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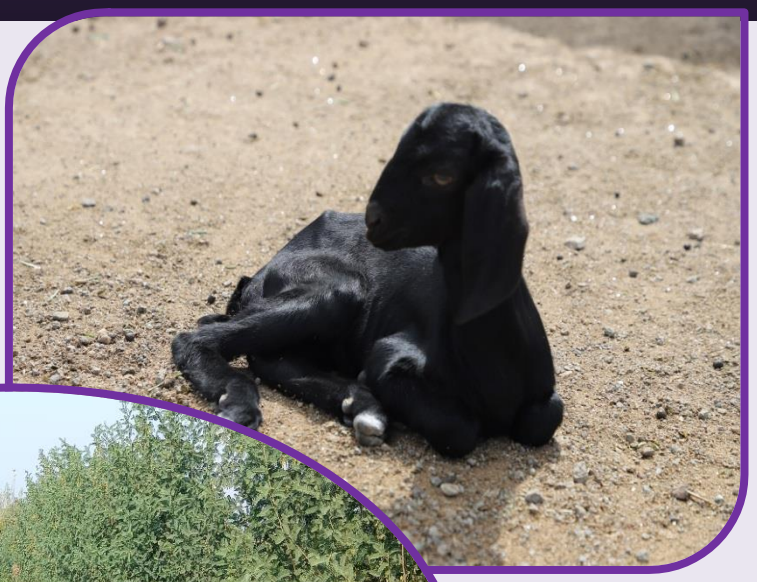

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PREFACE

Goat is a multipurpose animal that produces milk, meat, fiber, kid and manure. India has 148.88 million of goats (20th Livestock Census), 5th highest population in the world. Goat contributes 27.8 % of total Livestock population of India. There was a progressive growth in goat population with an increase of 10.14 per cent compared to previous Livestock Census Report-2012. Maharashtra ranks 6th in goat population with 10.60 million. Maharashtra is the third largest state in India in terms of geographical area. It comes under tropical agro-climatic zone where annual precipitation records a marked degree of variation throughout the agro-climatic zones. Goats can adopt to wide variety of Agro-climatic conditions ranging from arid dry to cold arid to hot humid, they can thrive well with poor quality roughages. Goat farming has tremendous potential in employment generation and poverty reduction in small, marginal and landless farmers in rural areas. Goat are small sized docile animals; they can be easily reared by the women and children and also requires less space for housing. Goat meat has no religious taboo and it has got high demand from all community because of less fat and more protein. Goat meat has higher prices in the market. The goat manure and urine are rich source of nitrogen, potash and phosphorus. Despite high demand and optimum market price for goats, there are some production constraints that are hindering the growth of goat farming. The availability of grazing land is the biggest concern in goat farming. Moreover, the decrease in grazing resource in terms of quality and quantity, increase in grazing pressure due to increasing in goat population, unavailability of labors for grazing of animals as well as high rates of labors are the major challenges in goat farming. Increase in cost of feed and fodder increases the input cost. Abiotic stresses such as heavy rains, heat and cold stress, nutritional stress due to less rainfall, adversely affects the productive and reproductive performance in goats. To mitigate the effects of climate change on goat production systems and obtain sustainable production and income, self-sustaining goat farming is developed by integrating Osmanabadi goat breed, climate smart housing system and sustainable livestock feeding and management practices. This information provided in this technical bulletin may serve as reference for the students, academicians, scientists, teachers, farmers and policy makers interested in promoting goat farming in abiotic stress regions. This can also help in orientation of research and development programs aiming at improvement of livelihood of small, marginal and landless farmers through goat farming.

Authors

CONTENT

1. Introduction

In changing climatic conditions, supply of food for increasing human population with decreasing land and natural resources is a big challenge across the globe. Climate change also has an impact on the animal production system, making it difficult to meet the increasing demand for animal protein. Increase in economic status and purchasing power, urbanization, and a shift in family values towards animal protein are all likely to drive up demand for meat in the future (Sahoo et al 2015). Diversification of livestock components with crops will help make the farmer's farming system more resilient. Livestock is an integral part of the farming system; it provides consistent income and nutritional security to households while also alleviating rural poverty by providing consistent income throughout the year in changing climatic conditions. The landless and small farmers get employment from livestock sector during lean agricultural season. Income from livestock in mixed farming in small and medium-sized farmers are higher and more sustainable. In rural areas, livestock rearing has a significant positive impact on equity in terms of income, employment, and poverty reduction. Goat farming provides insurance against the crop failure in Agriculture mixed farming practices (Rahane and Shelke, 2020). Animal husbandry sector provides employment opportunities to the rural unemployed youth. About 20.5 million people depend upon livestock for their livelihood. Goat is considered as resilient animal species in dry land agriculture.

Goats are tolerant to most of the environmental stresses and can survive with least resources. Goat farming can be carried out in less fertile areas like rain fed regions in a sustainable way. One fifth of the world’s livestock population is present in India. India has nearly 20% of worlds goat population. Total Goat Population in the country is 148.88 million during 2019. Total Goat population has increased by 10.14% over previous Livestock Census (2012). About 27.8% of the total livestock is contributed by goats in India. Progress in this sector leads to more balanced rural economic development and an improvement in the economic status of poor people associated with livestock. Goats rearing is carried out mainly by feeding locally available fodder resources, supplementing with top feeds and crop residues for meeting their feed and fodder requirements, but these resources are declining day by day in our country. The rearing practice of goat are gradually transformed from transhumane and extensive production system to semi-intensive and intensive system, which involves greater input to meet the deficit and to harness profit as well (Sahoo et al 2015). Vihan (2010) reported that goat will produce more milk and meat production per unit of live body weight as compared to buffalo, camel and sheep.

Rahimi et al (2022) reported that shifting herd composition towards the inclusion of, or replacement with, goats can secure production and resilience against climate change.

The forage supply from grazing land is decreasing due to higher grazing pressure and stocking density. Goat is considered as black gold; the animals can be sold at any time during the requirement of money. There is lot of demand for goat meat because of its taste and nutritional value, goat meat is leaner and has low cholesterol level, is expected to rise at a faster pace in the domestic as well as international markets (Kumar et al., 2010). The meat and milk of goat is accepted by peoples of most of the communities. Many peoples are interested in goat farming, but due to lack of sufficient grazing resources due to decreasing grazing land, unavailability of labour for grazing the goat, people face difficulties in goat farming. Keeping in view the above business opportunities and constraints in goat farming we have developed self-sustaining goat farming model for semi-arid regions. By adopting this technology module, the rural youth as well as entrepreneurs can comfortably carry out goat farming business. To obtain sustainable yield and income, self-sustaining goat farming model is developed by selecting suitable goat breeds (Osmanabadi goat breed) as per the prevailing agroclimatic conditions, adopting climate smart housing system and following sustainable livestock feeding and management practices. The details of establishment of fodder on boundary, developing fodder protein bank, climate smart loose housing system, shed design and sustainable management practices are discussed in this bulletin. This information will help in orientation of research and development programs aiming at improvement of livelihood of small, marginal and landless farmers through goat farming in limited irrigation conditions.

