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Dates Palm Replanting Sustainable Strategies and Risk Aversion in Oman

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Abstract

Date Palm (ploenix dactylifera) is the most important cultivar and economic fruit in Middle East and Oman and occupies 35% of total cultivated area and 78% of the total fruit trees area in Oman. The Ministry of Agriculture and Fisheries attempted to improve Date Production but due to environmental constrains and climate change agricultural production has shown instability in production and resources degradation. The Government announced Date Palm replanting and replacement of 800 thousand date palm trees up to 2020. The study applied a stochastic modeling approach to evaluate Date Palm varieties in Batinah Region of Oman and identify the most sustainable and risk efficient varieties. Stochastic Efficiency with Respect to a Function (SERF) performed and found that Naghal variety is the most risk efficient variety followed by Shahil and Khussab variety. Certainly Equivalent CE values over a range of risk aversion coefficients are calculated by using (SERF) analysis. The study reveals that optimal replanting age is 55 years for Khussab variety at Batinah Region. Date Palm Replanting and replacement program in Oman should consider farming system and economic sustainability. Adaptable Date Palm variety in term of drought and salt tolerance varieties, Date quality and price parameters need to be addressed. The market absorption of Date variety and consumer preference is important factor and needs to be considered by policy maker in Date Replacement Program. Risk premium of RO 533 per one hectare can be given to Farmer as economic incentives to keep Um Saila Date Palm variety in their land and encourage replanting low yield sustainable varieties in marginal area and improve crop diversification for each region.

Keywords: Stochastic Efficiency with Respect to a Function, risk efficient, simulation model, resilience ecosystem, sustainability

1. Introduction

The Date Palm cultivation is considered as the most important agricultural activities in Oman with a large number of varieties and spread over a large integrated ecological and farming system. It occupies 35% of total cultivated area and 78% of the total fruit trees in Oman as per Ministry of Agriculture Statistics (2013).The Date Palm trees occupies about 24 120 Ha. and includes 6,79 Million productive trees. The total date production at year 2013 reached 308 thousand ton 53% for direct human consumption, 20% used as animal feed, 16% for industry use and 11% for export.

Oman has about 200 date palm varieties and 30 types of these varieties are recognized as good varieties and have commercial and high market absorption demand. Top good varieties such as Khalas produce about 8% of total production and second top varieties date such as Zabad , Khanizi , Barni and Madlozi are commercial dates varieties and can be stored and sale off the season with a reasonable price. Oman benefited from different environmental and climate zones and adopted farming systems which extend the harvesting season to six months from May to November, (Kheiry H. M. Ishag et al., 1994). Accordingly date palm varieties can also be grouped as early, intermediate and late mature varieties. The early mature date palm varieties such as Nagal which is 11% from total dates production in Oman is cultivated at Batinah i.e. 38% and Dakhiliyah regions i.e. 30% of total Nagal production. Farad, Khanizi and Khalas are intermediate mature varieties and cultivated at Batinah and Sherqiah regions. A late mature Date variety such as Khasab is cultivated at Batinah and Dakhiliyah regions. However, farmers are diversifying date palm cultivated varieties to manage risk associated with price and yield uncertainty in term of extending harvesting period and producing different type of dates for different use i.e. human, industrial, animal feed. Farmers managed to develop resilience agricultural systems by introducing

affordable technologies and strategies such that ecosystem functions and services can be maintained and livelihoods can be protected, (Brenda B. Lin, 2011).

The date Palm farming systems in Oman can be grouped to six regions. Batinah Region considers as the leading region and produces 136 thousand tons in year 2013, which represent about 44% of the total date's production in Oman. The second region is Dakhiliyah Region and produces 63 thousand tons i.e. 20% followed by Sherqiah Region 14% and Dahirah Region which produce 11% of the total Oman production of Dates. Dakhiliyah Region got the highest Date Palm average productivity per tree with 62 kg/tree followed by Dahirah Region 47Kg/tree and Batinah 46 Kg/tree and Sherqiah Region 39 Kg/tree, and Muscat Region 30 Kg/tree. Region production and Date Palm tree productivity depend on many factors such as date palm varieties, cropping pattern, soils and soil fertilities, irrigation system, water quality and availability and farming system resilience and survivals.

Social sustainability in term of consumers' perception of the farm's products, selling products through short chain systems and availability of local regional market, farm land and waste management and multifunctional farm's activities such as selling manure and feeding dates to animal have important role in farming system sustainability, (Anna Gaviglio et al., 2016).

However, comparing Date Palm Regions in term of region production, number of date palm trees at each region and tree productivity ignoring farming systems profitability and economic sustainability will not give a full picture to understand problems and develop strategy for Date Palm sector in Oman, (Kheiry H. M. Ishag et al., 1997). The region economic sustainability and risk efficiency is the most important issue need to be studied to provide data for policy advisers.

