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Fodder crop re-allocation sustainability and risk efficiency

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Abstract

Rhodes Grass crop is continuously cultivated in coastal area of Salalah and Batinah region of Sultanate of Oman and created a negative impact on agriculture production. The government authority stopped Rhodes grass cultivation in coastal area and encouraged farmers to develop new area at Najed. New irrigation water policy regulations imposed to reduce risk of underground water deficit and insure sustainable fodder production. Due to uncertainty of underground water availability, investors have little data to help in making investment decisions. Under these circumstances this research aims to study performance and sustainability of Rhodes grass cultivation at new developed area. The study applied a stochastic budgeting approach to evaluate proposed incentive strategies under different level of underground water. The stochastic budgeting simulation is done by using @Risk software that allows the representation of risk and uncertainty as probability distributions. Stochastic Efficiency with Respect to a Function (SERF) performed to rank different incentive alternatives for decision makers with different degrees of risk aversion and select the risk-efficient incentive strategies. The study calculated risk premium needs to be paid to a decision maker to justify switch from present location (Salalah) to new proposed area which is equal RO 97 thousand for (Hanfeed) and RO 557 thousand for (Dawkah) location. The breakeven risk aversion coefficients were calculated under different Government supporting incentives. Under lower RAC Salalah, Hanfeet2 and Dawkah2 were the most preferred scenarios respectively, whereas under upper RAC Dawkah2 followed by Hanfeet2 and Salalah were the most preferred scenarios. The results illustrate possible conflicts between risk efficiency and sustainability. Change in water policy with raw material subsidy could improve risk efficiency and encourage investors to sustain fodder crop re-allocation activates at new area at Najed.

Keywords: Stochastic efficiency with respect to a function; Risk efficient; Simulation model; Risk management strategy; Sustainability

Background

Farmers in the Al-Batinah and Salalah coastal plains exploiting the good ground water resources and increase land cultivated by Rhodes Grass which is easy to grow and crop can be taken out at least six times a year. The excessive use of the freshwater has led to ingression of salinity in the area (Water Science and Technology Association and Ministry of Regional Municipalities and Water Resources 2010). This situation threats the ecosystem. The Ministry of Agriculture and Fisheries (MAF) was seized of this problem and carried out an exercise to solve the problem, at the same time meeting the fodder requirements of the livestock to match the needs of a growing population. The (MAF) decided to gradually stop the cultivation of Rhodes Grass in Al-Batinah and Salalah plains and re-allocate fodder crop growing at substitute areas in the Najed to meet the fodder requirement.

The fodder production at Najed Area depends on the availability of irrigation water from underground. Farming in this area influenced by activities of farmers and farmers involvements in the water management; the interdependence creates difficulties to predict expected amount of irrigation water and increases complexity in decision making in crop and water allocation. Moreover, farmers at new area must also cope with other uncertain key variables such as yield, price and inputs cost. Water requirements for crops in Najed area are fulfilled by underground water. As a result, the availability of water depends on natural as well as human and policy factors, argued Abdelhafidh H. et. al., (2011). The excessive use of underground water might affect the availability of irrigation water in Najed Area in Oman and affect farming sustainability and cause environment problems. This paper investigated the appropriate incentives scenarios by ranking risky alternatives. The study also test new water policy at project area and evaluate subsidy required to reduce the risk and sustain fodder production from Najed project.

The water use authority announced new water policy and advised the allowed quantities of water to be extracted out in the project area at Najed. The total quantity of water allowed to be extracted should not exceed 112 million cubic M/year and water extraction per well restricted to 30 Lit/Sec only. It is decided that the distance and spacing between wells at project area should not be less than 1KM X 1KM so that water flow should not be affected. Moreover, the water policy also reduced the total center pivot cultivated area to 22 Hectares in stat of 50 Hectares in other coastal areas. As a result the total cultivated area constitutes of 20 % of the total project area and this increased operation and capital cost of the project. As a result, investment in desert farming at new Najed area still rely heavily on government support. This is due to the fact that it is a capital intensive investment associated with great uncertainty. It is not only the common risk factors such as market prices and high capital cost that are relevant to desert farming projects but also risk factors such as annual fodder production and technical reliability.

The application of new water policy increased capital and operation cost and included uncertainty factors which will impact economic efficiency of the resources utilization and project viability. The risk and uncertainty are best thought of as representing a spectrum of unknown situations with which an analyst may be dealing, ranging from perfect knowledge of the likelihood of all the possible outcomes at one end (risk) to no knowledge of the likelihood of possible outcomes at the other (uncertainty).

The Government Authorities decided to re-allocate Rhodes grass cultivation to Najed area and encourage farmers and investors to develop Najed Area by giving lands to farmers and give capital grants to project to achieve financial sustainability. However, the sustainable development of Najed Area should financially be viable and meet the needs of the present without compromising the ability of future generations to meet their own needs.

Monte Carlo Simulation models were used in this study to quantify risk and uncertainty in desert farming at Najed Area. The quantitative risk analysis will provide decision makers a means of estimating the probability that the project NPV will fall below zero, or that the project IRR will fall below the opportunity cost of capital. The model will also help in improving water management policy and achieve project objectives simultaneously: sustaining irrigated agriculture for food security and preserving the associated natural environment. Quiroga et al. (2010) use Monte Carlo simulations to estimate crop yield risk to water variability. In this study government investment subsidy at Hanfeet and Dawkah location compared with base scenario location at Salalah. For the new location at Hanfeet and Dawkah underground water level change and depletion were tested.

