SUDAN UNIVERSITY OF SCIENCE & TECHNOOLOGY
COLLEGE OF GRADUATE STUDIES

ECONOMIC APPRAISAL OF FODDER CROPS PRODUCTION UNDER RISK AND UNCERTAINTY IN SULTANATE OF OMAN

الجـدوى الاقتصــادية لانتاج محاصيل الاعــــلاف في ظل المخاطرة واللايقين بسـلطنة عـــــمان

A THESIS SUBMITTED FOR THE FULFILMENT OF THE REQUIERMENT FOR THE DEGREE OF DOCTOR OF PHILOPHISY IN AGRICULRTRAL ECONOMICS

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DECLARATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, this thesis, and the research underpinning it, is entirely my own work. It has not been submitted in any previous application for a degree. All quotations in the thesis have been distinguished by quotation marks, and the sources of information specifically acknowledged.

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بسم الله الرحمن الرحيم

Text in Al-Quran

وَقَالَ يَٰبَنِيَّ لَا تَدۡخُلُواْ مِنۢ بَابٖ وَٰحِدٖ وَٱدۡخُلُواْ مِنۡ أَبۡوَٰبٖ
مُّتَفَرِّقَةٖۖ وَمَآ أُغۡنِي عَنكُم مِّنَ ٱللَّهِ مِن شَيۡءٍۖ إِنِ ٱلۡحُكۡمُ
إِلَّا لِلَّهِۖ عَلَيۡهِ تَوَكَّلۡتُۖ وَعَلَيۡهِ فَلۡيَتَوَكَّلِ ٱلۡمُتَوَكِّلُونَ ٦٧

"O my children, do not enter the capital of Egypt by one gate but go into it by different gates. However, know it well that I cannot ward off you Allah's will for none other than He has nay authority whatsoever. In Him I have put my trust and all who want to rely upon anyone should put their trust in Him alone."

(Surah Yusuf: Verse 67)

Hadith from Prophet Muhammad s.a.w

Prophet (peace be upon him) once asked a Bedouin who had left his camel untied, "Why do you not tie your camel?" The Bedouin answered, "I put my trust in God." The Prophet PBUH then said, "tie up your camel first then put your trust in God."

ABSTRACT

Irrigated agriculture for Rhodes Grass and fodder production forms the backbone of many farmers in Al-Batinah and Salalah Plain of Sultanate of Oman. Ecological deterioration and inefficient water resource use have resulted in a significant threat to the livelihoods of those most dependent on agricultural sector. Inefficient water use has led to rising ground water tables and widespread water and soil salinization has resulted. The high water demand in the region for crop production renders farmers vulnerable to the recurrently predicted decrease in water supply.

The government authority stopped the cultivation of Rhodes grass in coastal area and support farmers with incentive systems in order to increase fodder production investment at Najed area. Due to new irrigation water policy regulations, new technical solutions required, underground water availability, fodder investors have little data to help in making investment decisions. In addition, fodder production investments are characterized by much uncertainty due to the nature of the desert farming which is relying on many factors that cannot be controlled. In this study a dynamic evaluation model was formed and developed as a method of analyzing the economic feasibility of fodder cultivation investment project with regard to project profitability under risk environment.

The main objective of this research is to understand capital budgeting techniques for fodder crops re-allocation project. In particular, it analyzes; Net Present Value (NPV) by using conventional approach, Monte Carlo Simulation techniques, and compares these approaches in terms of their treatment of uncertainty variables, their acknowledgement of flexibility, and their usefulness for strategic decision making.

The specific objectives of the research is to determine the profitability of producing Rhodes grass in Najed area, given new fodder crop re-allocation program and new water policy implemented in Najed area. The comparison of new proposed cultivation area to costal area is performed and Risk Premium calculated. Moreover, risk efficient policy and rank alternative risk management strategies are performed to support decision makers for sustainable Rhodes grass farming at new area. The study also determine incentive requirement to compensate risk associated with project location.

Economic feasibility of the investment is evaluated through calculation of the Net Present Value and IRR by using Monte Carlo Simulation models. Our objective is to formulate a dynamic programming simulation model for the investment decision with incorporating risk and uncertainty parameters

in a probabilistic manner. To this end, a static, stochastic model was developed to evaluate risk and explore potential risk reducing strategies for farmers, while accounting for the ecological consequences of potential agriculture policies. Worldwide, mathematical modelling has proven to be an effective instrument for increasing the overall understanding of the complexity of water management and determine best combination of risk management strategies for decision makers with alternative preferences for risk aversion and achieve resource-saving alternatives that are both economically and ecologically sustainable.

Risks and uncertainties of project developments arise from various sources of errors including data, model and forecasting errors. It was found that the most influential factors affecting risk and uncertainty resulted from forecasting errors. Data errors and model errors were found to have unimportant effects. It was argued by many analysts that scenarios do not forecast what will happen but scenarios indicate only what can happen from given alternatives. It was suggested that the probability distributions of end products of the project appraisal such as Internal Rate of Return, Net Present Value, and Benefit Cost Ratios that take forecasting errors into account are feasible decision tools for economic evaluation. The study constructed Monte Carlo Simulation model to perform dynamic stochastic budgeting simulation analysis by using @Risk software that allows the representation of uncertainty as probability distributions.

The sample data generated by Latin hypercube sampling method from Monte Carlo Simulation model has been used to performed stochastic dominance analysis and Stochastic Efficiency with Respect to a Function (SERF) were also used to select the risk-efficient strategies. The analysis shows government investment subsidy reduced risk at new location at Najed but still more support is needed. Minimum Revenue Guarantee, raw material subsidy analysis is performed and could be one of the risk management tool uses in Najed Project.

The study shows dynamic stochastic simulation model are more powerful than deterministic models and could be used to estimate the probability distribution for select key output such as (NPV) and (IRR) of a Rhodes Grass farm production facility in three alternative locations in Oman (Hanfeet, Dawkah and Salalah Plain). The dynamic models used in the study assess the impact of new water policy for each farm location. The study indicates dynamic models are better than conventional analysis and could help policy makers to review water policy to get a sustainable farming in desert area and achieve positive economic gains and economic sustainability for Najed area.

The study also performed SERF analysis and calculate Certainty Equivalents (CE) to rank risky alternatives. Certainty Equivalent value shows the amount of money that the decision maker would have to be paid to be indifferent between the particular scenario and a no risk investment. We also estimated confidence premiums for each alternative and calculate government incentives required for each location. Confidence premium indicates how much a decision maker has to be paid to switch from the preferred strategy (Salalah) location to new area. The results illustrate possible conflicts between risk efficiency and sustainability and risk management strategies, change in water policy with raw material subsidy alternatives could improve risk efficiency and encourage investors to sustain agriculture activates at new developed area at Najed.

الملخص :
تمثل الزراعة المروية لمحصول حشيشة الرودس و الاعلاف الخضراء العمود الفقري لكثير من المزارعين في سهل صلالة والباطنة بسلطنة عمان. وقد أدى الاستخدام المفرط للمياه وعدم كفاءة استخدام الموارد المائية إلى تهديد وتدهور البيئة فى المنطقة ومن ثم التأثير على حياة الكثير من المزارعين الذين يعتمدون على القطاع الزراعي. ان عدم كفاءة استخدام المياه أدى إلى انخفاض مستوى المياه الجوفية وانتشار مياه البحر المالحة في الابار مما ادى الى تملح التربة. كما ان ارتفاع الطلب على مياه الري بالمنطقة لإنتاج المحاصيل الزراعية يجعل المزارعين عرضة بشكل متكرر لتوقع الانخفاض في إمدادات المياه والتاثير على سلوكهم.

ولايقاف التدهور المائي اصدرت الحكومة قرار وزاري لمنع زراعة حشيشة الرودس جراس في المناطق الساحلية ودعم المزارعين وتحفيزهم للاستثمار في زراعة الحشائش بمنطقة النجد في محافظة ظفار. حيث ان اصدار السياسات المائية الجديدة بمنطقة النجد واستخدام تقنيات ومضخات الري الحديثة وعدم توفر معلومات كافيه عن كميات المياه الجوفية المتاحة اصبح عائق لاتخاذ قرار الاستثمار بزراعة الحشائش بالنجد. بالاضافة الى ذلك نجد ان قرار الاستثمار في زراعة الاعلاف اصبح يتسم بالكثير من البلبلة بسبب طبيعة الزراعة بالصحراء والتي تعتمد على العديد من العوامل التي لا يمكن السيطرة عليها. وفي هذه الدراسة تم استخدام النموذج الديناميكي للتقييم الاقتصادي للاستثمار في مشروعات زراعة الاعلاف بالمنطقة من خلال تحليل الجدوى الاقتصادية وتحديد ربحية المشروعات في ظروف البيئة المحيطة بالمخاطر وعد اليقين.