2. Methodology

The research work was designed to develop self-sustaining goat farming model in semi-arid region with limited irrigation conditions. The model is developed at ICAR-National Institute of Abiotic Stress Management, Baramati. The National Institute of Abiotic Stress Management (NIASM) is situated at 18°09’ N latitude and 74°30’ E longitude with an altitude of 550 m MSL. In political division, it comes under the Pune district, part of the Western Maharashtra region of India. As per the agro-climatic zonation, the area falls under the scarcity zone (NARP zone: AZ-95). It is a well governed place of Deccan plateau. The area comes under dry land region with an average annual rainfall of 55 cm. The rainfall distribution is also a highly skewed in nature. Most of the rainfall occurs in the period from June to October. The July to August usually relatively a dry period with low rainfall occurrence while September is wet one. The

temperature of this region ranged from a low of 13.6 degree Celsius to the maximum at 38.9 degree Celsius. The experiment was conducted during the period from April 2021 to March 2022 for a period of one year duration. The experiment conducted dealt with the following parameters. Growth performance and reproductive performance of Osmanabadi goat fed with fodder shrubs grown on boundaries of field with limited irrigation, climate smart loose housing system for goats and cost economics of rearing. For developing self-sustaining goat farming model, available six (06) Osmanabadi female and 04 male goat were used. The Osmanabadi goat's adaptability to extreme weather conditions such as drought and heat stress, as well as its versatile feeding habits and high production ability, all contribute to its success in this region. Most of the farmers in Maharashtra prefer the "Osmanabadi" goat breed, which is dual-purpose breed and reared mostly for meat production. This breed is native of Osmanabad district of Maharashtra, its breeding tract extends to Latur, Solapur, Parbhani, Ahmednagar and other neighboring districts of Maharashtra and also found in the north-eastern districts of Karnataka state. Body is medium in size with long body and legs and well suited to arid and semi-arid regions. This breed is famous for meat production, higher kidding percentage of twins and triplets and early puberty. The Osmanabadi breed of goat is ideal for smallholder farmers due to its high kidding percentage, disease resistance, rapid growth, and suitability for all types of rearing systems. They are mostly black in colour, white color patches can also be seen on the neck and the forehead. They have small straight/curved horns that are turned backwards, upwards, and downwards. They have drooping ears. Growth parameters such as birth weight of kids and body weight of goats were recorded. The birth weight of kids was recorded using a digital weighing balance immediately after kidding. The birth weight of kids was recorded within 24 hours after birth. The body weight of kids was recorded every fortnight till the end of the experiments with the help of digital balance. This was performed in the morning before the animals were allowed for grazing at fortnight intervals. The Reproductive parameters were recorded such as kidding rate and twinning percentage. The kidding rate in Osamanbadi goat was measured as the number of kids born to the total number of does/Goats mated. The twinning percentage was measured as the number of does giving birth to twins to the total number of animals mated in each rearing system. All the animals were dewormed before starting the experiments. Random fecal samples were collected for screening of the parasitic diseases.

2a. Feeding Management

Goats are browser in feeding habit and they prefer tender leaves of herbs, shrubs and small trees (Skerman, 1977). The DM requirement of goat dual-purpose breed of goat is 3% - 5 %. They digest poor quality roughage efficiently (Silanikove, 1997). Goats have highly flexible foraging behavior in changing conditions (Zobel et al 2014). The total area available for grazing of sheep and goats in 1951 was 82.1 million ha, which has now decreased by 47% to 43.3 million ha, but the small ruminant population has increased by 105%, resulting in overstocking and overgrazing of available land and resources. The area required for grazing as per the reports of CSWRI, Avikanagar, is 1.3 hectre/ACU, but availability is 0.77 hectare/ACU. To maintain the production in future, farmers have to search for alternative goat or sheep rearing systems, intensive rearing with minimal inputs is one of the promising options (Singh and Shalander Kumar, 2007). For greater sustainability of small ruminant production systems, it is necessary to utilize locally available feed resources through scientific and economic feeding practices (Sahoo et al 2015). The most promising fodder trees and shrubs are Leucaena leucocephala, Sesbania sesban, Ziziphus nummularia, Moringa oleifera, Medicago sativa, Tamarindus indica (Raskar et al., 2018) can be produced and fed to the goats. For feeding to goats, fodder was given in rectangular feeder, twice in a day, in the morning and evening. Upreti etal (2005) reported that rectangular feeder in which tree leaves, grasses, concentrates and crop residues can be fed simultaneously, has lowest feed wastage and contamination, and hence is suitable for feeding goats in stall-fed management system. Goats prefer browsing and also graze on grasses and weeds. Fodder should not be over fed to goat. Over feeding may cause bloating in animal and can cause mortality. Feeds was given clean and fresh, since goats eat nothing that is dirty or foul-smelling. They dislike wet, stale or trampled fodder. For this reason, it is advisable to feed them in hayracks or hang the feed in bundles. Drastic changes to the diets of goats should be avoided to avoid a major digestive problem. Make change in their diets slowly, giving the rumen microorganism to adjust with the feed. The animals were fed with 5 kg green fodder fodder/day/animals without concentrate feed. The animals were fed with fodder (Sesbenia aegyptiaca, Moringa oleifera, Morus spp., Leucaena leucocephla, Desmanthus, Medicago sativa Cajanus cajan). Hassan et al (2015) reported that M. oleifera and L. leucocepha fodder can be fed to goats without any adverse effect on their growth performance. All the animals were provided with clean, fresh ad libitum drinking water in the shed during the period. In addition to green fodder, dry fodder in terms of crop reside available can be used for feeding of goats. Dry fodder @ 0.5-1.0 kg/day/animal can be fed to adult goat. During the

monsoon season, dry fodder should be provided to the animals to ensure good digestive health and performance. Devasena and Rama Prasad (2014) reported that farmers generally feed crop residues, particularly leguminous straws, which have valuable edible biomass due to their high nutritional value and can serve as a potential feed resource during the lean period. Devasena and Rama Prasad (2014) conducted growth trial in weaner kids of 4 months age for a period of 120 days to evaluate groundnut haulms (GNH; Arachis hypogia) and red gram bhusa (RGB; Cicer arietum) based complete rations (CR-I and CR-II, respectively) with roughage: concentrate ratio of 70:30, and reported the average daily gain (g/d) of 52.17 in CR- I and 50.00 in CR-II. Rama Prasad et al (2000) reported that these crop residues can be incorporated up to 60% as basal roughage in the complete diets of small ruminants.

