Growing Forage with Limited Water: A Guide for Goat Farms in Saudi Arabia

Crops, soil preparation, and feed planning for a family raising 100 goats.

Alvaro D. Garcia DVM PhD

Preface

Having visited several farms, towns, and cities across the United Arab Emirates, I have developed a deep admiration and respect for the farmers and livestock producers who make their agricultural systems work despite the region's challenging environmental conditions. Their resilience, resourcefulness, and ability to adapt are truly inspiring. These experiences have encouraged me to share some of my own knowledge and experience in goat production, with the aim of making a modest and practical contribution to the development of goat farming in Saudi Arabia and the wider region.

My intention is not to prescribe solutions, but to explore how lessons and practices from goat production can be adapted to local conditions, combining practical experience with the invaluable knowledge of local farmers.

Introduction

Saudi Arabia's efforts to conserve groundwater are changing how livestock producers approach forage cultivation. Restrictions on water-intensive perennial forage crops have increased the importance of alternatives that can produce useful animal feed with less irrigation. For small family farms, particularly those raising goats, the challenge is not simply identifying crops that tolerate heat and drought. It is developing a forage production system that makes economic sense when water is scarce, expensive, or available only during certain months of the year.

Consider a family in Jazan, southwestern Saudi Arabia, raising approximately 100 goats on two hectares of agricultural land. The family may have suitable soil, farming experience, and access to forage seed, but these resources alone do not guarantee successful production. The deciding factor is how much water can be obtained sustainably and how efficiently that water can be converted into nutritious feed. A successful farm may cultivate only part of its available land, concentrate production during favorable seasons, and purchase additional feed when irrigation becomes too costly. The objective is not forage self-sufficiency at any price, but a reliable feeding system that protects both the family's income and its water resources.

Jazan offers an instructive example because its agricultural environments range from hot coastal plains to foothills and mountainous areas receiving more rainfall. These differences influence crop selection, planting dates, irrigation needs, and the amount of forage that can be harvested. Although the November 2026 restrictions apply to six designated sedimentary

aquifer regions and not to Jazan, they reflect the broader national priority of conserving groundwater used for forage production.

The region also has a tradition of small-ruminant production, making it relevant for families combining livestock husbandry with small-scale agriculture. However, recommendations developed for irrigated coastal soils cannot automatically be transferred to rainfed fields in the foothills.

For our example, the family owns two hectares, but the cultivated area will be determined by its water supply rather than by the amount of land available.



Figure 1. Jazan's Agricultural Environments. *Conceptual representation of Jazan's coastal plains, foothills, and mountainous environments. Elevation influences rainfall, temperature, and opportunities for seasonal forage production.*

Start with the Water, Not the Seed

Before purchasing seed or preparing the soil, the farmer needs to answer three practical questions: How much water is available? When is it available? And what does it cost to deliver that water to the field?

Water may come from a permitted well, stored rainfall, a community irrigation system, or another authorized source. Each has different implications for planning. Groundwater may provide a predictable supply but involve pumping expenses and restrictions. Rainfall may be

inexpensive but highly variable, while stored water requires investment in collection and storage facilities.

The first step is to establish a monthly water budget.

Consider a family with an annual irrigation water allowance of 3,000 cubic meters. Although hypothetical, this example illustrates the importance of matching the cultivated area to the available water supply. Spread over one hectare, this volume would provide 300 mm of irrigation, but only 150 mm if distributed across two hectares. These amounts exclude rainfall and do not account for irrigation losses. Concentrating the available water on a smaller area may therefore be more productive than attempting to cultivate the entire farm.

The farmer must also account for water reserved for livestock drinking, equipment cleaning, and household needs. These uses should not compete with the irrigation allowance.

Water quality deserves equal attention. Salinity can reduce crop growth even when sufficient water is applied. Testing irrigation water for electrical conductivity and sodium-related hazards, together with a soil analysis, should precede any investment in a new cropping system.

Choosing Forage Crops for Limited Water

Not all drought-tolerant crops are equally productive, and not all high-yielding crops are suitable for water-limited farms. The farmer must distinguish between a plant's ability to survive dry conditions and its ability to produce economically useful quantities of forage under those conditions.

