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VALUE CHAIN ANALYSIS FOR LIVESTOCK FEED PRODUCTION USING SALINE IRRIGATION DRAINAGE WATER IN TURKMENISTAN

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Abstract

Irrigation return flows increase the salt concentrations of receiving water bodies and cause water logging which affect agricultural productivity in Turkmenistan. Flooding irrigation drainage water using on natural pastures has also had adverse effects on the long-term productivity of desert ranges. This study examines the economics of halophytes as feed for sheep using saline irrigation water from drainage collector systems on a representative farm. Cost-benefit and rate of return analyses show that the project is economically feasible for reused water with 1400 mg/l mineralization levels or less. At higher mineral concentrations in water, or in more saline soils, bioremediation through halophyte fodder production can be profitably implemented if new market incentives exist. Value chain analysis is applied to evaluate alternative incentive systems for sheep operations based on saline water irrigated halophyte fodder production.

Key words: *halophytes, pasture land conservation, saline drainage water reuse, sheep production, soil salinity, value chain analysis*

INTRODUCTION

Due to the inherent soil salinity and the consumptive use of water by irrigated crops, salt concentrations have been increasing in irrigation water return flows in Turkmenistan. A majority of the return flows from irrigation are now collected through extensive drainage networks and channeled away. This prevents or reduces the saline water from water-logging or infiltrating into the ground water. The collected saline water, called Collector Drainage Water (CDW), could be used to grow halophytes, many species of which are known to be excellent feed for livestock. Halophytes not only tolerate high levels of salinity, they also remove salts, bioremediating highly saline soils. The purpose of this paper is to evaluate the economics of halophytic fodder production for sheep using irrigation return flow water on saline soils. The practice would also conserve water quality and restore natural pastures, providing social benefits.

Turkmenistan has a total land area of 49.1 million hectares (ha) of which 40.2 million are classified as agricultural land. About 1.7 million ha are irrigated (less than five percent). The agricultural crops on the irrigated hectares are cotton (42%), wheat (49%), fodder (5%) and other crops (4%). The remaining 38.5 million ha of non-irrigated agricultural land is used for pasture. Approximately a quarter of a million hectares of pasture land (0.65%) is under private ownership. The rest is held by Daikhan Unions (DUs), loosely translated as farmers' associations. The productivity of natural pastures is extremely low. The Karakum Desert region produces 80 to 150 kg forage per hectare. About 7 million hectares of pasture (18% of the total) have been identified as priority areas for land reclamation [1].

Turkmenistan's Amu Darya River, the major source of water for the country, provides 22

km^3 per year. Other rivers and streams contribute another 3 km^3 per year. Ground water withdrawals contribute 1.3 km^3 per year [1]. Irrigation water use is about 17.6 km^3. There is an estimated total of 41,200 km of irrigation canals in Turkmenistan, of which 33,200 km are intra-farm canals. The Collector Drainage Water (CDW) system is 35,500 km long, of which 26,500 km are intra-farm networks. The mineralization level of CDW is as high as 5000mg/l. Previously, CDW was discharged into lakes, rivers and onto deserts. Now CDW is diverted into Turkmen Lake, a 130 km^3 capacity man-made reservoir. Turkmen Lake receives CDW from two collection systems: 3.7 km^3/ year from the main system, and up to 6.7 km^3 per year from the Dashoguz system [1]. The diversion of CDW into Turkmen Lake reduces the flow of CDW into the Amu Darya River and other places. Over 400,000 ha of desert pastures are currently flooded with CDW drainage water, increasing soil salinity and decreasing the productivity of the pastures. A proposal currently under serious consideration is to use some CDW to produce halophytic feed for sheep, especially if it could raise sheep output or sheep industry profitability. For example, if 10% of the CDW were used to grow fodder for sheep, irrigating approximately 100,000 ha (at the rate of 10,000m^3/ha), it might expand sheep output while conserving water quality and natural pasture land.

Sheep production in Turkmenistan is organized by Daikhan Unions (DUs) in each velayet (province). The DUs allocate public pasture to sheep producers much like federal grazing allotments in the U.S. The DUs also provide ewes and replacement ewes to start or maintain producers' herds. The allocated grazing lands have shallow wells for watering livestock and other uses. The well water is slightly saline on top, and more saline at greater depths. Each producer's operation is monitored carefully by the DU to ensure proper management. The DUs also provide veterinary services. In return, each producer shares 50% of their lamb crop with the DU, which are sold, redistributed as replacement ewes, or allocated to new producers. Thus the reuse of saline water to grow halophytes and other feed will depend on cooperation with the DUs. To be adopted, the practice must generate private economic returns for the producers and the DU, which may also depend on government subsidies related to the social benefits due to the project. The non-market, social benefits may include reduced water-logging, improved water quality in rivers and streams, improved desert wildlife habitat, as well as higher range productivity for both wildlife and livestock.

