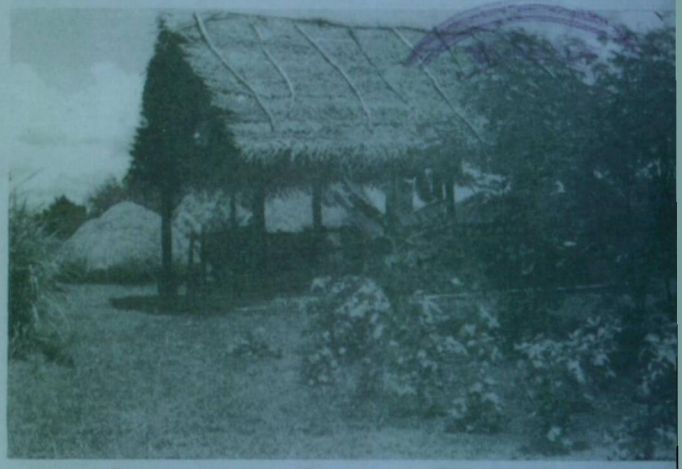

Crop-Livestock Integration for Maximizing Smallholder Farm Income

Farmers' Guide for Optimum Utilization of Farm Resources for Increased Productivity and Income

SAREC/NSF Buffalo Research and Development Programme
Peradeniya, Sri Lanka

Information Leaflet No.10 (1998)

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What is crop-livestock integration and why is it important to the farmer

Crop/livestock integrated farming refers to the complementary use of crop and livestock farming to maximise the returns from a unit area of land. Crop residues and fodder resources provide animal feed such as rice straw, maize stover pasture and tree fodder. Animals on the other hand provide, in addition to products like milk, meat, draught power and animal waste (dung and urine). The latter is an excellent source of organic fertilizer to enrich the fertility of the soil. Most importantly , livestock provide a regular supplementary income to meet daily cash needs and hence helps the farmer to avoid falling prey to agricultural debt. Therefore livestock is an important component in all smallholder agricultural pursuits in all agro-ecological zones of the country. This feature is observed more in the dry and intermediate zones, where income generating opportunities are less.

Traditionally most smallholder farmers engage themselves in crop production as the primary agricultural activity but also rear a few cattle and buffalo cows, feeding them on communal grazing areas (i.e. extensive management systems), most instances for draught and milk. But, in view of the progressive decline in the size of land holdings, the time has come for the smallholder farmer to practice greater integration of crops and livestock in order to increase their income. Moreover, the traditional extensive system of management of cattle and buffaloes has become increasingly difficult to practice, considering the fragmentation of land holdings and dwindling availability of communal grazing grounds. However the need for supplementary income by rural smallholder farmers has never been so great, and in that context livestock is still one of the most affordable and a sustainable way of enhancing rural household incomes, provided that more appropriate livestock management systems are adopted.

Constraints faced by the farmers engaged in extensive management of livestock can be identified as follows:

a) Inability to feed the animals as a result of reduction in the extent of communal grazing areas, due to the clearing of vast jungle tracts and scrub lands for crop production and human settlements. Free grazing animals frequently trespass crop areas and damage crops and irrigation bunds and canals. This usually result in conflicts among farmers, particularly in new settlement areas such as Mahawali.

b) Seasonal fodder shortages during the long dry spells and fluctuation in the quality of roughage.

c) Low productivity of the existing stock, mainly due to poor genetic make up and poor nutrition.

The plausible solution to overcome these constraints would be to reduce the herd size to manageable numbers in keeping with the available resources and improve the milk production potential of the animals through genetic upgrading in addition to better feeding and management. Research conducted in Sri Lanka and elsewhere have addressed these problems and generated a wealth of information on the appropriate technologies that could be adopted to overcome the above problems. The following approaches could be adopted to overcome some of the pressing problems.

1. Intensify livestock management practices through greater crop-livestock integration with recycling of by products and by adopting appropriate stock management practices in feeding, breeding and health care.
2. Overcome the feed shortage by a). improving the fodder base in the homestead and b) better utilization of locally available pasture fodder species, tree fodder, and non-conventional feed resources (eg. rice straw).
3. Rational and economic use of a) concentrate feed such as coconut poonac, rice bran and d) strategic feed supplements such as urea , molasses and urea-molasses-mineral multinutrient feed supplements to overcome nutritional deficiencies.

For this purpose, the SAREC/NARESA Water Buffalo Information Dissemination Programme has made available a series of information

leaflets (10 in number) containing guidelines on feeding, reproduction, breeding, management, preventive health and also the use of catalytic feed supplements (urea-molasses multinutrient feed formulae). This leaflet is the last in this series and the purpose of it is to provide information for the development and management of a crop livestock integrated farms. Specific guidelines are given for,

1) the establishment and management of the feed base,
2) construction of a cattle shed,
3) management of the animals including milking and record keeping and
4) recycling of crop-residues, agro-industrial by-products and animal waste for optimum returns from smallholder crop livestock integrated farm.

Please note that these recommendations are applicable to all agro-ecological zones.

1. Forage Production, Management and Utilization

As the profits of a smallholder livestock operation is largely dependent on the cost of feed, the use of expensive concentrate feed must be kept to a minimum level. Green forages (grass, fodder and tree fodders) are the cheaper sources of nutrients in the system. The efficient production of green forages within the system is therefore an essential feature towards maximisation of production from your crop-livestock farm.

Forage production in an integrated system could be easily incorporated into your homestead through the cultivation of fodder, grasses and tree fodders in the following manner as illustrated in Fig. 1.

- Fodder trees along the main boundary fence
- Fodder trees as internal hedges / hedgerows
- Fodder grass cultivation in suitable areas around the cattle shed
- Pasture cultivation in identified area for rotational harvesting.