الهدف الرئيسي من هذا البحث هو مقارنة الطريقة التقليدية لتحليل الجدوى الاقتصادية من اقامة مشروعات زراعة الاعلاف ومقارنتها مع النموذج الديناميكي للتقييم الاقتصادي (مونت كارلو تقنيات المحاكاة) لحساب معدل العائد الداخلي وصافي القيمة الحاضرة لربحية المشروع في ظل وجود مخاطر محددات لبعض عناصر المشروع في معالجة المتغيرات من عدم اليقين وفائدتها الاستراتيجية لصنع القرار.

ان الأهداف الاخرى الثانوية من هذا البحث هو تحديد ربحية إنتاج حشائش الرودس جراس في منطقة النجد ضمن برامج اعادة توطين زراعة المحاصيل العلفية بالنجد مع طرح وتطبيق السياسات الجديدة لاستخدام المياه الجوفية لري محاصيل الاعلاف بالنجد. حيث تم مقارنة المواقع الجديدة المقترحة لزراعة الاعلاف بالنجد مع زراعتها بالمساحة المزروعة في المنطقة الساحلية من خلال إجراء حساب المخاطرة. وعلاوة على ذلك، تحديد كفاءة ادارة المخاطر للسياسات المائية وترتيب سياسات إدارة المخاطر لاستراتيجيات البديلة لمساعدة ودعم صناع القرار على تحديد اساس وسياسات الزراعة المستدامة للاعلاف في المنطقة. وايضا دراسة وتحديد الحوافز التعويضية للحد من المخاطر المرتبطة بموقع تنفيذ المشروع.

تم تقييم الجدوى الاقتصادية من الاستثمار في مشروعات زراعة الاعلاف بتقييم حساب صافي القيمة الحالية للمشروع باستخدام نموذج مونت كارلو للمحاكاة. حيث ان الهدف من الدراسة هو وضع برنامج لنموذج محاكاة ديناميكية لتقييم الاستثمار في ظل وجود وإدراج المخاطر وعدم اليقين في عناصر تقييم المشروعات. وتحقيقا لهذه الغاية، تم تحليل المعلومات بالطرق الثابتة التقليدية ومقارنتها مع الطرق الحديثة بوضع نموذج تقييم المخاطر واستكشاف استراتيجيات الحد من

الأخطار المحتملة للمزارعين وتقييم السياسات الزراعة في ظل وجود امخاطر وعدم اليقين. ان استخدام النماذج الرياضية كأداء تستخدم في تقييم السياسات قد اثبتت فعاليتها في زيادة تفهم تعقيدات إدارة المياه وتحديد أفضل مزيج من السياسات المائية ولتحديد استراتيجيات إدارة المخاطر ومساعدة صناع القرار لتحديد افضل البديل للحد من المخاطر وتحقيق وفورات في استخدام الموارد وايجاد بدائل اقتصادية مستدامه ومحافظة للبيئة.

كما ان وجود المخاطر وعدم اليقين في دراسات متابعة تطورات المشروع تنشأ عادة من عدة مصادر بما فيها من أخطاء في البيانات او النماذج اواخطاء في طرق التنبؤ بالمعلومات. وقد تبين أن معظم العوامل المؤثرة في دراسات معرفة المخاطر وعدم اليقين ناتجة من أخطاء التنبؤ حيث ان الاخطاء في البيانات والاخطاء في النماذج قد لا يهم كثيرا وليس لها اثار. فقد ذهب كثير من المحللين أن تحليل السيناريوهات لا يفيد ولا يتوقع ما سيحدث ولكن السيناريوهات تشير إلى ما يمكن أن يحدث عند استخدام البدائل في وسائل الانتاج او في وضع السياسات الزراعية البدائلة. حيث ان رسم دالة توزيعات الاحتمالات لمعايير ومقاييس تقييم المشروعات مثل معدل العائد الداخلي وصافي القيمة الحالية للمشروع تكون ذات فائدة اكبر للمستثمرين لاتخاذ قرارات الاستثمار الصحيحة حيث انها تأخذ في الاعتبار أخطاء البيانات واخطاء التنبؤ الممكنة وتفيد في اتخاذ قرارات التقييم الاقتصادي. وقد قامت الدراسة باعداد نماذج محاكاة ديناميكية لتقييم الاستثمار باستخدام برنامج (@Risk) والذي يسمح بمعالجة المخاطر وعدم اليقين للمعاملات الاقتصادية ووضع نتائج التحليل الاقتصادي ومعايير التقييم في شكل دالة الاحتمالات.

لقد تم تجميع البيانات من تكاليف وايرادات في شكل نماذج للعينات (Latin Hypercubic) واستخدام نتائجها في نموذج محاكاة مونتي كارلو وقد تم استخدامها في إجراء تحليل أداء مؤشر ستوكاستيك الهيمنة والكفاءة العشوائية فيما يتعلق بدراسة المخاطر بهدف استخدم التحليل لتحديد الاستراتيجيات الفعالة للمخاطر. يبين التحليل إعانة متخذي القرار في الاستثمارات الحكومية والعمل على تخفيض المخاطر في الموقع الزراعية الجديدة في النجد ولكن لا تزال هناك حاجة للمزيد من الدعم من قبل الحكومة لضمان الحد الأدنى من الدخل للمزراعين، ودعم جزء من كلفة المواد الخام والتي يمكن أن يكون واحدا من أداة لإدارة المخاطر التي تستخدم في المشروع .

تظهر الدراسة ان استخدام نموذج المحاكاة العشوائية الديناميكية هي أقوى من النماذج التقليدية ويمكن أن تستخدم لتقدير التوزيعات الاحتمالية لتحديد نتائج ومعايير التقييم الاقتصادي الرئيسية مثل (تحليل صافي القيمة الحالية) و معدل العائد الداخلي (IRR) لمشروعات زراعة وانتاج حشائش الرودس في ثلاثة مواقع بديلة في عمان (دوكاه وحنفيت وسهل صلالة). حيث قام نماذج التحليل الديناميكي المستخدمة في الدراسة بتقييم تأثير السياسة المائية الجديدة لكل موقع من المواقع المذكورة اعلاه. وتشير الدراسة إلى نماذج التحليل الديناميكي أفضل من نماذج التحليل التقليدي، ويمكن أن تساعد واضعي السياسات لمراجعة السياسة المائية للحصول على الزراعة المستدامة في منطقة صحراوية بالنجد، وتحقيق مكاسب اقتصادية إيجابية والاستدامة الاقتصادية لمزارعي منطقة النجد .

كما أجريت الدراسة أيضا تحليل المخاطر وحساب القيمة البديلة للاستثمار (CE) لترتيب البدائل المحفوفة بالمخاطر وتحديد القيمة المكافئة من الاموال والتي يجب الحصول عليها كتعويض من

المخاطر لصانع القرار في الاستثمار وتفادي المخاطر. قدرنا أيضا أقساط التعويض لكل بديل وحساب الحوافز الحكومية اللازمة لكل موقع. قسط التعويض يدل على القيمة البديله لديه صانع القرار والتي يجب أن تدفع للتبديل من موقع الاستراتيجية المفضلة (صلالة) إلى منطقة النجد. وتوضح نتائج التحليل التضارب المحتمل بين المخاطر وكفاءة ترتيب استراتيجيات الاستدامة وإدارة المخاطر، والتغير في السياسة المائية مع توفير الدعم للمواد الخام حيث يمكن أن تتحسن كفاءة استخدام الموارد وادارة المخاطر و تشجيع المستثمرين للحفاظ على الزراعة المستدامة في منطقة النجد .

To my Father's Memory,

My Mother

And

Beloved wife and family

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Chapter One

Introduction

CHAPTER 1
INTRODUCTION

1.1 Introduction

Agricultural industry is a project based industry. Project is a gathering of people for one uniquely defined objective for a limited timeframe. In agricultural industry, where the learning of organizations is solely depended on project related information, the need for focusing on project success factors has increased. As the global business force companies to position themselves within the global competitive environment, projects tend to be more complex and require a collaboration of different disciplines in a short period of time. With the increase of uncertainties stemming from the characteristics of international undertakings, the necessity for handling uncertainties arose and risk management concept in international and multi-project environment gained significant importance.

Risk management concept mainly consists of identifying, assessing, handling and monitoring phases. Risk has an important role in decision making and forming polices in an organization and government. Many researches confirmed the importance of risk management in project management area. Companies mostly focus on the estimation and quantification of risks and uncertainties in early stages of a project whereas they lack further investigation of cause-impact relation of risk management strategies on further stages. The major risk is the lost knowledge at the end of the project (Kazi, 2005). Continuity in knowledge transfer from project level to enterprise level is required for an efficient organizational learning. Lessons learned from a project, must be documented to become a part of the organizational memory.

1.2 The nature and problems of irrigated agriculture

Irrigated agriculture plays an important role in meeting ever growing food demands around the world. More than 40% of the world’s agricultural production originates from only 17% of the world’s arable land (IFPRI, 2004), and the total world area under irrigated agriculture has increased fivefold since the beginning of the 20th century (Rosegrant et al., 2002). An increased diversion of crops for biofuel production as well as droughts in many of the primary grain supplying countries, has significantly decreased food availability in recent years; agricultural commodity prices have increased worldwide during the last few years and the head of the United Nations World Food Programme recently described the soaring food prices as a ‘silent tsunami’ due to the vast number of people affected by resulting food shortages (OECD-FAO, 2006; WFP, 2008). Therefore, under rising demand and limited room for expansion of production, irrigated agriculture, which produces yields on average 2.3 times higher than rain fed agriculture (Garces- Restrepo et al., 2007), is becoming more important in securing food supply and stabilizing agricultural production prices around the world.

