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Nonconventional Technology for Agricultural Development in Developing Countries

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Summary

This paper concerns the economic assessment of a nonconventional technology to provide a cheap food and/or feed for many developing countries, using wasted resources, i.e. coastal arid areas irrigated directly with seawater to grow a halophyte crop (Salicornia-sos-7). It was cultivated for two successive years in Kuwait. The analysis showed that the harvested yield was 20 tons per hectare, which provided 12.42 MT of straw for sale and 1.7 MT of oil seeds for processing. Processed seeds of 1-hectare provide 425 kg of food oil and 1.1 MT of feed meal. Under Kuwait conditions, on per hectare basis, the total costs of production (fixed & variable costs) were $3088. However, simulation of this technology under a conventional developing country like Egypt with much less probability of sever sandy winds and less cost to adjust the irrigation network and much cheaper labor, much lower costs per hectare was achieved. Accordingly, the costs schedule would be $ 2903 (investment costs), i. e. less than the current desert land reclamation costs in Egypt ($3000/ha). $1401 (variable costs) and 1588 (total costs of production). Under Kuwait conditions, the reached yield made a negative net farm income of 6.5% of the total costs of production. Under Egyptian condition, the same level of yield generated a positive gross margin of about 52% of the variable costs and a net farm income of 45% above the total costs of production. The ERR under Egyptian condition was 45% from investment in "Salicornia" production.

Among several social benefits, such technology would introduce a much cheaper water resource. Under Kuwait condition costs was 1.2 cents/m3 of seawater, i.e. equivalent to 7% of the costs of brackish water production. Sheep-Hay Response Analysis showed that: At the current feed and livestock prices , to use salicornia hay is feasible up to 37% of the ration and the rest could be fulfilled from alfalfa hay. Cultivation of Salicornia at the wasted coastal area would save 1/3 of the berseem area in Egypt. This area could be devoted to produce 2000,000 tons of wheat. One hectare with livestock could provide sufficient livelihood for a family of five persons.

Introduction

Some believe that conventional resources (arable area, fresh water availability and climatic conditions) will not limit the production of food due to

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technology progress (Hayami and Ruttan, 1985). "Knowledge is the most powerful engine of production" as quoted from Alfred Marshall by T. W. Schultz (1980) in his Nobel prize paper. The appropriate technology was defined by Matlock, (1977) as that technology which is appropriate for a certain nation, its people and its resources. However, emphasis to date has been focused on considering the appropriate technology as accumulation of machinery tools and/or automation of production process that does not have to be the case of the very limited water resource area.

On the other hand, Computation between urban expansion and industrial activities against agricultural use of limited water supply makes the challenge to be very serious in future. Arable land and land under permanent crops is less than 10% in Africa and less than 15% in the Middle East. Much of the other land is unsuitable for intensive agricultural use. Agricultural land in USA is used under high technology at about two-thirds hectare per capita to produce such high protein-calories diet. The per capita land available in the world today is around 0.35 hectare (FAO, Production Yearbook, 1988). Thus it would be physically impossible to feed the current world population, particularly, the developing countries (most of their lands are arid lands) a diet similar to that consumed in the USA, on basis of the land constraint alone (FAO, 1984).

However, land itself is probably not the major fact in limiting agricultural development in the arid lands. Availability of water is the key to agricultural development in the developing countries. The lack of water may be the principal constraint to efforts to expand world food output. Establishment of a developing country based upon exploitation of stored ground water and ignoring future consequence of depiction or depending entirely on marginal fluctuated rainfall is immoral (Lagache, P., 1977). Thereof, utilization of nonconventional technology that make use of nonconventional resources, is a rational outlook for agricultural development in developing countries. Accordingly, this study focuses upon the feasibility of starting now a serious "Bios line Program" to increase the self-sufficiency from basic agriculture produce while minimizing the demand for fresh water resources, to be saved for other expanding urban uses. The core of this program is to grow a promising "Halophytes" on high saline water, up to seawater strength, to produce oilseeds, grains, fodders, or ornamental plants. The present study deals with the feasibility and socio-economic impacts of transfer the "Salicornia SOS-7" as an oilseed salt-tolerant crop under "Halophytes". It relies on the scale-up of field experiments conducted along two successive years under the sever conditions of Kuwait on coastal wasteland (very high temperature in summer, strong sandy winds and lack of sufficient experience). The costs schedule was adjusted as another proposed scenario under a moderate conditions of a developing economy, represented by Egypt, which enjoys less sever climate, much cheaper labor. In addition, in the simulation model the improper technology constructions, which were used in the experiment of Kuwait, were avoided. Therefore, the adjustments made under the simulation model would make the technology assessment under a potential performance. The study made also an assessment for the limits of substitutability of salicornia-hay as a fodder to replace the conventional cultivated fodder, which saves the irrigated land devoted for fodder cultivation. The saved water could be used for production wheat as a subsistence food crop, which would diminish imports of wheat and feedstuffs.