Table 1: Fodder yield and cultivation practices of different fodder shrubs on farm boundaries

Fodder shrubs/crop on boundary	First cutting after sowing	Space between rows (cm)	Average fodder yield (kg/meter running length cutting) after well established
Shevari *(Sesbania sesban)*	6 months	40	8
Dashrath grass *(Desmanthus leptophyllous)*	2.5 months	30	1.2
Perennial Pigeon pea *(Cajanus cajan)*	4 months	40	9
Hybrid Napier *(Pennisetum purpureum*	3 months	40	3.5

Fig. 1. Boundary plantation of different fodder shrubs for fodder production for goats

Fig. 2. Boundary plantation of different fodder shrubs for fodder production for goats

Table 2: Agronomic practices for cultivation of fodder shrubs in protein bank

Fodder species	Mulberry	Subabul	Shevari	Drumstick	Dasharath
Scientific name	*Morus alba*	*Leucaena leucocephala*	*Sesbania aaegyptiaca*	*Moringa oleifera*	*Desmanthus virgatus*
Varieties	V1 (Victory) S-32, Anantha and S32	Nirbija, K636, Wondergraze and Tarramba	Local selection	Location-specific, PKM 1 & 2, Odissi	Hedge Lucerne (local variety)
Important feature	Grows in wide soil & climatic conditions leaves consist of 20-22 % protein, 10-12 5 nutrients, nutritious fodder, deep-rooted & fast-growing deciduous woody perennial plant.	Fast growing, nitrogen-fixing, high protein content 20-25 %, drought resistant, high coppice rate, care must be taken while feeding to young animals due to mimosine content	fast-growing, perennial legume tree grows well in dry zones, reaching a height of up to 8 m, but has a shallow root system, multipurpose species, average N content was 4.3%	Multipurpose in nature, fodder is nutritious, fast growing, hardy to water stress, have protein content of 15-25 %	The legume crop boasts of 22% crude protein content and is abundant in essential vitamins and minerals. It facilitates nitrogen fixation in soil and has the potential to produce fodder for a period of 3-4 years
Spacing	Block 2m×1m or 3m×1.5m	Block: 1m×1m	Broad-casting in row as live fence or	Block: 1m×1m	45-60 cm apart is

Fodder species	Mulberry	Subabul	Shevari	Drumstick	Dasharath
	Boundary: at every 2-3 m aways	Boundary: 1.5 to 2 m away	paired row planting at 1m×0.5m.	Boundary: 2 m to 3 m away (dual purpose)	recommended .
When & how to plant	Pensile size cutting of 10-12-month-old branches used for planting in July to November months in pits or polybags	Broadcasting of seeds or seeds can be sown in root trainers or polybags; sowing or planting in July-August gives the better establishmen t	Seeds are widely used for sowing. Mansoon is best season for planting.	Seeds or cutting are the best source of planting material. On average, 1 kg of seed gives around 2500 seedlings under field conditions. Monsoon planting is best season.	This crop can be grown year-round with irrigation, but it is typically a rainfed crop from June to October. Soaking seeds (20 kg/ha) in sulphuric acid for 8-10 minutes before planting.
Irrigation	Requires irrigation for profuse sprouting at least once in 10-15 days	Once in 15-20 days, drip irrigation gives better results	Mostly rainfed, every 25-30 days depending on soil moisture.	At least once in 15 days or depending on soil conditions	The crop is typically cultivated as a rainfed crop, with irrigation provided every 12-15 days when required.
When to harvest	After planting, 4-5 months for the first harvest and subsequentl y every 40-45 days	The first harvest takes 4 months after sowing or transplanting, a sharp cut at 100-150 cm above ground yields profusely.	First harvest after 6 months of sowing, subsequently at every 40-50 days. A cutting height of 75-100 cm is recommended .	First harvest 4-6 months after sowing & Subsequent cutting at every 50 days at 1 to 1.5 m height	Harvested after 3-4 months of growth. It is recommended to cut the plants when they are 30-40 cm tall. The plant can be harvested up to 5-6 times per year.
Green fodder yield (tonnes ha^{-1})	35-45 tonnes of fresh leaf	15-20 tonnes	20-25 tonnes	50-60 tonnes	60-80 tonnes

Fig. 3. Fodder Management for Goats

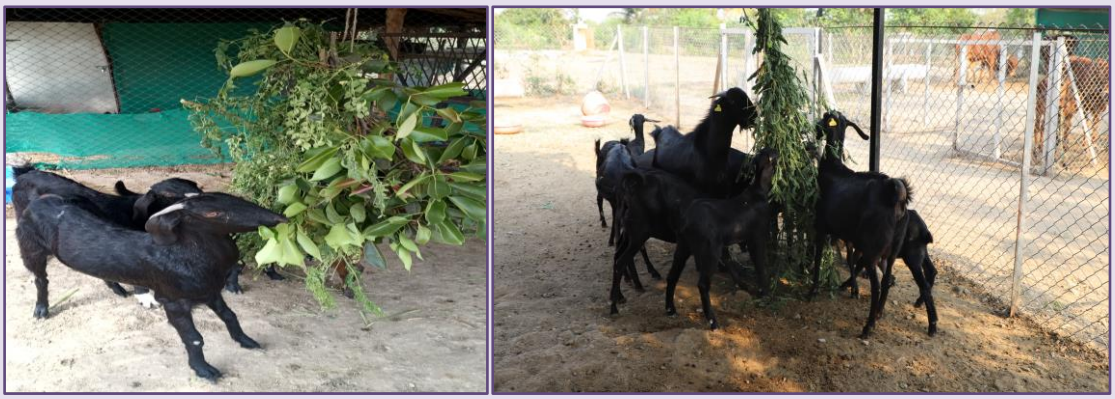


Fig. 4. Feeding the fodder shrubs and tree leaves by hanging

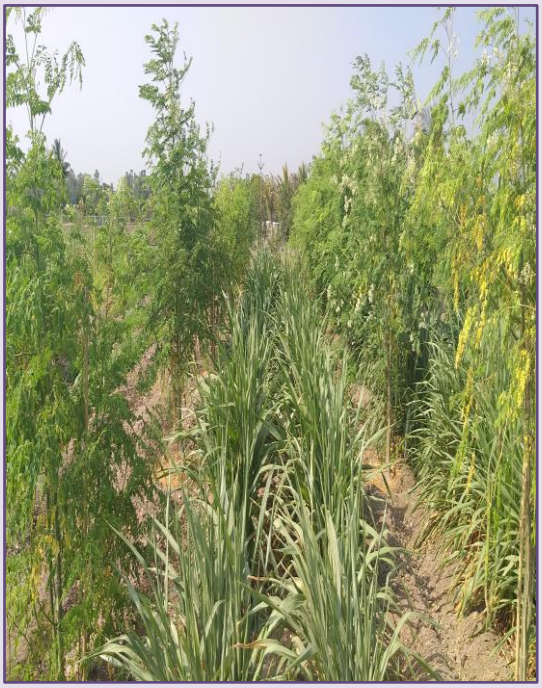
Table 3: Fodder yield of Protein Bank for Goat