Numerous recent studies investigated various halophyte species, cultivation methods, productivity, and halophytes as an animal feed from a nutritional point of view [2], [3], [4], [5], [6], [7], [8] and [9]. Studies of halophytes in Turkmenistan include [10], [11], [12], [13], [14] and [15]. There are no detailed economic analyses of halophyte fodder production in general, much less about arid lands in Central Asia in particular, where the economy is less privatized.

Experiments conducted by the Turkmenistan Institute for Deserts, Flora and Fauna in the Ministry of Nature Protection, and by other scientific institutions in Turkmenistan, indicate that CDW water with mineralization levels between 2,800 to 4,800 mg/l can be used to grow many livestock feeds such as beets, sorghum, Sudan grass, corn and barley [13].

Experiments conducted in Central Asia, including Turkmenistan, estimate the productivity of halophytes irrigated with water at 2500 mg/l mineralization level at yields from 4.5 to 21.1tons per hectare dry weight. And from soils with 30 to 48 t/ha salinity in the 0-100 cm layer, the halophytes remove an estimated at 9 t/ha salts per year. For soil salinity between 8.4 to 21 t/ha, halophyte-alfalfa combinations (70% /30% or 50% / 50%) remove 4.5 to 6.3 t /ha salts per year [15].

Field trials were conducted [16] on sowings of eight halophyte species under no irrigation, saline water irrigation, and fresh water irrigation on lands of the Dashoguz Velayat Daikhan Union (DU). Table 1 summarizes the data from these trials about *Climacoptera turcomanica*, the most productive halophyte species. This yield parameter is used in this paper to evaluate the economics of halophytes irrigated with CDW as feed for sheep.

Table1: Productivity of *Climacoptera turcomanica*

treatment	*Climacoptera turcomanica* plant weight (air-dry), kg/ha			
	2004	2005	2006	Average 2004-06
no irrigation	3810	2140	2730	2893
saline water irrigation	8850	11280	7450	9193
Fresh water irrigation	12100	9258	8842	10066

MATERIALS AND METHODS

Two procedures are used in this study. First, cost-benefit analysis is used to evaluate the economic feasibility of growing fodder for sheep using drainage water on saline soils from a private producer's point of view. It does not consider any measures of the social benefits since data are scant. Second, because private adoption of the practice depends on the profitability of the sheep industry, value chain analysis is used to evaluate alternative incentive mechanisms and policies as well as other ways to improve economic efficiency that could make the practice economically attractive.

Cost-benefit analysis

The cost-benefit analysis is based on a 250 ha representative farm growing combinations of perennial alfalfa and the halophyte *Climacoptera turcomanica,* which establishes and produces comparatively well in the desert conditions of Turkmenistan as shown by [16]. Nine cropping scenarios are considered, corresponding to three mineralization levels in the CDW irrigation water (1400 mg/l, 3000 mg/l, and 5000 mg/l) and three levels of soil salinity in the top 100 cm of soil profile (10 t/ha, 25 t/ha, and 50 t/ha). A different proportion of alfalfa and halophyte are planted in each scenario, as specified in Table 2. The rationales are that a larger proportion of alfalfa can be planted where water quality is better and soil salinity is lower, given the sensitivity of alfalfa to salts. At higher soil salinity levels only the halophyte can be grown. Cultivating halophytes on saline soils, however, reduces the salinity each year.

Because the productive life span of a typical alfalfa stand is three years in Turkmenistan (with seven annual cuttings), the ground is plowed up every three years, and a new mix can be established based on the soil salinity at that time, accounting for the salt removal by the halophyte. For example, a farm that has 50 t/ha saline soil and irrigation water at 3000 mg/l will plant 100% halophytes for the first 3 years. After 3 years the soil is expected to have less than 25 t/ha of salt in the top 100 cm of soil, so the farm would be planted with 30% alfalfa and 70% halophyte. After six years, the soil salinity is expected to be around 10t/ha, so a mix of 50% alfalfa/50% halophyte could be established. Similarly, three phase 3-year rotations are proposed for all cases with 50 t/ha soil salinity, as shown in Table 2. In the case of 3000 mg/l water quality and 10t/ha soil salinity, 50% alfalfa/50% halophytes will be planted every three years. For the case of 3000 mg/l water quality and 25 t/ha soil salinity, there will be a two phase 3-year rotation. In the first three years, 30% alfalfa/70% halophytes will be planted. The soil salinity after that is not expected to exceed 10 t/ha. For the next 3 years 50% alfalfa/50% halophytes will be grown.