The methodology and stages of the process of using Monte Carlo Simulation dynamic model for project appraisal was addressed by Savvides (1994). He argued that this integrated analysis provided a range of outcomes that can reduce the risk of uncertainty and give more reliable results for investor. Additional information related to adaptive and robust policies applied to the management of water and aquatic ecosystems can be found in Blumenfeld et al. (2009); Carpenter et al. (1999); Chen et al. (2009); Folke et al. (2002), MA (Millennium Ecosystem Assessment) (2005); Saunders and Lewis (2003).

The stochastic efficiency of alternative Government incentive strategies for decision-makers with varying levels of risk aversion is determined with a technique developed by Hardaker et al. (2004) called stochastic efficiency with respect to a function (SERF). SERF is based on the notion that ranking risky alternatives in terms of utility is the same as ranking alternatives with certainty equivalents (CE). CE is defined as the sure sum with the same utility as the expected utility of the risky prospect (Hardaker et al., 2004). (Lien et al., 2006) used Stochastic Efficiency with Respect to a Function (SERF) to supplement sustainability criterion. Pandey (1990) used stochastic dominance analysis to estimate the value of irrigation investment for risk averse farmers' according to risk-efficient irrigation strategies for winter wheat. He found that higher levels of water application were risk efficient at low levels of risk aversion.

Project risk analysis and management is a process which enables decision maker and project management to mitigate risks associated with a project. Properly undertaken it will increase the likelihood of successful completion of a project to cost, time and performance objectives. Risks for which there is ample data can be assessed statistically but due to insufficient data available regarding underground water risk analysis needs to be performed. The study considers (Hanfeet1) scenario as no water re-charge and (Hanfeet2) scenario with water recharge model. For Dawkah location the study also consider two scenarios with and without underground water recharges in (Dawkah2) and (Dawkah1), respectively.

Dealing with risks in projects is therefore different from situations where there is sufficient data to adopt an actuarial approach. Because projects invariably involve a strong technical, engineering, environment and water policy innovative or strategic content a systematic process has proven preferable to an intuitive approach. Project risk analysis and management has been developed to meet this requirement.

The main objective of this paper is to investigate fodder crop re-allocation sustainability and compare risk efficiency of risk management tools that can be used to mitigate risk.

Methods

The task of project evaluation is to estimate the future values of the projected project variables by using available information regarding a specific situation of the past to predict a possible future outcome of the similar project. The approach normal used in investment appraisal is to calculate a "best estimate" based on the available data and use it as an input in the evaluation project model. The single value estimate is usually the most likely outcome (NPV) or (IRR).

Net present value

The NPV was used as an evaluation criterion. The net cash flow, calculated by subtracting the cost from the revenue, was discounted by the interest rate to obtain the NPV of the project. If NPV is a function of all both deterministic and stochastic variables, the resulting NPV gets a range of values instead of a single value obtained in a conventional deterministic financial evaluation. NPV is obtained from the below formula.

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n}$$

Where,

ci = the net cash flow in year n (n = 0, 1, 2, ….. n), represented by farm income in this study.

n = the planning period which equals twenty years in the current analysis.

r = the discount rate.

Monte Carlo simulation

Monte Carlo simulation is a computational algorithm designed to evaluate the variability or stochastic of the input variables of a model. It can be used to model the effects of key variables on the NPV of a given proposal. The process involves, first, the identification and assessment of the key variables. For each key variable, we fit a probability density function that best describes the range of uncertainty around the expected value. For this purpose, we used historical data at growing area and data from MAF statistics (2013) and Agricultural and Livestock Research, Annual Report (2007). The model including these variables is then calculated using randomly-generated input values taken from the underlying probabilistic distribution function. The computer model combines these inputs to generate an estimated outcome value for (NPV) and (IRR). The process is repeated (ten thousand times). Monte Carlo simulation model is currently regarded as the most powerful technique for cash-flow analysis. It is useful when there are many variables with significant uncertainties. The more complex the project and the more risks and uncertainty that are associated, the more valuable Monte Carlo simulation analysis will be.

The dynamic simulation model based on the Net Present Value (NPV) and the Internal Rate of Return (IRR) were used in this research for the evaluation of project feasibility of fodder crop growing at two locations at Najed Area and Salalah to rank best alternatives for decision makers with different degrees of risk aversion. The stochastic budgeting and stochastic efficiency methods are used to consider risk and uncertainty variables in the model presented in study area.

Firstly a dynamic, stochastic simulation model of a Rhodes Grass farming was developed to evaluate the economics of investments in desert farming and economic sustainability. The model was designed to characterize agriculture parameters and economical complexities of a Rhodes Grass farming within a partial budgeting framework by examining the cost and benefit streams for ten years coinciding with investment in desert farming and high risk areas. The second aim of the study was to develop the model to test the effect of underground water recharge on NPV at new locations at Hanfeet and Dawkah compared to basic model at Salalah. The @Risk 5.7 (Student Version for Academic Use) from (Palisade Corporation, Ithaca, New York) add-in for Excel was utilized to account for the stochastic nature of key variables in the Monte Carlo simulation model.

Data collection

Data were collected to perform partial budget analysis for alternatives location at study area (Salalah- Hanfeet - Dawkah) such as yield, sale price, cost of inputs and operation for each location. For Monte Carlo Simulation analysis the study also identified stochastic variables to be incorporated in the model such as Yields, input cost, and output prices. The study also identified the probability distributions of the risky input variables (triangle – normal - bionomial) so that Probability Distribution Function (PDF) of the output (NPV), (IRR) can be calculated.