Protein Bank (Fodder Name)	Fodder yield (kg/sq.m)
Mulberry *(Morus spp.)*	6.5
Subabool (*Leucaena leucocephla*)	8.4
Shevari *(Sesbania aegyptiaca)*	8.6
Drumstick (*Moringa oleifera)* + Dashrath *(Desmanthus Virgatus)*	1.8

Dasharath

Subabul

Mulbery



Moringa+ Hybrid napier

Fig. 5. Fodder shrubs for goat feeding

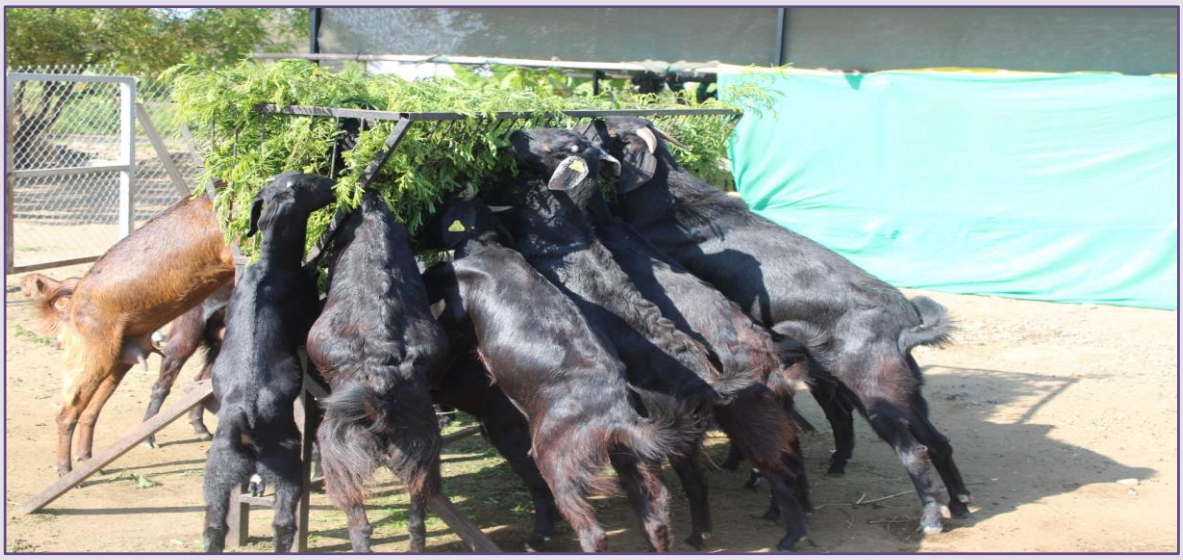


Fig. 6. Feeding goats with fodder shrubs in triangular feeder

Table 4. Structural constituents of fodder tree leaves and shrubs of dryland areas on dry matter basis

Sr. No.	English Name	Scientific name	Per cent Structural Constituents					
			DM	CP	CF	NDF	ADF	Hemicelluloses
1	Banyan	*Ficus bengalensis*	31.70	4.41	34.0	68.2	58.5	9.70
2	Jamun	*Syzygium cumini*	33.22	2.56	28.5	66.2	62.7	3.50
3	Guava	*Psidium guajava*	36.54	6.74	21.5	61.8	56.8	5.00
4	Indian Thorny Bamboo	*Bambusa bambos*	56.60	4.32	24.0	77.4	52.9	24.50
5	Drumstick	*Moringa oleifera*	18.88	7.08	19.0	36.0	26.9	9.10
6	Amla,	*Phyllanthus emblica*	39.63	3.23	26.5	44.2	36.0	8.20
7	Peepal	*Ficus religiosa*	22.40	3.56	24.0	50.8	45.4	5.40
8	Ber	*Ziziphus maurintina*	30.03	7.03	29.0	71.0	56.4	14.60
9	Tamarind	*Tamarindus indica*	32.68	4.13	24.0	57.6	42.2	15.40
10	Common sesban	*Sesbania sesban*	16.92	6.41	22.5	40.8	38.4	2.40
11	Subabul	*Leucaena leucocephala*	28.74	6.12	16.0	56.2	40.8	15.40
12	Gum Arabic	*Acacia nilotica subsp. Indica*	49.37	1.71	9.0	36.0	33.8	2.20
13	Quickstick	*Gliricidia sepium*	20.55	5.74	16.5	48.2	44.5	3.70
14	Saras	*Albizia lebbeck*	40.93	6.12	26.0	58.6	53.6	5.00
15	Neem	*Azadirachta indica*	33.49	4.74	22.5	55.8	51.4	4.40
16	Bel, Wood apple	*Aegle marmelos*	35.32	2.47	22.0	55.0	49.3	5.70
17	Apta	*Bauhinia 10acemose*	49.93	3.28	22.0	66.2	60.2	6.00
18	Soft Fig	*Ficus mollis*	28.93	2.80	27.5	70.0	66.9	3.10

Source: Gaikwad et al (2017)

2b. Housing Management

One of the most important management strategies for maximizing output from livestock farming is the housing system. The construction of housing for goats will vary according to the type of production system, the size of the herd, and the agroclimatic conditions. Animal housing can range from environment-controlled animal house with precision waterers and feeding facility to very simple sheds with only a roof and no walls. Housing systems protect the animals against climatic stresses such as heat, cold, or heavy precipitation, as well as providing an ideal environment that aids in the improvement of their production performance, behavior and welfare. The adult animals and kids were provided with a covered area of 1 m2 and 0.5 m2/animal respectively. Optimum floor space was provided to the animals for better performance and welfare. Panda et al (2016) reported that provision of floor space was positively correlated with the growth performance of Osmanabadi kids. The animals were provided with an extra open space for free movements. Provision of open space for free movements of animals is very important in intensive system of goat housing. Sufficient feeding and watering space was provided to avoid crowding and uniform access to fodder and water. Feeders and waterer were cleaned regularly in the sheds and maintained hygienically throughout the experimental period. The sheds were cleaned daily in the morning and lime was applied at monthly intervals in the animal shed. Housing provided was well ventilated with free access of sunlight particularly during winter. There floor was kept dry in condition. The purpose of ventilation is to provide the desired amount of fresh air to all parts of the shelter, to keep temperatures within specified limits and to keep the floor dry. If proper deign of shed is made, the shed will have sufficiently ventilation and sunlight. Hence height of roof of the goat shed was kept 10 feet the sides and 12 feet at the center for proper ventilation. Loose housing system was selected. In this system animals are kept loose by fencing the boundaries with chain-link fencing. In this system common feeding and watering facility was provided. The animals were protected by adverse climatic conditions with the help of shelter. In loose housing system, the animals have a choice of spending time either under a shed during heat period or in open paddocks in morning and evening hours as per their choice and season. Loose housing system is economical as the cost of construction is significantly lower than conventional type. Also, it is possible to make further expansion in herd size without much changes. Loose housing facilitates easy breeding of animals. Animal behavioral needs are also fulfilled, animal gets optimum exercise, feel free and perform well with even minimum nutrition having better health and production. Murum flooring (Kachha) was used as flooring material. Dampness and

stagnation of water/urine due to improper drainage is one of the important factors for responsible for diseases in goat. Wakchaure et al (2020) observed that Osmanabadi kids exhibited superior growth performance under murum flooring as compared to concrete flooring and also reported that stall-fed goat farmers may adopt murum flooring for obtaining maximum profit. Bhakat and Nagpaul (2003) reported that the kaccha floor has good practical economic significance as compared to the concrete floor. Jadhav and Killedar (2018) observed that goats under tree shade in open housing were more comfortable as the frequency of resting was higher also frequency of other activities was found to be optimum. Their observations and results suggest that the tree shade housing is the best housing system for Surti goats. Selda (2019) reported that instead of traditional housing, alternative new barn designs that take into account local area preferences and behavior indices are needed to increase goat production and their welfare. The Dimensions of climate smart loose housing system and climate smart animal shed for goats is developed are presented in fig. 8 and 9 along with photograph.