Pearl millet is a promising warm-season option because it tolerates high temperatures and can establish quickly. Its fibrous root system helps it exploit soil moisture, while its rapid growth allows farmers to adjust harvesting schedules. Nevertheless, adequate moisture is essential during germination and early establishment, and severe water stress reduces forage yield.

Cowpea offers a complementary advantage. As a legume, it can provide protein-rich forage and contribute biologically fixed nitrogen to the cropping system when effective nodulation occurs. It may be grown separately or in association with millet, although competition between the crops and differences in maturity must be managed.

Oats and berseem clover deserve consideration during cooler months when atmospheric evaporative demand is lower. Their suitability depends on local temperatures, soil conditions, water availability, and the intended harvest period. Berseem can produce nutritious forage, but repeated cuttings require continued moisture. It should not automatically be considered a low-water crop.

Spineless cactus and saltbush offer different possibilities. Cactus can provide moisture-rich supplemental feed after establishment, but its high water content means that impressive fresh yields may represent little dry matter. Saltbush can tolerate saline conditions, although palatability, salt intake, and nutritional balance limit its role in goat diets. Neither should be regarded as a complete forage replacement.

Crop	Main advantage	Principal limitation	Suggested role
Pearl millet	Heat tolerance and rapid growth	Yield falls under severe water stress	Primary warm-season candidate
Cowpea	Protein contribution and nitrogen fixation	Establishment moisture and harvesting losses	Legume supplement
Oats	Suitable for cooler growing conditions	Heat sensitivity	Winter forage
Berseem clover	High-quality forage	Water required for regrowth	Selective winter production
Spineless cactus	Moisture-rich feed, drought resilience after establishment	Low dry matter concentration	Strategic supplement
Saltbush	Tolerance of saline soils	High mineral content and variable intake	Limited supplemental forage

These comparisons are qualitative. Crop rankings based on water productivity require local measurements of irrigation, effective rainfall, harvested dry matter, and forage quality. A crop producing more fresh material may actually deliver less useful feed per cubic meter of water.

Preparing the Soil to Capture and Retain Moisture

In a water-limited system, soil preparation must accomplish more than creating a suitable seedbed. It should promote the infiltration of rainfall and irrigation water, improve moisture retention, and minimize losses through runoff and evaporation. The first step is a soil assessment, including texture, pH, electrical conductivity, organic matter, and major nutrients. Soil texture is particularly important because sandy soils retain less plant-available water than medium-textured soils, while compaction and poor drainage can restrict root development and reduce the efficiency of irrigation.

Excessive tillage should be avoided because it can accelerate moisture losses and disturb soil structure. Where practical, retaining crop residues on the surface helps reduce evaporation, prevent crusting, and moderate soil temperature, although residue management must also consider pest pressure and seedbed preparation. On sloping land, contour cultivation and appropriately designed bunds can slow runoff and improve infiltration, while small basins or furrows may help retain rainfall on flatter fields. These practices must be adapted to local drainage and salinity conditions, with safe overflow routes provided where intense rainfall could cause erosion.

Organic amendments can further improve soil structure and water retention over time, particularly in coarse-textured soils. Well-composted goat manure represents a potentially valuable resource for family farms, contributing organic matter and nutrients while supporting more efficient use of limited water. However, application rates should be based on soil analysis, crop nutrient requirements, and manure composition, including its salt content, to avoid excessive nutrient accumulation or salinity problems.

A practical soil-preparation sequence

1. Test the soil and irrigation water. Identify salinity, texture, nutrient limitations, and infiltration problems.
2. Inspect the field after rainfall. Locate runoff pathways, standing water, and areas where moisture is retained.
3. Correct physical limitations. Address compaction only where necessary and avoid unnecessary deep cultivation.
4. Incorporate suitable organic amendments. Use tested, well-composted manure where beneficial.
5. Prepare a firm, uniform seedbed. Match planting depth and row spacing to the selected crop.
6. Install and test irrigation equipment before sowing. Uniform water delivery is especially important during establishment.

How Much Forage Do 100 Goats Actually Need?