Over 70% of fresh water around the world is used for irrigation and water demand for irrigation already exceeds the current supply (IFPRI, 2004). There is a considerable need to increase irrigation efficiency globally as losses during field irrigation, transportation in channels and during field application are major sources of water loss in irrigated agriculture. According to FAO (2002), the overall water use efficiency must be increased, i.e. 'more crop per drop', from 38% to 42%, between 1998 and 2030 in more than 90 developing countries in order to have sufficient water resources to cover irrigation water demand. The impacts of water scarcity are particularly acute in countries where the food economy is heavily dependent on irrigated agriculture, such as in Oman.

1.3 Risk and uncertainty in agricultural activities

In rain-fed agriculture, rain is considered as a main source of water to cover water demand of crops. As a result, availability of rain water is considered as the main uncertainty factor, as it is fully dependent on the natural conditions. The risk caused by unpredictable nature is often considered as production risk, which is induced by factors not related to human activities.

Water requirements for crops in irrigated agriculture in Oman are fulfilled by rain as well as underground water. In this case, the availability of water depends on natural as well as human factors. Similar to rain-fed agriculture, natural factors (e.g. precipitation, air temperature) might affect the availability of irrigation water in most regions in Oman. More specific to irrigated agriculture is the availability of irrigation water from underground at Al-Batinah and Salalah plain regions influenced by activities of farmers in these regions and farmers involved 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, producers must cope with yield uncertainties caused by weather changes, diseases and pest damages and price uncertainties caused by changes in markets as well (Quiroga, Fernandez-Haddad, & Iglesias, 2010).

Agricultural landowners and farmers in the Al-Batinah and Salalah plains exploiting the good ground water resources took to wide scale cultivation of Rhodes Grass which is easy to grow and crop can be taken out at least six times a year. The excessive use of the precious freshwater has led to ingression of salinity in the area. This causes a grave threat to 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 concerned ministries apprised His Majesty of the situation and His concern for the environment is also reflected in the policy of the Government on fodder cultivation in Oman. It is decided by the government to gradually stop the cultivation of fodder in Al-Batinah and Salalah plains and at the same time develop substitute areas in the Najed to meet the fodder requirements.

The 9th Gulf Water Conference organized in Muscat at 22-25 March 2010 by the Water Science and Technology Association and Oman Government (Ministry of Regional Municipalities and Water Resources) under title of "Water sustainability in GCC countries - The Need for a Socio-Economic and Environmental Definition" outline that the imbalance between supply and demand of water resources are mainly due to the lack of policies and strategies for managing water resources and the lack of an integrated approaches and supported by appropriate institutional structures and effective legislative framework in GCC countries. The Conference outlined the most important challenges points facing GCC countries as under :

- Continuous reduction in per capita availability of fresh water in the region, increase competition on water resources by consuming sectors and continuous deterioration of water quality.
- The increase in water requirement for population and food production and exceeding the GCC countries capacity in developing their water resources.
- The inadequate and inefficient water planning and management.

The conference urges the GCC countries to consider the following recommendations:

- Implementation of national water strategies based on the principles of integrated water resources management in terms of economic efficiency, social equity and environmental sustainability.
- Setting compatible agricultural policies in line with the capacity of available traditional and non-conventional water resources.
- Design national plans and programs for the optimum utilization of different water resources.

As per the above recommendations, the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) 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. Moreover, the (MRMEWR) determined 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. Along with this policy, the government decided to stop cultivation of Rhodes Grass in Al-Batinah and Salalah plains to cope with uncertainty caused by underground irrigation water supply which gained attention as one of the main subjects needing to be addressed following the drought years in Oman and Gulf region.

1.4 Research Problem :

Water requirements for crops in irrigated agriculture in Oman are fulfilled by rain as well as underground water. In this case, the availability of water depends on natural as well as human factors. Similar to rain-fed agriculture, natural factors (e.g. precipitation, air temperature) might affect the availability of irrigation water in most regions in Oman. More specific the irrigated agriculture is depend on the availability of irrigation water from underground at Al-Batinah and Salalah plain regions which is influenced by activities of farmers in these regions and farmers involved 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, producers must cope with yield uncertainties caused by underground water availability, diseases and pest damages and price uncertainties caused by changes in markets as well.

Agricultural farmers in the Al-Batinah and Salalah plains exploiting the good ground water resources took to wide scale cultivation of Rhodes Grass which is easy to grow and crop can be taken out at least six times a year. The excessive use of the precious freshwater has led to ingression of salinity in the area (Water Science and Technology Association, 2010). This causes a grave threat to 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 concerned ministries apprised His Majesty of the situation and His concern for the environment is also reflected in the policy of the government on fodder cultivation in Oman. It is decided by the government to gradually stop the cultivation of Rhodes Grass in Al-Batinah and Salalah plains and at the same time develop substitute areas in the Najed to meet the fodder requirement. The government asked private companies to establish Joint Stock Company for fodder cultivation at Najed in Dhofar Region.

The Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) 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. Moreover, the (MRMEWR) determined 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

The application of new water policy will increase capital and operation cost and includes uncertainty factors which will affect economic efficiency of the resources. 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).

It is not the real-world situation itself, which is either risky or uncertain, but merely the information available to analysts, which defines it as such. All actual project outcomes are unknown, because they occur in the future and are subject to influence by a number of variables, each of which may take different values. If we have reliable historical or forecast data such that a probability distribution can be constructed for such variables, the situation can be modeled as risky. If we do not have such data we can only describe the future in terms of uncertainty. The range of crop yield treated as risky and underground water availability treated as uncertainty in our model.

A quantitative risk analysis can be performed a couple of different ways. One way uses single-point estimates, or is deterministic in nature. Using this method, an analyst may assign values for discrete scenarios to see what the outcome might be in each. For example, in a financial model, an analyst commonly examines three different outcomes i.e. the worst case, best case, and most likely case.

However, there are several problems with deterministic approach analysis as it considers only a few discrete outcomes and ignoring hundreds or thousands of others. It also gives equal weight to each outcome and ignores the interdependence between inputs, and impact of different inputs to the outcome, as a result dynamic model for project evaluation under risk and uncertainty is used and examined in this research.

1.5 Research objectives

The main aim objective of the research is to understand capital budgeting techniques for fodder crops re-allocation project. In particular, it analyzes; Net Present Value (NPV) by using conventional approach, Monte Carlo Simulation techniques, and compares these approaches in terms of their treatment of uncertainty variables, their acknowledgement of flexibility, and their usefulness for strategic decision making.

Specific Objectives

1. Determine the profitability of producing Rhodes grass in Najed area, given new fodder crop re-allocation program and new water policy implemented in Najed area.
2. Comparison of proposed cultivation area to costal area and calculate Risk Premium.
3. Determine risk efficient policy and rank alternative risk management strategies for supporting Rhodes grass farming at new area.
4. Determine incentive requirement to compensate risk associated with project location.

The primary goal of the PhD research is to test different techniques of risk and uncertainty analysis and enhanced methods for risk analysis to aid decision-making in project management. The research will also help to increase the level of understanding of how improvements in risk analysis can enhance the existing water policy and productivity of the project areas. The research will quantify the risk of implementation new water policy and additional capital and operation cost required to implement new water policy and the effect of these additional cost on Najed project profitability.

1.6 Research questions

The research will answer the following questions :

- Can the establishment of private project supported by public funds be examined and justified by using conventional investment approach? And which techniques are the most appropriate for risk assessment associated to the critical variables?
- Are public funds and Government support help in reducing risk effect facing private companies' investment? And how much government

subsidy and risk premium is needed to reduce the risk in Al-Najed Agriculture Development Project?
- How risk and uncertainty analysis in investment appraisal improve investment decision? And calculate probability distributions of uncertainty variables and its all possible expected return (NPV & IRR).
- What is the impact of new water policy on Najed project profitability? How policy makers identify the most useful water policy instruments to reduce their risk effect.
- Is Government incentive sufficient enough to compensate risk associated with project location (Farming in desert) and it is economic viability?

1.7 Organization of the thesis

The thesis has both a technology and a policy component. The technology component lies in the application of the traditional deterministic and stochastic simulation valuation methodologies to irrigation infrastructure project. The objective of this component is to improve the understanding of the theoretical advantages and disadvantages of each approach, the assumptions and information required for each one, and to determine the consequences that the application of each approach has on the nature of irrigation infrastructure project. The policy component refers to the implementation feasibility of each approach, taking into account the specific institutional and water policy relevant to the project being analyzed.

Chapter one presents an introduction to the nature and problem of irrigated agriculture and risk and uncertainty in agricultural projects. Risk and uncertainty analysis definition, and difference of deterministic and stochastic risk analysis are outlined in this chapter. The scope and aims of the present research are described. Chapter one also include research problem, research objectives, research questions and thesis organization.