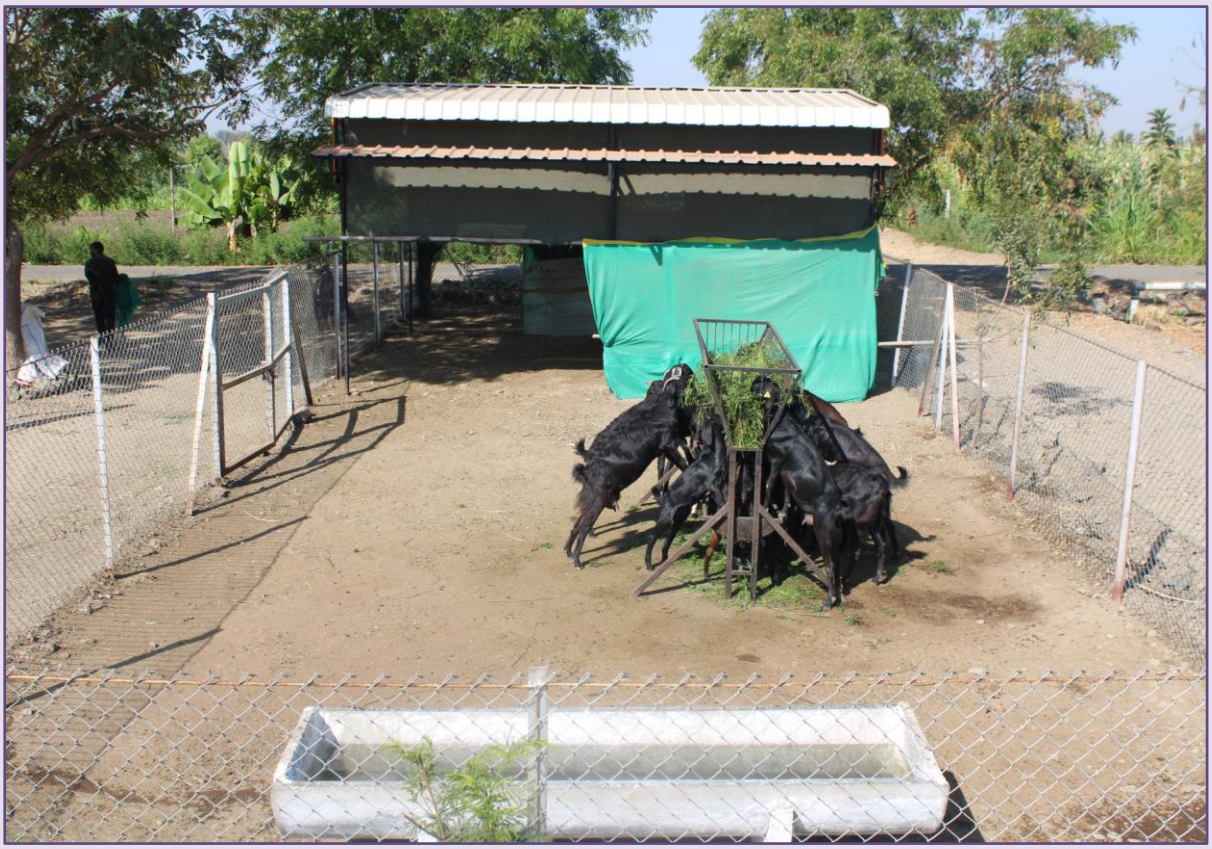


Fig. 7. Climate smart loose housing system for goats

Sr. no	Dimensions (feet)	
1	Length of chain-link fence	66
2	Width of chain-link fence	20
3	Height of chain-link fence	5
4	Size of Chain-link mesh (Inch)	2
5	Gauge of Chain-link wire	12
6	Gate- Length	8
7	Gate -Height	5
8	Total open space available (Sq.ft.)	1320

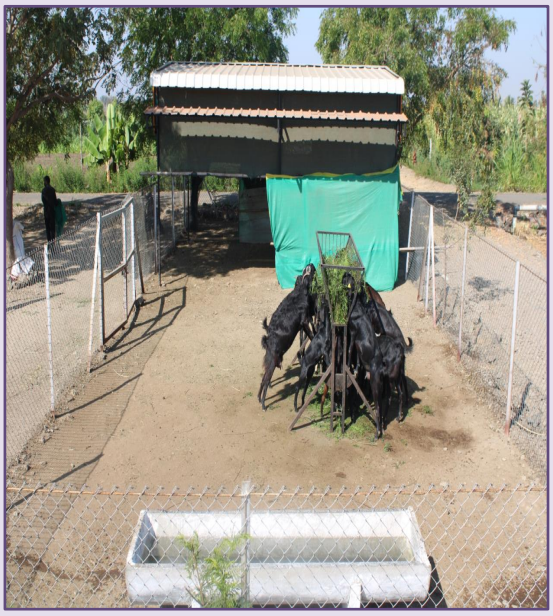


Fig. 8. Dimensions of climate smart loose housing system for goats

Sr. no	Dimensions of shed (feet)	
1	Roof type and material	Two pan roof, steel sheets
2	Floor type	Kachha/Murum
3	Length of shed	20
4	Width of shed	15
	Height of shed	
	Center	12
	Side	10
5	Total covered floor Area (Sq. ft.)	300
6	Widthwise Top side covered with steel	3.5
7	Bottom side Covered	4
	Overhang for shed	3.0 feet
8	Height at Overhang from ground	7.5