The next step is to estimate feed requirements before deciding how much land to cultivate. A herd of 100 goats includes animals with different nutritional needs, from lactating and pregnant does to growing replacements, breeding bucks, and dry does. Feed intake varies with body weight, physiological stage, production level, forage quality, and access to grazing. For planning purposes, an average daily intake of 1.5 kg of dietary dry matter per goat provides a reasonable illustrative assumption, although individual requirements will differ.

At this intake, the herd would consume approximately 54.8 metric tons of feed dry matter annually. If forage represents 60% of the total diet, annual forage requirements would approach 32.9 metric tons, before accounting for harvesting, storage, and feeding losses. These figures demonstrate why complete forage self-sufficiency may be unrealistic for a family operation with limited land and irrigation water, particularly when the available water must also support other farm activities. Producing even a portion of the herd's forage requirements can nevertheless reduce dependence on purchased feeds, improve feed security, and help stabilize feeding costs. The objective should be to produce forage economically without compromising animal nutrition or exhausting available water resources. Purchased hay, concentrates, and mineral supplements will remain necessary whenever homegrown forage is insufficient in quantity or nutritional quality.

A Water-Limited Farm Plan: Two Hectares, but Only Partly Cultivated

To illustrate the planning process, consider the hypothetical farm with 3,000 m^3 of irrigation available annually. Assume that the farmer initially evaluates a single seasonal forage crop on 0.5 hectare, while leaving the remainder uncultivated or under suitable non-irrigated use. If all 3,000 m^3 were applied to the 0.5-hectare plot, the irrigation depth would equal 600 mm.

