.

Last but not least, we sincerely express our gratitude to our communication team at the INBAR headquarters for assistance in completing this manual in a timely manner.

Authors

1.Bamboo Feed and Fodder

The livestock sector contributes about 40 percent to global gross agricultural output and is the world's largest user of land(FAO,2009). Livestock production is rapidly increasing to meet the demands of population growth; urbanization and rising incomes have increased through the consumption of animal products. Livestock directly provide food security for 1.3 billion people, and the livestock sector is a driver of agricultural growth (World Food Security,2016). This sector is now undergoing change at a rapid pace. The surging demand for food and products derived from animals has led to structural changes in the industry; commercial livestock production and its associated food chains have evolved to meet this demand. The shortage of cultivated fodder and feed resources compels farmers to allow livestock to graze on community lands and forests. This activity depletes vegetation, erodes the soil and reduces the land's ability to provide the nutrient requirements of livestock. Consequently, involved households are facing challenges for green fodder during winter or the dry season to meet the demands of feed livestock.

The average dry matter feed requirements for dairy animals is 3 kilograms for every 100 kilograms of body weight, of which 60–80 percent should be green fodder or straw and the remaining 20–40 percent concentrated feed (Gupta,2014). The nutrient components in feed maintain the quality health of the livestock in a productive way. The bamboo feed supplements the required nutrient to provide a balanced diet for livestock. The dry matter per hectare of bamboo leaf biomass averages 11.7 metric tonnes , while the natural pasture biomass yield is 1–3 metric tonnes and the crude protein (CP) of bamboo leaves is high at 16–20 percent; this plant can be a protein supplement for livestock (Kitil Farm,2013).

Bamboo leaves contain chlorophyll, which fights infections; lactone, which is good for the cardiovascular system; and chlorophyll, which aids in the formation of red blood cells and in building a stronger immune system. Powdered bamboo shoots used as chicken feed promote weight gain. Bamboo charcoal (BC) and bamboo leaf dietary supplementation improve growth performance, feed intake, feed conversion efficiency and quality of meat.. Meat from chickens that consume feed supplemented with bamboo has lower cholesterol levels and is higher in unsaturated fats.

Therefore, bamboo plantations are an inexpensive feed source for the increasing number of organic chicken producers catering to markets that are driven by health benefits. Studies have demonstrated that bamboo shoots, leaves (dry and fresh) and bamboo branches less than 5 millimetres (mm) in diameter are the preferred natural fodder for mountain gorillas, mules, donkeys, goats, cows, sheep, elephants, poultry and pandas. Bamboo grows in different climatic zones in Africa. Rural households cultivate bamboo near their homesteads and on farm boundaries. This perennial resource may be used as green feed and fodder for livestock and can be processed in several different forms. It can create livelihoods and employment in a multi-faceted way.

1.1 Bamboo Leaves as Fodder

Green fodder is the main source of carbohydrates and crude fibre for livestock. Legumes, cereal crops, grasses or tree-based crops can be classified as green fodder. This type of fodder maintains animal health and reproductive efficiency. Green fodder is palatable and easy to digest and has a cooling effect on the body. It provides fresh nutrients in their natural forms. Bamboo sheds its leaves throughout the year, thereby providing a thick layer of litter that is a source of chicken forage. Bamboo clumps provide shelter for chicken and are a home for insects and worms, which also serve as chicken feed in addition to leaves and twigs. Homestead farmers can pick young leaves from the nearby stands, cut them into small pieces and feed them to chickens. The leaves can be ground or pelletised to provide an effective feed.