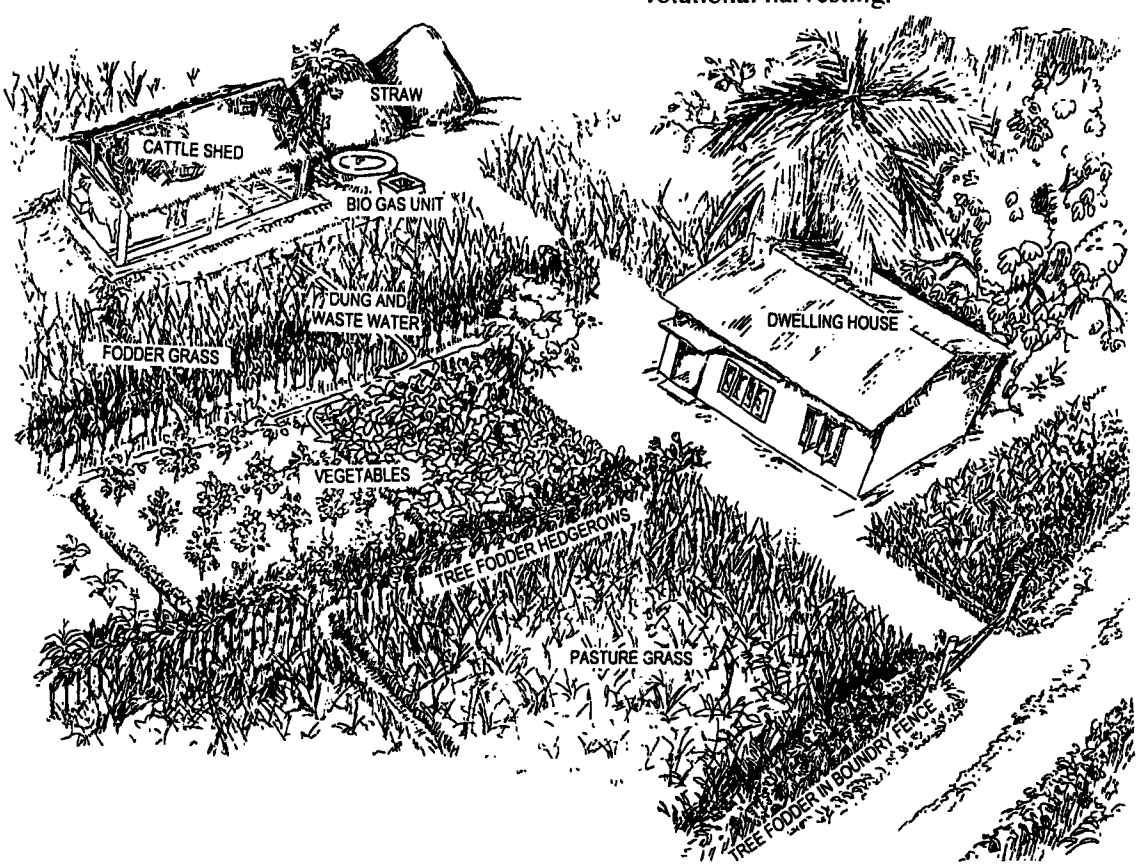


Fig. 1. Diagrammatic presentation of a layout for a crop-livestock integrated smallholder farm.

a) *Forages in the main boundary fence*

Fodder trees could be established and maintained as a live fence as far as possible. Live fences reduce the cost of fence maintenance, particularly the need to replace fence posts. The planting material is inexpensive and is available locally. e.g. Gliricidia, Ipil-Ipil, Dadap. Fodder trees along fences are commonly planted at a spacing of 0.5-1.0 m (2 or 3 ft) and harvested at a height of 1.0-2.5m (3.5 - 8 ft). Harvesting can be done at 3 month intervals. In general, 100 trees would provide enough fodder for two milking cows throughout the year. This is perhaps one of the most widespread uses of tree fodders, in small home garden systems. Live fences of Leucaena around an acre of land can produce enough fodder to satisfy 30% of the intake of the roughage needs of a cow throughout the year. (Fig. 2).

Fig. 2. Diagrammatic sketch of tree fodder on boundary fence

The advantages of having a live fence with fodder trees in the boundary of your home garden are many. They provide 1) shade and shelter for livestock, 2) stabilise sloping lands against soil erosion because of their deep-rooted nature, 3) supply high quality (protein rich) forage for feeding animals, 4) provide nitrogen-rich manure (green manure) for crops, 5) a source of timber and fire wood, 6) act as a wind barrier and 7) useful as live trellises for climbing crops like pepper.

Common tree fodder species recommended for different agro-ecological zones and their yields are summarised in Table 1.

Table 1: Tree Fodder species recommended and expected yields

Tree fodder species	Recommended zone	Defoliation frequency (months)	Fresh leaf yield (Av) kg/tree/Yr
Gliricidia	MC, DZ, C▲, LCWZ	3 - 4	7 - 10
Leucaena (Ipil Ipil)	MC, DZ, C▲, LCWZ	3 - 4	5 - 6
Erythrena (dadap)	HC, MC, DZ	3 - 4	5 - 7
Albizia	MC, DZ, C▲, LCWZ	3 -5	4 - 6

Mid country = MC, Hill country = HC, Dry zone = DZ,
Low Country Wet Zone = LCWZ, Coconut Triangle =C▲

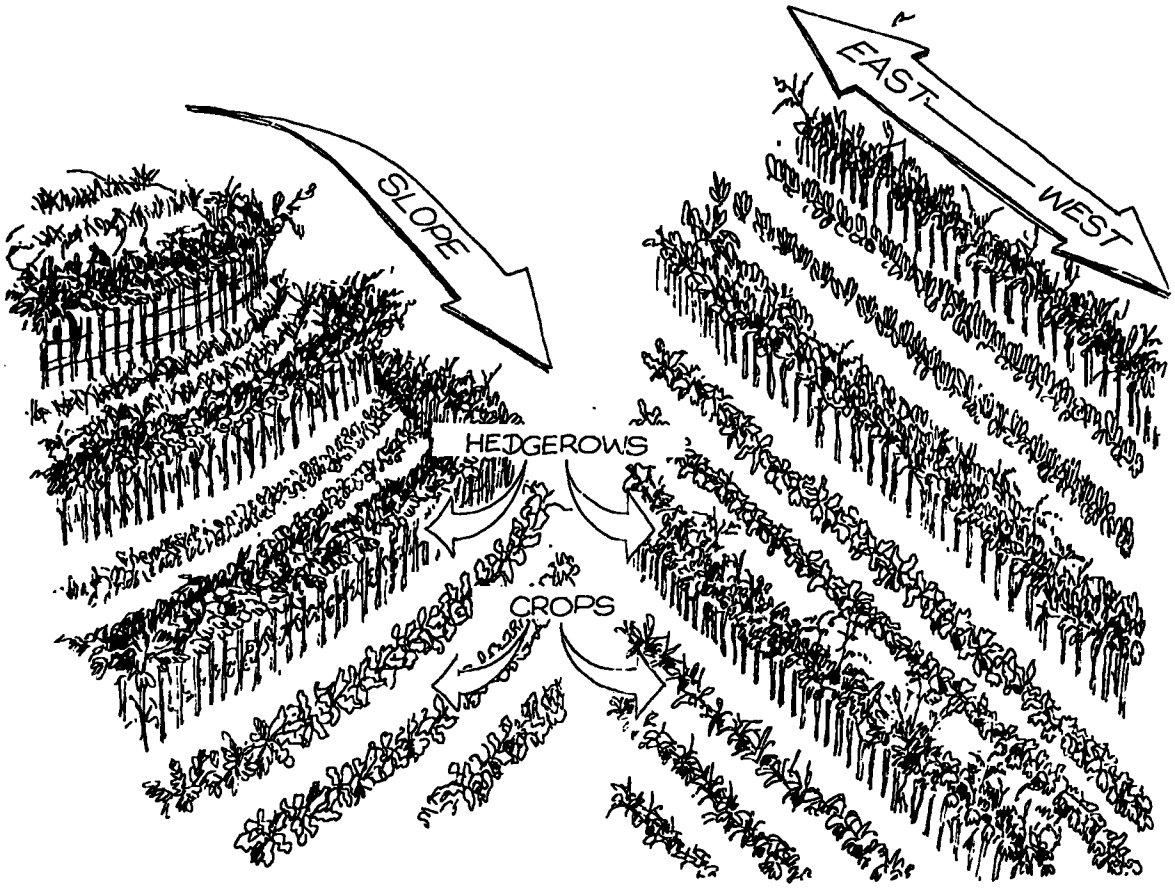
b) *Forage as Internal hedges / hedgerows*

Hedgerow intercropping in a home garden is a practice where perennial tree legumes or shrubs are grown together with vegetables and pasture crops. The recommended tree (shrub) species suitable for internal hedges are Gliricidia, Leucaena, Calliandra, Flemingia, Sesbania spp., Accacia and Erythrena.