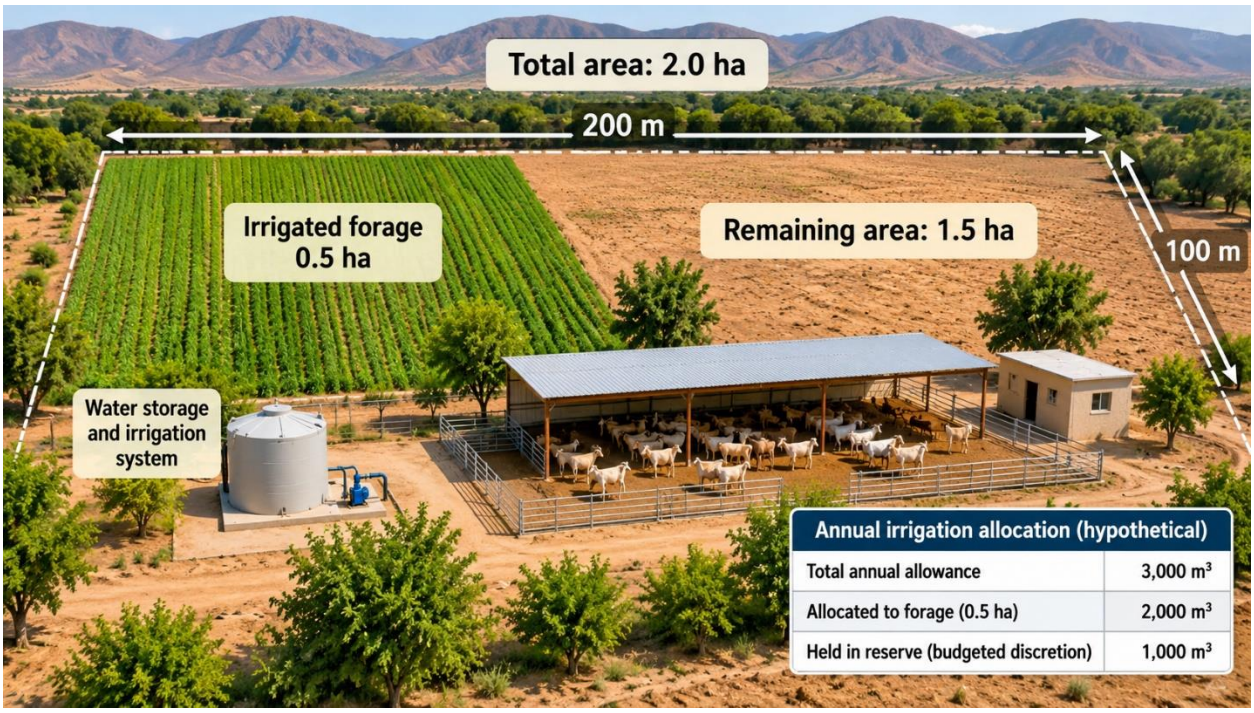

Figure 2. A Water-Limited Farm Plan: Two Hectares, but Only Partly Cultivated.
Illustrative layout of a two-hectare family goat farm. Approximately 0.5 hectare is allocated to irrigated forage production, while the remaining 1.5 hectares include livestock housing, handling facilities, and non-irrigated land.

That is an upper allocation, not a recommendation to apply that amount. The actual requirement depends on crop evapotranspiration, effective rainfall, soil-water storage, irrigation efficiency, and the growing season.

A more conservative first-year plan would reserve some water for contingencies and use a smaller amount for a pilot planting. This allows the farmer to measure water use and forage production before expanding.

Illustrative Allocation	
Annual irrigation allowance	3,000 m³
Initial pilot irrigation budget	2,000 m³
Water held in reserve	1,000 m³
Initial cultivated area	0.5 ha
Water applied to pilot area	400 mm

Hypothetical planning figures only. The 400 mm irrigation allocation is not a validated seasonal requirement for any particular crop.

A farmer might begin with pearl millet during a suitable warm-season planting window or oats during a locally suitable cooler period. The decision should follow local weather records and soil-water conditions, rather than a fixed national planting calendar.

The pilot should record irrigation volume, rainfall, harvested fresh weight, forage dry matter percentage, and crop quality. After the first season, the family can calculate both harvested and usable forage dry matter per cubic meter of irrigation water. Accounting for storage and feeding losses provides a more realistic measure of the forage available to the herd.

Measuring the Value of Every Cubic Meter of Water

Water productivity provides a useful way to compare forage crops and growing seasons. It expresses the kilograms of forage dry matter harvested for every cubic meter of irrigation water applied. This allows farmers to evaluate whether a crop is making efficient use of their limited water supply.

Suppose the 0.5-hectare pilot produces 2,500 kg of harvested forage dry matter using 2,000 m^3 of irrigation water.