Table 2: Proposed Cropping Patterns

Soil Salinity (t/ha in 0-100 cm soil layer)	Applied Water Quality (mg/l)		
	1400 mg/l	3000 mg/l	5000 mg/l
10	100% Alfalfa	50% Alfalfa/ 50% Halophyte	30% Alfalfa/ 70% Halophyte
25	50% Alfalfa/ 50% Halophyte	30% Alfalfa/ 70% Halophyte	100% Halophyte
50	30% Alfalfa/ 70% Halophyte	100% Halophyte	100% Halophyte

For all scenarios it is assumed that the water table is low enough for alfalfa to grow well (because it has deep roots). Where the water table is a problem, other fodder crops may be considered for planting with the halophyte. It is also assumed that the leaching fraction varies as dictated by the soil and water salinity conditions. Leaching in late autumn or early spring when abundant good quality water is available is recommended so that seeds can effectively germinate.

To complete the cost-benefit analysis, forage yields, sheep production and the average annual money value of the meat and wool produced are calculated for each cropping pattern in Table 2. Revenues from hides and milk are currently insignificant in Turkmenistan and so are excluded from this analysis. The estimated monetary returns from the sheep and wool measure the gross private benefits. The revenues net of expenses accrue to the producer and the DU. Expenses are estimated using the standard procedures established by the Turkmenistan government. Both sunk costs and annually recurring costs are included in the standard accounting framework. The share of net revenue retained by producer is the return to his labor. The share to the DU is the return to natural pasture (economic rent) plus the returns to the services, including managerial and veterinary services, provided by the DU.

Subtracting the costs (C_t) each year from the returns (R_t) gives the series of net private benefits $\{V\}_{t=0}^{T}$ for the life of the project (from time t=0 to T=20), for each soil and water quality scenario. Net present values (NPV), benefit-cost ratios (B/C), and internal rates of return (IRR) are calculated to examine economic feasibilities. The measures indicate if the project is worth undertaking at market prices (without subsidy) or if a subsidy is needed to make the project economically viable.

(1) $$NPV = \sum_{t=0}^{T} \frac{V_t}{(1+i)^t}$$

(2) $$B/C = \sum_{t=0}^{T} \frac{R_t}{(1+i)^t} \div \sum_{t=0}^{T} \frac{C_t}{(1+i)^t}$$

(3) IRR = the interest rate (i) that results in a zero NPV.

Value chain analysis

Value chain analysis is a technique for evaluating national, industry, industry sub-sector or firm level competitiveness [17]. Accessible explanations of value chain analysis can be found in [18], [19] and [20]. It is applied here to show how different mechanisms can affect the incentive to adopt the practice of reusing saline water to grow halophytes for feed. Value chain analysis begins from the world (or border) price of the product. This analysis proceeds through each stage of the supply chain from the border to the farm, computing the returns to each stage. At each stage in the supply chain, the services provided or regulations in place can be seen as activities. The set of activities can be disaggregated into subsets of activities in much the same way they were conceived by "activity analysis" scholars to investigate the efficiency of various operations of firms or industries [21] and [22].

From a producer's perspective, the main idea of the value chain is that at each stage, activities may be undertaken to raise productivity or lower costs, differentiate products, or raise product quality, to increase net revenue. The decisions made at one stage in the value chain may change the revenues at other stages in the chain, including at the farm level. Value chain analysis is a visual tool that aids in the analyses of how these activities impact the revenue stream along the entire supply chain. In the presence or absence of competitive markets, it shows the distributional implications of alternate incentive mechanisms and thus helps parties to discuss or negotiate and make decisions.

To investigate the economics of halophyte fodder production we apply value chain analysis to compare the status quo to several different alternatives or combinations of alternatives. The basic alternatives chosen after discussions with the Turkmenistan Institute for Deserts, Flora and Fauna include: 1) investment in the irrigation infrastructure to use CWD to grow halophyte fodder, 2) reduce grazing and conserve natural pastures; 3) government bearing the capital cost of the irrigation infrastructure capital 4) adding supplements to the sheep diet; and 5) meat pricing alternatives with quality assurance and grading.