The trees are planted in wide rows and vegetable crops, cereal crops like maize or sorghum and pasture spp. are grown in the interspaces or alleys between the rows as shown in Fig. 3. During the cropping season the trees are pruned and the prunings are used as mulch for crops to improve the organic status of the soil and provide nitrogen to the soil. Hedges should be placed along the contour of the land or in an East-West direction to allow maximum sunlight for the crops. However, the slope of the land is the main factor that needs consideration particularly in steep/slopy lands. It is always better to plant the hedgerows along the contour to prevent soil erosion. If hedges are placed along the slope, taking into consideration the direction of the path of the sun, strips of short grass (e.g. Guinea, Setaria, Savandara) should be grown along the contour .See Fig.3a

The right choice of tree species for hedgerow farming is extremely important and to a large extent will determine the success or failure of the system. There are several attributes which should be considered when selecting the tree species. In most areas, row spacing between trees range from 2-7 m, with 4-6 m being commonly used. However, the spacing may vary according to the slope of the land. Spacing of trees within rows should be as close as possible. Experience with species such as Leucaena, Gliricidia and Sesbania indicate that trees should be spaced 30 cm (1 ft) apart or as near as possible to form a solid hedge along the row. This helps a favourable leaf to stem ratio, provide a more effective barrier to soil movement in sloping lands and creates a better microenvironment for crop growth. Hedgerows or alley cropping is recommended for flat land as well, because it improves the productivity of the system.(see Fig. 3b).

The advantages of the internal hedges and hedgerows are many: They 1) increase the productivity of the land due to the addition of nutrients and organic matter to the soil, 2) reduce or eliminate the use of chemical fertilisers 3) act as physical barriers when trees are planted in rows on sloping lands, resulting in significant reduction in erosion losses; 4) provide high quality forage and (protein rich) leaf meal for animals and 5) help weed control (due to shade effect on the ground) and improve the appearance of the home garden.



3a. Sloping land

3b. Flat land

Fig. 3 Diagrammatic sketch of tree fodder as hedgerows

c) *Forage around the cattle shed*

If there are open spaces or less shady places around the cattle shed, high yielding fodder grasses such as Napier and its hybrids. (Bana, clone-13, NB-21, Co-1, Panama etc.) can be grown as shown in Fig. 1. Since these grasses prefer higher levels of soil nutrients and water, the area around the cattle shed provides a better environment. However, these grasses are not adapted to water logging conditions. In general 40 kg of fresh grass (average daily requirement of a dairy cow) can be harvested from a 50 square foot plot under good management. Therefore, do not neglect to plant at least a small plot of a high yielding variety of fodder in an open space near the cattle shed.

d) *Management of forage plants for maximum yields*

Good management of the forage plants throughout the entire year is essential. Appropriate harvesting practices, fertiliser application, weed control and careful management will ensure maximum forage production in the system.

Cutting frequency (cutting interval) and cutting height (cutting intensity): Cutting management is a very important factor that influences the productivity of tree legumes, pasture and fodder grasses in the system. Severe pruning or harvesting cause adverse effects on the subsequent growth. (see Table 2 for details)

Table 2 Recommended cutting height and frequencies

	Cutting frequencies in days	Cutting heights
Tree fodder in the main fence	75-90	4 -5 ft
Tree fodder in the internal hedges	45-60	2 ft
Grasses around the shed	30	5 inches
Grasses in open places	30	3 inches

Please remember that :

- when lopping fodder trees, a sharp knife or trimmer must be used
- frequent pruning at a lower height can minimise the shading effect of the hedgerows and would reduce the effectiveness of the biomass production of the hedgerow and nutrient recycling.

e) Fertiliser application

Fertiliser application : You should remember that soil nutrients in the farm are constantly being removed either directly through the crops like pasture and fodder, vegetables and fruits and indirectly through milk and other animal products. Hence it is vital that nutrients extracted from the soil should be replaced eventually to bring about a balance.

Organic fertiliser : Use organic fertiliser on your forage plants and other crops wherever possible It will be more advantageous to use cow dung and shed washings available in your own farm, as this will reduce the cost on chemical fertiliser in crop production. Farm yard manure (FYM) can be used in many forms:

a) as dry solid manure, b) as compost manure and c) as liquid manure

Advantages of using organic manure are that :

- it increases the organic matter content of the soil
- It improves the soil structure and help to increase aeration, water movement, microbial activity, root penetration etc.
- It can be applied as a mulch to the soil surface to control weed growth, conserve soil moisture and reduce soil erosion.
- It can increase the microbial population of soil and improve the fertility
- It can absorb excess nutrients and toxic substances
- It could be directed to a bio-gas plant to generate bio energy for household cooking and lighting.

Details of the preparation of compost and other forms of manure and their application on crops may be obtained from the farmer information leaflets issued by the Departments of Agriculture and Animal Production and Health. Organic fertiliser is best applied before planting or after the fodder is harvested.

Use of Chemical fertiliser : If the organic manure is in short supply, at the time when the need for fertiliser arises, chemical fertiliser may be used as a general mixture if and when necessary in the ratio given below See Table 3. Fertiliser application is usually practised twice a year with the onset of rains. When small plots are planted proportionate amounts of the mixture may be applied as per requirement.

Table 2 Application of chemical fertiliser

	Application Rate	
Fertiliser Ingredients	**kg (Ha /Yr)**	**kg (Ac Yr)**
Urea	200	80
Murate of Potash	120	50
Triple Super Phosphate	120	50

1 ha=2.47 acs

Weed Control Weeds begin to appear particularly in newly established pasture and fodder blocks in the system. This can be minimised with good management practices. Regular manual weeding is the usual method of weed control in smallholder systems.

2. *Animal Housing*

Housing is an essential component of an intensively managed dairy farm. Hygienic animal housing is a pre-requisite for clean milk production. However, the cattle shed need not be an elaborate and expensive construction. It can be a low cost structure, provided the basic structural features are incorporated on a scientific basis as shown in Fig 4 (cattle shed for the Dry, Intermediate, Low and Mid country zones) and Fig. 5 (cattle shed for Hill country wet zone)

a) Specification for a cattle shed (3 cow unit) recommended for the Dry, Intermediate, Mid and Low country zones (see Fig. 4 .1 to 4.7 for details):

Length of shed- The length of the shed required to house 3 cows with an enclosure for calves is 20 feet (add 4'3" for each additional cow).