1.1 Problem Statement

Date Palm is the most dominant crop cultivated in Oman and occupies 35% of total cultivated area and 78% of the total fruit trees area. The Government Authorities tried to improve Date production through supporting Research, Extension and Farmers. The production increased during 1999-2001 and reduced due to environmental constrain, water resource shortages and drought climate in 2002 and 2004. The unsustainable situation encourages Government to announce for long term Date Palm development programs and to cultivate One Million Date Palm Trees and Replacement Program of 800 thousand Date Palm trees. The Ministry of Agriculture and Fisheries recommend replacing old low quality trees with high yield and good quality dates. The study investigates and aims to identify the sustainable varieties and strategies of replanting and replacement of old Date Palm trees in Batinah Region which contribute to 44% of country date production.

1.2 Literature Review

Investment in Date Palm farms needs a long term investment decision with uncertain date production and market price. Moreover, Date Palm farming sustainability and system ability to maintain productivity in spite of major constrains and disturbance is important to get return from investment and avoid future farm resources degradation. The investment ability to continue in the future in term of financial viability can be taken as a measurement to choice between alternative Date Palm varieties, (Lien G. et al., 2007a). Stochastic and dynamic nature of the Date Palm farming investment can be model and probability of getting positive return for each variety and farming system can be calculated.

Monte Carlo Simulation dynamic model for project appraisal was addressed by many researchers. The dynamic analysis provided a range of outcomes that can reduce the risk of uncertainty and give more reliable results for investor. Additional information related to long term trees investment and risk management can be found in (Brazee and Newman, 1999; Kangas and Kangas, 2004).

Monte Carlo Simulation models were used in this study to quantify risk and uncertainty associated with Date Palm replanting investment. The quantitative risk analysis will provide decision makers a means of estimating probability distribution of Date Palm farming and investment returns and getting positive NPVs. The study will also help policy maker to improve Date Palm cultivation and farm management practices. The Date Palm replanting program and One Million Date Trees Project objectives can work simultaneously after identifying sustainable varieties for reach region in Oman. The stochastic efficiency analysis and technique can rank alternative Date Palm varieties to be replanted in the farm over a range of risk aversion. This technique developed by Hardaker et al. (2004a) and 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). The certainty equivalent is defined as the sure sum with the same utility as the expected utility of the risky prospect (Hardaker et. al., 2004b). Lien et al., (2007b) used Stochastic Efficiency with Respect to a Function (SERF) to identify optimal forest replanting age with different risk aviation

coefficient. Hemesiri B.K. et al., (2013) used comparison of equivalent annual net revenue to estimated optimal Date Palm replanting age in Oman and estimate replanting age of 50-55 years.

In this study, (SERF) technique is applied to assess a set of alternative date palm varieties and farming systems for Batinah Region in Oman over a range of risk aversion levels. SERF can compare any level of decision maker preferences including risk-averse, risk neutral and risk loving. The aggregated Date Palm area, production and cost data at Batinah Region level were calculated. These values were multiplied by average date market price for each date varieties cultivated in the region to obtain revenue. Capital and annual operation cost were estimated. Five stochastic simulation models were employed to estimate NPV distribution for the Batinah Region. The main objective of this paper is to investigate sustainable Date Palm varieties and the most risk efficiency one over a range of risk aversion level and estimate optimal replanting ages.

2. Methodology

2.1 Net Present Value

The Date Palm Project evaluation depend on estimation of 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 data available to be used as an input in the evaluation project model. The single value estimate is usually the most likely outcome (NPV).

The NPV of each variety was used as an evaluation criterion. The net cash flow for 25 years calculated by subtracting the cost from the revenue. The interest rate of 10 % was used to discount cash flows and obtain the NPV for main date cultivar in Batinah Region. 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.

Five main Date Palm varieties i.e. Um Saila, Shahil, Khussab, Naghal and Khunaizi cultivated at Batinah Region were selected to represent Batinah Region farming system. Batinah Region produces 93% of total Um Saila, 84% of Shahil, 43% of Khussab, 39% of Naghal and 32% of Khunaizi dates of total country production. The most risk efficient varieties will be identified and selected for Date palm replanting projects.

2.2 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.

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). The process is repeated (five thousand times). Monte Carlo simulation model is currently recorded as the most powerful technique for cash-flow analysis. It is useful when there are some 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) used in this research for the evaluation different Date Palm varieties and identifying their economic sustainability and risk efficiency within different degrees of risk aversion. The stochastic budgeting and stochastic efficiency methods are used to consider risk and uncertainty of key variables such as price and production in Batinah Region. The @Risk 7.5 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. The main parameters and cost used are presented in Table 1.

2.3 Data Collection

Data were collected to perform partial budget analysis for alternatives Date Palm varieties and consider parameters such as date palm varieties, number of date palm panted trees per hectare, yield, sale price, cost of inputs and other operation cost for each variety. The study used Monte Carlo Simulation analysis to 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 uncertain input variables (triangle – normal - bionomial) so that Cumulative Distribution Function (CDF) of the output (NPV) for each variety can be calculated.