Economic returns and project cost data

All the parameters used in the calculations and their sources are listed in Table 3. The yield estimates for alfalfa is 15t air-dried based on application of fresh water at 10,000m^3/ha. The halophyte biomass is 8.3 t/ha based on Table 1 with fresh water application. Only 55% of halophyte biomass is edible matter because the plant has thick stems [23]. Percentage yield reductions due to irrigation with saline water for alfalfa and halophyte are also shown in Table 3 at different levels of irrigation water quality (items 4-7). Alfalfa yield reductions are 10% at the mineralization level of 1400 mg/l, 33% at 3000 mg/l and 50% at 5000 mg/l. Halophyte yields are 8% lower than fresh water yield for all salinity levels.

Karakul sheep, the predominant breed in the Karakum Desert of Turkmenistan, are a fat-tailed breed. They are capable of storing a large percent of their body weight in energy and protein to meet gestation and lactation needs. Karakul sheep consume about 1.7 kg per day per head (Table 3, item 8).

Table 3: Parameters Used to Calculate Yields and Economic Returns

Parameter Source	Value
alfalfa biomass (air dry); fresh water (500 mg/l) [13]	15t/ha
halophyte biomass (air dry); fresh water (500 mg/l) [11]	10t/ha
halophyte edible matter [23]	55%
Alfalfa yield reduction at 1400 mg/l irrigation water [24]	10%
Alfalfa yield reduction at 3000 mg/l irrigation water [13] and [24]	33%
Alfalfa yield reduction at 5000 mg/l irrigation water [24]	50%
Halophyte yield reductions at 1400, 3000, 5000 mg/l [11]	8%
Average forage consumption/sheep at 1.7 kg/day [25] and [26]	0.62 kg/yr
Percent of live animals slaughtered [27]	63%
Average animal weight at slaughter [26]	45 kg
Dressed weight/carcass weight [25]	53%
Price of lamb meat at wholesale [28]	$2.72/kg
Sheep and Wool production {26], [28] and [29]	1.75 kg
Price of wool [29] and [30]	$0.94/kg
Natural pasture land to sustain one sheep [26]	8 ha

The analysis will consider alternative cropping and management scenarios to match various water and soil qualities. Table 4 shows the air-dry annualized yields of combined fodder for each cropping scenario (Table 1) as the first numbers in each cell, (based on Table 3, items 4-7). Yields range from a high of 13.5 t/ha for 100% alfalfa planting to a low of 5.06 t/ha for 100% halophyte. The second number in each cell of Table 4 shows the number of sheep sustainable based on the combined fodder yields from 250 hectares and the rate of feed consumption (Table 3, item 8) assuming that no pasture is grazed.

Table 4: Fodder Yields, Numbers of sheep, and Sheep Farm Revenues

Soil Salinity (t/ha in 0-100 cm soil layer)	Applied Water Quality (mg/l)		
	1400 mg/l	3000 mg/l	5000 mg/l
10	13.50 t/ha 5,439 $ 231,242	7.56 t/ha 3,044 $129,410	5.79 t/ha 2,334 $99,212
25	9.28 t/ha 3,739 $158,958	6.56 t/ha 2,642 $112,293	5.06 t/ha 2,039 $86,673
50	7.59 t/ha 3,059 $130,044	5.06 t/ha 2,039 $86,673	5.06 t/ha 2,039 $86,673

The estimates of sheep slaughtered annually (lambs, culled ewes and rams) as a percentage of the stock of sheep (Table 3) varies over time due to a number of factors such as the price of meat, feed costs, availability of feed on natural pastures due to drought etc. From 1992-2010 FAO data the percent varied from 44% to 63%, with an upward trend [27]. The percentages are low relative to other countries due to a relatively low lamb crop yield rate of about 110% and relatively high death losses (of both sheep and lambs). We use the most recent 2010 estimate of 63% for this study.

Given the average live weight of 45 kg/sheep, and meat dressed weight as 53 percent of carcass weight (or higher, if supplements are fed), total meat in kg is computed. Given the wholesale price in Turkmenistan of $2.72/kg, gross revenues from meat sales are calculated. Wool revenues are calculated assuming 1.75

kg of wool per sheep, at the 2010 autumn price of $0.94/kg, as compiled by [30] based on Neutral Turkmenistan, a government English weekly publication.

From these calculations, total annual gross revenues are shown in the last figure in each cell of Table 4, in 2012 U.S. dollar terms. Total annual revenues vary from a low of $86,673 in the high soil and water salinity scenario to a high of $231,242 for the low salinity scenario. These are the estimated gross private benefits to farmers and their DU. It is important to note that the productivity of the sheep operations is higher per hectare when CDW water is used to grow halophyte fodder. A farmer can raise the same number of sheep feeding them fodder irrigated with saline water instead of grazing them. There is a trade-off between conserving pasture and expanding the number of sheep with halophyte/alfalfa feed produced from saline water.