Width of shed- 12' 6"

Height of the shed - The minimum height of the shed at the ridge is 13' and at the sides is 8'6"

Pillars - While the use of locally available material is encouraged, hard wood (9" diameter) should be used. If hard wood cannot be found, concrete pillars (6" diameter) are recommended.

Roofing - It is always better to use cadjans or straw to cover the roof if the environment is hot and humid. Aluminium and zinc sheets tend to increase heat stress on the animals in a hot environment.

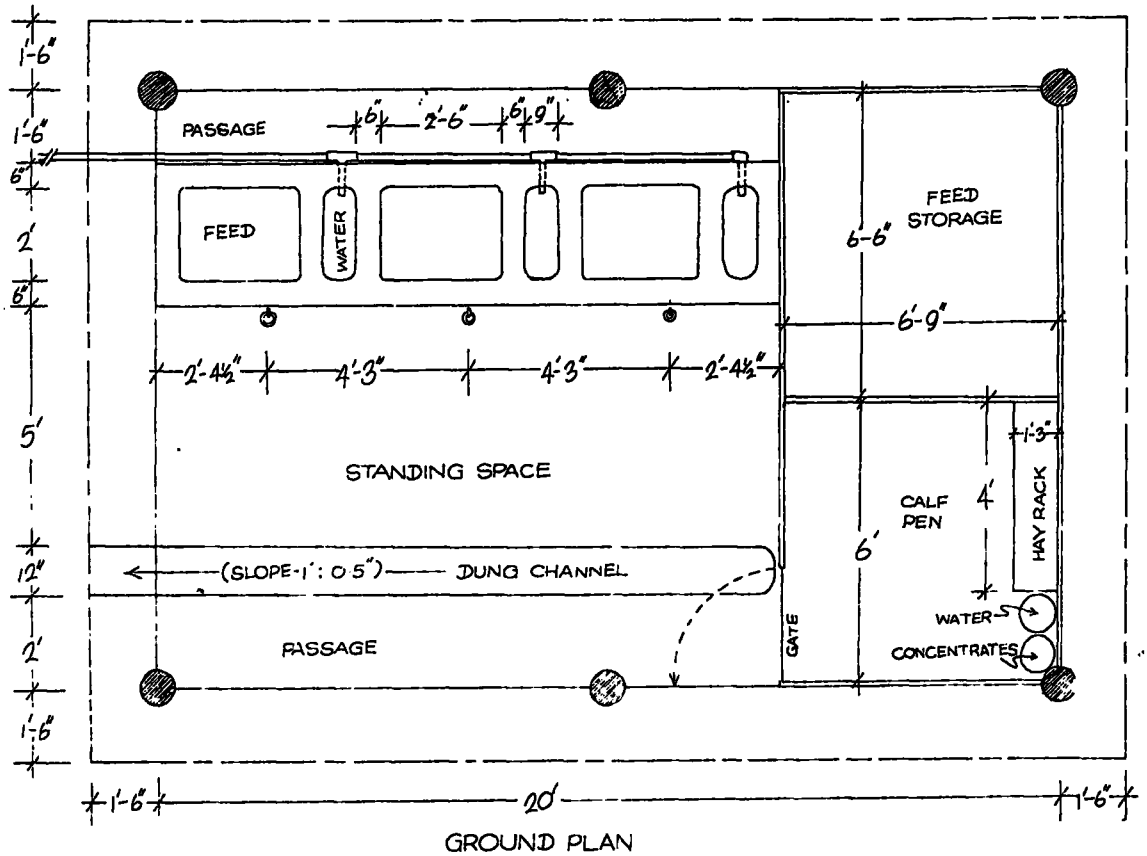
Floor - The floor must be properly paved. The standing area of the cow and the dung channel should be made with concrete. The rest of the shed could be paved with bricks or rubble and cemented. The standing should be 4' 9" or 5'. Floor should slope 0.5" to 2' from tie point to dung channel. Dung cannel should be 12" wide and sloping to one side. Keep a slope of 0.5" to every 2' (starting from 4" in depth to 10" at the deep end) (see Fig. 4).

Feeder space The length and width of feeder space required for a cow is 4'3" x 2'

Water troughs These could be placed in between feeders as shown in Fig.4.1.

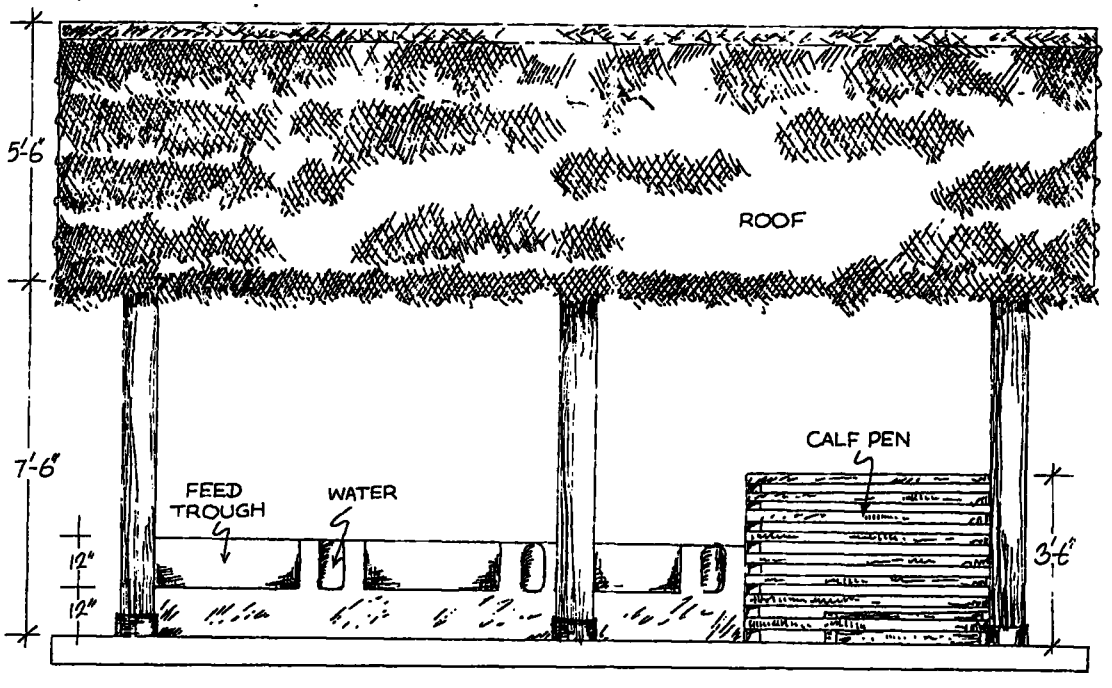
Special features

i) a simple sprinkler system with ½" PVC pipes perforated (2" apart) for spraying water over the animals during the hot part of the day (Fig. 4..5). ii) storage space in the attic for straw and other crop residues (Fig.4.6). iii) Hayrack for calves (Fig. 4.7)