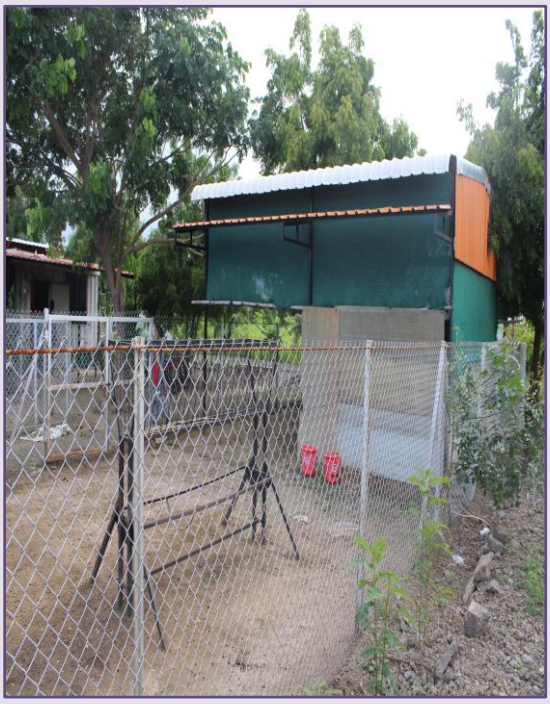


Fig 9. Dimensions of shed in loose housing system for goats

Table 5: Recommended space requirements for Indian conditions

Age groups	Covered space (sq.m)	Opened space
Up to 3 months	0.2-0.25	0.4-0.5
3 months to 6 months	0.5-0.75	1.0-1.5
6 months to 12 months	0.75-1.0	1.5-2.0
Adult animal	1.5	3.0
Male, Pregnant or lactating doe	1.5-2.0	3.0- 4.0

Table 6: Feeding and watering space requirement

Type of animal	Space per animal (cm)	Width of manger/ water trough (cm)	Depth of manger/ water trough (cm)	Height of inner wall of manger/ water trough (cm)
Goat	40 - 50	50	30	35
Kid	30 - 35	50	20	25

2c. General Management of Goat

Management of doe

- A drastic change in the feeding schedule should be avoided.
- Regular cleaning of houses, feeders and waterers should be done.
- Goat should be dewormed before breeding.
- Spot and isolate the sick animals to avoid disease transmission.
- Most fetal growth, along with mammary gland development, occurs during the last trimester/stage of gestation. Goat should consume about dry matter 3% of their bodyweight daily that contain 55 to 60% TDN, 11 to 12% crude protein in the diet.
- Clean, cool and fresh water should be made available round the clock.
- All does should be routinely vaccinated against endemic diseases.
- Pregnant animals should not be allowed to travel for long distance, particularly during hot period.
- Supply of balanced and adequate quantity of feed during pregnancy is necessary to reduce doe and kid mortality.
- Vitamin and mineral mixture should be given in sufficient quantity.

Care and management of kids

- The dam should give birth in a clean environment or stall bedded with straw.
- Immediately after the birth of kid, clean the excess mucus in the nasal passages.
- Disinfect the navel by dipping the cord in a solution of 7% tincture of iodine to prevent entry of disease-causing organisms.
- Making sure that the kid consumes enough colostrum of about 10% of their body within 24 hours.

- Immediately after kidding the strong and healthy kid should stand on their legs and make attempt for suckling doe. It should be ensured that the weak one should get sufficient milk from its mother in case of twin and triplet.
- Protect kids from extreme cold and heat during the first two months of their age.
- At the age of 14 – 21 days fresh green leaves or grass should be made available to the kids.
- Growth of kids should be recorded for selection and breeding purpose.
- Stunted one should be culled from the stock.

General breeding management practices in Goat

- The male female ratio should be 1:20
- The males should be replaced or exchanged once in two years to avoid inbreeding.
- Breeding ewe of indigenous breeds should be of 18 to 24 months.
- Breeding too young goats result in more weakling and thus results in higher kid loss.
- The normal breeding season is Sept to Oct, Feb to march and May to June.
- No kidding for complete one year they should be removed from flock.

Deworming

- Deworming should be done at an interval of 2 to 3 months in goats. In kids deworming should be done at the age of 3 months.
- When deworming, it is best to change deworming medicine for better results.

Prevention and control of infection

- Isolate the sick animals from healthy ones and house them separately.
- Provide foot dips containing disinfectants at the entry of the farm to avoid entry of Infection.
- Waterers and feed troughs should be kept clean and free of contaminants.
- All new arrivals to the farm should be dewormed and kept in quarantine for at least 30 days.
- Vaccines may be used to prevent infection if suitable vaccines are available.

3. Growth and Reproductive Performance of Osmanabadi Goats:

The mean body weight at birth in male and female was 2.58±0.21and 2.42±0.14, respectively which is similar to the birth weight reported by Das et al (2022) who reported average birth weight of Osmanabadi goat kids was 2.607±0.234 kg. Feeding of different shrubs fodder without concentrate did not influence the birth weight of kids and body weight at different stages. Meel et al (2018) reported that feeding of Moringa oleifera leaves replacing concentrate feed at 25%, 50%, 75% and 100% levels improved body weights and average daily body weight gain as well as feed intake and overall health of Sirohi goat kids. Rahman et al (2015) reported that green grass, diets supplemented with tree forages resulted in better weight gain, digestibility, and nitrogen balance. He also reported that goat diets can be supplemented with tree forages of S. grandiflora, L. leucocephala, E. orientalis, and M. alba for improved growth performance.

Table 7: Mean body weight of Osmanabadi kids at different stages fed with shrubs without concentrate feed

Goat kids	Body weight at birth	Body weight at 1 month	Body weight at 3 months	Body weight at 6 months	Body weight at 9 months	Body weight at 12 months
Male kids (5)	2.58±0.21	3.80±0.25	7.58±0.10	11.44±0.19	14.88±0.19	18.60±0.13
Female kids (4)	2.42±0.14	3.82±0.25	7.45±0.26	11.30±0.18	14.75±0.23	18.25±0.22

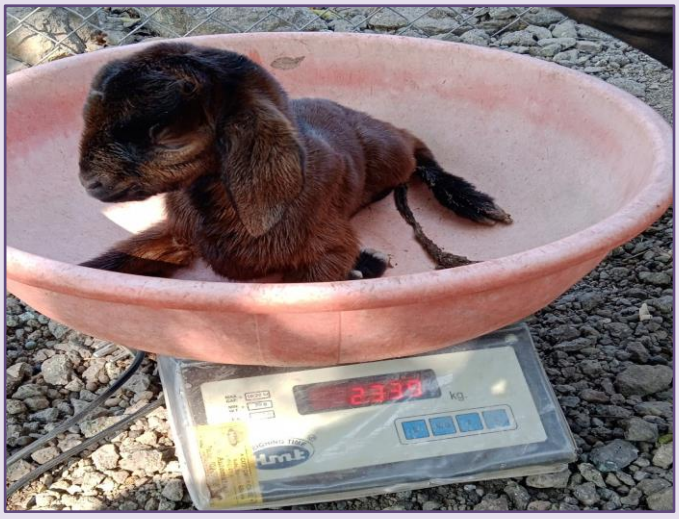


Fig. 10. Recording of body weight at birth in kids

Table 8: Twinning and Kidding percentage in Osmanabadi Goat fed with shrubs without concentrate feed

Kidding Rate			
Total no. of breed-able Goats	Total no. of goats mated	No. of goat produced young ones	Kidding %
6	6	8	133
Twining %			
Total no. of breed-able Goats	Total no. of kidding	No. of goat produced Twins	Twinning %
6	8	2	25

Kidding percentage and twinning ability are the most important parameters to study reproductive efficiency in a herd. These parameters are related to production and profit in goat farming. The kidding % and twining % was 133 and 25 respectively, which was higher than the reports of Sahare et al (2009) who has reported that the kidding percentage and twinning ability 55.87 % and 10.52 % respectively in Osmanabadi goat reared in organized farm and Deokar et a1. (2006) reported kidding percentage ranged between 80 to 90%.