Chapter two provides a review of the literature and mathematical foundations for risk analysis, such as probability theory and principles of Monte Carlo Simulation analysis is described. Some common probability distributions for modeling risk and uncertainty that are used in the present study are detailed. Previous investigations and methods of agricultural variable’s distribution and crop yield model analysis are also reviewed.

Chapter three, provides an overview of agricultural activities and water resources in Oman. The agro-ecological and socio-economic situation in Oman and project area outlined. The water resources deficit and new water policy stated by Government are summarized in this chapter.

Chapter four is a methodology and empirical model, include data collection and a comparison of the traditional project evaluation such as NPV and IRR and the Monte Carlo Simulation analysis methods in agricultural projects risk analysis is carried out and different scenarios at Najed Project Area are tested and analysed by using deterministic and stochastic analysis methods. When applying the Monte Carlo Simulation analysis method, a sensitivity analysis is carried out by investigating the effect of different water policy on Rhodes grass yield and revenue is performed. Different NPV and IRR probability distributions compared with different water levels at each project location are also examined in this Chapter.

Stochastic mathematical programming was used to analyze the link between the government water policy, farm income, risk and environmental aspects of different land use options. The theoretical background and methodology used in stochastic MCS programming are reviewed in this Chapter.

Chapter five Farm location analyses, presents the model results from the base run and from different farm location, government subsidies, water policy scenarios are presented. This chapter also presented typology of risk in project area and outlined risk factors included in dynamic model. Risk allocation and each partner responsibilities at project area provided in this chapter. Evaluation criteria for each location model and interpretation of dynamic location models results outlined in this chapter.

Chapter six risk management tools and strategies, presents the model results from the base run and from different government subsidies, water policy scenarios are presented. This chapter also provided risk sharing mechanisms and different risk management tools and strategies could be used to mitigate and reduce risk effect. The minimum revenue guarantee, sale price subsidy, raw material subsidy were examined in this chapter.

Chapter seven presents the model results from the base run and from different government support and incentives programs. A stochastic efficiency model compares the net present values under different scenarios and combinations of risk management strategies. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives for decision makers with different risk aversion preferences. The discussion of the results from each scenario analysis is carried out in this chapter. Chapter eight presents the model results for each scenario and risk management strategies. Research conclusions and recommendations and for future research needed are outlined in this chapter.

Chapter 2

Literature Review and Background

CHAPTER 2
LITERATURE REVIEW AND BACKGROUND

2.1 Literature review introduction and background

Uncertainty and risk analysis is not new; however, as a tool in business it has historically been of limited use. This is surprising considering that many business decisions are based on a figure that has been calculated from analysis of some kind. A number on its own is only half the picture; to fully understand the result it is necessary to have an estimate of the uncertainty related to project investment and implementation.

Risk analysis has become increasingly popular in recent years. Therefore, identify some of the main areas of difficulty and possible practicable methods suggestions are required.

This research will give an overview of how to carry out uncertainty and risk analysis modeling projects. In particular, it focuses on the use of Monte Carlo Simulation in a spreadsheet model. This is not only because this is a simple and very powerful technique, but also because by applying this technique most of the fundamental uncertainty and risk analysis problems will be covered (Savvakis & Savvides, 1994; Omer, 2008).

Accounting for risk in the analysis of project appraisal is much harder than pretending it doesn't exist. In the past, the difficulties have been compounded by confusion over just what risk is and how it can be measured.

Risk analysis in agriculture has faltered in the past because of difficulties in estimate and categorizing farmers' attitudes to risk. It is argued that risk aversion may not be as important for some choices as commonly believed; there are some rough and ready ways to estimate the relevant range of the risk for some target group. Methods of stochastic efficiency analysis then allow at least something to be said about better and worse solutions.

Some risk analyses that have been based on the assumptions about the degree of risk aversion has overlooked some of the complexity in making the move from utility of wealth to utility of gains and losses or the utility of income. Moreover, very few such analyses have recognized that risk aversion for permanent income is likely to be much more important than is risk aversion for temporary income.

Risk analysis has also been avoided in the past because so many would-be analysts were afraid to tackle the evaluation of risky choices when too few hard data were available to work out the required probability distributions. Too many of those who braved the waters of risk analysis left untold or under-emphasized the dubious relevance to the problem at hand of the data they used to represent uncertainty. It seems that the task of finding better ways to work out the probability distributions that describe the risks that farmers face has been relatively neglected by agricultural economists.

Risk is a fundamental component of agricultural production and various studies of farmers' attitudes to risk have generally found that farmers are risk averse (Chavas and Holt 1990 and Pope and Just 1991). Risk analysis is quite a young discipline, the base of which was established by Knight، in 1933. After some decades the structure of risk analysis was very similar in the books of Raiffa (1968) and Schlaifer (1959، 1969). Risk analysis started to improve dynamically in the end of the 70s which can be noticed in the books of the 80s with the main principles of the field (Barry (1984), Lindley (1985), Robison and Barry (1987), illetve Gregory (1988)). In some works the risk of agriculture is considered with high relevance (Halter and Dean (1971), Dillon (1971)). Risk analysis is surveyed with deep mathematical tools in Spetzler and von Holstein (1975), Smith (1988)، Smith and Mandac (1995) and Pratt et al. (1995).The book of Anderson et al. (1977) is mighty comprehensive with several agricultural applications and the operation research aspects are considered as well. In Clemen (1996), a general description of modern risk analysis with data management and decision analysis can be found. Just (2003) gives an outlook to the possible improvements in the following 25 years, especially with respect of agricultural risk. The book of Hardaker et al. (2004) is an excellent monograph in which there is a special emphasis on agricultural risk.

Probability theory concepts provide the theoretical framework for analysing risks and various methods have been suggested. Some sophisticated methods such as Monte Carlo simulation are well understood but there is still a gap between the theory and the techniques applied in practice. The quantitative techniques appropriate to the analysis of risk require further development and a step-by-step procedure for estimating the impact of risk has not been provided.

The reasons for this may be due firstly to the necessity and importance of quantified risk analysis not being recognized. Most people in practice believe that it is possible to deal with risk competently, consistently, and comprehensively with the use of very little mathematics. Also, there are quite strong opinions that there is no such thing as a software-only solution to the problem of risk management. Risk analysis software can help to process and complete risk management sufficiently. Precisely, comprehensive and competent risk analysis is primarily dependent on the attitude of the appropriate decision maker and their advisers. Secondly, to analyses risk quantitatively may be too costly and needs trained people.

However, due to the rapid developments in the agricultural business, no one can ignore the tools and techniques that can improve the quality and accuracy of risk analysis. Also the dramatic growth of computer technology, especially the development of cheaper and more powerful desktop personal computers, implies the need for the appropriate techniques is more urgent than ever.

The question posed in this thesis is of great relevance and importance given that the rate of economic growth in any country is highly dependent on the existence of adequate agriculture infrastructure. Identifying the optimal portfolio of infrastructure projects to be developed, and maximizing the return on the infrastructure investment are therefore critical to the economic growth of developing countries. Consequently, understanding which methodologies should be used to value which projects is of utmost importance in the development process. As proposed, the thesis will be informative and useful for planners and decision makers in the national and regional planning institutes, politicians, managers of public utilities, and large agriculture and construction companies. It will provide valuable insights on how to optimize the valuation procedures for agriculture and infrastructure projects and investment.

The thesis has both a technology and a policy component. The technology component lies in the application of the valuation methodologies to agriculture investment and infrastructure projects. The objective of this component is to improve the understanding of the theoretical advantages and disadvantages of each approach, the assumptions and information required for each one, and to determine the consequences that the application of each approach has on the nature of agriculture investment and infrastructure projects.

The policy component refers to the application of risk and uncertainty analysis and implementation feasibility of each approach to understand the effect of new water policy on project profitability, taking into account the specific institutional and cultural framework relevant to the projects being analyzed. Risk management tools and appropriate strategies will be recommended in this research.

2.2 Risk and uncertainty analysis

The terms "risk" and "uncertainty" are applied generically to the analysis of situations with unknown outcomes. We adopt here the conventional distinction between risk and uncertainty made in literature. According to it, in essence, risk is a quantity subject to empirical measurement, while uncertainty is of a non-quantifiable type. In a risk situation it is possible to indicate the likelihood of the realized value of a variable falling within stated limits – typically described by the fluctuations around the average of a probability calculus. In situations of uncertainty, the fluctuations of a variable are such that they cannot be described by a probability distribution.

Thus, 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 (Monacciani, 2011).

It is not the real-world situation itself, which is either risky or uncertain, but merely the information available to planners and analysts, which defines it as such. All actual project outcomes are unknown, because they occur in the future and are subject to influence by a number of variables, each of which may take different values (James et al., 2007). If we have reliable historical or forecast data such that a probability distribution can be constructed for such variables, the situation can be modeled as risky. If we do not have such data we can only describe the future in terms of uncertainty.