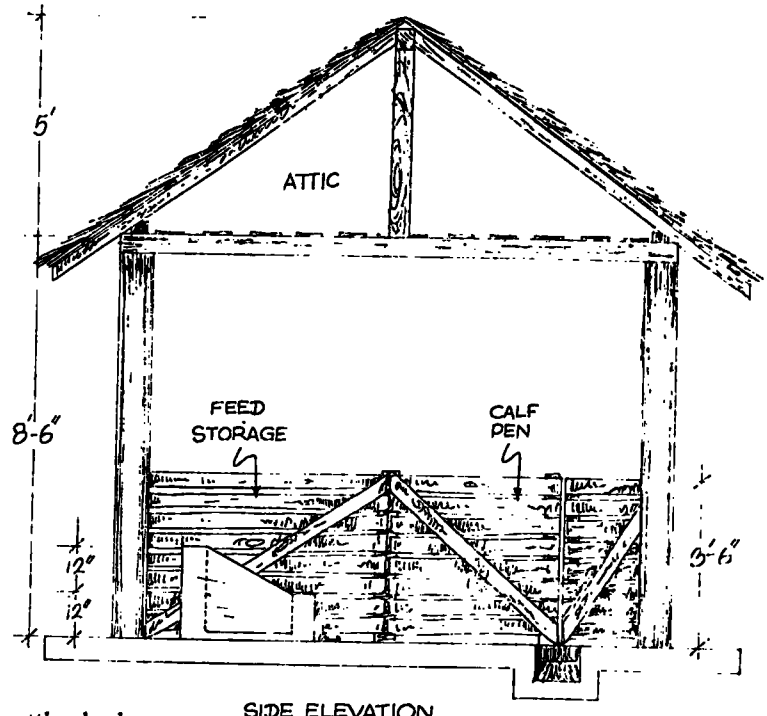
GROUND PLAN

4.1) Floor plan of cattle shed

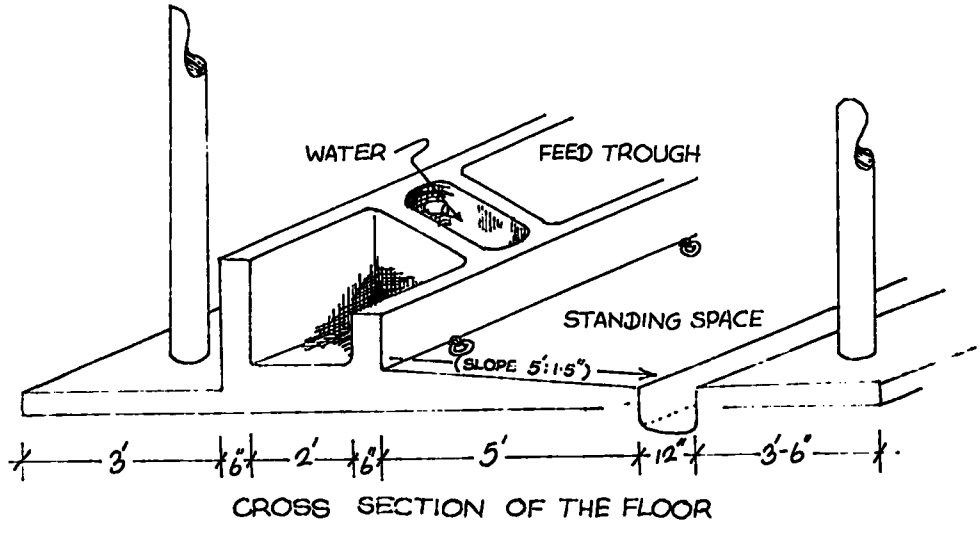


4.2). Front view of cattle shed

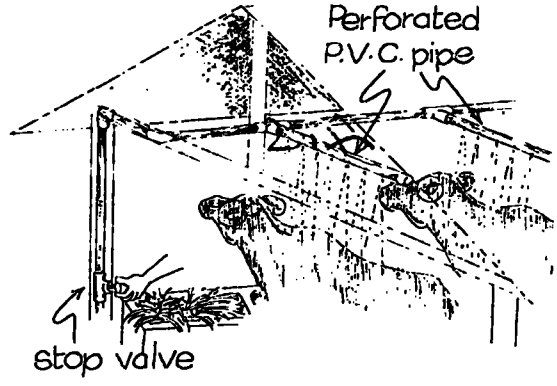
FRONT ELEVATION



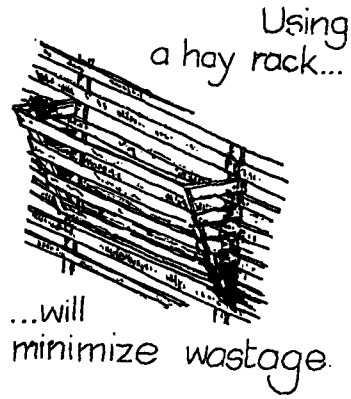
4.3). Side view cattle shed



4.4.) Cross sectional view if cattle shed floor



4.5.) Overhead sprinkler system to spray water on buffaloes



4.6) Storage space in the attic for rice straw and other crop residues

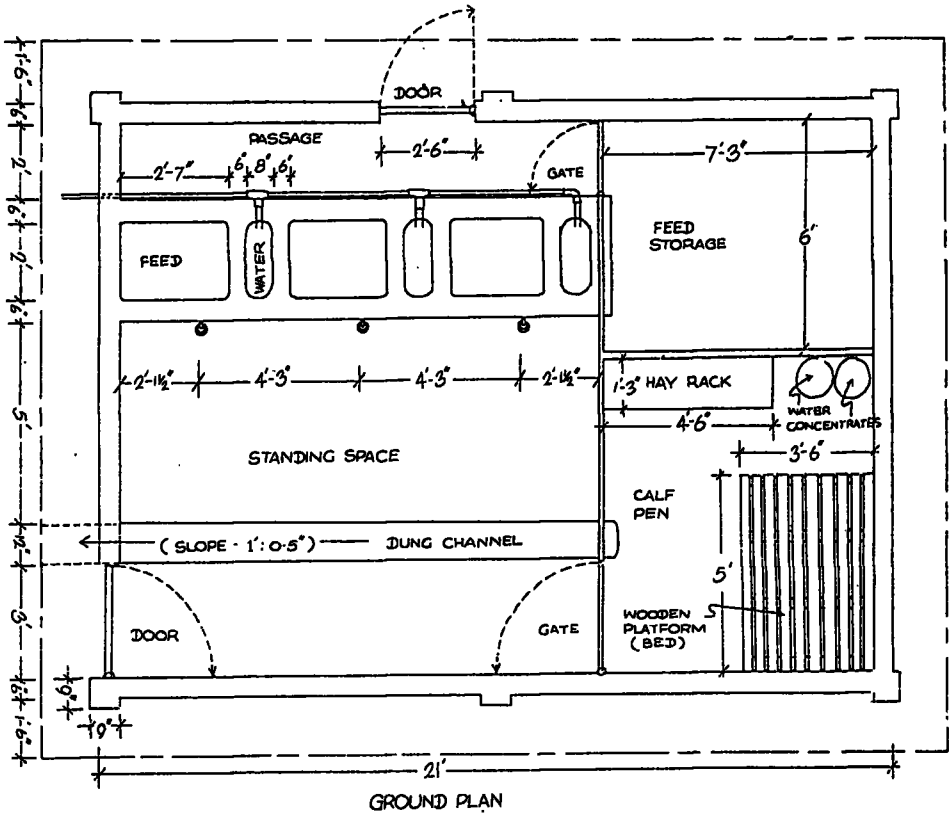
4.7) Hayrack for calves

b) Specifications for a simple cattle shed (3 cow unit) recommended for the Hill country Wet zone.