DATA BASE

Data Used for Salicornia production

The data was derived from two successive years experiments (in 89 & 90) conducted in the Kuwait institute for scientific research (KISR). 2.5 hectares were selected at the coastal areas of Kuwait, at a distance of 0.5-km from the Arabic Gulf shore. The irrigation network composed of a well, pumps, and pipes. It was designed to provide at least an amount of seawater equivalent to twice the potential evapotranspiration rate, in order to provide enough water for plant growth and leaching of salts. Planting took place in November. The area was divided into 50 replicates. The site was irrigated after seeding and approximately every four days thereafter. The growing period is around 200 days. Urea-Fertilizer was applied at 800kg per hectare. Crop was harvested manually. Costs were derived from the records and adjusted for the analysis purposes. As a new crop its output was nonmarketable Therefore, the value of output was imputed, using equivalent prices of comparable products .

Data Used for Sheep Feeding on Salicornia Hay :

Sheep-Feed response relied upon "whether of Australian sheep" that put on feeding trails, conducted in the experimental station in (KISR), in 1989. The trails were six, which differed in the feeds combinations. Each trail included 9 heads of initial weight around 30 kg live-weight per head. The proportion of salicornia hay was different in each combination, i.e. 100%, 75%, 50%, 25%, 12.5%, and 0.0%. The rest of the ration combination in each trail was completed by Alfalfa hay. Accordingly, it was possible to assess the substitutability of the salicornia hay for conventional hay. Animal and feed weights were recorded biweekly for two months. There were 216 observations available for response function estimation.

Analytical Procedures

Salicornia Production:

Costs of operating such production system under the introduced technology were separated into those falling directly on the producer, which are the variable costs and the fixed costs, and those paid by the state (or society) to provide the necessary support system and infrastructure, which are nominated as investment costs. Costs of some items and equipments were excluded from the current analysis because they were for experimental purposes and not applicable for this production system as a commercial enterprise. The cost items were scaled-up for 1-hectare. In addition to the producer direct benefits (profitability), there are social benefits which, mainly, include utilization of nonconventional natural resources particularly, seawater and costal wasteland. Accordingly, the costs of using such water in comparison with conventional brackish water's costs were investigated. Figure 1, shows the decomposition of the target crop output. The salable products have not yet transact via an active market. The farm gate salable output includes washed straw and seeds in barn. The imputed prices for those two products were applied. Salicornia straw as animal feed is, nutritional, equivalent to alfalfa hay except that the former has 7% protein and the later has 10.6% protein content. The average price of alfalfa hay in Kuwait market in 1990 was KD 90 per ton, i.e. $ 306/ ton, at exchange rate of $3.4/1KD (Ministry of planning of Kuwait, 1990). This price was weighted by the salicornia to alfalfa protein ratio to derive the equivalent price of salicornia hay, which was $202/ton in 1990. Salicornia seeds have almost the same content of protein as soybean. Accordingly, the price of the salicornia seeds price was considered as equivalent to the soybean seeds price, i.e. $245 per ton in 1990 (Ministry of planning of Kuwait, 1990). The Break-Even budget model was applied (Brawn, 1979) to derive the break-even yield per one hectare. Such break-even yield was compared with the actual acquired yield. The relative difference between the actual and the break-even yield was calculated as a percentage of the costs per hectare to express the expected profit margin. The gross margin was considered as the minimum accepted profit margin when it was derived from the breakeven yield derived from the variable costs, rather than total costs. If the break-even yield was calculated at the total costs the profit margin would be the net farm income. Gross margin is the return above the variable costs. The net farm income is the return to the farmer's own resources used (management, family labor, and farmer's capital invested). Return to investment (IRR) is also estimated (Brawn, 1979).