To perform Stochastic Efficiency with Respect to a Function (SERF) Analysis for different scenarios, the data were collected and calculated to generate and calculate Certainty Equivalent (CEs) and ranking risky alternatives and scenarios. The data collected for this study is grouped to three categories as under:

Current and proposed alternative Location parameters (yields, price, inputs costs):

- Farmers survey at three locations.
- Historical data from Farmers in costal and desert area at Najed.
- Agricultural Research Center and JICA reports.
- Ministry of Agriculture statistics (2013).
- Previous studies.

Capital cost of the project (irrigation system – agri. Machineries):

- Quotation of the irrigation system and machineries.
- Najed Project Company reports & feasibility study.

Water policy & new regulation:

- Ministry of water resource.
- Ministry of Agriculture & Fisheries.

Stochastic Efficiency with Respect to a Function (SERF)

Simulation model is used to investigate risk management tool that can be used to improve sustainability of desert farming and find out whether water policy affect sustainability. The model is run for 10 years in the future to assess the sustainability of different alternatives. The project failure measured in financial terms of getting a negative NPV (Hansen and Jones, 1996).

A stochastic efficiency model performed to compare the NPV of seven scenarios to compare sustainability and risk efficiency of the performance of three farms location, three water levels and Government incentives were tested. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives simultaneously for decision makers with different risk aversion preferences. Risk Premium is also calculated by subtracting CE Certainty equivalent for less preferred alternative from dominant alternative. Given a utility function u(·), a random wealth variable X, and an initial level of wealth w0, the certainty equivalent is:

$$CE = u - 1\{E[u(X + w0)]\} - w0,$$

The risk premium measure the minimum amount that would have to be paid to a decision maker to justify a switch from alternative present farm location to new proposed area under different Government supporting incentives. An analysis of risk management strategies for cultivated 878 Hectares Rhodes Grass farm in three locations Salalah, Hanfeet and Dawkah are conducted using a ten year farm level data and simulation model. Underground water level effect to NPV were tested and incorporated in the strategies models. The model simulates the costs and returns of the farm for seven combinations of the risk management strategies. The NPV probability distributions generated by the simulation model are used to rank the best alternative scenarios across a full range of RACs.

Stoplight graphs analysis were used to show the probability of NPV being greater than a target value (0) and less than another target value across risky alternatives. Stoplights are quickly interpretable, as they are read much like a traffic stoplight, in this case red is bad, yellow is marginal, and green is good (Richardson et al. 2006).

Model structure

The modeling process began by defining a series of inputs to describe the initial status and behavior of the farm. The underlying behavior of the Rhodes Grass growing system was represented using current knowledge and recorded data from MAF and literature. The purpose of qualitative risk analysis in this study is to provide a high level of understanding of risks of growing Rhodes grass at Najed. Such analysis may increase attention of water policy team members to the top risks they need to manage effectively, Qiu Ling (2001) and Richardson et al. (2007).

The main risk and uncertainty variables identified in Najed Project models were :

- Project capital increase and it is effect on NPV and IRR.
- Underground water availability and it is effect on crop yield and NPV and IRR.
- Crop selling price volatility and it is effect on NPV and IRR.
- Cost of production per ton and it is effects on NPV and IRR.
- Annual increase in sales price and unit cost.
- Total sale volume for year one of the project.
- Irrigation water policies and it is effect on cost, crop yield and NPV and IRR.
- Rhodes Grass crop yield variation at three locations i.e. Salalah, Hanfeet and Dwakah.

The quantitative risk analysis is performed after selecting key parameters and the probability and consequence of all individuals risk combined on parameters affecting the project financial performance and cash flows. The result of the analysis includes a probability that a project will meet its quantitative objectives and cash flow projection. The probability distributions of the parameters are incorporated in to Monte Carlo Simulation Model which allows evaluation and quantified risks range as shown in Table 1.

The study runs seven model tests with and without raw materials subsidies and three water level scenarios. The Stochastic Monte Carlo Simulation Models and Stochastic Efficiency with Respect to a Function (SERF) were used to evaluate the following:

- Compare Salalah Basic Model with two new farm locations model at Hanfeet and Dawkah area.
- Investigate impact of the new water policy to NPV and IRR of the project.
- Perform Stochastic Efficiency with Respect to a Function (SERF) to select the risk-efficient strategies.
- Test capital and raw material incentive and its effect in fodder crop re-allocation policy sustainability.

Salalah location model represent area with no water shortage and constrains, whereas the other two location scenarios represent different water shortage levels and new water policy implementation area. Parameters used in the Salalah scenario and Najed area scenarios reflects an expected new water policy, project capital cost, crop yield, total sale volume, sale price and per unit cost of production for each farm location. The estimation of each input variable and probability distribution at each location identified and incorporated in the analysis. Table 2 present water policy models parameters, water constrain and Government subsidy alternatives.

A Latin hypercube sampling procedure with @risk add-in software from Palisade Corporation (5.7 Student Version for Academic Use) was used to evaluate the budgets for a large number of iterations, Rajaa et al. (2005). In the simulation, values of parameters entering into the model were chosen from their respective probability distributions by Latin hypercube sampling technics and were combined according to functional relationships in the model to determine NPV and IRR

Table 1 Input parameters distribution used in MCS models

Risk	Affects	Distribution	Absolut/ percentage	Impacts		
				Min	Most likely	Max
1st year Sale volume	Revenue	Normal	Absolut	19 667		21 072
Increase in sales ton	Revenue	Triangular	Percentage	1 %	2 %	5 %
Sale Price/ton	Revenue	Triangular	Absolut	90	95	100
Unit cost/ton	Cost	Triangular	Percentage	65 %	68 %	70 %
Increase in sales price	Revenue	Triangular	Percentage	1 %	3 %	5 %
Yield reduction	Revenue	Compound	Percentage	2 %	5 %	7 %
Water reduction Probi.	Yield	Risksimtable	Absolut	0.1	0.3	0.5
Water reduction/year	Yield	Binomial	Absolut		0.1	
Water recharge/year	Yield	Binomial	Absolut		0.2	
Discount rate	NPV		Percentage		10 %	