The specifications recommended earlier for the Dry, Intermediate and other zones need modifications for colder areas in high elevations such as the hill country wet zone (eg. Nuwara Eliya, Maskeliya, etc) and in the colder and wet areas of Mid country. Modifications required for such areas are as follows:

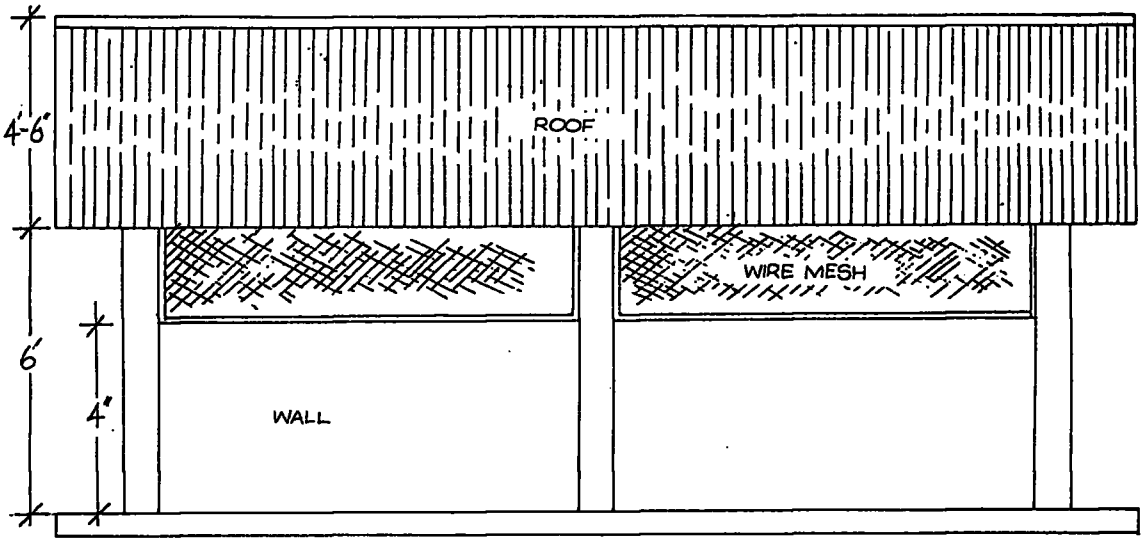
Length of shed:	21 feet
Width of shed:	15 feet
Height of the shed:	The minimum height at the ridge should be 10' and the sides 6'6" (height of pillars)
Pillars:	The pillars could be made of concrete (6" diameter).
Roof:	Straw cover may be the cheapest, but needs replacement regularly. Therefore aluminium or zinc sheets are recommended. Due to the wet cold weather prevalent in these areas, this type of roof material would not cause heat stress on the animals.
Special features:	
Boundary wall:	Provide a 4' high boundary wall round the cattle shed to protect the animals from cold and wind. If possible cover the upper part of the wall by a wire mesh (1"x1"). During very cold weather, this area may be covered by suitable material (eg. gunny bags, polythene) see fig 5
Door:	As the cattle shed is enclosed from all the sides, fix a door of 6'x3' on one side. Provide a door at the back to enter the feeding passage and the feed storage area, and a gate for the calf pen. (see fig 5.1)
Calf pen:	Provide a slatted wooden platform 5' x 3'6" for the calves to sleep as the cement floor is very cold. The platform should be raised 3" - 4" from the floor. It should also be movable for cleaning the floor.

Diagrammatic sketches of the floor plan, lateral and frontal views and cross sectional view of the floor of the cattle shed recommended for the hill country wet zone are given in Fig. 5.1 to 5.4.