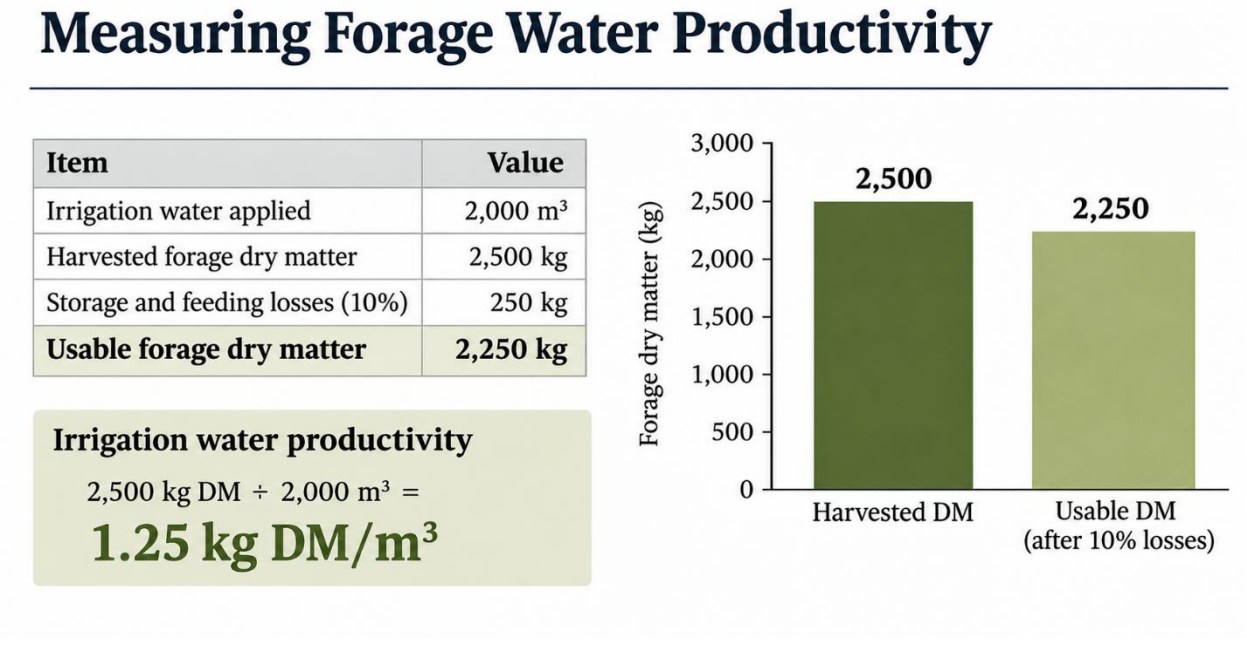

Figure 3. Measuring Forage Water Productivity. *Hypothetical example showing that 2,000 m³ of irrigation water produces 2,500 kg of harvested forage dry matter, equivalent to 1.25 kg DM/m³. After 10% storage and feeding losses, 2,250 kg remain available.*

This is an illustrative calculation, not a measured yield for Jazan. It excludes rainfall from the denominator and therefore measures productivity per unit of irrigation water applied not total crop water consumption.

The result becomes more useful when combined with forage quality and production costs. For example, a kilogram of high-quality legume forage may supply more protein than a kilogram of mature grass, but producing it may require more irrigation or harvesting expense.

Farmers should therefore compare not only kilograms of dry matter per cubic meter of water, but also the cost of producing a kilogram of usable nutrients.

Saudi Arabia's National Research and Development Center for Sustainable Agriculture, Estidamah, has evaluated seasonal forage alternatives under local conditions. Its research program reported promising winter forage production and substantial water-saving potential compared with perennial systems. However, those findings should not be interpreted as guaranteed yields or water savings for small farms in Jazan.

Irrigation: Delivering Water Where It Is Needed

The irrigation system should be matched to the crop, soil, field size, and available water supply. Drip irrigation may offer advantages for widely spaced crops by delivering water close to the root zone, but it is not necessarily the best option for densely planted forage crops requiring uniform soil wetting. Small sprinkler systems can even provide coverage, although wind drift and evaporation may reduce efficiency. Surface irrigation is less expensive to install, but uneven application and runoff can increase water losses.

Regardless of the system selected, irrigation should follow crop requirements rather than a fixed weekly schedule. Soil moisture, crop development, recent rainfall, and weather conditions should guide water application. Particular attention is needed during germination, establishment, flowering, and regrowth following cutting, when water stress can reduce forage production. Simple soil-moisture sensors or regular inspection at rooting depth can help farmers avoid both water deficits and unnecessary irrigation.

Water quality must also be considered when determining irrigation requirements. Where saline water is used, excessive reductions in irrigation may encourage salt accumulation in the root zone, potentially restricting crop growth. Maintaining adequate drainage and providing sufficient water for controlled salt leaching may therefore be necessary. These additional

water requirements must be included in the farm's irrigation budget, reinforcing the importance of matching cultivated area to the water that can be reliably supplied.

A Seasonal Forage Calendar for Jazan

Jazan's coastal and mountainous environments differ considerably. Published research describes annual rainfall around 150 mm in parts of the coastal plain, compared with more than 600 mm in some mountain environments. Consequently, one planting calendar cannot represent the entire region. The following calendar is a preliminary guide to crop suitability, not a locally validated planting schedule.

Period	Potential crop strategy	Water-management priority
December–February	Evaluate oats or berseem in suitable cooler locations	Use lower evaporative demand where possible
March–May	Consider warm-season millet or cowpea as temperatures rise	Ensure establishment moisture
June–August	Restrict planting where heat and irrigation demand are excessive	Protect water reserves; use purchased forage if necessary
September–November	Reassess soil moisture and seasonal crop opportunities	Coordinate planting with rainfall and available irrigation

Actual sowing dates should be adjusted using local weather records, altitude, soil moisture, and agricultural extension recommendations. The farm should not attempt continuous cropping simply because the land is available.