For example, analysis of any agriculture project may be undertaken in terms of "optimistic" or "pessimistic" assumption about domestic and commercial product demand level (and different returns predicted under such different scenarios), or may be modeled on the basis of a distribution of outcomes of future demand which itself depends upon estimates of economic growth, population growth etc., and which may be described on the basis of their probabilities of occurrence. In both cases there is nothing inherently different about the circumstances of the projects themselves, only the data available to the analyst which makes modeling of risk more or less possible.

This distinction between risk (unknown but quantified outcomes) and uncertainty (unknown and unquantified outcomes) is not usually so clearly made in typical financial analysis. UK Treasury Taskforce, for example, quotes the following definition of risk:" A simple definition of risk as used by the accounting profession is uncertainty as to the amount of benefits. The term includes potential for gain and exposure to loss."

Such a distinction (mentioned above) is in fact very useful because it helps to separate those situations which may be subject to quantitative analysis from those which are not.

2.3 Deterministic and stochastic risk analysis

A quantitative risk analysis can be performed a couple of different ways. One way uses single-point estimates, or is deterministic in nature. Using this method, an analyst may assign values for discrete scenarios to see what the outcome might be in each. For example, in a financial model, an analyst commonly examines three different outcomes i.e. the worst case, best case, and most likely case, Alkaraan and Northcott (2006).

The worst case scenario can present all inputs and operation costs at the highest possible value, and crop yield and sales revenues are the lowest of possible projections. In this case the outcome will lose money and business is not a profitable.

On the other hand the best case scenario can present the cost of inputs at the lowest possible value, and crop yield and revenues are the highest of possible projections. In This case the outcome is making money.

The most likely scenario presents the values in the middle for costs, crop yield and revenue, and the outcome shows business making a moderate amount of money.

However, there are several problems with deterministic approach analysis such as :

- It considers only a few discrete outcomes, ignoring hundreds or thousands of others.
- It gives equal weight to each outcome. That is, no attempt is made to assess the likelihood of each outcome.
- Interdependence between inputs, and impact of different inputs relative to the outcome, which could result a reduction in model accuracy.

Although may problems and dis accuracy of the deterministic model analysis but many analysts are still using this type of analysis. In stochastic and Monte Carlo simulation, risk and uncertainty is represented by probability distributions which recognise that each value in a range of potential outcomes has its own probability of occurring (Brittany D. Morris et.al. 2009), Probability distributions are therefore a much more realistic way of describing uncertainty in risk analysis.

During a Monte Carlo simulation, values are sampled from the probability distributions hundreds or thousands of times and the spreadsheet or project plan recalculated each time. These recalculations allow us to graph the distribution of hundreds or thousands of potential scenarios. In this way, Monte Carlo simulation provides a much more useful view of what may happen for decision making (Gill, 2002; Botterud & Korpa, 2007).

2.4 Risk assessment definitions

Traditionally, provision for risk in public-funded projects has been provided through the use of contingencies, in which an amount (often 10%) is added to the public budget for construction and projects to allow for unforeseen circumstances or additional works. However, projects require a much more sophisticated analysis of risk and their impacts to support the process for risk allocation and mitigation.

Composition of risk
The impact of risk may be defined as follows:

Impact of risk = Intensity of risk x Likely occurrence of risk

Risk intensity
The intensity of risk means its magnitude or impact, which is influenced by:

Effect:
If a risk occurs, its effect on the project may be expressed in a number of ways, e.g. 1-year delay in construction, reduced in crop yield volumes of 10%, lower revenue by 5%. These will in turn have cost implications and impact on the estimated financial or economic results.

Timing:
Different risks may affect the project at different times in the life of the project. For example, construction risk will generally affect the project in the early stages. The effect of inflation must also be borne in mind, if likely to be differential over a period.

Risk occurrence

Estimating probabilities is not an exact science, and assumptions have to be made. Assumptions must be reasonable and fully documented. There are some risks whose probability is low, but the risk cannot be dismissed as negligible because the impact will be high (for example, the failure of the project due to underground water unavailability).

In this case a small change in the assumed probability can have a major effect on the expected value of the risks. Together with estimating the probability of a risk occurring, it is also necessary to estimate whether the probability is likely to change over the lifetime of the project. The probability of water reduction increases over project lifetime.

A subjective estimation of probability is based on past experience or current best practice, and supported by reliable information, if available. If reliable information is not available, experts will have to make assumptions about the logical, commonsense likelihood of a risk occurring. We will discuss the probability of underground water reduction effect to Rhodes grass yield at Najed Project later in chapter 4-5 of this study.

However, if the probability of a risk occurring is high or the potential impact is significant, and there is sufficient reliable information, an advanced technique should be used as it can provide more conclusive results.

Breakdown into sub-risks

Risks must be assessed with respect to their component sub-risks. The risk of a decrease in crop yield may be linked to a number of parameters which could then be assessed more accurately. Construction and civil work risk will be composed of the combined risk of a number of contributing factors or sub-risks:

- cost of raw materials is higher than assumed
- cost of labor is higher than assumed
- delay in construction results in increased construction costs

Each sub-risk has its own intensity (cost and timing implications) and likelihood of occurrence.

Qualitative risk analysis

At a preliminary stage, a qualitative risk analysis can be performed. At this stage, the likelihood and consequences can be assessed qualitatively e.g. on a scale from A to E (A very low, B low, C mean, D high, E very high) and later the likelihood can be assessed in percentage and subsequently in monetary terms.

The qualitative risk assessment on an A to E scale can be used to transfer non- transparent lists of risks into a priority list of risks using a scoring-risk matrix. Once risks can be assessed in more detail or exact in percentage (likelihood) and monetary terms (consequences), the applied scores can be adjusted.

Decision makers can develop a risk matrix e.g. with a score from 1 to 10.
If a risk X is predicted with likelihood B and consequences B the score is 2.
If a risk Y is predicted with likelihood C and consequences E the score is 9.
If a risk Z is predicted with likelihood E and consequences E the score is 10.
Consequently Z has the highest priority with the score 10, followed by Y with a score of 9 and X with a score of 2.

Quantitative Risk analysis

Quantitative risk analysis is performed from the feasibility study stage, which, for major projects, uses special software with the assistance of an experienced risk analyst. Quantitative risk analysis determines the impact of risk on major cost and revenue centers in a financial or economic model for project analysis.

Project values are entered in the financial or economic model as probable value spreads in place of absolute values. The model can then compute impact on financial and economic indicators in terms of estimated spreads, representing likely overall risk exposure of the project.

The preferred method to present the impact of risks is by a separate cash-flow item which promotes a focus on the costs of each risk and enables an understanding of how risk can be transferred and what its financial effects are. In addition to this, valuing each risk as a separate cash-flow item accounts for the time implication of that risk (some risks may only have an impact at the beginning of a project, and the impact of other risks may diminish or escalate over the life of the project).

There are many tools available to model risk and uncertainty:
Work breakdown structure (WBS), risk breakdown structure, fault tree, event tree, cause-consequence analysis, influence line diagramming, CPM and Pert networks, decision tree, decision analysis, stochastic simulation, sensitivity analysis and conceptual models/artificial intelligence. Sensitivity analysis and stochastic simulation are among the most relevant and used

tools by private investors to assess the risks linked to public, private partnerships project, which will be used in this study.

Sensitivity analysis

Sensitivity analysis can be used to model the effect of one or more changes in variables. It is useful but simplistic and does not include the likely possibility of each change. For this purpose, one or more input assumptions to the financial model are modified which provides an estimate of the impact of this/these variations on the project cash flow/ profit. For instance, using this method it is possible to change say, either individually or together, the cost of project construction, include a construction delay factor and to reduce yield to thus calculate the impact of these changes on the cash flow/profit.

Stochastic Models - Monte Carlo

Statistical risk measurements, which are much more sophisticated, are particularly useful for assessing the impact of a number of simultaneous risks and their probability. Multivariable analysis techniques, like Monte Carlo simulation, have been successfully used in the valuation of risks for big socio economic and infrastructures projects (Asian Development Bank, 2002).

Stochastic modeling builds volatility and variability (randomness) into the simulation and therefore provides a better representation of real life from more angles. This type of analysis requires estimating a range of possible risks together with their probabilities of occurring, and the maximum and minimum project costs for the different scenarios. For instance, rather than setting investment returns according to their most likely estimate, the model uses random variations to look at what investment conditions might be like. Then this is done again with a new set of random variables. In fact, this process is repeated thousands of times. The result is a distribution of outcomes which shows not only what the most likely estimate but also the ranges which could be expected.

Monte-Carlo simulations can be used to model the range of economic indicators (discounted or undiscounted NPV, IRR, ROI, ROE, payback period, or other economic indicators) or activities from the time schedule (e.g. completion of project construction, start of operation or end of concession).

A key disadvantage of multivariate analysis is that it requires a large amount of reliable information and can also be more complicated to calculate and interpret. It may also shift the focus away from the analysis of individual risks that may need to be understood individually.