The project cost for using CDW to grow fodder is estimated by Aganov, 2012 based on Turkmenistan Government guidelines. Both capital costs (direct outlay and indirect outlays) as well as annual operating costs are shown in Table 5. Fixed costs include the design of the drainage water conveyance system to the farm, intake structure, on-farm take-outs, intra-farm irrigation network, surveying, and other costs. The total fixed cost is $832,800 borne at the beginning of the project. Of the $188,000 total operating cost, according to Turkmenistan guidelines, item 7 in Table 5 is a $69,400 one-time overhauling cost in the tenth year (not a variable cost). And $34,700 (item 8 in Table 5) is depreciation, paid into a project replacement fund to equal the direct capital outlay (also not a variable cost). Variable costs include seeds, other inputs, repairs and maintenance, and costs such as materials or hired labor. Thus only $84,700 is the estimated annual variable cost.

Table 5: Estimated Costs of Project per 250 hectare farm (2012 U.S. Dollars)

Item	element	Cost per Unit ($)	Amount	Total ($)
	A. Direct Capital Outlay			
1	Main waterway network/ha	68	250	17000
2	Irrigation network/ha	1914	250	478500
3	Head water intake/ha	222	250	55500
4	Collected drainage network/ha	572	250	143000
	Total Direct Capital Outlay			**694000**
	B. Indirect Capital Outlay			
5	Projecting and surveying work (5% of direct outlay)			34700
6	Unforeseen expenses (15% of direct outlay)			104100
	Total Indirect Capital Outlay			**138800**
	Total Capital Outlay			**832800**
	C. Operating Costs			
7	General overhaul (10% of direct, once in 10 years)			69400
8	Annual Depreciation (5% of direct, each year)			34700
9	Seeds and fertilizers/ha	200	250	50000
10	Running repairs (5% of direct outlay)			34700
	Total operating costs (including capital related costs) ***Annual variable cost***			**188800** **84700**

RESULTS AND DISCUSSIONS

Economic Incentives to reuse saline water in halophyte fodder production

Assuming a 20 year project life, net present values (NPV) at 5% and 2% discount rates, benefit-cost (B/C) ratios, and the internal rate of return (IRR) are calculated to assess the economic feasibility of the project, ignoring the project replacement fund and abstracting from any explicit consideration of the project's unpriced environmental ("social") benefits. When the reused water has a mineralization level of up to 1400 mg/l, the NPVs are positive for all three cropping patterns (100% alfalfa, 50%alfalfa /50%halophyte and 30% alfalfa /70% halophyte) at all three levels of soil salinity. The internal rates of return (IRR) are 21%, 13% and 9% for the positive NPV scenarios, respectively. The corresponding benefit-cost (B/C) ratios are 1.5, 1.25 and 1.09 at the 5% discount rate, and 1.67, 1.38 and 1.22 at the 2% discount rate. The other scenarios have negative net present values at both discount rates, and less than unitary B/C ratios.

This analysis makes it clear that there may be private incentives at current market prices to reuse 1400 mg/l saline drainage water. But in general, for water quality worse than 1400 mg/l, there is currently no private economic incentive to use saline water to grow feed for sheep.

Value chain analysis and implementation for the sheep industry

There are a variety of alternative mechanisms for adoption by farmers, the DUs, and/or the government that could change the incentives to invest in the infrastructure and use CDW to grow halophytes for feed rather than grazing sheep. As noted earlier, they are: 1) private investment in the irrigation infrastructure to use CWD to grow halophyte fodder, grazing on 1/3 and idling 2/3 of the pasture; 2) government investment in the irrigation infrastructure and private use of CDW to grow halophytes for fodder while also idling 2/3 of the pasture; 3) alternatives (1) & (2) plus adding supplements to the sheep diet; and 4) the alternatives in (3) plus quality grading and pricing.

To understand how these alternatives affect incentives throughout the sheep industry, value-chain analysis can be prepared for each cropping pattern scenario (Table 2). For this paper, we focus on a representative farm with CDW at mineralization level of 3000mg/l and the soil has 25 t/ha salinity, growing 50% alfalfa/50% halophytes, where the project would not be cost-effective, all else equal (Table 4). Figure 1 shows the value chain(s) for both the baseline and three of the four alternative mechanisms (indicated by dashed boxes). Note that because the effects of the alternatives on net revenue are additive, it is possible to examine any combination or levels of the alternative mechanisms.