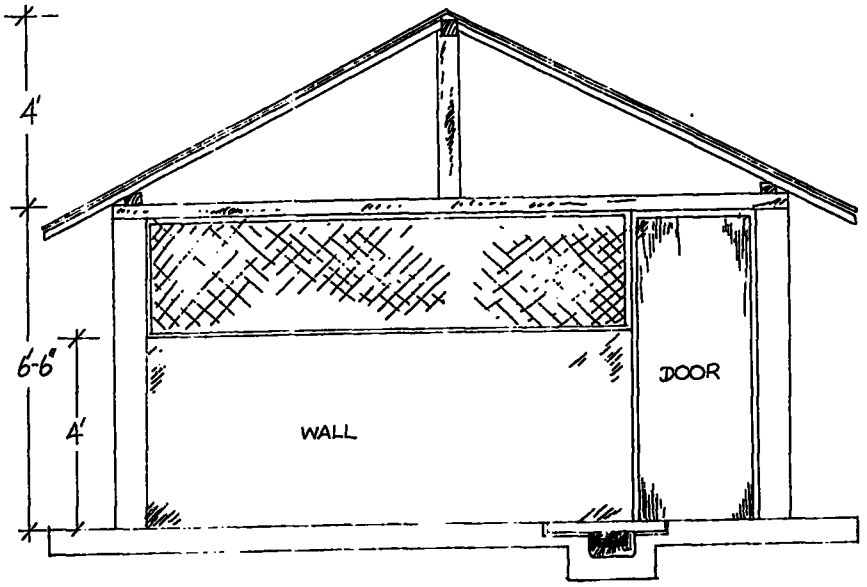
GROUND PLAN

5.1) Floor plan



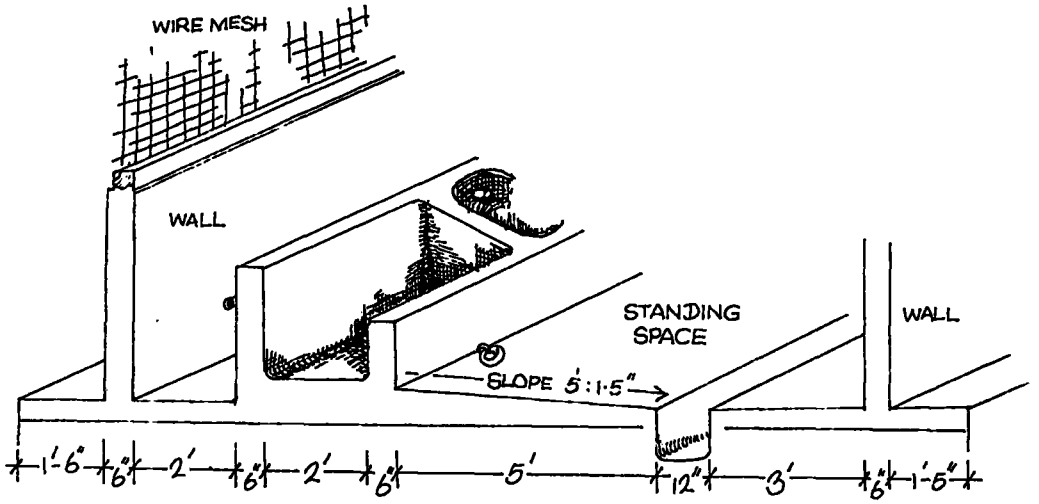
FRONT ELEVATION

5.2) Front view



SIDE ELEVATION

5.3) Side view



CROSS SECTION OF THE FLOOR

5.4) Cross sectional view of the cattle shed floor

Locating the shed : The cattle shed should preferably be sited at a relatively higher elevation in the farm or homestead, so as to facilitate the use of cattle manure, urine and shed washing to fertilize the fodder and vegetable plots through gravity irrigation. This could be achieved through a system of well designed, simple drains originating from the cattle shed.(see Fig. 1)

Cleaning and maintenance of the shed: The shed should be cleaned twice a day prior to milking. The animals should also be washed and cleaned at the same time. Soiled animal bedding and left over roughage feed should be collected and put away in a separate place or put into the compost pit before washing the shed. Then the dung and urine should be pushed out through the dung channel. Subsequently the shed should be washed, cleaned and the washings directed to the dung pit away from the shed and or to the bio gas plant. The dung may be recycled as raw material for compost, generation of biogas and in other ways described elsewhere.

3. *Management of the animals*

Good management of animals is a prerequisite to an efficient farm operation. Management involves several activities such as, handling and management of animals which include feeding, milking, reproduction and breeding, health care and maintenance of records. Detail descriptions on the above activities have been published in other leaflets in this series listed below.

No	Title
01	Fibrous Feeds and their Utilization
02	Urea Molasses Mineral (UMM) Multi nutrient Feed supplement
03	Body Condition Scoring System for Assessing the nutritional status of Buffaloes and Cattle
04	Reproduction in Buffaloes and Cattle
05	Breeding of Buffaloes and Cattle
06	Health and Diseases of Buffaloes and Cattle
07	Use of Tree Fodder for in Ruminant Feeding
08	Management of Buffaloes and Dairy Cattle
09	Feed formulation for Cattle and Buffaloes
10	Crop-Livestock Integration for maximising Smallholder Farm Income

In this leaflet emphasis has been given to important subjects that have not been included in the others. It has also provided information on some of the more important topics relevant to crop/stock integration in summary form, though some of them have been discussed elsewhere.

Handling and management : Animals need love and care, and when these are provided, they operate at maximum efficiency. Therefore, herdsman or farmer must become very friendly with the animals and handle them with gentleness on every occasion. The place at which animals are kept must be properly ventilated and provided with good lighting. During the hot part of the day regular bathing of animals is required to facilitate reduction in body temperature. This is particularly important for buffaloes whose body cooling mechanism is not very efficient. That is why they need to wallow in water during the hot part of the day. If buffaloes are reared indoors, sprinkling or splashing of water over the body at 1-2 hour intervals 3-4 times a day during midday is very desirable.

Feeding : Dairy cows and buffaloes must be fed adequately to obtain optimal milk and meat production. In general they must be given grass and fodder ad libitum and the requirement is 10% of the body weight on wet weight basis. The limitations, and method of overcoming limitations in ruminant feeding have been described in Leaflets 1,2,3,8. Grass and fodder should be available in sufficient quantities always in the feed trough, so that animals could feed during the day and night. If grasses and fodder are poor in quality and not available in sufficient quantities, they must be supplemented with a suitable feed supplement such as concentrate feed (Leaflet No 9), UMM feed supplement (Leaflet No 2.) or tree fodder (Leaflet No 7). Animals must be fed to satisfy both the maintenance and production requirements. A practical guideline to decide on the level of feeding is given in Leaflet No 3.

Water requirements : Provision of an adequate supply of clean drinking water throughout the day is of paramount importance. Thirsty stock do not eat as much food as those which are well watered. An average cow (200-300 kg) requires about 30-40 litres of water (15% of the body weight) for maintenance and an additional 4-5 litres for each litre of milk produced. It is best that animals should have access to clean drinking water throughout the day, and ideally it could be provided in a built in water trough within the feed trough as shown in the diagram given in this leaflet. This water trough could be filled via a storage tank of a reasonable size, constructed at the end of the shed with a simple ball valve device. As the water level in the trough goes down, it will be filled automatically through a gravity feed system.

Milking and clean milk production: The ultimate aim of dairy farming is to produce milk and market it as a safe human food. Therefore, hygienic practices with regard to milking is of paramount importance in dairy farming. In almost all smallholder operations, cows are milked by hand. The cows are usually accustomed to a stimulus for milk let-down. In

zebu animals and indigenous buffaloes, milk let-down is stimulated by the sight of the calf and/or suckling by the calf. For most dairy breeds of cattle and buffaloes, the routine procedure at the milking place such as the time of milking, washing the udder with warm or cold water, noise of milking bucket, feeding of concentrate, etc. have become adequate stimuli for milk "let-down". Milk removal is done by 3 methods :

1) *Strip milking* - where the teat is held between the thumb and first finger and milk is squeezed out by pulling the hand down along the teat,
2) *Pinch milking* – where the teat is pinched and stripped rhythmically, holding the teat between thumb and middle fingers and
3) *Rhythmic squeezing* - In this method the teat is rhythmically squeezed by encircling the upper part of the teat with the thumb and first fingers while keeping the remainder of the fingers in close contact. The milk is squeezed out by tightening the fingers starting at the index finger, followed by middle and then little fingers. All fingers are relaxed simultaneously and a new squeezing sequence begins. (Fig 6). This methods is the most preferred method as it causes no damage to the teat, compared to first two methods.

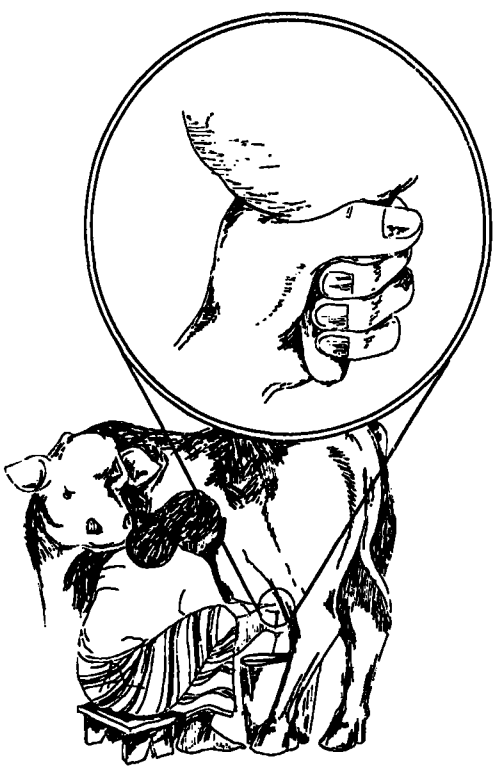


Fig. 6. Recommended method of milking - *rhythmic squeezing*

The milk collected from the teat must be free of any pathogenic organisms and should not be contaminated with other organisms, which spoils the milk within a short period. Hence the following procedure is recommended in milking your cows.

a) Wash the milk collection bucket soon after milking and also before commencement of the next milking.
b) Clean the udder and teats with water and dry the teats before

commencement of milking

c) If zero suckling is practised (calf not allowed to suckle), dip the teats in a suitable antiseptic solution after milking: Formic acid 1.6% solution is a common and cheap antiseptic that could be used for this purpose.

d) Milk must be transported in clean bulk containers (5 or 10 litre cans) and it should be done without a delay.