As a result, better way to perform quantitative risk analysis is by using Monte Carlo Simulation. In Monte Carlo Simulation, uncertain inputs in a model are represented using ranges of possible values known as probability distributions (David, 2004). By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis. Common probability distributions includes normal distribution (bell curve), lognormal distribution (in which values are positively skewed, not symmetric like a normal distribution). The uniform distributions shows all values have an equal chance of occurring, in this distribution the analyst may simply defines the minimum and maximum values of the inputs. In triangular distribution (the analyst could defines the minimum, most likely and maximum crop yield values. Values around the most likely are more likely to occur.

In Monte Carlo Simulation model, the values are sampled at random from the input probability distributions many times. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Monte Carlo Simulation does this hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this way, Monte Carlo Simulation provides a much more comprehensive view of what may happen. It tells you not only what could happen, but how likely it is to happen (Qiu, 2001).

Monte Carlo Simulation model provides a number of advantages over deterministic model analysis:

- Probabilistic Results. Results show not only what could happen, but how likely each outcome is.
- Graphical Results. Because of the data a Monte Carlo simulation generates, it's easy to create graphs of different outcomes and their chances of occurrence. This is important for communicating findings to policy makers and other stakeholders.
- Sensitivity Analysis. With just a few cases, deterministic analysis makes it difficult to see which variables impact the outcome the most. In Monte Carlo simulation, it's easy to see which inputs had the biggest effect on bottom-line results.
- Scenario Analysis. In deterministic models, it's very difficult to model different combinations of values for different inputs to see the effects of

truly different scenarios. Using Monte Carlo simulation, analysts can see exactly which inputs had which values together when certain outcomes occurred. This is invaluable for pursuing further analysis.

- Correlation of Inputs. In Monte Carlo simulation, it's possible to model interdependent relationships between input variables. It's important for accuracy to represent how, in reality, when some factors goes up, others go up or down accordingly.

2.5 Risk and risk management definitions

Many definitions of 'risk' exist (Kelman 2003; Thywissen 2006). Risk is defined by the risk management standard AS/NZS 4360:2004 as (p. 4):

'The chance of something happening that will have an impact on objectives. A risk is often specified in terms of an event or circumstance and the consequences that may flow from it. Risk is measured in terms of a combination of the consequences of an event and their likelihood.'

'Likelihood' describes how often a risk and hazard is likely to occur and is commonly referred to as the probability or frequency of an event. 'Consequence' describes the effect or impact of a risk and hazard on a community. Both likelihood and consequence may be expressed using either descriptive words (i.e. qualitative measures) or numerical values (i.e. quantitative measures) to communicate the magnitude of the potential impact (AS/NZS 4360:2004).

In Agriculture According to White (1994), agronomists and engineers (for instance Nash and Nash, 1995) tend to define risk as a loss, while economists tend to use the word as a synonym of "probability of occurrence of a damaging event".

Even supposed experts use the term 'risk' in several different ways, these differences cause considerable confusion especially when systematic efforts are made to measure risk and to evaluate it. Among many usages of the word, three common interpretations are:

1. The chance of a bad outcome;
2. The variability of outcomes; and
3. Uncertainty of outcomes.

Although seemingly similar, these three definitions imply quite different ways of measuring risk. Moreover, when formally defined they can be seen to be mutually inconsistent. It will be argued here that, while the first two meanings are in common usage, clarity is best served by defining risk, at least for formal analyses, as the uncertainty of outcomes.

2.6 Risks in public sector projects

While risk aversion at the individual level is well documented, the question of whether or not government institutions should be risk-neutral has been the subject of controversy. Should risk be considered in the analysis of agricultural infrastructure and public sector projects?

It has been argued that although individuals are risk-averse, governments should take a risk-neutral stance because, given that project benefits and costs are spread over a large number of individuals in the society, the risk faced by each one is negligible. This implies that governments should be indifferent between a high-risk and a low-risk project provided that the two have the same expected net present value (Arrow and Lind, 1970).

This argument is valid only up to a point. The reality of developing countries suggests otherwise. Governmental decisions should be based on the opportunity cost to society of the resources invested in the project and on the loss of economic assets, functions, and products. In view of the responsibility vested in the public sector for the administration of scarce resources, and considering issues such as water resources, livestock and a wide range of other socio-economic, agro-ecological, and political concerns (such as in Najed project), governments should not be risk-neutral.

The investment of the government in Najd Agriculture Development Project aims to encourage private sector to invest in the project and improve farming activities at Al-Batinah and Salalah costal area through stopping the cultivation of Rhodes Grass and maintains underground water recharge and maintain socio-economic and agro-ecological sustain in Al-Batinah and Salalah regions.

2.7 Risk and uncertainty in agriculture

Many definitions are used in different studies for the terms uncertainty and risk, and the distinction between them dates back to Knight (1921). According to Knight’s explanation, risk refers a situation in which mathematical probabilities can be assigned to a random event. In contrast, uncertainty exists in a situation where randomness cannot be measured and probabilities cannot be assigned. The distinction between risk and uncertainty, however, is not always possible in usual farm planning due to the limited time period for the estimation of income distributions or subjective assessment of probabilities assigned by farmers (Hazell and Norton, 1986).

Risk in agriculture is multidimensional and may include separately or simultaneously production, market, institutional, socio-economic relationship as well as human risk (Hardaker et al., 2004; McConnell and Dillon, 2002). The main sources of production risk include unpredictable weather conditions or underground water availability for irrigation, or the impact on production of unpredicted natural factors such as pests and diseases or other unexpected events. Market risks usually result from unpredictable input and output prices which are caused by variations in production and supply. Institutional regulations and political relationship could cause risk result from unexpected policy and macroeconomic changes, or changes in contact agreements. Hardaker (2000) distinguishes the human risk separately from other risk types, and defines human risk as a risk associated with farmers or farm workers, accidents in agricultural activities, such as using machinery, and improper input application including irrigation water.

Different potential sources and types of risk are numerous and vary depending on geographic location, as well as on the socioeconomic environment. Due to an infinite number of possible risks, studies often focus on an isolated risk and exclude other potentially relevant risk sources. McConnell and Dillon (1997), two pioneers in the field of agricultural risk management, argued that the most important forms of risk come from the natural environment and markets due to the high dependency of agricultural production on agro-ecological conditions. Unpredictable weather conditions, underground water availability for irrigation, pests and diseases all create instability in terms of yields, therefore rendering agriculture a risky business. Price, yield and resource uncertainty within agricultural systems are thus considered as the main stochastic variables in most of the studies dealing with risk in agriculture (Anderson, 1979).

Variations in temperature, humidity, moisture or water availability and other growth factors may cause annual yield fluctuations, thereby creating income instability. Similarly, income is vulnerable to local and world market prices. Decision making on farm activities therefore becomes more difficult under uncertainty.

The major risk in agricultural companies is the knowledge loss at the end of the project and resulting organizational data loss (Dikmen et al, 2005). Tah and Carr (2000) clearly state that the success of a project is dependent on the extent, to which the risks that affect it can be measured, understood, reported, communicated and allocated accordingly. On projects in a stable business environment, uncertainty is high at the time of the project conceptualization and will be lowered with proactive planning and efficient decision making (cited Jaafari, 2001). However, complex projects and changing conditions in the business environment forces companies and farmers to focus on a continuous investigation of project variables and re-evaluation of the status of objective function (Drummond, 1999). The variation on the project variables and agricultural inputs will cause changes on uncertainties exposed to risks. New risks can be encountered due to this fuzziness. Strategic decision making procedures foreseen in the early stages of the project can be subjected to change in time. Against this background of complexity and uncertainty the challenge is to pursue project objectives earnestly and to look for opportunities to further improve the project's base value (Jaafari, 2001).

The architecture for Risk Analysis Management for Project (RAMP) follows a more complex multilevel breakdown structure. The top-level processes within this structure are process launch, risk review, risk management and process closedown. The lower-level processes break these down further. All approaches to risk management emphasize the need to identify risk sources at the outset. This involves determining what risks may be present and classifying them appropriately.

Cooper and Chapman (1987) chose to classify agricultural risks by their nature and magnitude, categorizing the risks into two major groups: primary and secondary. Tah et al. (1994) used a risk breakdown structure according to their origin and their impact location within the project. External risks are those which are relatively uncontrollable, including inflation, currency exchange rate fluctuations, policy and legislative changes. Because of their uncontrollable nature, there is a need for the continual scanning and forecasting of these risks and for the development of a company strategy for managing and controlling the effects of external forces.

Internal risks are relatively more controllable and will vary between projects. Examples of internal risks include resource availability, experience in the type of work, the location of the project, and the conditions of contract. Internal risks have been separated into two subgroups: global risks, which affect the project itself and cannot be associated with individual tasks or work packages; and local risks, which affect individual work packages within a project.

2.8 Risk and uncertainty and crop yield

Framers and producers of field crops are confronted with relatively high production risk compared to industrial manufacturers. Risk and uncertainty in crop yields face danger from several sources.