Table 2 Study models and scenarios

Model	Water Policy	Water level & constrain	Government subsidy		
			Min RM	Add RM	Capital
Salalah	(Basic Model)	No water constrain	-	-	-
Hanfeet1	No re-charge	Water constrain level1	-	-	yes
Hanfeet2	Water re-charge	Water constrain level2	yes	-	yes
Dawkah1	No re-charge	Water constrain level1	-	-	yes
Dawkah2	Water re-charge	Water constrain level2	yes	-	yes
Salalah	(Basic Model)	No water constrain	-	-	-
Hanfeet3	Water re-charge	Water constrain level2	-	yes	yes
Hanfeet2	Water re-charge	Water constrain level2	yes	-	yes
Dawkah3	Water re-charge	Water constrain level2	-	yes	yes
Dawkah2	Water re-charge	Water constrain level2	yes	-	yes

project outcome. The process was repeated a large number of times to give estimates of the output distributions of the performance measure which was expressed as cumulative distribution functions (CDFs) and summarized in terms of the moments of the distributions. The results presented here are based on 10,000 sample simulation experiments.

Project risk allocation

Risks are generally shared by the different partners but some are better able to cope with certain specific risks than others. The risk-sharing must be reasonable with risk-taking offset by profit as the objective is not to maximize risk transfer but optimize risk allocation.

In Najed Project investors are not prepared to bear some of the risks related to the development and operation of the new desert area at Najed. They think that the associated risks are too high, and that if they bore the risks they would not be able to recover their costs. The risks that investors cannot control and are not prepared to bear are:

- Yield reduction risk: The risk that not enough yields will be produced from the project, or that there will be no enough yield to recover the operation and investment cost of the project. The perceived risk is high mainly because local farmers in the project areas have low levels of yield compare to costal area.
- Control of sale price risk: The risk that Government wants to keep sale price below RO 100 /ton. The perceived risk is high mainly because livestock farmers in the areas have low levels of income and cannot offer high fodder crop price.
- Cost per ton increase risk: The risk of raw material cost, operation and maintenance cost will be increased.
- Hydrology risk: Risk that there is not enough water and water level drawdown. The new water policy imposed control the extraction of water to (30 liters/sec) from well. The Government must bear this risk.
- Capital cost increase risk : The capital cost of the project increase from 16 Million to 22.8 Million and project cost overrun reach 142 %. The Government provided a grant of RO 11.26 Million to support internal infrastructure and to compensate capital cost increased and reduce the effect of project overrun.

According to the net present value distribution, we can analyze the feasibility of the project. From the NPV distribution characteristics, we can get some information such as NPV expectation value, loss probability of the project. The study finally test government raw material subsidy for Hanfeet and Dwakah area and performed Stochastic Efficiency with Respect to a Function (SERF) to select the risk-efficient strategies.

Result and discussion

Cost of production and NPV of Rhodes Grass crop cultivation for three farm locations

Static and deterministic model used to calculate the net profit and NPV of a project in three locations to asses economic viability. In financial theory, if there is a choice between two exclusively independent alternatives, the one with the higher NPV should be selected. The result shows NPV and IRR for Salalah location is preferred compare to new farm locations at Najed area. Dynamic model can give complete picture for decision makers as static model does not incorporate risk and uncertainty variables. A summary of the three farm locations and the relevant values of NPV are given in Table 3.

Government subsidy and underground water level analysis

The study investigated underground water depletion risk at new proposed area (Hanfeet and Dawkah). Hanfeet1 and Dawkah1 models represent no water re-charge, whereas Hanfeet2 and dawkah2 represent underground water re-charges. Model Hanfeet3 and Dawkah3 represent underground water re-charges with raw material

Table 3 Cost of production per year of Rhodes Grass for three farm locations (RO)

Item	Salalah	Hanfeet	Dawkah	Difference
	Coastal area	New location at Najed		Hanfeet-Salalah
Cultivated area/ha	878	878	770	0
Capital cost	4 791 524	7 596 000	7 430 000	2 804 476
Revenue	2 502 300	2 502 300	1 975 050	0
Raw material cost	378 418	506 167	443 905	127 749
Land rent	18 000	50 400	43 200	32 400
Utilities cost	131 700	173 844	152 460	42 144
Vehicle running cost	31 608	40 388	35 420	8 780
Overhead cost	70 240	140 480	123 200	70 240
Labour cost	93 132	93 132	93 132	0
Misc expenses	30 730	30 730	26 950	0
Total variables cost	**753 828**	**1 035 141**	**918 267**	**281 313**
Administration Salary	140 166	202 566	93 366	62 400
Administration cost	65 850	65 850	57 750	0
Depreciation cost	369 787	572 000	495 600	202 2013
Finance cost	240 000	87 120	85 200	−152 880
Tax	137 120	71 609	45 608	−65 511
Total Overhead cost	952 923	999 145	777 524	46 222
Net profit	795 549	468 014	279 259	−327 535
NPV	**2 878 601**	**−2 895 923**	**−3 793 210**	**17 322**
IRR	**18 %**	**3 %**	**−1 %**	**−15 %**

subsidy. The Models simulated to see the effect of water level risk on NPV and results are presented in Table 4. The analysis shows that Government capital subsidy are not enough to mitigate underground water resource depletion risk and raw material subsidy are required to encourage farmers to develop new area. Model Hanfeet3 and Dawkah3 shows high value of PNV means but risk of getting negative NPV is high. However, this indicates that examining NPV mean values is useful for economic performance measurements, but it is also important to examine NPV variability and CVs to determine if risk affects the decision to use one alternative or another. The raw material subsidy models show a low positive Skewness figure which indicates downside risk control.