The value chain in Figure 1 is based on: i) the yield and price parameters in Table 3; the production parameters in Table 4 for this scenario; iii) project costs shown in Table 5 ($832,400 capital costs plus the $64,900 overhaul cost in the tenth year, amortized over 20 years at 5% interest, resulting in a $69,324 annualized capital cost; and annual variable costs of $84,700); iv) a shearing cost of $0.094/kg (at 10% of revenue); and v) a slaughter and meat cutting cost of $15/animal. The results of the analyses of the following alternatives corresponding to the above scenario are summarized in table 6.

Baseline Analysis (Status Quo)

In the baseline/status quo, there is no CDW water project, no subsidies, incentives, or feed supplements. To sustain 2,642 sheep on 250ha with yields of the 50/50 fodder, (needing 8ha per sheep to graze), will require 21,135ha of natural pasture. The baseline sheep farming operation's net private benefit is $86,898, shared by the producers and the DU.

CDW Project (Expand Flock and Conserve Natural Pastures)

For the scenario under consideration, (i.e. applied water quality of 3000 mg/l and soil salinity of 25t), a flock of 2,642 head of sheep can be sustained by the fodder grown on 250ha as shown in Table 5. However, there is no reason to abandon grazing altogether. Here we assume that the farmers will conserve 2/3 of the natural pasture, and graze the other third. This means they can increase their flocks by 1/3, to 3,515 head. If demands for sheep meat and wool are perfectly elastic (for example, when the additional supply is sold on world markets), the gross revenues (and costs) from the wool and meat from the larger flock of sheep will also be a third again higher. Nevertheless, as shown at the end of the second column of value chain alternatives in Figure 1, the net private return will be a loss of $38,418. If producers and the DUs were to bear the full cost of the saline water irrigation infrastructure, there is no private incentive to finance this project which would also conserve water quality and natural pasture land.

CDW Project with Feed Supplementation

In the baseline, no supplements or concentrates are added to the sheep diet. In practice this is due to the additional cost, or to lack of local availability. Information about sheep rations from other major sheep producing countries suggests adding concentrates to the rations in Turkmenistan could also raise revenues. In other countries, the recommended supplemental sheep ration is about 0.7 kg in dry weight roughage and up to1 kg of concentrates. This increases weight gain, promotes a healthier herd and multiple births, and produces a higher quality lamb crop. Feed supplements are particularly important if the sheep are fed halophytes. Based on [3], if barley is added to the diet for 120 days at 250gm/day/animal, this will increase the dressed weight by 6 kg per sheep slaughtered. At $250/t barely, the feed supplements would cost an additional $26,354 per flock. However, due to the gained weight, the producers will also earn higher gross meat revenue of $179,737. The economically profitable alternative of feed supplementation does not, however, make the whole CDW project preferred to the status quo. If the producer and the DUs bear the full costs of the CDW project as well, they face an annual net loss of $28,644 (not shown in Figure 1).

CDW Project Capital Cost Subsidy (k-subsidy)

There are two aspects to getting CDW water to sheep producing farms: conveying it to the farm; and distributing it within the farm through intra-farm canal systems. There are three possible financial sponsors: the sheep producers, the DUs, or the government. Where market opportunities, soils and CDW water quality supports net returns at least as large as the status quo, producers and the DUs may be willing to finance the project. Otherwise, the government may consider financing the project. The motivation would be to secure the unpriced environmental (social) benefits from the project: improved water quality, reduced soil salinity, conserved pasture lands, etc. For similar benefits, other country governments either pay for the infrastructure or subsidize such projects by providing low or zero interest loans. In Turkmenistan, if the project is approved, the government would pay the capital and capital-related operating costs (the infrastructure costs of $832,400 and the overhaul cost of $64,900 in the tenth year). Farmers and the DUs would pay the annual variable costs of $84,700. In that case, producers would avoid the $69,324 annualized capital and related costs, and earn a net return of $30,906 annually. This is shown at the end of the third set of value chains in Figure 1.

CDW Project with K-Subsidy and Feed Supplementation

If the sheep farmers graze on a third of the natural pasture as well as grow fodder through a CDW project, plus supplement the feed with the barley ration, and the government bears the capital costs as in, the net private return to the farmers and their DUs are $40,680, shown at the end of the fourth value chain in Figure 1. This also has a positive NPV and a B/C ratio > 1, but it does not yet dominate the net private return of the status quo.