First, production of most crops often takes several months and yield is highly sensitive to many uncontrollable factors such as water resources availability, weather, pests and diseases. Second, varying crop management practices that can be controlled by farmers – adoption of new production techniques (irrigation techniques), new input (for example, fertilizer) application level, timing of input application, and choice of varieties – is likely to result in high yield volatility. In addition, human and asset risks such as illness or death of a farm operator, loss or damage to the farm machinery and livestock may have significant impacts on crop yields.

Yield risk for a given crop can differ systematically over space and farm location due to changing agro-ecological conditions, mainly climate and soil type. Studies by Economic Research Service (ERS), USDA found that corn yield volatility (which often measured by coefficient of variation (CV) indicator) tends to be lowest in irrigated areas where climate and soils are ideal for corn production. It is typically higher outside the Corn Belt and in areas where corn acreage tends to be low.

A wide array of risk management tools and strategies are available for managing farm income risk which stems from yield and price risks, such as crop insurance, forward contracts, futures options and crop diversification. Accurate characterizations of farm level yield distributions, especially their lower tails, are important to many parties including farmers, insurance companies, banks and lenders and the Government.

They are necessary for government to encourage farmers to make sensible risk-management decisions, for insurance companies in Oman to provide crop insurance and to precisely rate insurance premiums, and for lenders and the government to devise and provide farm risk management products and forming appropriate agricultural policies. In chapter 4 and 5 of this thesis, more discussion will be given to water and crop yield distribution and risk management tools.

Modeling and estimation of farm-level crop yield distributions is difficult for several reasons. First, historical farm yield data are not available for long time at most 20 years and generally much less (Ker and Coble), which makes it difficult to estimate yield probability density function (PDF). Most studies resorted to county level or higher levels of aggregate time series data that cover longer time periods, which may lead to improper representation of farm-level yield distributions. Yield volatility is likely to be lower at the county, district, state and national levels than at the individual farm level due to the averaging effect over the region of aggregation. Farm-level yield risk can be seriously underestimated with county-level or higher levels of data. Second, time-series crop yield data are usually found to be not stationary, i.e., they are not the outcome of the same data generating process. Potential upward trend and increase in yield variance over time further complicates the estimation of yield PDF. Third, it has been recognized that crop yields may not be normally distributed in the relevant production range. However, there is little theoretical guidance regarding the most appropriate representation for the shape of the crop yield distribution.

2.9 Risk and decision criteria in farming and project investment

Risk Management is a process of systematically identification, analysis and response to risk items. The aim of this process is to minimize the impacts of risks on projects objectives by elimination or sharing of risks. The agricultural industry is considered to be more risky basically because of nature of the product, agriculture projects. The number of involved parties in a project, determinants of demand and the vulnerability of environmental conditions to changes are considered as factors defining the risks in agricultural industry.

By using a discount rate that allows for risk، investment decision criteria normally used in deterministic analysis maintain their validity and comparability. The expected value of the probability distribution of NPV calculated and generated using the same discount rate as the one used in conventional appraisal is a summary indicator of the project worth which is directly comparable and similar to the NPV figure arrived at in the deterministic appraisal of the same project. Through the expected value of the NPV distribution therefore the decision criteria of investment appraisal still maintain their applicability.

However, because risk analysis presents the decision maker with an additional aspect of the project -such as environment objectives, the risk and return profile – the investment decision may be revised accordingly. The final decision is therefore subjective and rests to a large extent on the investor's and project goals.

In dealing with governmental and societal attitudes toward natural hazards, planners can benefit from multicriteria analysis or, as it is sometimes called, multiple conflicting objectives analysis. This method has been used in environmental assessments and is gaining increasing acceptance for the incorporation of societal goals and priorities into the selection of investment projects.

Multicriteria analysis entails the establishment of a set of objectives and a subset of attributes representing alternative social, economic, political, and environmental goals which are to be fulfilled by specific projects such as Najd Agricultural Development Project. The relevant social groups (government, interest groups, community leaders, etc.) participate in establishing the objectives and attributes and placing discriminatory weights on them. Projects can then be evaluated in terms of their capacity to fulfill the stated goal. If the establishment of the objectives and attributes is properly oriented, risk analysis criteria should be introduced into the analysis along with the other goals (Vira and Haimes, 1983; Haimes et al., 1978; Keeney and Raiffa, 1976).

It is important to remember that regardless of the methods used in project evaluation, it is not planners but decision-makers who will ultimately rule on public investment options. Multicriteria analysis forces decision-makers to state their evaluation criteria explicitly. While most decision-makers will give low vulnerability a high priority in project selection for economic or political reasons, risk analysis should always be considered in the final decision especially if this risk will contribute to the project failure in (such as ground water availability for agricultural project).

Multicriteria analysis can be applied throughout the project cycle, from the profile stage to the feasibility study, but since it is effective in the early identification of more desirable projects and project components, its use at the beginning stages of project planning maximizes its benefits.

Stochastic dominance could be one of the main methods of ordering risky alternatives (choices, prospects) when the preference function is unknown. Only limited information is required about the preference of the decision maker, and is mainly restricted to risk preferences (Hardaker et al., 2004). In this method, alternative risky activities are compared in terms of full distribution of outcomes and the comparison is done at each risk point along the distributions. Several stochastic dominance criteria can be derived depending on the assumptions about risk preference of the decision maker; these include first, second and third-degree stochastic dominance.

First-degree stochastic dominance (FSD) assumes that the decision maker has positive marginal utility, where the preference function is an increasing function of returns (monotonically increasing) (Bawa, 1975). In this case, the decision maker behaves rationally and seeks to maximize his own utility by selecting the activity with the highest payoffs.

The expected utility approach is the most used decision rule in economics is the principle of expected utility (the Bernoulli principle) (Hazell and Norton, 1986). According to the expected utility theory, developed by Von Neuman and Morgenstern (1944), the decision maker prefers the activity with the highest expected utility among the risky alternatives.

While stochastic dominance and the expected utility approach can be used for ordering risky choices in the farm planning process, the mathematical programming approach is used in cases where too many alternatives exist. Mathematical programming may be required as it is able to support a whole-farm planning process. A stochastic efficiency models were used to compare the NPV under different scenarios combinations of risk management strategies. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives for decision makers with different risk aversion preferences (Hardaker et al. 2004b).

Finally Differing Meanings of Risk can be quoted as :

Even though Krimsky and Plough (1988) highlight that the topic of risk can be established as far back as to the Babylonians of 3200 B.C., today it is still exceptionally difficult to pinpoint a straightforward definition of risk. David Garland (2002), provides an interesting overview:

Today's accounts of risk are remarkable for their multiplicity and for the variety of senses they give to the term.

Risk is a calculation. Risk is a commodity. Risk is a capital. Risk is a technique of government. Risk is objective and scientifically knowable. Risk is subjective and socially constructed. Risk is a problem, a threat, a source of insecurity. Risk is a pleasure, a thrill, a source of profit and freedom. Risk is the means whereby we colonize and control the future. 'Risk society' is our late modern world spinning out of control. (p.1)

From :
A Risk Perception Primer: A Narrative Research Review of the Risk Perception Literature in Behavioral Accounting and Behavioral Finance
By: Victor Ricciardi -Golden Gate University
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Chapter Three

Agricultural Activities in Oman

CHAPTER 3
AGRICULTURAL ACTIVITIES IN OMAN

3.1. Introduction

The Sultanate of Oman located at the eastern corner of the Arabian Peninsula, stretching more than 1700 km from the Strait of Hormuz in the north to the frontiers of Yemen in the south. The Musandam peninsula, the most northern point of Oman is separated from the rest of the country by Fujaira, which is one of the United Arab Emirates (Fig. 1). The country is located between latitudes 16° 40'N and 26° 20'N and longitude 51°E and 59° 40'E. It occupies total area of about 309,500 sq. km, of which mountains, deserts and coastal plains represent 16%, 81% and 3%, respectively. It can be divided into the following physiographic regions, (i). the whole coastal plain- the most important parts are the Batinah Plain in the north, which is the principal agricultural area, and the Salalah Plain in the south; (ii). the mountain ranges- that run in the north close to the Batinah Plain is the Al-Jabal Al-Akhdar with a peak at 3,000 meters and in the extreme southern part of the country, with peaks from 1,000 to 2,000 meters and (iii). The interior regions- which lay between the coastal plain and the mountains in the north and south consist of several plains with elevations not exceeding 500 meters.

The climate in Oman varies from arid in the interior regions, to humid in coastal areas to tropical in the southern parts of the country with a temperature ranges from below zero (in Al-Jabal Al-Akhdar and Al-Jabal Shams) to 50°C in summer in the desert. The average annual rainfall is about 100 mm, mostly distributed between November and February, except in the Dhofar region where there is monsoon rainfall (200-250 mm) during kharif (July-September) period.

3.2. Agricultural activities in Oman

Oman has two main agro-climatic zones based on parameters which influence potential of the main resources such as land resources, water resources and cropping patterns. Northern Oman climate zone including Batinah Coastal plain, Interior Oman and Dhahira plains, Al-Jabal Al-Akhdar and Sharqiya plains and Southern Oman climate zone includes Dhofar Region which include Salalah plain, Dhofar Jabal and Najed.