<u>Sheep-Hay Response</u>

Nine replicates (animals) were introduced under each treatment to exclude the possibility of autocorrelation of the error due to successive observations (successive weight values for the same animal under the same treatment over the feeding period). Number of treatments was sufficient to estimate a response function form up to 6 parameters (Heady & Dillon, 1972). On the other hand, the bio-economic concepts of the livestock feed response functions imply a curvilinear form of such functions (Soliman, 1973). Accordingly, three functional forms were tried to specify the target response function shown by equation (1) where: G is the live weight gain in Kg, A is the alfalfa hay in kg, s is the salicornia hay in kg and i and j identify the animal and the observation, respectively .

$G_{ij} = f(A_{ij}, S_{ij})$ .... (1)

These forms are Cobb-Douglas, Quadratic and Square root function. Selection of the best fitted from depended upon the statistical significance of the value of the adjusted coefficient of determination (R^{-2}), the statistical significance of the estimated parameters and the economic logic of the estimates, i.e. their directions (dimensioning return). In order to determine the required feeding period associated with the optimum (economic) level of grain and feed combination, a time function is estimated (Heady & Dillon, 1972) . This function expresses the relation between the two concerned feeds levels and the time variable (T) in days required to consume the various levels of feeds (Equation 2). The same procedure applied for specification of the best-fitted form of equation (1) was followed with the model of the equation (2).

$T_{ij} = f(A_{ij}, S_{ij})$..................................... (2)

RESULTS and DISCUSSION

The Analysis would include the cost schedule, $_{ij}$ break-even yield estimation, profitability and (IRR), under the scaling up simulation model of both Kuwait experiment and adjusted proposed cost schedule for Egypt. On the other hand, the sheep response analysis would include the estimation of the best-fitted function forms and derived techno-economic estimates that fit the objectives of estimating the economic efficiency and role of salicornia hay in the least cost ration at optimum weight, to identify the feasible level of substitution for alfalfa-hay. The expected social benefits were presented.

INVESTMENT COSTS OF SALICORNIA PRODUCTION

Table 1 shows the investment cost items of infrastructure scaled up per 1-ha. They include six major items, which are the site preparation, well establishment, irrigation system, power generation, residential costs, and environmental production (windbreak system). The average annual cost per hectare was $5650 under Kuwait experiment. Simulation of this technology, Under Egyptian conditions, would exclude the following items from the model. These are: (1) The well establishment costs, as the water could be lifted and pumped directly from the sea to the field by adjusting the irrigation system. (2) The wind break system, under Kuwait conditions, was so complicated and expensive in order to protect the crop against the very sandy strong and severe storms which blow-up annually in Kuwait. Under the conditions of a country like Egypt a much more simpler system would be enough , which costs only 10% of the applied one in Kuwait, i.e. about $ 217 per ha. Annually, instead of $2173 in Kuwait's model. Accordingly, the investment costs per hectare would be dropped from $ 5650 (in Kuwait) to $ 2903 (in Egypt). This level of costs is less than the average costs for the current investment costs for land reclamation in Egypt which was $3000/ha in 1990, (Ministry of Agriculture and land reclamation, Egypt, 1990)

COSTS OF PRODUCTION OF SALICORNIA CROP

Table 2 presents the fixed cost items per hectare per year. The total fixed cost per one hectare a year was $187 under Kuwait experiment. Total variable costs were $2901 per hectare per season (table 3). Thereof, the total costs of production of 1-ha of salicornia was $ 3088. However, the wage rate in Kuwait market is relatively very high, i.e. $10 man-day in 1990 (Ministry of Planning, Kuwait, 1990) in comparison with a country like Egypt where the wage rate is around $2.5 man-day (Agricultural Economic Research Institute, Egypt, 1990). Accordingly, the total variable costs of production per hectare per year under Egyptian conditions would decrease to about \$1401/ha./year and the total costs per hectare would decrease to \$1588. Whereas, the drop in the yield level under Kuwait experiment was drastic because of the delay in the plantation time for two months beyond the optimum date (November) and due to poor wind break system established in the first year of the experiment, in the second year most of the problems were avoided. Therefore,. the harvested biomass per hectare raised to 20 tons.