Government subsidy and cumulated distribution function analysis

To test water level and risk management appropriate strategy the Cumulated Distribution Function CDF analysis performed. The analysis investigates the range and probabilities of net present value for combinations of risk management strategies. Fig. 1 (A) shows (Hanfeet1) and (Dawkah1) are exposed to risk and Salalah model is preferred as its CDF distribution line on the right of the other models. Hanfeet1 and Dawkah1 option (with no water recharge) could manage downside risk but were not viable and dominated models and replaced by Hanfeet3 and Dawkah3 (with water recharge and raw material subsidy) in Fig. 1 (B).

The CDF lines for alternatives in Fig. 1 crossing each other and there is no clear ranking decision can be produced for the Decision Makers under different RAC. As a result, more integrated stochastic efficiency ranking tools such as SERF were used in study for further clarification.

Government raw material subsidy and StopLight graph analysis

Stoplight graphs are simple graphical illustrations that show the probability of NPV being greater than a target value (0) and less than another target value across risky alternatives. Stoplights are quickly interpretable, as they are read much like a traffic stoplight, in this case red is bad, yellow is marginal, and green is good (Richardson, Schumann, and Feldman 2006).

Table 4 Government subsidy for Hanfeet, Dawkah compared to Salalah – statistics for NPVs for each scenario

Models	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Location	Salalah		Hanfeet Location			Dawkah Location	
Subsidy		Hanfeet1	Hanfeet2	Hanfeet3	Dawkah1	Dawkah2	Dawkah3
Mean	62 181	(4 441 315)	(1 846 437)	347 660	(5 554 459)	(3 013 694)	347 803
SD	4 553 273	2 971 229	2 962 446	5 000 396	1 764 989	1 755 468	4 887 834
CV	73.23 %	0.67 %	1.60 %	14.38 %	0.317 %	0.582 %	14.053 %
Skewness	0.0222	0.0539	0.0421	0.0058	0.10045	0.0830	0.02714
Kurtosis	3.0568	3.0840	3.1004	3.0239	3.1502	3.1493	3.0310
Min	(17 598 320)	(17 647 894)	(15 903 188)	(22 404 056)	(11 754 193)	(10 219 702)	(17 392 901)
Max	18 037 151	6 286 159	9 520 626	19 700 196	1 488 082	4 483 129	18 625 350
Range	35 635 471	23 934 053	25 423 814	42 104 252	13 242 275	14 702 831	36 018 251

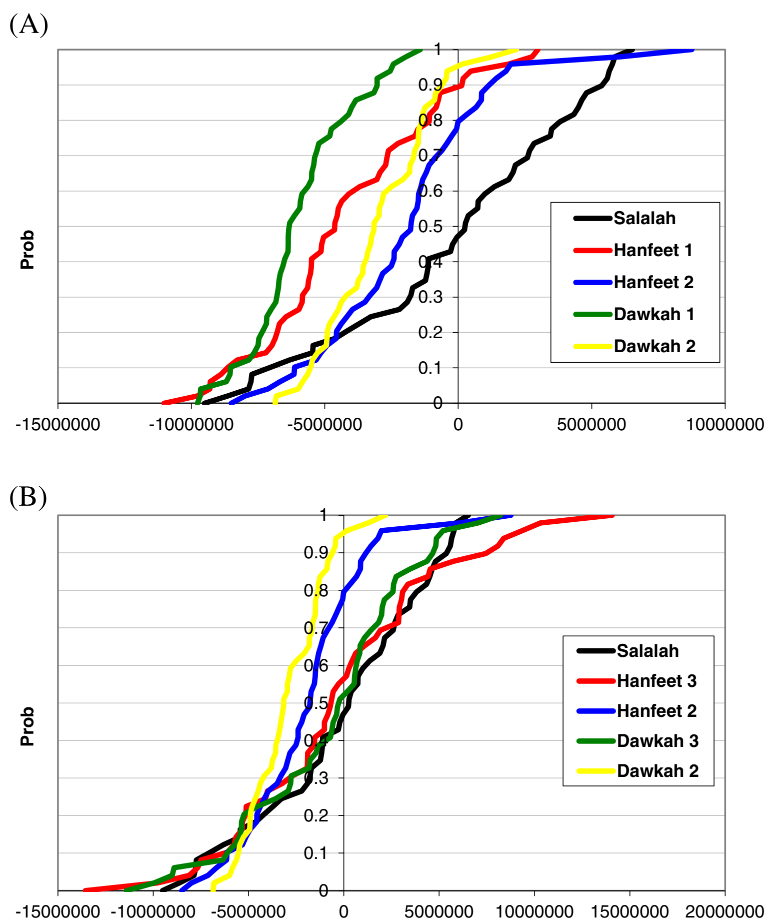

Fig. 1 Comparison of 5 CDF Scenarios for risk management strategies of capital and raw material subsidies. **(A)** Comparison of 5 CDF Scenarios with & without Water Re-Charges & Government Capital Subsidy. **(B)** Comparison of 5 CDF Scenarios with Water Re-Charges & Government Capital and Raw Material Subsidy

The probability of a risky alternative generating a net present value less than the lower bound value (0) is illustrated by a red region on a bar graph; thus, bad. The probability of an alternative generating a net present value greater than the upper bound value (one Million Rials) is illustrated by a green region; thus, good. The region between the upper and lower bounds is yellow and shows the probability of NPV being between the upper and lower bounds.