The study performed Stochastic Efficiency with Respect to a Function (SERF) Analysis for different varieties and generates Certainty Equivalent (CEs) and ranking risky alternatives varieties within different risk aversion.

The optimal replanting age will be obtained by plotting Certainty Equivalent (CEs) against tree ages. The historical data collected for this study obtained from different sources i.e. Ministry of Agriculture statistics (2013), Date Palm Production survey (2013) and previous studies. The Regional data level obtain the following :

Batinah Region current farming systems and main Date Palm varieties data such as :

- Date Palm yields, price, inputs required.
- Cost of land preparation and Date offshoots planting trees.
- Operation and inputs cost for each Date Palm varieties.

Table 1. Models parameters and cost of production of one hectare Date Palm cultivars in Batinah Region

Models	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Varieties	Um Saila	Shahil	Khussab	Naghal	Khunaizi
Trees/Ha	157	157	157	157	157
Offshoots cost	8	11	10	9	12
Replanting cost	2 478	2 955	2 796	2 637	3 114
Annual operation cost					
Manure	353	353	353	353	353
Fertilizers	205	205	205	205	205
Harvesting cost	19	25	25	30	20
Packing cost	15	18	18	20	20
Labour cost	918	950	960	970	920
Irrigation cost	51	51	51	51	51
Maintenance cost	17	17	17	17	17
Pesticides cost	25	35	30	25	30
Total Operation	1 603	1 654	1 659	1 671	1 616
Revenue					
Yield / tree/Kg	40	49	50	59	39
Price/Ton	600	800	750	700	650
Total Revenue	3 768	6 154	5 888	6 484	3 980
Gross profit	2 165	4 500	4 229	4 813	2 364

2.4 Model Structure

The modeling process began by defining inputs and parameters effecting Date Palm cultivation income and return. The purpose of qualitative risk analysis in this study is to provide a high level of understanding of risks of growing Date Palm in Batinah Region. Such analysis may increase attention of old Date Palm trees replacement policy adviser to the top risks they need to manage effectively, (Qiu Ling Guo, 2001; James, 2007).

The main risk and uncertainty variables identified in the models were :

- Main Date Palm varieties cultivated in Batinah Region.
- Date Palm yield variation for five main varieties.
- Investment cost variation and it is effect on NPV.
- Dates varieties selling price volatility and their effect on NPV.
- Cost of production per ton and it is effects on NPV.
- Sale volume and annual increase in sales price and unit cost.

The study runs five simulation models tests and scenarios. The Stochastic Monte Carlo Simulation Models and Stochastic Efficiency with Respect to a Function (SERF) were used to evaluate and compare Um Saila variety

(Basic Model) with other varieties. The Stochastic Efficiency with Respect to a Function (SERF) performed to select the risk-efficient Date Palm variety and identify the optimal replanting age for each variety.

A Latin hypercube sampling procedure with @Risk add-in software from Palisade Corporation (7.5.0 Version) was used to calculate NPVs and statistic results with 5000 number of iterations. 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 variety outcome and return i.e. NPV. 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.

2.5 Stochastic Efficiency with Respect to a Function (SERF)

Simulation model is used to investigate replanting strategies which can be used to improve Date Palm cultivation sustainability and find out the optimal replanting age in Batinah Region in Oman. The model is run for 25 years in the future to assess the economic 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 NPVs of five main Date Palm cultivars which produce about 62% of total date in Batinal Region. 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 variety and 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 need to be paid to farmers and decision maker to justify a switch from present cultivated variety to other less risky Date Palm variety. An analysis of Date Palm varieties grown in the Region was conducted using a five years farm level data and simulation model. Total number of Date Palm trees and varieties within the region, yield, price, investment and operation cost are collected from Date Palm Production Survey and Ministry of Agriculture Statistics (2013). The model simulated the costs and returns for one hectare and calculates NPVs probability distributions generated by the simulation model. The model used to rank the best alternative Date Palm variety across a full range of RACs.

According to the net present value distribution, we can analyze the feasibility of the Date Palm replanting investment. From the NPV distribution characteristics, we can get some information such as NPV expectation positive value and loss probability. The study finally performed CE analysis to estimate premium price and subsidy should be given to farmers to replant Date Palm trees in a less risky farming system practices and utilizing their farm land, saline soil and poor quality irrigated water in a sustainable manner.

3. Result and Discussion

3.1 Batinah Date Palm Farming Systems

Oman is located within Date Palm Belt area (15-27°) north latitude with long summer season extended for six months and warm winter and low rain fall. Date Palm farming system in Oman can be grouped into two main farming systems spread over county regions. The first one is the coastal farming system which is similar to coastal oasis farming system type and located near the sea and Batinah Region represent this type of farming. The second is the interior farming system which located inland and experience with small farm areas. Date Palm in interior farming system grown in intercropping systems and high density plantation is recorded.