BREAK-EVEN YIELD .PROFITABILITY AND RETURN TO INVESTMENT

The break-even yield shows the minimal acceptable level of output, above which the producer can make profit (Brawn, 1979). Table 4, shows the weighted average revenue per ton as an output of selling the seeds and straw at the farm gate. The biomass for sale generates revenue of \$145 per ton. The weighted price was used to derive the break-even yield per hectare of salicornia, (table 5).The break-even yield that covers the total variable costs was almost 20 tons under Kuwait conditions, i.e. equal to the acquired yield from the experiment in the second year. Even though, It did not generate any positive return above the variable costs, i.e. the gross margin was almost zero. While under proposed application in Egypt the break even yield was 9.66 tons, with a probable gross margin about 51 percent above the variable costs at the potential yield (20 tons/ha). The break-even yield that covers the total costs of production per hectare was 21.3 tons in Kuwait while it reached only 11 tons under Egyptian conditions. Such estimates resulted in a loss of 6.5% per hectare under Kuwait conditions, comparing to a high level of 45.2% margin above the total costs per hectare under Egyptian condition at a yield of 20 tons per hectare. It addition a higher yield than the 20 tons harvested in the second year experiment of Kuwait seems not possible. However to surpass 20tons/ha under Egyptian conditions is most probable. The evidence is that 25 tons per hectare was commercially obtained in the coastal regions of Arizona of USA, and Mexico (Riley, 1988). Under Egyptian Condition ERR was 45.3%, i.e. an attractive investment incentive that would even cover the probable losses that might stem from risks.

ESTIMATION OF THE FEED RESPONSE FUNCTION

According to the criteria mentioned in the methodology the quadratic form was the best fitted form for both the feed response function and the time function which as shown by equations (3) and (4), respectively.

$$G = -2.7271 + 0.4683A^{**} + 0.4495S^{**} - 0.0053A^{2*} - 0.0087S^{2*} - 0.00334AS \quad .. (3)$$

$$(0.1539) \quad (0.1491) \quad (0.0064) \quad (0.0064) \quad (0.0114)$$

$$R^{-2} = 0.6756, F = 5.582^{**}$$

$$T = -10.1523 + 20.7725A^{*} + 3.8594S^{*} - 0.0262A^{2*} - 0.052S^{2*} - 0.0660AS \quad (4)$$

$$(0.9016) \quad (1.3906) \quad (0.0117) \quad (0.0299) \quad (0.0529)$$

$$R^{-2} = 0.7894, \; , F = 9.247^{**}$$

Where, Values between parentheses beneath the estimated parameters are the standard errors of the regression coefficients and (*) means significant at p < .05

and (**) means significant at P< .01

PRODUCTIVE EFFICIENCY OF SALICORNIA HAY

From the estimated response function (equation 3), the marginal productivity was derived from equations *5* and 6, which is the marginal physical product (MPP) of alfalfa hay, and salicornia hay, respectively.

$$MPP_a = 0.4683 - 0.010106A \text{............. (5)}$$

$$MPP_s = 0.4495 - 0.0174S \text{.................. (6)}$$

The estimated parameter of the product term of both substitute feeds in each equation (AS) was not significant in equation. Thus the marginal physical product as shown by equations 5 and 6 was decreasing at a constant rate , but the rate of decrease in salicornia hay productivity was faster than alfalfa hay rate ,at various levels of feed consumption per head. Generally, this result showed that the efficiency of salicornia hay was less than that of alfalfa hay, because of two issues related to its composition. First, its protein content is 7% while it is 10.5% for alfalfa hay. Secondly, in spite of washing the salicornia hay after harvesting, its salt content is still high (but not harmful to the animal).