The Stoplight graph in Fig. 2 illustrates the probability of NPV being less than zero and greater than RO 1,000,000. Fig. 2 (B) reinforces the results found in the NPV CDFs (Fig. 1). For example, Hanfeet1 and Dawkah1 (with no water recharge) in Fig. 2 (A) has more than 88 % chance of negative NPV (i.e., red area) and are replaced by Hanfeet3 and Dawkah3 (with water recharge) in Fig. 2 (B) which are the strategies with more than 44 % and 48 % chance of getting positive NPV and near to Salalah location model which is getting 52 % chance of getting positive NPV. The analysis indicate that even with Government capital support and raw material subsidies, the new farm location are not profitable and could not substitute Salalah location. Hanfeet farm location will get a negative NPV with 56 % probability, whereas, Dawkah farm location getting negative NPV with 52 % probability even with Government raw material subsidy program.

Fig. 2 StopLight chart for NPVs of Three Farms with **(B)** & without **(A)** RM subsidies. TopLight chart for NPV probability less than 0.0 and greater than 1,000,000 RO (no RM subsidy). TopLight chart for NPV probability less than 0.0 and greater than 1,000,000 RO (with RM subsidy)

SERF analysis and risk management strategies ranking

The SERF method calls for calculating Certainly Equivalent CE values over a range of absolute risk aversion coefficients (ARACs). The ARAC represents a decision maker's degree of risk aversion. Decision makers are risk averse if ARAC > 0, risk neutral if ARAC = 0, and risk preferring if ARAC < 0. The ARAC values used in this analysis ranged from (−0.0000008) represent risk preference to (+0.0000008) represent extremely risk averse.

The upper ARAC value was calculated using the following formula proposed by (Hardaker et al. 2004: 2):

$$\text{ARACrw} = \frac{\text{rr(w)}}{\text{w}} = 4/\text{Wealth (Absolute value of the largest average NPV} = 5,000,000)$$

where:

rr(w) is the relative risk aversion coefficient with respect to wealth (w). As proposed by Anderson and Dillon 1992 rr (w) was set equal to 4 (extremely risk averse). Wealth (w) was calculated based on the respective net present value means from seven alternatives under test.

The Excel Add-In SIMETAR was used to conduct the SERF analysis based on a negative exponential utility function. Certainty equivalent graphs were constructed to display ordinal rankings of NPV across the specified range of ARAC values. The risk premiums were also calculated for each risk management strategies by subtracting alternative NPV CE values from preferred (Salalah NPV) CE values at given ARAC values.

In Fig. 3(A) the SERF method is used to compare five risk management alternatives simultaneously for all ARAC values in the range of (−0.0000008) to (+0.0000008), and identifies alternatives Hanfeet2, Salalah and Dawkah2 as the utility-efficient set. Alternative Hanfeet2 dominates over the range of (−0.0000008) to (−0.0000006) and alternative Salalah from (−0.0000006) to (0.00000033) and Dawkah2 dominates for the risk aversion range of (0.00000033) to (0.0000008). With the SERF method alternative Hanfeet1 and Dawkah1 are not utility-efficient as it is dominated by one of the other alternatives at every level of risk aversion.

In Fig. 3(B) raw materials subsidy introduced and SERF method is used to compare five risk management alternatives simultaneously for all ARAC values in the range of