The Coastal Farming System located near the sea in low lying land and regular floods from mountains allowed considerable aquifer recharge and leaching salt from soils. Land located far distance from sea has good irrigation water and crop is irrigated with wells, (Tariq M. Alzidgali et al., 1993). The Coastal Farming System includes 57% of total Date Palm trees and produce 54% of Oman production.

The country date production in year 2013 reached 308 427 tons about 44% produced in Batinah Region. Batinah Region considered as the largest Date Palm area in Oman and cultivate more than 2.5 Million Date Palm trees. Batinah Region can be grouped to three different farming zone :

Coastal area : with high saline water and soil and low yield date palm trees. The area is located in a tropical climate zone and characterized by high temperatures and humidity. Date Palm is cultivated in intercropping with Alfalfa and lime trees and small area of vegetables and cereal crops is grown. The rapid expansion of cultivated area created water deficit in aquifer recharge and compensated by sea saline water and vegetable and Alfalfa

crops moved inland. Date Palm cultivated varieties dominated by low yield and stable varieties such as Um-Saila and Mabsali. Farmers introduce other activities such as fishing activities and boiled dried dates are exported.

Sahel area : with a medium farm size (5-15 acres) and well-organized farms and use modern irrigation systems. Irrigation water is saline and water quality determined the cropping pattern in this area. The climate is dry and Rhodes Grass crop is dominant cultivated crop. Farmers use fertilizers and pesticide and chemicals and modern bumps for irrigation. Date Palm cultivated varieties dominated by good quality and high yield varieties such as Khalas and Khussab and Um-Saila which is mainly used as animal feed.

Large Modern Farms area : near mounting area established recently as a large commercial farm. Date Palm cultivated with Rhodes Grass crop and Alfalfa and fruit trees. Date Palm cultivated in this area is of good quality varieties and cropping density is low compared to other regions.

Batinah Region cropping pattern dominated by fruit trees i.e. 45% such as dates, mango and lime trees, 30% fodder crops and 17% vegetable crops. Due to water and soil salinity the cropping pattern has been changed and sensitive fruit trees such as mango, lemon, banana and orange trees area reduced tremendously. The Date Palm area also reduced by 36% from 37 852 Ha. in year 2000 to 24 120 Ha. in 2013 to cope with water shortage and salinity problems, Table 2. Moreover, low yield salinity tolerance variety area i.e. Um-Saila has been increased.

Crop diversification and inter cropping practices is observed at Batinah Region and farmers are growing more than 31 Date Palm varieties to mitigate revenue risk and cope with yield uncertainty and price volatility and improve ecosystems. Moreover, farmers reduce Date Palm planting density to 126 trees per Ha. (Agriculture Research Center recommends i.e. 157 trees per Ha) to cope with water shortage and water salinity problems. However, this may explain the reasons for high yield production per tree and increased region contribution in production from 42% to 44% and also explain ecosystem resilience of Date Palm cultivation in Batinah Region.

Table 2. Cropping pattern development and cultivated area in Oman in Ha. (2000- 2013)

Location	2000	2009	2010	2011	2012	2013
Vegetables	2 591	5 730	6 182	7 777	6 292	11 580
%	9%	8%	11%	8%	8%	17%
Field Crops	6 182	14 166	6 138	10 092	9 614	5 601
%	8%	19%	8%	13%	13%	8%
Fodder Crops	17 874	16 223	20 415	20 480	18 150	20 475
%	25%	22%	28%	27%	25%	30%
Fruits	42 144	37 067	38 352	39 080	39 080	30 845
%	58%	50%	53%	51%	54%	45%
Total cultivated area	72 792	73 639	72 682	75 945	72 788	68 502
Dates area/Ha.	37 852	35 489	29 753	31 347	31 347	24 120
%	52%	48%	41%	41%	43%	35%
Production ton	266 900	257 146	276 227	262 928	281 324	308 427
Batinah Region						
Dates area/Ha.	12 000	11 816	11 462	11 118	10 784	8 520
Production ton (000)	111	114	123	118	124	136
% Total Production	42%	44%	45%	45%	44%	44%

3.2 Monte Carlo Simulation Models Run Results

The study investigated the Date Palm varieties economic performance and sustainability and calculates NPV by using farm level data. The analysis shows Naghal variety is the most risk efficient alternative and obtain the highest NPV i.e. 49 140 Rials followed by Shahil 46 989 and Khussab 43 198 Rials. 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 variety or another.

The Coefficient on of Variation of the probability distribution of NPV was low for Naghal, Shahil and Khussab

varieties and indicates Net Present Value sustainability for these varieties, Table 3. The result also shows that all selected Dates varieties will get a positive NPV more than 80% probability. Naghal variety model show a low positive Skewness figure and indicates downside risk control, whereas, Shahil variety shows upside risk control and positive farm returns. Farmer cultivate Naghal Date Palm variety got a frequent small gain but few extreme losses.