LEAST COST RATION AND OPTIMUM MARKET WEIGHT OF SHEEP

According to the economic principal when the value of marginal product (VMP) equals the marginal cost, the least combination of both feeds is determined, which minimizes the feed costs and maximizes the profit above the feed costs. In Egypt market the average price of alfalfa hay was around $80 per ton in 1990 (I-$ =3 Egyptian pounds) and the average price per Kg of fed sheep for slaughter was about $1.8 in 1990[1]. AS Salicornia, hay has no active market, it was considered of the same price as alfalfa hay. Thus multiplying equations 5 and 6 by the price of 1-kg live wirght derived the value of marginal product of each feed, as shown by equation (7) for alfalfa and by equation (8) for salicornia.

$$VMP = 2.5765 - 0.0583A \text{...................... (7)}$$

$$VMP = 2.47225 - 0.0957S \text{.................... (8)}$$

The estimated least cost feed combination was. About 40.07 Kg of alfalfa hay and 23.3 KG of salicornia hay. Substitution of such feed levels into Equation 3 showed that the optimum live weight gain was about 15.55 Kg. Adding the initial weight (35 Kg live weight). The optimum market weight would be 50.55 kg live - Weight. Therefore, the total feed least costs were $5.06, where salicornia hay share in feed costs was 36 .75 %. The feed costs share in total cost was 65% for red meat production (Soliman, 1973). Therefore, by adding the share of other costs (35% of the total) the profit was $20.21 per head, i.e. $1.3 per one Kg live weight, or 70% of

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[1] Average price collected from field visit to the livestock Market in Tanta city (middle of Nile Delta in December 1990

the sale price. Substitution of the least costs feed quantities in equation, 4 showed that the time required to reach about 50 kg live weight was around 79 days with a 196 grams average daily gain. In conclusion at the current feed and livestock prices, to use salicornia hay is feasible up to 37% of the ration and the rest could be fulfilled from alfalfa hay.

SOCIAL BENEFITS OF CULTIVATION OF SALICORNIA CROP

Expansion in Salicornia production would provide some main social benefits. Using seawater directly for irrigation without any treatment provides very cheap additional water resource to the development programs. Table 6 shows that the costs of delivering 1-m^3 of seawater to the field (from Kuwait experiment) was 1.2cents/m^3. The alternative water resource for irrigation was the Brackish (sub ground) water. Its costs of production were 16cents/m^3 in 1990.Thereof, the costs of using the seawater was less than 7% of the brackish water. Nerveless, the costs of using the seawater in Kuwait, is considered the ceiling level of using any high saline sub - ground water. This is because the sophisticated system used in the experiment to lift the seawater from to adjacent coastal land for irrigation. With a simpler network the costs would be much less than 1.2 cents/m^3. In addition,, the costs of using the brackish water might include the costs of distribution plus the costs of production (table 7). In Egypt, using the conventional water resources for irrigation Would be insecure in the future because of the competition between agricultural usages versus urban, municipal and industrial purposes. This crisis would be more dramatic in the third world countries, because of high population growth and large proportion of desert lands with depleting water resources.

Other social benefits include creation of new communities for settlement of excess urban population associated with feasible opportunity of employment and enlargement of self-reliance in food and feed supply from domestic production. Production of Salicornia hay as feed supply from a crop cultivated on the wasted coastal area would save around one - third of the main fodder such as Egyptian Clover (Berseem) that occupies a large area in winter in Egypt. Berseem occupies 1/3 of the cultivated area and provides 70% of the feeds supply in Egypt (Soliman & Imam, 87). The saved area, could be devoted to produce 2000,000 tons of wheat. Thereof, decreases the imports volume of wheat, which reached more than 5 million tons in 1988. 1-ha of salicornia with sheep fattening provide enough earn of living to settle a young family with two children. An industry for oil and meal production from salicornia seeds could be established in the same area to enlarge the value added and generate more employment opportunities for the new established community. The salicornia oil and meal would help in narrowing the domestic gap between production and consumption of vegetal foof oils and concentrate feed.