Quality Grading and Pricing (G&P)

In Figure 1, both the world market (border) prices of sheep meat and wool and their domestic prices in Turkmenistan are shown. The world wholesale market price for sheep meat is $6.50/ kg [27]. The domestic wholesale price in Turkmenistan is $2.72/ kg in the baseline or status quo scenario.

The $3.78/ kg difference or margin is due to the government's trade and pricing policies, transport costs from major shippers of sheep meat to Turkmenistan, and the quality of

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domestic sheep meat. Consider the implications along the value chain of lowering the margin to $2.00, so that producers earn a higher domestic price for sheep meat. For example, higher domestic prices may be paid for higher quality domestic meat. With a sheep meat grading system and quality pricing, farmers who would like to increase meat quality would have economic incentives to do so.

When sheep are graded and priced for quality, the higher prices will provide incentives to use saline irrigation water to grow halophytes for fodder in addition to feeding supplements.

The value chain analysis highlights that if quality is graded and priced accordingly--at $4.50/kg, still well below border prices-- the net private return of $88,978 would exceed the private net return from the status quo of $86,898 (at the end of the last value chain in Figure 1).

A privately financed CDW project that conserves two-thirds the natural pastures, without any subsidy, would be more attractive to producers and DUs than the status quo. This underscores the power of efficient private markets with respect to investments that benefit the public.

Table 6: Summary of Alternative Value Chains for a Sheep Operation with 250ha fodder

	Status Quo	CDW project	CDW project + feed supplement	CDW project + K-subsidy	CDW project + K-subsidy + feed supplement	CDW project + Quality G&P + feed supplement
head of sheep	2,642	3,514	3,514	3,514	3,514	3,514
hectares grazed	21,136	6,975	6,975	6,975	6,975	6,975
meat revenue	$ 107,947	$ 143,609	$ 179,737	$ 143,609	$ 179,737	$ 297,360
meat cost	$ 24,960	$ 33,206	$ 59,560	$ 33,206	$ 59,560	$ 59,560
meat net revenue	$ 82,987	$ 110,403	$ 120,177	$ 110,403	$ 120,177	$ 237,800
wool revenue	$ 4,346	$ 5,780	$ 5,780	$ 5,780	$ 5,780	$ 5,780
wool costs	$ 435	$ 578	$ 578	$ 578	$ 578	$ 578
wool net revenue	$ 3,911	$ 5,202	$ 5,202	$ 5,202	$ 5,202	$ 5,202
CDW project cost	$ -	$ 69,324	$ 69,324	$ -	$ -	$ 69,324
Variable costs	$ -	$ 84,700	$ 84,700	$ 84,700	$ 84,700	$ 84,700
Net Revenue	**$ 86,898**	**$ (38,418)**	**$ (28,644)**	**$ 30,906**	**$ 40,680**	**$ 88,978**