Large amounts of these leaves are shed, and they create a vast renewable feedstock for livestock. Bamboo leaves and shoots contain an appreciable quantity of carbohydrates and a distinctive set of flavonoids and protein. A prior study reported that bamboo leaves are rich in crude protein (9–19 percent) and low in crude fibre (18–34 percent); however, 70 percent of the total ash content was reported to be silica and other insoluble mineral matter (Singh, 1999).The leaves were poor in phosphorus, potassium and sodium; normal to rich in zinc; and rich in calcium, magnesium, copper and manganese substances. According to a joint field investigation of FIFAMANOR, PROSPERER and INBAR(2017) on bamboo feed and fodder in Madagascar to find suitable bamboo species, *Bambusa balcoa, Bambusa tulda, Bambusa vulgaris* and *Dendrocalamus asper* contain an average of 57.05 per cent dry matter (DM), 29.08 per cent crude fibre (CF) and 12.53 per cent crude protein (CP).Bamboo leaves are included along with other silage at a ratio of 3:1 or 1:1 to produce concentrated feed for livestock, to yield a potential source of feed supplements for ruminants and to overcome feed shortages in winter or during the dry season in Madagascar(FIFAMANOR,PROSPERER and INBAR,2017).

1.2 Bamboo as Forage

Like all grasses, bamboo is an important forage plant. Bamboo grows in diverse environmental conditions and from tropical to temperate areas. It maintains a continuous vegetative cover even during drought or cold conditions. The shed leaves create a thick layer of litter, which maintains the under-storey microclimate and retains soil moisture. Its dense root system allows bamboo to grow upward as a clump and horizontally form a rhizome net. This extensive internal rooting system contributes to the restoration of slash and burn ('jhum') cultivated land on hill slopes and controls runoff and soil erosion.

When used for winter forage, bamboo is able to maintain the nutritional value of livestock and chicken intake. Planting bamboo near homesteads and farm boundaries promotes its use as forage to maintain livestock health so the animals are in good condition to produce milk and eggs. Bamboo is therefore an added value product to generate income and improve livelihoods. Most other tree species shed their leaves seasonally and are usually bare in winter, a period when other grasses are also not available. Bamboo only sheds its old leaves, and the plant's leaves continue to grow in winter. During this season, there is often a shortage of fresh green fodder; households often run out of stored feed in winter, especially in hilly and mountainous areas.

The nutritional potential of bamboo leaves for dairy cattle could lead to farmers to widely adopt this multipurpose resource and integrate bamboo cultivation in their forage system to improve feed sufficiency (FIFAMANOR, PROSPERER and INBAR, 2017).

1.3 Bamboo as a Hay Crop

Bamboo belongs to the grass family, and livestock owners use it as a hay crop similar to alfalfa. Clumps of bamboo can produce extensive yields without requiring much maintenance. Bamboo should be thinned when green by trimming the tops about two feet from the ground. At the time of thinning, some shoots may be harvested for food. Livestock can also graze on bamboo; like any other hay crop, it can be mixed with different types of feed grains. Bamboo as a hay crop feed for livestock is found in many bamboo cultivating areas. It saves time for animal husbandry farming households and allows for the participation of women. Homesteads that practice bamboo farming could lead to increased systems development and the adoption of sustainable harvesting and management, which may allow bamboo to be used as a hay crop.

1.4 Bamboo as Grass Silage

Actively grown bamboo leaves that are harvested (usually chopped) retain a high moisture content of 40–80 percent. They are packed tightly to eliminate oxygen and then allowed to ferment at low pH conditions for preservation. The end product is a ruminant forage called silage.

Most wild animals prefer young, tender bamboo shoots, as do domestic animals. Bamboo shoots are cheap and are dried and mixed with the typical grain silage. Bamboo can be used as a buffer-stock for livestock feed. Silage is preserved fodder, which is used to feed livestock during dry seasons when natural pastureland is less available. The silage-making process involves fermentation, which is carried out by microscopic organisms living in the bamboo. This process requires acidic conditions to preserve nutrients within the bamboo. If fermentation is done at higher pH levels, it results in silage that has a bad taste and lower amounts of sugar and proteins.