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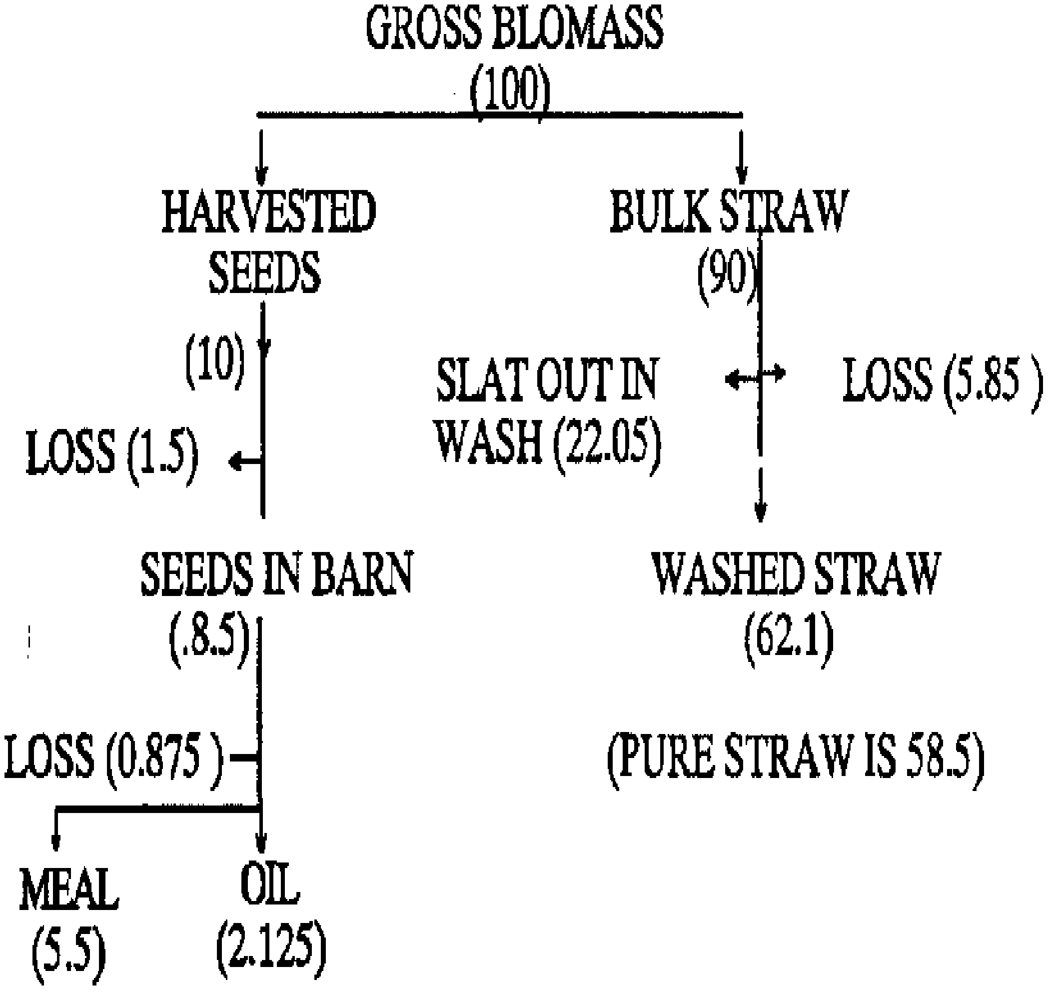

FLGURE 1 . DECOMPOSITION OF SALICORNIA BIOMASS

TABLE 1 INFRASTRUCTURE COSTS for SALICORNIA PRODUCTION per Hectare

Cost Item	Total Costs ($)	Useful Life (Years)	Annual Costs ($)	Scale in Ha	Costs/Ha / Year
1. Site Preparation	29440	50	589	2	294.5
2. Well 's Establishment	39566	50	791	1	791.0
3. Irrigation System	28050	50	561	2	280.5
4.Power Supply for Irrigation System	10030	8	1254	2	627.0
5-Residential costs	29682	8	3710	2.5	1484
6.Environment Protection					
Protection Wall	25092	10	2509	5	502.0
Soil Fixation materials	5100	2	2250	5	510.0
Shade Cloth	9292	4	2323	2	1161.5
Total	176252		13987		5650.5