CONCLUSIONS

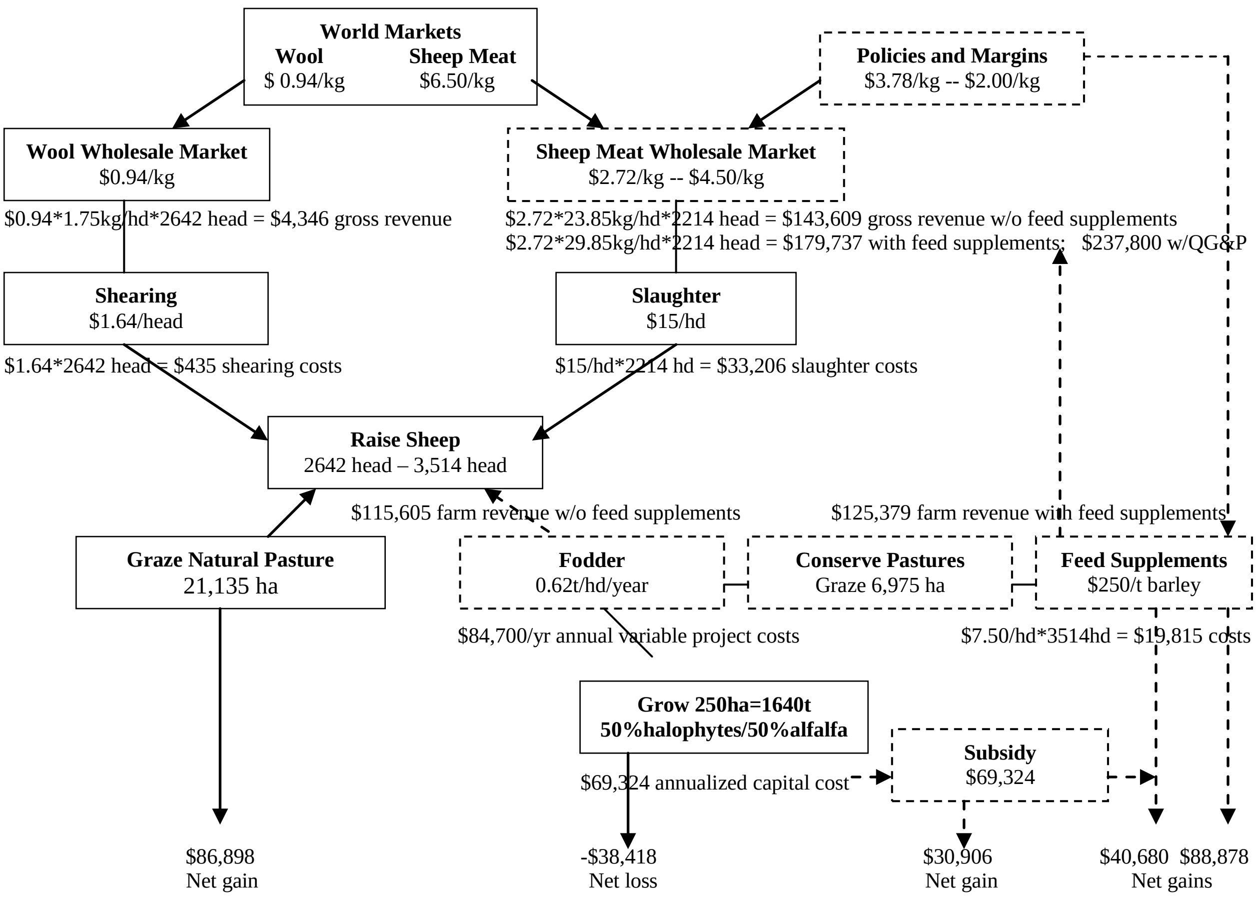
This study evaluates the economics of halophyte production for livestock feed using saline irrigation drainage (CDW) water. If the applied water has mineralization levels of 1400 mg/l or less, benefit/cost analysis shows that the CDW halophyte project is economically feasible in Turkmenistan. At higher concentrations of water and soil salinity, if there are no improvements in market pricing policies or sheep nutrition, the project will not be economically preferred to the status quo even if capital costs are fully subsidized. Value-chain analysis shows that if sheep farmers feed supplements, graze a portion (~33%) of the pasture while conserving 67%, and participate in quality grading and pricing, the CDW project economically dominates the status quo without any subsidization by the government.

Four major points should be noted. First, the cultivation and feeding of halophytes allows for an increase in sheep production as well as pasture land conservation, water conservation, and the bioremediation of saline soils. Second, because CDW conveyance and halophyte cultivation projects are not costless, market or nonmarket incentives (subsidies) will be required to encourage implementation. Third, although subsidies may be justified by the social benefits in terms of improved water quality and soil conservation, in the absence of market incentives, even a full capital cost subsidy would not make such projects economically preferred by private farmers and their associations (DUs) to the status quo. However, market incentives such as a legal system of meat quality grading and pricing are sufficient to encourage CDW project implementation (no subsidies needed). Fourth, the net economic benefit of adding supplements to sheep feed rations, necessary to leverage the productivity benefits of implementing a CDW halophyte project, also depend on market incentives such as quality grading and pricing.

In sum, Turkmenistan has an opportunity to use their saline drainage water to expand their sheep industry and conserve their environment. Even if only10% of its CDW is used, up to 100,000 hectares of halophyte fodder could be irrigated. That fodder could sustain 1 to 2.5 million head of sheep while conserving at least 1.5 million hectares of natural pasture. No subsidies would be needed if market reforms such as quality grading and pricing were made available to those who implement CDW projects.

Several limitations of this study require further investigation. These include 1) sensitivity analysis with respect to the pasture, crop, animal, cost, and pricing parameter estimates used to derive the results; 2) more detailed parameterization or interpolation of the effects of water and soil salinity on yields, to parameterize a full non-linear optimization model; and 3) quantify the social benefits resulting from this project using both market and non-market valuation techniques.

Figure 1: Value Chain(s) for Representative Sheep Farm [1]



[1]The value chain figure is drawn for the scenario corresponding to applied water quality of 3000mg/l and soil salinity of 25t/ha and the cropping pattern with 50% halophyte and 50% alfalfa, as shown in Tables 1 and 4.

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