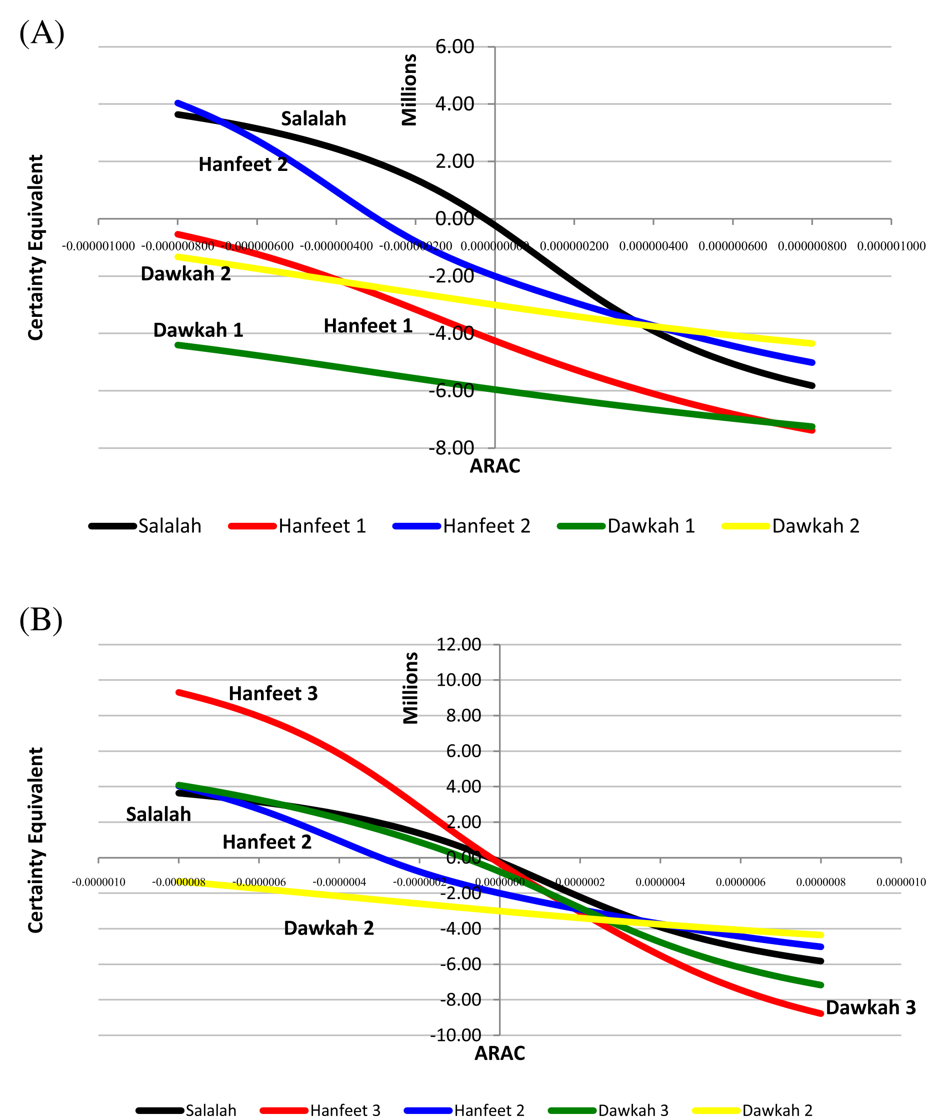

Fig. 3 SERF for NPVs of three farms with capital & raw material subsidy **(A)** No RM **(B)** with RM subsidy. Stochastic Efficiency with Respect to A Function (SERF) under Neg. Exponential Utility. Stochastic Efficiency with Respect to A Function (SERF) under Neg. Exponential Utility

(−0.0000008) to (+0.0000008), and identifies alternatives Hanfeet3, Salalah and Dawkah2 as the utility-efficient set. Alternative Hanfeet3 dominates over the range of (−0.0000008) to (0.0) and alternative Salalah from (0.0) to (0.0000004) and Dawkah2 dominates for the risk aversion range of (0.0000004) to (0.0000008). With the SERF method alternative Hanfeet2 and Dawkah3are not utility-efficient as it is dominated by one of the other alternatives at every level of risk aversion. We observed that with Raw Material subsidy Hanfeet2 is replaced by Hanfeet3 at a lower ARAC value and Salalah and Dawkah2 keeping their dominantion and risk-efficient at risk neutral and risk aversion level.

The benefits of un limited and un-control of underground water extraction at Salalah location were shown to be large, and irrigation was included in the efficient set based on a stochastic dominance analysis. The analysis shows that higher levels of water application were risk efficient at neutral and risk preference level and preference for water applications fell at somewhat higher risk aversion levels.

The NPV of Salalah Farm without Government subsidy is 62 thousand rials increased to 915 thousand Rials with raw material subsidy program. For Hanfeet and Dawkah Farms NPV with Government capital subsidy is negative and record −1.8 Million and −3 Million Rials respectively. These results shows Farms under new water policy imposed by Government Authorities are highly exposed to underground water availability risk and raw material subsidy are required for three farms location to achieve sustainability (Table 5).

Stochastic efficiency with respect to a function (SERF) ranks risky alternatives in terms of CE across a range of RACs. The calculated CEs are displayed on graphs, and the risky alternative with the highest CE at a particular RAC is the most preferred. Rankings five alternative risk management strategies using SERF, over the range of risk preference, neutral to extremely risk averse, are presented graphically in Fig. 3 and numerically in Table 5. Table 5 reveals that under normal risk aversion raw material subsidy are required for Salalah location and new area at Hanfeet and Dawkah. Fig. 3 also shows that CE lines are much higher in Salalah than their counterparts (no water shortage with no raw material subsidy options) compare to other alternative with (new water policy options) and lower irrigation levels.

Risk premium and willingness to payment

Risk premiums measure the value to a Decision Maker of one preferred alternative over a less preferred alternative, and are calculated by subtracting the CE of the less-preferred alternative from the CE of the preferred alternative at each RAC level. Because SERF generates CEs of the Decision Maker's preferences among alternatives at each risk aversion level, SERF can also estimate the utility-weighted risk premiums between alternatives and risk management strategies. Fig. 4 represent the difference

Table 5 Ranking of risky alternatives by risk aversion using CE for NPV (000) of Rhodes Grass Farms

Risk degree	Risk preference		Normal risk		Rather risk		Extremely risk	
ARAC	−0.0000008		0.0000000		0.00000033		0.0000008	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Hanfeet3	9 307	Salalah	−232	Salalah	−3 404	Dawkah2	−4 350
2	Dawkah3	4 089	Hanfeet3	−329	Hanfeet2	−3 468	Hanfeet2	−5 016
3	Hanfeet2	4 036	Dawkah3	−789	Dawkah2	−3 638	Salalah	−5 823
4	Salalah	3 636	Hanfeet2	−2 001	Dawkah3	−4 159	Dawkah3	−7 172
5	Dawkah2	−1 329	Dawkah2	−3 005	Hanfeet3	−4 725	Hanfeet3	−8 779