Table 3. Date Palm Varieties NPVs Statistics for Batinah Region

Models	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Varieties	Um Saila	Shahil	Khussab	Naghal	Khunaizi
Mean	29 872	46 989	43 198	49 140	30 609
SD	28 310	37 850	35 432	35 572	30 810
CV	95	81	82	72	101
Skewness	0,073	0,220	-0,045	0,044	-0,073
Kurtosis	-0,097	0,569	-0,132	0,305	-0,169
Min	(44 503)	(53 244)	(70 415)	(78 429)	(60 920)
Max	122 298	205 408	147 982	153 763	117 284
Range	166 801	258 652	218 397	232 192	178 204

The cultivated Date Palm varieties have an important and major effect on NPV and investment decision. The early dates such as Naghal and late maturity dates i.e. Khussab varieties has a high market absorption demand and can be sold with high price. Moreover, dates for human consumption such as (Khalas, Khunaizi, Hilali) has high market absorption rate and can be sold with high price within the season, whereas dates used for industrial purposes such as (Farad, Mabsili) and for animal feed such as (Um-Saila) has a relative low market price.

The Batinah Region cultivated Um-Silla Date variety and produces 93% of total country production. This variety is risk efficient under extreme risk aversion level and region production increased from 25 885 tons in year 1997 to 28 791 tons in 2013 due to resilience of regional farming system and its ability to retain productivity and cope with water deficits and high water salinity risk increase. However, this variety contributes about 24% of region date production and 26% of total Date Palm trees of the region. Farmer prefers to cultivate this date variety as it is a late maturity date variety and can be stored and consumed as dry date off the season. Moreover, the low quality of Um-Silla Date variety can also be used as animal feed to compensate expensive and insufficient fodder crop at Batinah Region.

The second variety in term of production at Batinah region is Shahil variety which contributes 13% followed by early maturity variety Naghal i.e. 11% and consumer favorites and premium price late maturity variety Khussab i.e.10% of date production. Mibsali variety accounting for 39% of Batinah Region production and can be boiled at Buser stage (unripe date stage) and export as a dried date and considered as risk management practices.

3.3 Date Palm Varieties and Cumulated Distribution Function Analysis

To test Date Palm varieties and Farming System sustainability the Cumulated Distribution Function CDF graphs performed to illustrate the range and probabilities of net present value for main Date Palm cultivars in Batinah Region. Due to CDF lines cross in the graph we could not ranked varieties according to their sustainability by using first degree stochastic dominance, and Stochastic Efficiency with respect to a Function (SERF) is used to have a better ranking analysis. The analysis indicates Naghal as the most risk efficient variety in Batinah Region as its distribution line located on the right and preferred to those on the left line, Figure 1.

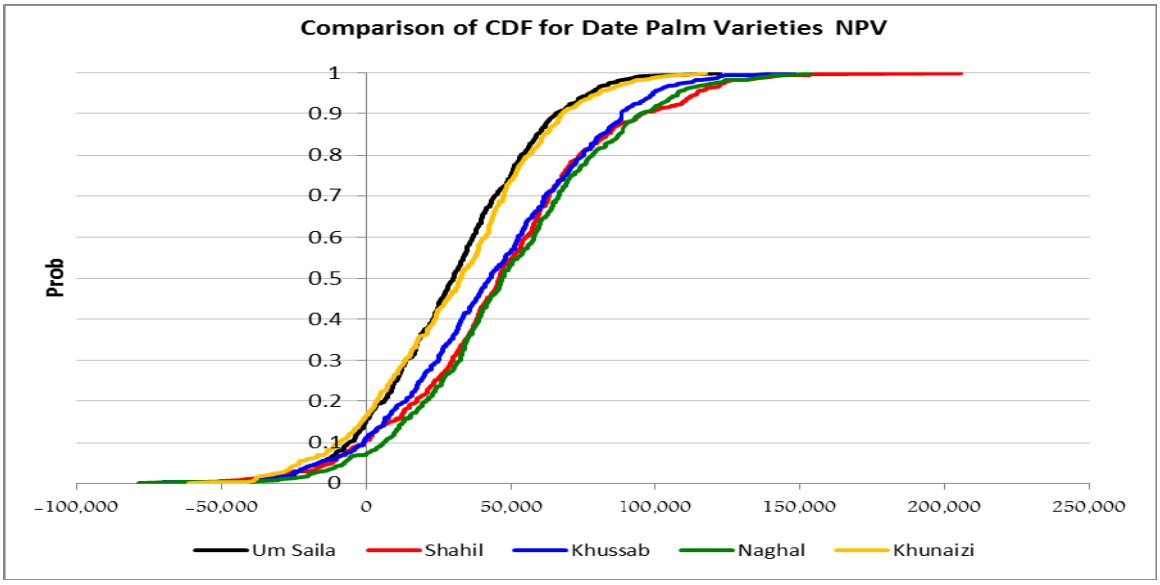

Figure 1. Comparison of 5 CDF of NPVs of Dates Palm Varieties at Batinah Region of Oman