Bamboo grass silage contains 7.65 percent starch and 1.12 percent digestible true protein, so it is more fibrous but higher in digestible protein than corn silage. Two cows with daily milk yields of 11 kilograms were fed 20 kilograms of bamboo grass silage instead of the same amount of corn silage. they produced 12 per cent less milk and 17.82 per cent less milk fat when compared with the control periods (Localharvest,2011). It will save money and increase the income of the farmers.

1.5 Bamboo Feed Additive: Charcoal and Vinegar

BC and bamboo activated carbon provide numerous benefits when added to animal feed. Bamboo's biomass has a unique cell structure, which makes bamboo charcoal (BC) an effective absorbent. High-quality BC can be processed by pyrolysis and ground into fine particles as 100-120 mesh size Bamboo vinegar is a by-product of bamboo carbonisation.

Bamboo charcoal and bamboo vinegar are beneficial either together or separately for the health of animals. The bamboo charcoal has a high adsorptive surface that binds to impurities from both water and feed and prevents them from reaching the animal's gut. It increases the absorption of nutrients from feed, helps to promote weight gain during reduced growth periods and absorbs ammonia

Bamboo charcoal added to the feed or drinking water improves the smell of the shed and helps keep down flies.

Photo courtesy: EcoPlanet Bamboo

to reduce the odour of livestock manure. The bamboo charcoal powder may be fed to cattle as a feed additive at a rate of 1–2 percent (by volume) or may be added to their drinking water to reduce the bad smell of manure by 50 percent(EcoPlanet,2017).

1.6 Bamboo Mixed Grain Feed

Bamboo leaves and shoots may be mixed with common grain feeds to reduce feed costs and provide optimum nutrient values as bamboo mixed grain feed for livestock. This mixture can be produced at the household level and become a micro-business enterprise.

Maize has a high starch content of about 70 percent and is low in fibre. It also contains 85–90 percent total digestible nutrients (TDN), 4 percent oil and 8–12 percent protein. In contrast, bamboo grass silage has 7.65 percent starch and 1.12 percent digestible true protein. It is more fibrous and also higher in digestible protein than maize silage.An analysis of 27 species of bamboo plants showed their nutrient content to be rich in crude protein (9-19%) and low in crude fibre (18-34%). However, 70 per cent of the total ash content was reported to be silica and other insoluble mineral matters. Leaves were poor in P, K and Na, normal to rich in Zn and Ca and rich in Ca, Mg, Cu and Mn content. Cu content was very high (17ppm) in ***Bambusa arundinacea*** leaves (Singh, 1999). Bamboo is high in CP and low in fibre content. Barley, however, is deficient in the amino acid lysine. Therefore, bamboo and barley are good feed supplements for livestock when given together. Moreover, bamboo leaves and shoots are cost-effective supplements to maize for livestock feed.

2. Bamboo Feed: Management Practices

The farmers should be encouraged to adopt scientific management practices of bamboo clumps for better yields; ; maximise leaf production at the desired browsing height, and plant climate friendly bamboo species.. This increases leaf production and makes it easy to pick/access leaves regardless of whether the leaves are mature or young.

2.1 Harvesting Technique

Livestock farmers should follow scientific processes and techniques to harvest bamboo leaves and to manage clumps intended for feed. These methods will help to reduce the costs and availability of feed and may generate income through the selling of bamboo feed in different forms. Preference should be given to harvesting young, soft green leaves from two- to three-year-old culms. These leaves have a good chemical composition and nutritional value. It is also advisable to avoid harvesting the bamboo leaves in the early morning . The leaves carry moisture condensed from the atmosphere, especially at night, and deposited in the form of small drops upon any cool surface. It has been observed that the cattle will not eat the bamboo shoots when they are wet. **De-topping:** Check that the bamboo has buds on its lower nodes. A new bamboo culm should be cut at a height of 1–1.5 metres(m) above the ground (relative to the target animal's feeding height). Only poles that are around 3 m tall should be de-topped, and this is best done before the leaves begin emerging from the top of the pole. In some cases, the entire culm should be also cut, resulting in profuse branching and leaf production. The cut culm is then dragged to the animals for feeding.