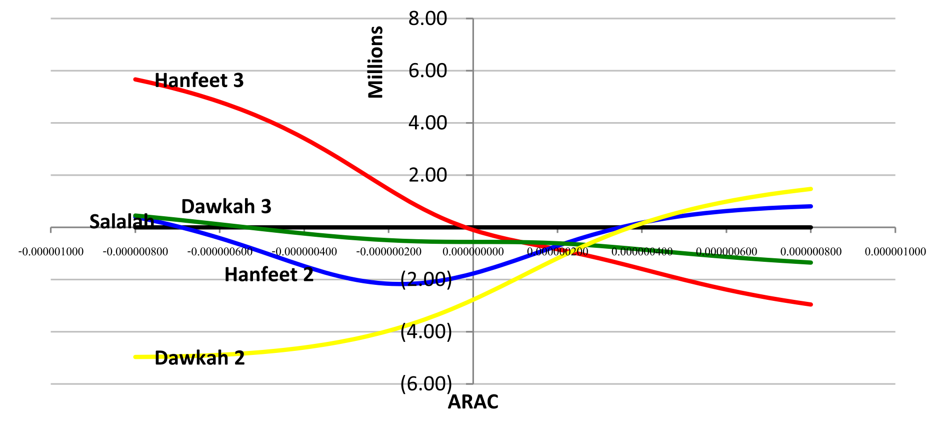

Fig. 4 Neg. Exponential Utility Weighted Risk Premium relative to Salalah farm location with RM subsidy

between CEs represents what it would take for a Decision Maker to be willing to exchange the preferred (Salalah) risky alternative for another less-preferred risky alternative. The value of WTP is calculated as the difference between the CE for a risky alternative and represents the payment necessary to make the farmers and investors indifferent between the less-preferred alternative and the preferred alternative (Salalah):

$$\text{WTP} = \text{CEpreferred - CEalternative}$$

The SERF rankings and WTP are used to examine sustainability and analyze risk management strategies for fodder crop re-allocation at Najed Area. Fig. 4 shows how the alternative scenarios examined in the study rank relative to the preferred base scenario (Salalah location) at various RACs. Table 5 shows the numerical risk premiums for four risk aversion levels.

From Table 6, it is evident that Decision Makers for the risk aversion levels examined have a small risk premium value between the preferred scenario (Salalah) and the second place alternative (Hanfeet3) with capital and raw material subsidy options at normal risk level (−97,000) and (−557,000) from third place alternative (Dawkah3) and (−1.769) million from fourth alternative (Hanfeet2). Therefore, a compensation of 97,000 RO has to be given as a premium for the DM and investors to sustain farming activities at Najed area. The study also indicates that Salalah location is the most preferred location for normal and rather risk farmers and models with raw material subsidy were risk efficient at low levels of risk aversion.

Table 6 Risk premium in (000) of different risk management strategies relative to Salalah location

Risk degree	Risk preference		Normal risk		Rather risk		Extremely risk	
ARAC	−0.0000008		0.0000000		0.00000033		0.0000008	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Hanfeet3	5 671	Salalah	0	Salalah	0	Dawkah2	1 473
2	Dawkah3	453	Hanfeet3	−97	Hanfeet2	−63	Hanfeet2	807
3	Hanfeet2	400	Dawkah3	−557	Dawkah2	−234	Salalah	0
4	Salalah	0	Hanfeet2	−1 769	Dawkah3	−755	Dawkah3	−1 349
5	Dawkah2	−4 966	Dawkah2	−2 773	Hanfeet3	−1 321	Hanfeet3	−2 956

Conclusion

The main task of this paper is to investigate fodder crop re-allocation sustainability and rank risky management strategies over the range of risk neutral to extremely risk averse. The study also evaluate project viability and estimate the future values of the projected raw material variable, crop yield and other main and key variables which effect NPV and project sustainability.

The study shows the effect of new water policy and underground water pumping restriction on fodder crop yield and net present value. The Government grant of 11.26 Million Rials which is given to develop new area and project infrastructure were evaluated. This grant increased farming viability in location of low risk of water availability, but with high risk of underground water shortage at Dawkah area more Government subsidy supports are needed to mitigate risk.

The study tested the proposal of raw material subsidy and recommend raw material subsidy to be imposed at fodder crop re-allocation area at Najed and new risk management tools should be introduced such as insurance and electricity cost subsidy program to sustain farming activities at new area.

A Decision Maker's willingness to pay represents the personal value, or utility, of a good to the Decision Makers. The value of purchasing insurance options is determined by calculating the difference in the CEs at each location and water level for the alternatives with and without raw material subsidy options. The study reveals the risk premium decreases at location with sufficient underground water, and raw material subsidy options are worth less to the Decision Makers at insufficient underground water locations.

The raw material subsidy at Hanfeet area (Hanfeet3) options could compensate Salalah location of RO 97,000 for normally risk averse Decision Makers, RO 1,321,000 for rather risk averse Decision Makers, and RO 2,956,000 for extremely risk averse DMs. Whereas, Dawkah area (Dawkah3) with raw material subsidy could compensate Salalah location of RO 557,000 for normally risk averse Decision Makers, RO 755,000 for rather risk averse Decision Makers, and RO 1,349,000 for extremely risk averse Decision Makers. As a result the proposed raw material subsidy program will mitigate risk of new water policy imposed at Najed area and uncertainty surrounding the impact of adoption of new irrigation technologies only for risk preference Farmers, as Hanfeet3 and Dawkah3 alternatives are preferred than Salalah location for risk preferred DMs as shown in Table 6 and Fig 4.

The new water policy imposed at Najed area needs to be re-adjusted and re-formed after getting more accurate data through further hydrologic studies at Najed area. The study should collect data regarding uncertain of the key variables and underground water quality and quantity available at study area.

The cost of uncertainty of the Dawkah Project Area is high due to lack of information available to investors. As a result, more information has to be obtained regarding underground water availability before Government Authorities distribute more lands to farmers and investors at Najed area.

Competing interests

The author declares that he has no competing interest.

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