Because rainfall patterns differ between Jazan's coastal plains and mountainous areas, planting decisions should be guided by local rainfall records and soil moisture rather than calendar dates alone.

The Economics of Producing or Purchasing Forage

Water scarcity changes the economics of forage production. A farmer who owns land and irrigation equipment may be tempted to grow as much feed as possible, particularly when purchased hay prices rise. However, homegrown forage has costs that are not always immediately visible.

These include seed, fertilizer, soil preparation, labor, irrigation equipment, electricity, or fuel for pumping, harvesting, transport, and storage losses. Water itself may have an opportunity cost even when the farmer does not pay a direct volumetric charge.

Consider two hypothetical options:

Item	Homegrown forage	Purchased forage
Usable forage DM	2,250 kg	2,250 kg
Total cost	SAR 3,150	SAR 2,700
Cost/kg usable DM	SAR 1.40	SAR 1.20

In this example, purchasing forage is less expensive. The assumed 2,250 kg of usable homegrown forage represents 2,500 kg harvested dry matter minus 10% combined storage and feeding losses.

The comparison does not establish that purchasing feed is always preferable. Homegrown forage may offer advantages in freshness, availability, and reduced exposure to market fluctuations. Conversely, purchased forage may be more consistent in quality and allow the farmer to conserve scarce water for higher-value uses.

A complete economic comparison should consider nutrient composition, transportation costs, feed losses, and the reliability of supply. This comparison assumes similar nutritional value and feeding suitability. Differences in digestibility, protein concentration, and feed losses could change the relative economics of the two alternatives.

Turning Harvested Forage into a Balanced Goat Diet

Producing forage is only part of the challenge. The harvested material must also meet the nutritional needs of the herd.

Millet harvested at an immature stage may provide more digestible forage than the same crop harvested after substantial stem development. Cowpea can improve protein supply, but its contribution depends on leaf retention, maturity, and preservation methods. Berseem may offer high-quality forage, while oats provide an alternative during suitable cool periods.

Cactus requires particular care because its high moisture content can make fresh-weight comparisons misleading. It must be combined with adequate effective fiber and sources of protein and minerals. Saltbush should be introduced cautiously and used as part of a balanced diet, especially where drinking-water quality is already compromised.

For a family with 100 goats, dividing the herd into practical feeding groups is more important than trying to develop a single ration for every animal. Lactating does and growing replacements require more nutrient-dense diets than dry mature goats. Late-pregnant animals also need particular attention because feed intake capacity may decline as fetal growth accelerates.

Forage analysis, even when performed periodically rather than for every harvest, can help the farmer identify protein and energy limitations and determine the appropriate amount of purchased supplementation.

A Practical First-Year Plan

Rather than committing the entire farm to a new cropping system, the family should begin with a manageable pilot and expand only after evaluating the results.

1. Before planting

Confirm water rights and supply, test irrigation water and soil, estimate the herd's forage requirements, and establish the maximum affordable irrigation budget.

2. First planting season

Cultivate a limited area with one suitable forage crop or use two small comparison plots if the available water permits. Record seed costs, irrigation volumes, rainfall, and labor.

3. At harvest

Weigh the forage, measure dry matter, obtain a basic nutrient analysis where feasible, and record harvesting and storage losses.

4. After harvest

Calculate kilograms of usable dry matter per cubic meter of irrigation water and the total cost per kilogram of usable forage.

5. Before the following season

Compare the results with purchased feed prices. Continue, modify, expand, or discontinue the crop according to water productivity, nutritional value, and economic performance.

A Different Measure of Success

For a small goat farm in Saudi Arabia, success should not be measured by the number of hectares cultivated or the quantity of green forage standing in the field. Those indicators can be misleading when water is scarce. A high-yielding crop that requires excessive irrigation

may be less valuable than a smaller harvest produced during a favorable season with modest water inputs.

For a family raising 100 goats in Jazan, a resilient feeding system combines carefully selected forage crops, efficient irrigation, appropriate forage preservation, and strategic feed purchases. Leaving land uncultivated during periods of water scarcity may be a sound economic decision rather than a sign of underutilization. The objective is to obtain the greatest nutritional and economic return from the water that can be reliably and sustainably supplied.

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