3.4 SERF Analysis and Certainly Equivalent

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 or risk normal if ARAC = 0, and risk preferring if ARAC < 0. The ARAC values used in this analysis ranged from (0.0) represent risk neutral to (0.4) represent extremely risk averse. Naghal variety obtained Certainly Equivalent CE values of RO 49,140 followed by Shahil variety RO 46,989 and Khussab RO 43,198 at neutral risk aversion coefficient as shown in Figure 2. Khunaizi and Um Saila varieties are less risk efficient under risk neutral risk aversion and need to be replaced by risk efficient varieties at optimal tree age. Um Saila Date Palm is risk efficient variety only under extreme risk aversion level as shown in Table 4 and Shahil Date Palm Varity is the second risk efficient variety overall risk aversion level.

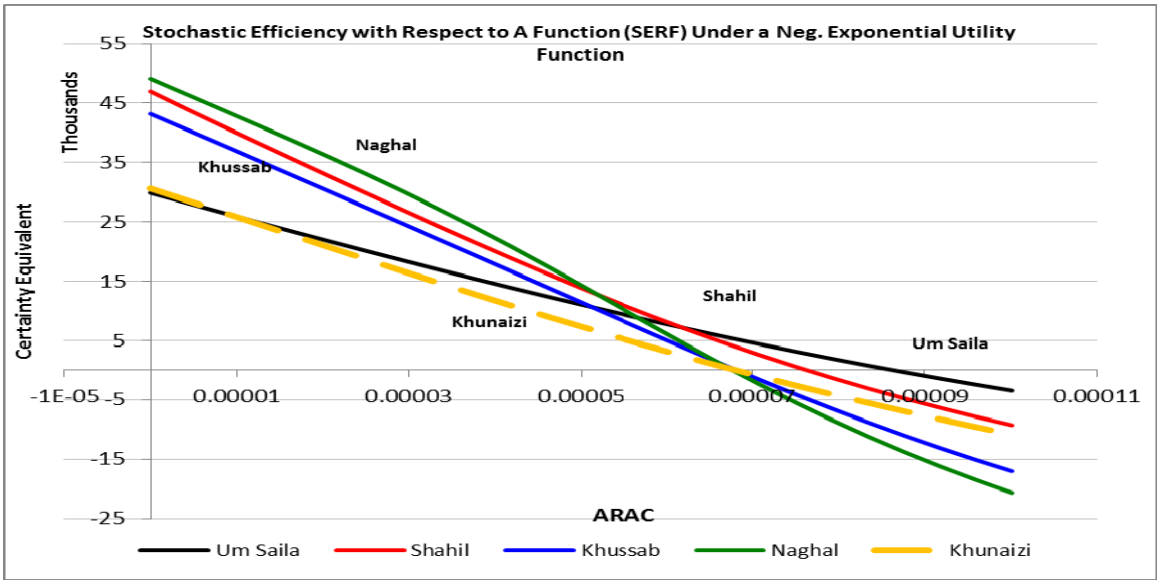

Figure 2. Stochastic Efficiency with Respect to Function SERF for NPVs of five Date Palm Varieties

Table 4. Ranking of Risky Alternatives Date Palm Varieties by Risk aversion using CE for NPV at Batinah

Risk	Normal Risk		Rather Risk		Rather Risk		Extreme Risk	
ARAC	0.00000		0.000021		0.00004		0.00006	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Naghal	49 140	Naghal	35 851	Naghal	20 937	Um Saila	5 621
2	Shahil	46 989	Shahil	32 619	Shahil	18 945	Shahil	4 599
3	Khussab	43 198	Khussab	30 044	Khussab	16 756	Khussab	871
4	Khunaizi	30 609	Um Saila	21 680	Um Saila	13 946	Naghal	749
5	Um Saila	29 872	Khunaizi	20 653	Khunaizi	10 966	Khunaizi	516

3.5 Certainly Equivalent and Date Palm Replacement Strategies

Risk premiums measure the value of one preferred alternative Date Palm variety over less preferred alternatives, and are calculated by subtracting the CE of the less-preferred variety from the CE of the preferred variety at different RAC level. Risk premium value can help policy maker to perform subsidy and incentive programs to encourage export and keeping Mabsili and Khunaizi varieties for boiled dray date export especially at saline water low yield area. Risk premium of RO 533 per one hectare can be given to Farmer to keep Um Saila Date Palm variety and invest in replanting low yield sustainable varieties in marginal area.