TABLE 2. FIXED COSTS PER HECTARE OF SALICORNIA PRODUCTION

Cost Item	Total Costs ($)	Useful Life (Years)	Annual Costs ($)	Scale in Ha	Costs/Ha/ Year
1. A Balance	595	7	85	5	17
2. Diesel Transfer Pump	255	5	51	2	25.5
3. Irrigation Valves	301	5	60	2	30
4. Hoses	136	3	45	2	22.5
5. Farm Boundary Fence	2295	1010	229,5	2.5	92
Total	3582		470.5		187

TABLE 3 VARIABLE *COSTS* PER HECTARE OF SALICORNLA PRODUCTION

Cost Item	Costs/Ha/Year.($)	% of Total
1. Fertilizer (1)	819	28.2
2.Salicornia Seeds (2)	24.5	0.8
3. Rental Tractor (3)	58.0	2.0
4. Labor (4)	2000.0	69.0
Total	2901.5	100

(1) 800 kg Urea = 400 kg Nitrogen Nitrogen/hectare. (2) 100 kg of seeds at equivalent price of Soybean i e. $ 245/ ton. (3) Loading the sands daily along the production season, at daily wage in Kuwait market of $ 10 for unskilled labor in 1990

TABLE 4. REVENUE PER TON OF SALICORNIA OUTPUT

Output (1)	Quantity (Ton) (2)	Price/Ton (Us$) (3)	Revenue (Us$)
Harvested Seed in Barn	.085	245	20.80
Washed Straw for Sale	.621	200	124.20
Bio - mass for Sale	.706		145.00

(1) There two Options at sale: (a) Bio - mass for sale, (b) Total Net Output. However, at farm gate the sale is as biomass.
(2) Derived according to the technical coefficients in figure 1
(3) Salicornia seeds equivalent price is the soybean's price in USA market in 1990. The salicornia hay equivalent price is the Alfalfa price weighted by protein content's ratio .

TABLE 5 . BREAK EVEN YIELD OF SALICORNIA GROSS BIOMASS

Cost Item	Under Kuwait Conditions			Under Egyptian Conditions		
	Costs	Break-Even Yield (Mt	Profit In Us$	Costs	Even Yield (Mt)	Profitability In Us$
Variable Costs	2901.5	20.01	0.000	1401.5	9.66	51.7
Total Costs	3088.5	21.3	(-6.5)	1588.5	10.96	45.2

* Break - even Yield was calculated at a weighted farm gate price per ton of $145 (table 4)

TABLE 6. COSTS OF 1-M^3 SEA WATER FOR SALICORNIA IRRIGATION PER HECTARE

Cost Item	Cost Value ($)
1) Well's Establishment	791
2) Irrigation System	280.5
3) Pump Set	626 .8
4) Maintenance (2% Of 1+2)	31.45
5) Pump Set Maintenance (15% Of 3)	62 .7
6) Fuel & Oil Consumption	300 .9
7) Opportunity Cost Of Capital (8%)	175 .95
8) Labor	1020 .0
9) Annual Total	3289 .3
10) Daily Average: (9) /365	9 .01

* Daily Charge Of The Well Was 760 M" 3

TABLE 7. COSTS OF BRACKISH WATER PER CUBIC METER IN DOLLARS

Cost Item	Cost Value ($)
Production	0.0591
Interest On Capital Costs	0.0013
Operating Costs	0.0875
Other Costs	0.0083
Subtotal (1)	0.1562
Distribution	0.1271
Interest On Capital Costs	0.0101
Operating Costs	0.068
Customer Services	0.0338
Loss And Waste	0.0456
Other Costs	0.0239
SUBTOTAL (2)	0.3085
Total (1) + (2)	0.4647