Reproduction and breeding : Heifers must be bred at the first detected heat if they have reached sufficient body weight or size (approximately 2/3 of the mature body weight). Cows should be bred at the first or second estrus which must occur within 60 days postpartum. It is recommended to skip if the first postpartum estrus occurs within 30-45 days postpartum, skipping the first estrus is recommended as the chances of conception is very low around this period. The cow should be examined for estrus at least 2-3 times a day, in addition to milking times. Get the cow inseminated between 10-18 hours after the onset of estrus for optimum success at conception. The cow should be examined again for estrus, more frequently between18 to 22 days after the service and if the animal has not returned to estrus get the animal examined by your veterinarian for pregnancy between 65 to 90 days after the service. Any cow which fails to conceive after 3 repeated inseminations must be checked by your veterinarian for necessary advice and treatment. Your goal is to get the cow pregnant within 90 days post-calving and thereby get one calf every year. For more details see leaflet No 4 (Reproduction in Buffaloes and Cattle) in this series. The right type of bull or semen to be used for mating your cow or buffalo depends on the genotype of your animal and the purpose and method of rearing which will vary with the agro-ecology of the region. Please refer to leaflet No 5 (Breeding of Buffaloes and Cattle) for more details on breeding.

Health care of the animals : The economic efficiency of your farm depends very much on the productivity of the animals and the health status . Detailed information on matters relating to health are given in Leaflet No 6 (Health and Diseases of Buffaloes and Cattle) and No 8 (Management of Buffaloes and Dairy Cattle) in this series. However, herein we given a brief summary of the important aspects of health care and disease prevention

Health of the animal is expressed by its appearance and physical activity. Shiny skin coat, alertness (i.e. quick response to stimuli), normal stance and gait and good appetite always signify good health. Any departure from these usually suggest an illness. Consult your veterinarian immediately for necessary advice and treatment. As some of the diseases are preventable, a programme for routine vaccination and worming are given below for practical guidance.

Table 2: Vaccination schedule against common infectious diseases of buffaloes and cattle

Disease	Primary Vaccination (Age)	Secondary vaccination (Age)	Booster vaccination (Age)
Haemorrhagic septicaemia	4 months	7 months	12 months + annually thereafter
FMD	4 months	5 months and 7 months	12 months and bi-annually thereafter
BQ	9 months	9 months	12 months and bi-annually (up to 2 years)

Table 3: Schedule for routine de-worming in buffaloes and cattle

Species and age group	Timing of Treatment	Recommended drug and procedure for worming
Buffalo Calves	Day 10-16 of age	Pyrantel Palmoate: 2 tablets or250 mg per calf. One worming is sufficient.
Adults	In general, adults do not require worm treatment. However, if animal show evidence of weight loss, diarrhoea, reduced milk production, contact a veterinarian for advice.	Follow the recommendations of your veterinarian
Cattle Calves	1st worming at one month 2nd worming at 3 months ***other recommendations:*** Calves managed intensively in the wet zone may be de-wormed once in 2-3 months up to 12 –18 months of age. In areas where worm infestation is endemic; worm the young animal at the commencement of Yala (April/May) and Maha (September/October) rains and on each occasions follow the same treatment 3 weeks later.	Albendazole; half a tablet or 750 mg per calf **.or** Febantel at the rate of 75 mg/kg body weight (about 3 grams per calf) There are other drugs suitable for worming. For details contact your local veterinarian
Adults	For young as well as adults de-worming is required only if the animal shows signs of worm infestation. Your veterinarian will examine dung samples and tell you whether worm treatment is required or not.	Follow the recommendations of your veterinarian

4 *Recycling of crop residues, agro-industrial by-products and animal waste*

4.1 Recycling crop residues and agro-industrial by products

The most advantages feature in crop-livestock integration is the opportunity to recycle animal waste and crop residues. In order to get maximum advantage, you must make all attempts to use crop residues as animal feed and animal waste as organic fertilizer for your crops.

Crop residues are mainly fibrous materials that are by-products of crop cultivation. e.g. rice straw, sugar cane bagasse, sugar cane tops, maize stover, soya bean and ground nut straw, cassava leaves, sweet potato vines etc. It has been reported that about 65-70 percent of the total bulk of the crops produced by the farmers go waste and hence a loss to the farm.

Agro-industrial by-products These are by-products generated in the manufacturing processes of main agricultural products like coconut oil, soya oil, milled rice, sugar, fruit

juices etc. The by-products that are generated in this process are, coconut poonac, soya meal, rice bran, molasses, cannery waste etc. Although these by-products may not be generated in the farm itself, they might be available in the farmers environment perhaps at reasonably low prices, which could reduce the feed cost of the farm stock. They are rich in nutrients compared to crop residues and could be used as strategic feed supplements as they are rich in essential nutrients such as soluble carbohydrates (eg. molasses), protein (eg. rice bran, canary. waste) and minerals (eg. molasses) If crop residues and agro-industrial by-products are properly utilized by the small holders for livestock feeding, a good part of the feed shortage during dry periods could be satisfied for greater improvement of dairy cattle and buffalo production. This is the most feasible solution to the ruminant feed shortage, particularly in the dry zone districts of Sri Lanka. For more details please see Leaflet No. 1 in this series.

4.2 Utilization of animal waste on farm crops

Cattle and buffalo dung and urine (Farm Yard Manure) is a good source of organic nutrients for the soil and plants. They are rich in nitrogen, phosphors and potassium. The proportion of nitrogen, phosphorus and potassium in farm yard manure is around 2, 0.4 and 1.7% respectively. Research studies indicate that the availability of nitrogen, phosphorus and potasium in farm yard manure is as follows: 1/3of nitrogen, ½ of phosphorus and most of the potassium required for vegetable crops. On the other hand 100 kg of farm yard manure is equivalent to 15-18 kg of urea, 12-15 kg of Triple Super Phosphate and 15-18 kg of Muriate of Potash. Faeces and urine when mixed will form an excellent organic fertiliser. Therefore animal dung (or slurry) could be applied to your crops thereby reducing the need as well as the cost on inorganic manure. Besides, it may also be recycled through a bio-gas plant to generate energy for domestic cooking and lighting at a relatively low cost.

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