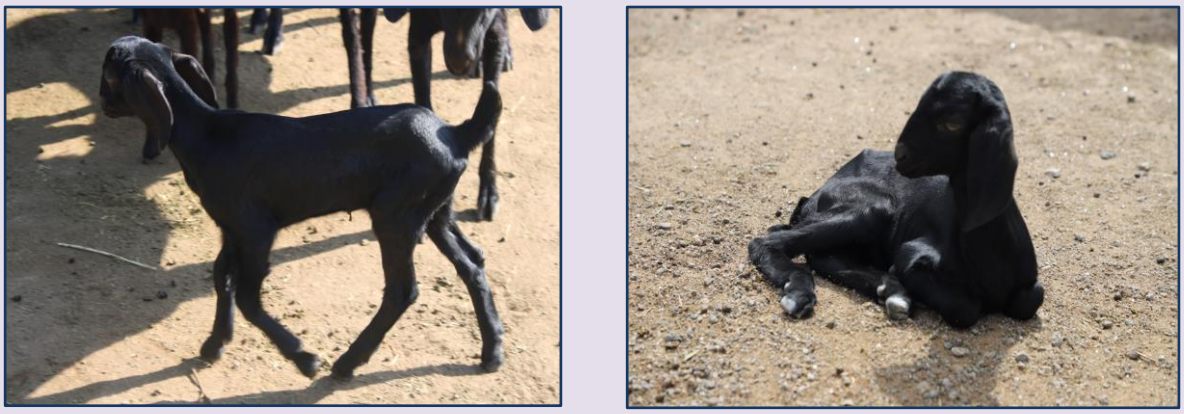


Fig. 11. Osmanabadi goat kids

4. Economics of Goat Farming

Goat farming has contributed to higher human development indices in semi-arid areas, which has been made possible by the use of technologies that make this production economically and environmentally feasible (Cavalcante 2016). The cost of rearing was calculated based on prevailing market rates for different items. The cost of production per ton of green fodder was taken and the labour cost per minimum wage was taken into account for the calculation of labour cost. The economics of goat unit is presented in table 9. The total recurring cost of production of (6+4) animals goat unit was Rs.38070 and the gross income was Rs.105512 with a B:C ratio of 2.77, without supplementation of concentrate feed. The net income obtained was

Rs.6744 goat/annum in our study. Kumar et al (2014) reported that the maintenance cost per goat was Rs. 790 per year without considering the family labors in low input production system in Bikaner District of Rajasthan. Also reported that among maintenance cost, highest expenditure was on feeding (65%) followed by shelter (21.67%) and veterinary medicines (13.31%). The gross and net profit was Rs. 102232 and 59300 in small flock size (5-10 goats). The net return worked was Rs. 6895 per goat/annum. Shivakumara and Siddaraju (2019) reported that among the variable cost, major cost incurred was on labour (50.61%), followed by fodder and concentrates (23.06 %) in intensive goat rearing. Also reported that the returns per rupee of investment was 2.1 in intensive goat rearing system.

Table 9: Economics of goat fed with shrubs without concentrate feed

Input				Outputs			
Items	Total requirement	Rate (Rs. / Unit)	Total amount of recurring cost (Rs.)	Items	Rate (Rs. / Unit)	Qty. (Kg)	Total Amount (Rs.)
Green fodder (Kg)	16060	1	16060	Live body weight gain	340	258.8	87992
Dry fodder (kg) /Farm Produce waste/weeds	190	4	760	Manure	3	5840	17520
Labour (day)	91	200	18250				
Medicine	3000		3000				
Total cost of rearing			38070				105512
Net income				67442			
B:C ratio	2.77						

5. Water Productivity

Livestock water productivity (LWP) is the ratio of livestock products and services to the amount of water depleted or utilized (Amole et al 2021). The water productivity of goat farming model was worked out, where water required for different routine activities such as drinking water, water required for cultivation of fodder, water required for cleaning of animal shed and animals are taken into account. The water utilized is divided by the gross income and net income to calculate the gross and net water productivity. Goat is one of the important livestock species that can be reared in dry lands and limited irrigation conditions. Major portion of water

was used in growing fodder for the goats. The net water productivity in this model was Rs 8.60 /m3. The water productivity for production of live weight of goat 33 g /m3. Haileslassie et al (2009) reported that improved feed sourcing, increased livestock productivity, and multiple livestock use strategies can all contribute to more water-efficient animal production systems. The livestock water productivity in this model is presented in table 10 and 11.

Table 10: Water productivity of Osmanabadi goat

Water Requirement	Water Lit
Drinking	73000
Washing and Cleaning	14600
Green Fodder	7403660
Dry Fodder	350360
Total Water used	7841620
m3	7841.62
Gross income	**105512**
Net income	**67442**
Gross Water productivity (Rs. /m3)	**13.45**
Net Water Productivity (Rs. /m3)	**8.60**

Table 11: Water productivity in Livestock/unit produce

Livestock	Water productivity (Rs/m3)	Water productivity for (unit /m3)
Goat	13.49	Live weight (Meat)-0.033

6. Summary

In changing climatic and socio-economic situation, there is need to develop new livestock production systems for obtaining sustainable income for small and marginal farmers from decreasing land and water resources. Goat meat has high demand in local as well international market. The goat meat also gets high price in local market. Farmers and rural youth are interested in goat farming, but constraints such as decrease in grazing resource in terms of quality and quantity, increase in grazing pressure, unavailability of labors for grazing of animals as well as high rates of labors discourage goat farming. To capture the potential of goat farming and related benefit, goat farming can be successfully done by integrating locally adapted goat

breed with climate smart loose housing system and growing different types of fodder shrubs on the boundaries of crop land with micro- irrigation. In this system sufficient amount of fodder can be produced from well-established fodder shrubs that can be feed to a goat unit of (6+4). The labor requirement for managing the animals is less and it is also easy to manage the animals in this system. The behavioral needs of the animals are also satisfied, which helps the animals perform better with limited fodder resources. This goat farming model has potential to generate employment to rural youth and landless farmers sustainably. The farmers can earn sustainable income with less land and limited water resource with adopting the strategies presented in this bulletin.