Lopping: Tertiary and sometimes secondary branches should be removed using a sharp knife or simply by hand. These branches are directly fed to the animals. In some places, this is a livelihood option; the branches can be bundled and sold at markets.

Pruning: Young bamboo leaves should be pruned at a height of 75 centimetres (cm) and made to form a 'tabletop' like that of tea bushes to make leaf picking easy. Besides fodder, such leaves could also be used as feed.

Hedging: The bamboo species, *Bambusa multiplex, Phyllostachys arundinorea and Phyllostachys aurea*,are particularly suitable for pruning into a hedge. However, almost all bamboo species, including those with medium diameter poles, can be made into a hedge. The smaller the diameter of the bamboo, the thicker the hedge. This causes more branching and leaf production.

The height at which the clump is pruned into a hedge can be the same as the feeding height of the target animal. Species trials should be undertaken to assess the bamboo's ability to withstand recurrent trimming and harvesting of leaves.

Grazing: Young bamboo plants in poly-pots should be rooted into the ground to allow adequate space for livestock to graze, which helps to trample the plants. Straight and circular bands can be made for this purpose. Circular bands would be suitable for small ruminants, such as goats that could be tethered to the centre of the circle and allowed to feed all around.

Thinning: Mature poles over three years of age are removed and sold or used in other ways. This removal helps the growth of new shoots with enhanced leaf production for livestock feed.

2.2 Feeding Methods

Feeding methods depend on the habits of the animals, the seasons and the locations of the bamboo growth. The leaves can be gathered, dried, stored and fed to ruminants. Dried leaves that have fallen on the ground can also be swept together and fed to animals. Poultry need young and soft leaves chopped to a size they can feed on, while grown chicken can feed on the entire leaves. Chicks feeding on bamboo leaves have longer intestinal tracts, which encourages healthy and natural but also significantly faster development. It is likely that starting chicks off on a bamboo mix feed and then later graduating them to a more conventional feed that still has bamboo added to the existing feed in an appropriate ratio may reduce feed costs.

Bending: Some farmers directly bend the bamboo for livestock feeding. This is a common practice in hilly areas where bamboo grows on slopes.

Cut and carry: When bending is difficult, farmers simply cut the top of the bamboo to allow branches and leaves to grow sideways at a lower height than breast level so that animals can access the leaves directly from the plant. However, if the bamboo is multi-purpose, the best method would be to cut and carry. In this case, farmers must indulge in shift harvesting.

Grazing and pasture feeding: Farmers should harvest/graze their animals so that no one area gets overused; shifting harvest or grazing methods can be applied to avoid damage to the whole stand. When grazing, young poles less than three years of age are the best quality as the foliage and twigs are more digestible. The most commonly used method of recognizing the age of bamboo culms is to identify the colours of culms or to mark new poles the year they emerge from the ground as new shoots.

Supplement feeding: Feed supplements may be produced from any processed form of bamboo, from grinding the leaves and culms into charcoal to the more technical extraction of individual components to be added to feed or used as a supplement. Bamboo supplements may also involve the addition of nutrients from other sources to meet the nutritional and dietary requirements of livestock.

Mulch: Bamboo leaf litter is an excellent natural mulch. All bamboo species shed their leaves throughout the year. When these leaves decompose, they add organic matter to the soil and feed organisms, such as earthworms and microorganisms. Earthworms improve soil drainage and nutrition by ingesting, grinding and digesting large quantities of soil. Chickens can also feed on these earthworms, which contain good quality protein.