SERF can also estimate the utility-weighted risk premiums between alternatives varieties and Date Palm optimal replacement age and strategies. The study performed SERF analysis for different rotation length in 10 years interval from 25 years up to 65 year for Khussab date variety as shown in Figure 3. The investment cost for replanting one hectare set at RO 2 796 and discount rate assumed to be 10% and NPV calculated for different ages. Investor risk aversion level shows substantial impact on CE for all replant rotation strategies, Table 5.

Table 5 show five Khussab replanting strategies and identify the difference between CEs which represents Investor and Decision Maker willing to exchange the preferred Date Palm optimal age for Khussab variety. The Certainly Equivalent CE values are plotted against the age to identify the optimal Khussab replanting age. If the CE value is large than land value at the same land area and similar water saline level it will be optimal for investor to replant, but if it is lower farmer can see other suitable crop for his land or can sell the land.

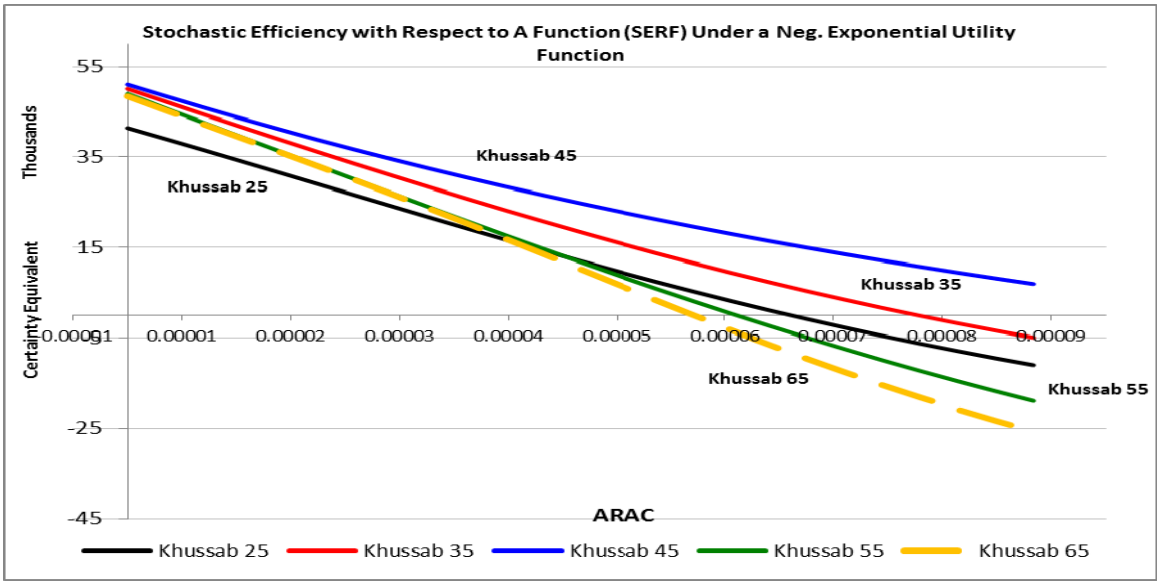

Figure 3. CE values of optimal Khussab Date Palm variety replant age for different risk aversion

Table 5. Ranking of Khussab Date varieties ages by Risk Aversion using CE for NPV

Risk	Normal Risk		Rather Risk		Rather Risk		Extreme Risk	
ARAC	0.00000		0.000014		0.000031		0.000045	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Khussab45	51 056	Khussab45	41 180	Khussab45	30 408	Khussab45	22 968
2	Khussab35	50 099	Khussab35	38 933	Khussab35	25 724	Khussab35	16 014
3	Khussab55	48 974	Khussab55	36 330	Khussab55	20 758	Khussab25	9 665
4	Khussab65	48 440	Khussab65	36 173	Khussab65	20 253	Khussab55	8 783
5	Khussab25	41 434	Khussab25	31 598	Khussab25	19 145	Khussab25	6 737

The market value of the one hectare land at study area record RO 49 000 and the optimal replanting age for Khussab variety at neutral risk aversion level is 55 years as shown by Figure 4. Hemesiri B.K. et al., (2013) used comparison of equivalent annual net revenue to estimated optimal Date Palm replanting age at 50-55 years.