Fig. 12. Demonstration of Model to Farmers

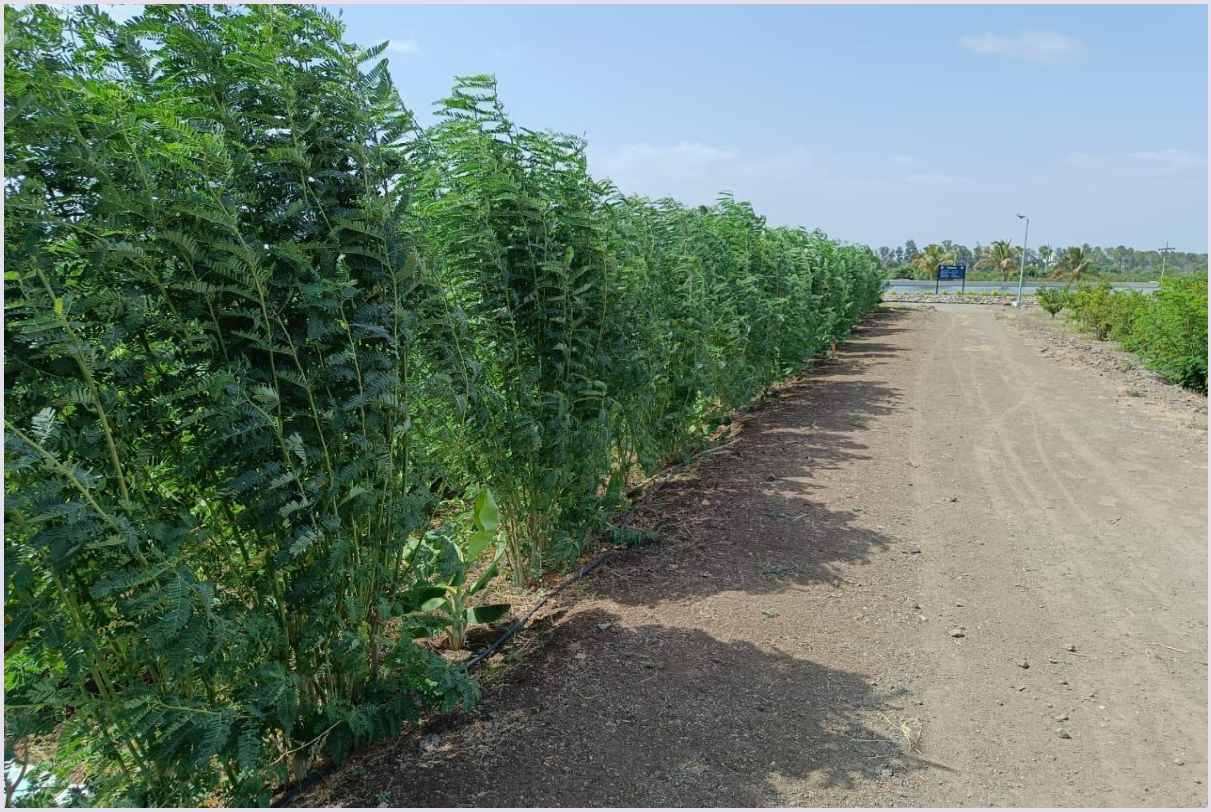


Fig. 13. Boundary plantation of shrubs

Fig. 14. Demonstration of Model to Trainees

Fig. 15. Protein Bank for Goats

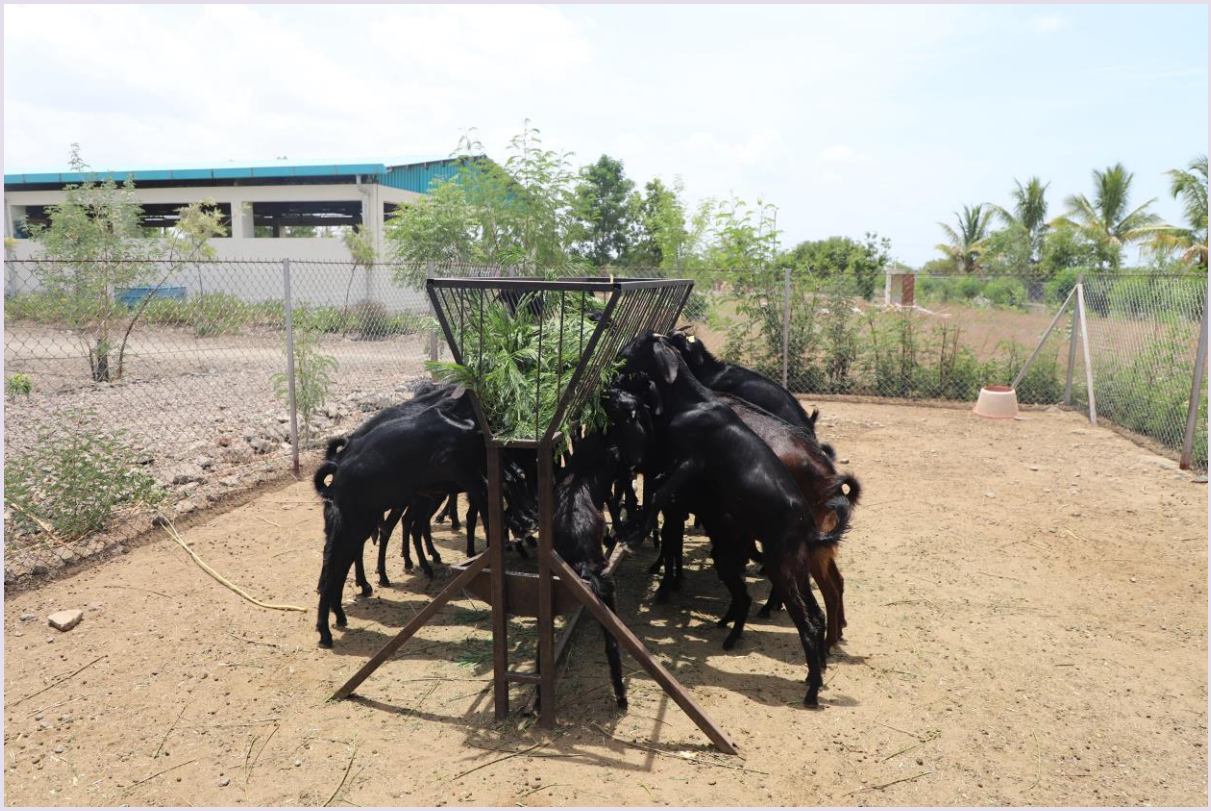


Fig. 16. Feeding fodder in hay racks for Goats

7. Recommendations

- The locally adapted goat should be selected for goat farming because the animals are adapted to the local climatic conditions and will perform best with the limited available resources in that region
- Different types of fodder shrubs should be planted on boundaries using micro-irrigation systems, which will provide a year-round sufficient amount of fodder resources with a higher nutritive value on less land and with limited water resources.
- Climate-smart loose housing system for housing goats should be used, where maximum comfort can be provided to the animals for higher production and they can be easily managed with less labor.

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