Photo: Bamboo leaf feeding for livestock in the South-south Phase-II project

3. Conclusions and Recommendation

Bamboo is a promising natural resource where food-feed competition is not an issue. It supplements and concentrates feeds while also providing forage on homesteads in intensive and semi-intensive production systems. Bamboo leaves provide nutrients to promote the faster growth of livestock and can generate income and improve livelihoods. The medicinal and curative properties of bamboo have immense value in protecting livestock from diseases. The bamboo extracts, charcoal and vinegar, help to enhance the eggshell quality, growth performance and meat quality of livestock. They also adsorb microorganisms and toxins to prevent cold stress.

Finally, bamboo should be promoted in farming systems development, including an agroforestry model, through a people-participation approach to customizing bamboo as feed and fodder for livestock.

Each day, dairy cattle require good nutrition and a sufficient diet to meet their nutritional requirements, to maintain good health and to achieve their potential milk yield. Bamboo can produce a large green biomass throughout the year that can be used as fodder, especially during forage shortages in the dry season.

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Annex-I: Chemical Composition of Bamboo Leaves

Chemical Composition of Bamboo Leaves

Sl.No.	Name of the Species	DM(%)	Ash (%)	Crude Fibre(%)	Crude Protein(%)	ADF(%)	ADL(%)	NDF(%)
1	*Bambusa balcooa*	58.5	17.05	28.04	7.71	54	12	78
2	*Bambusa bambos*	57.2	6.68	26.32	15.43	49	14	76
3	*Bambusa tulda*	57.1	10.92	31.84	13.42	54	15	77
4	*Bambusa vulgaris*	57.1	16.12	26.96	14.95	54	12	77
5	*Dendrocalamus asper*	44.5	11.32	32.64	11.76	51	11	75
6	*Dendrocalamus giganteus*	52.7	12.17	29.24	14.29	51	11	72
7	*Dendrocalamus strictus*	59.8	18.51	25.88	10.68	52	10	74
8	*Phyllostachys aurea*	64.6	10.95	28.78	11.57	44	11	79
9	*Phyllostachys arundinorea*	61.9	17.54	31.99	12.94	55	13	79

DM: Dry matter, ADF: Acid detergent fibre, ADL: Acid detergent lignin, NDF: Neutral detergent fibre

Source: FIFAMANOR, PROSPERER and INBAR (2017) unpublished bamboo fodder action research report in Madagascar in South-south Phase-II, IFAD-EU project.

Annex-II: Advantages of Bamboo as a Feed/Feed Supplement

S. No.	Properties of bamboo	Benefits
All poultry production systems		
1	Chlorophyll fights infections, helps form red blood cells and builds a stronger immune system	Diseases are prevented Healthier birds
2	Lactone is good for the cardiovascular system	
3	Powdered bamboo extract in chicken feed	Higher body weight gain
4	Bamboo charcoal (BC) and bamboo leaf (BL) dietary supplementation	Improves growth performance, feed intake, feed conversion efficiency and meat quality
		Reduces mortality rates
5	High dry matter (all nutrients in a feed except water; this includes protein, fibre, fat and minerals) content	Affects feed intake as most breakdowns of feed quality like energy and protein are measured in terms of the dry matter
Extensive free-range production system		
7	Bamboo clumps help in soil conservation and provide a habitat for insects and earthworms	Chickens can forage under bamboo clumps for fallen leaves, insects and earthworms.
		Inexpensive feed supplement
8	Bamboo leaves (leaf litter is an excellent natural mulch)	Meat has lower cholesterol levels and is higher in unsaturated fats
9	Bamboos shed their leaves throughout the year	Natural food available throughout the year

The International Organisation for Bamboo and Rattan (INBAR) is an intergovernmental organization established in 1997. INBAR is dedicated to improving the social, economic and environmental benefits of bamboo and rattan. INBAR plays a unique role in finding and demonstrating innovative ways of bamboo and rattan to protect environments and biodiversity, alleviate poverty and facilitate fairer pro-poor trade. INBAR connects a global network of partners from the government, private, and not-for-profit sectors in over 50 countries to define and implement a global agenda for sustainable development through bamboo and rattan.