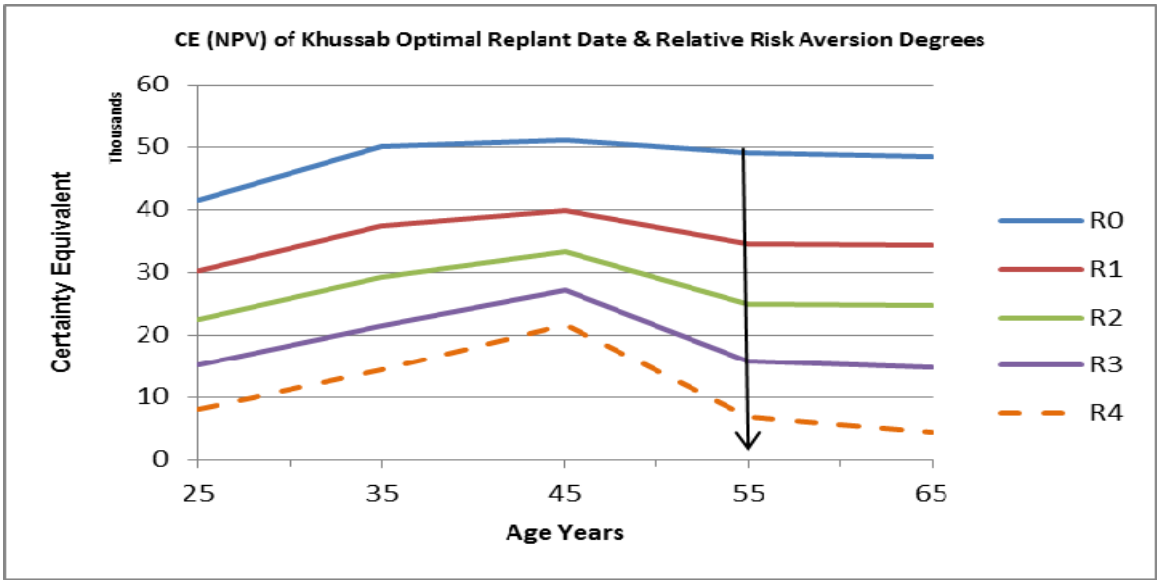

Figure 4. CE values of optimal Khussab Date Palm variety at different risk aversion level

The study also indicates that Batinah Farmers benefit from cultivation different Date Palm varieties and crop diversification to cope with water salinity and increase ecosystem resilience and economic benefits. Farmers should replant Date Palm to replace unsustainable old Date Palm trees and select suitable sustainable varieties that can cope with water salinity and farm local environment as good Date quality variety may not be sustainable and tolerance to water salinity level at the farm. The study calculate risk premium of RO 533 per one hectare to be given to Farmer to keep Um Saila Date Palm variety and replant low yield but sustainable varieties in marginal area and improve crop diversification and ecosystem resilience for each region.

4. Conclusion

The main task of this paper is to investigate Date Palm replanting strategies with different investor risk aversion level. Sustainable Date Palm replanting strategies depend on two main factors. The first one is identifying sustainable Date Palm varieties within Farm location area i.e. (Batinah Region) and the second is the selection of optimal replanting age of unsustainable varieties needs to be replaced.

The main Date Palm cultivated varieties at Batinah Region such as Um Saila, Shahil are mainly used for industrial purposes and Kussab, Naghal and Khunaizi used for direct human consumption were tested to select and identify the most risk efficient and sustainable variety. The economic sustainability and investment return future value of different Date Palm varieties obtained by calculation of NPVs for 25 years. The study found that Naghal Date Palm variety is the most risk efficient and sustainable cultivar followed by Shahil and Khussab varieties at normal risk aversion level. These Date varieties can be recommended to replace old Date Palm trees

at good water salinity level. Um Saila which is contribute of 93% of total Um Saila country production and 26% of Batinah Region Date Palms trees is found the most risk efficient at extreme risk aversion level followed by Shahil and Khussab Date Palm varieties.

The replanting strategies of old Date Palm trees is investigated by calculating NPVs of Khussab Date Palm for different tree ages from 25 years up to 65 years with 10 years intervals. The CE value of different ages of Khussab variety found that Khussab45 is the most risk efficient optimal replanting age and keeping Date Palm trees for additional years depends on land value and farm location near residential area and Farmers interest to change agriculture land to commercial land. The other agriculture use of land and water salinity level can also affect Date Palm replanting investment decision.

Batinah Regions farmers are diversifying date palm cultivated varieties to manage risk associated with price and yield uncertainty in term of extending harvesting period and benefit from different date ripening stages i.e. (Busir, Rutab and Tamr) and producing different type of dates for different use i.e. direct human consumption, industrial, animal feed. Farmers in Batinah Regions are manage to develop resilience agricultural systems by introducing tolerance Date Palm varieties and using affordable technologies and strategies such that ecosystem functions and services can be maintained and livelihoods can be protected. Although Batinah Region has a highest water deficit consist of 69% of total country deficit but the region mange to cope with water shortage risk and ranked as the most risk efficient region for Date Palm cultivation in Oman.

Replanting and replacement of 800 thousand Date Palm trees in Oman should consider farming system sustainability, economic sustainability and variety adaptability in term of water shortage and dates yield, quality and price. The market access and market absorption of date variety yields is also important and needs to be considered by policy maker in replacement program.

Risk premium analysis can be used for Date Palm replacement program and policy makers should investigate application of economic incentives to encourage replanting risk efficient and sustainable Date Palm varieties in marginal area and improve crop diversification for each region.

Competing interests

The author declared that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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