Northern Oman climatic zone :

Batinah Coastal Area

By far the most important agricultural area in Oman is the Batinah region. It is a low-lying alluvial plain extending for about 240 km from Muscat to the borders with U.A.E., and extending about 30 km inland from the coast. It is located between the Hajar mountain ranges and the Gulf of Oman. The Batinah region occupies almost 60% of the agricultural production area and has witnessed dynamic agricultural development in recent years. Crop production depends entirely on irrigation, the main crops being dates, fruit crops, alfalfa, vegetables, and other forage crops such as maze, sorghum and Rhodes grass crop.

The climate of the Batinah region is characterized generally by high temperatures reaching 48oC in the summer and mild temperatures ranging from 15oC to 24oC in the winter. Relative humidity may reach over 90%. Daily wind runs are comparatively short and mean annual rainfall ranges from 76 to100 mm. Over pumping of water in the last couple of decades, has led to gradual seawater intrusion causing irrigation water more saline. As a result, several agricultural lands of the coastal areas have become unsuitable for cultivation and Government recently implemented a new water policy.

The Batinah region can be visualized as divided by the main highway to U.A.E. into two subzones, namely one extending from the main highway to the coast (the coastal sub-zone) and the other extending to the west (the inland sub-zone). Although climate-wise these two sub-zones are indistinguishable, differences exist in microclimate, quality of irrigation water, cropping pattern and the age of plantations. The inland sub-zone has developed more recently and modern systems of irrigation are in use. The coastal sub-zone includes old date plantations of low productivity because of salinity. They are usually intercropped with other tree and forage crops. The plant genetic resources for food and agriculture (PGRFA) diversity within these two sub-zones may have been affected due to changes in the quality of irrigation water.

Interior Oman and Dhahira plains

The interior plains lie within the inner foothills of the Hajar mountain ranges and constitute a transitional range classified either as the mountain region or the interior lowlands. They include Buraimi plain, Ibri, Wadi Quriyat, Bahla and Nizwa. The main crop in this zone is dates occupying 9463.2 ha (MAF, 2005*). Intercropping with fruit trees is practiced but not to the extent of that in the Batinah. In order of importance, alfalfa follows date cultivations with

5.6% of the cultivated land, (38368.1 ha) (MAF, 2005*). The climate of this zone is characterized by high temperatures during summer. Somewhat lower humidity prevails as compared to that in the Batinah coastal plain. The development of the ground water resources of the interior plains and the wadi region has been achieved either through the traditional falaj system or through wells. Nearly 20% of the total area under irrigation is served by the falaj system and 74% by wells (Agricultural Census, 2013). The range of farm size irrigated from wells is 0.5 to 3.0 ha. Water is pumped in a small distribution reservoir from where it is channeled to the fields through cement canals. Farmers in the interior plain practice basin or border irrigation. The quality of water of the interior plains varies extensively. Most falaj water is generally of good quality.

Al-Jabal Al-Akhdar or Saiq Plateau

Al-Jabal Al-Akhdar reaches an altitude of 3000 m. It constitutes a unique climatic zone as compared to any other region of the Sultanate. It is characterized by lower winter temperatures, which satisfy the chilling requirements of number of temperate deciduous fruit and nut trees such as pomegranates, peaches, apricots, apples, pears, walnuts and almonds. The summer temperatures average 30oC. Annual rainfall (300 mm) is significantly higher than elsewhere in Oman, with the exception of Dhofar Jabal, and it is distributed throughout the year.

Figure (1) : Sultanate of Oman Map :

Sharqiya Plains

In wadi Al Batha, agriculture is concentrated around Ibra, Ad-Dariz, Al-Ghabbi and Al- Wafi. The area under crops is about 1500 ha in 26 oases irrigated mainly by falaj system. The Sur plains seem to have a very limited potential for development due to sea water intrusion. In contrast, the Wadi Batha plain seems to offer best potential for agriculture because of the existence of highly suitable soils associated with good quality groundwater in the Jalaan district around Al-Kamil and Al-Wafi. Irrigation in this region is achieved by falaj systems. Private farms employ flood or furrow irrigation methods.

Southern Oman climatic zone :

The southern region occupies approximately one third of the area of the Sultanate. Apart from the coastal plain extending from Raysut in the west past Salalah, the woody hills reach up to 1500 m elevation behind the plain constitute a separate climatic zone. The southern slopes of the hills known as the ‘Jabal’ are rather steep, deeply incised narrow wadis, and receive southern monsoon rains. The northern slopes called ‘Najed’ are much gentle and the wadis dissecting them are wider and less deeply incised.

Salalah Plain

Salalah plain is located in the coastal area of the southern province of Dhofar. Dhofar is the only region in Oman to benefit from a substantial amount of rainfall from the southern monsoon Kharif. The average annual rainfall is about 110 mm but can range from about 70 to 360 mm. July-August is normally the ‘Wet’ period. Ground water derived from aquifers in the central part of plain is of good quality. Some of the spring water is utilized by falaj to provide irrigation water for parts of the plain. Recharge is by underflow from the mountains and from the springs. Irrigation practices and methods are similar to those employed in the Batinah. Modern irrigation techniques are in operation in large commercial farms mainly for the production of forage crops such as Rhodes grass.

Dhofar Jabal

The Jabal mountain ranges compose a separate agro-climatic zone of their own. Rainfall is particularly high, ranging from 600 mm to 700 mm, the highest as compared to any other area in the country, supporting a permanent vegetation cover. The rainfed pasture land is concentrated on some half a million hectares on the Jabals- Qara and Qamar. The Dhofar Jabal maintains two thirds of the total cattle and one third of the total goat populations in the Sultanate.

Najed Area

In contrast to the Jabal and the coastal plain, in Najed, there is a quick decrease in precipitation and moisture marked by a rapid transition from the grasslands and savannah-type vegetation found on the Jabal. Temperature is higher in Najed as compared to the plain and the southern slopes. Rainfall in Najed is only in traces. The region is characterized by an extensive carbonate aquifer. Water quality is generally poor and soils are structure less, of poor fertility and highly permeable. Although the agricultural potential of these areas is limited, investigations have identified suitable areas of Najed with potential for agricultural development. The Ministry of Regional Municipalities and Water Resources (MRMWR) and The Ministry of Agriculture and Fisheries (MAF) recommended three locations at Najed to grow Rhodes Grass crop with a potential and reasonable production.

3.3 Agricultural land classification and desertification in Oman

Agricultural lands in Oman estimated by the soil survey of MAF revealed that out of the total area of the country amounting to 30.95 million hectares only 2.223 million hectares are suitable for agricultural activities or about 8% of the country area (see Table 1). However, the total cultivated area in 2011 was 75,947 hectares only due to water resources un-availability, and desertification problems.

Table (1) Total land and soil suitable for agricultural activities in Oman:-

Land Class	Area in Ha	Area in %
Class S1 (Highly to moderately suitable)	791,651	2.56%
Class S2 (Marginally suitable)	1,431,406	4.62%
Total suitable land	**2,223,057**	**7.18%**
Total unsuitable land	28,726,409	92.82%
Total land	**30,950,000**	**100%**

(source: MAF 1990 , modified 2004).

Desertification Problems in Oman

Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variation and human activities.

Desertification is the man-made process of the degradation of land so that it loses its capacity to provide economic returns under cultivation or grazing.

In other words, desertification leads to the increase of the deserted area and the decrease of the fertile and productive land.

The process has been recognized internationally as a world-wide problem since the United Nations Conference on Desertification held in Nairobi, Kenya in 1977. Accordingly, desertification commonly appears as the deterioration of land, water and other natural resources under ecological stress. Deterioration implies that activities in an area have been unsuitable, either in degree or in kind. Such activities may have been pursued because of lack of environmental knowledge or experience, because alternatives were lacking or, in an attempt to maximize short-term gain at the expense of long-term productivity. Education, social and economic advancement and the adjustment of population growth to the development resources are the key elements responsible for initiation of desertification for successfully combating it. In the Sultanate of Oman, desertification could be attributed mainly to physical factors and socio-economic factors.

Physical factors causing desertification in Oman

Physical factors leading to desertification in the Sultanate of Oman are mainly:

- The climate in Oman is characterized by low and erratic rainfall over most parts of the country and high temperatures as well. The country occasionally is hit by storms leading to sand drifts, desert encroachment and soil erosion.
- Water scarcity makes it by far the most critical resource in Oman at present and in future. The way water is being used at present does not give the impression that water scarcity is appreciated. Water misuse is happening everywhere, especially in the agricultural sector. Over-exploited aquifer through thousands of wells supplied with diesel pumps has led to severe salinization of the cultivated lands in Batinah and salalah Plains. Now available information, however, is available about the area of salinized lands, but one should consider the magnitude of this problem as over 57% of the cropped area of Oman is located in Batinah Plain.
- Over-abstraction of groundwater leads to salinization of water as a direct consequence to sea water intrusion in the coastal plains i.e. Batinah and salalah which worsens the situation. Changes of salt concentration in irrigation water need to be monitored so as to outline the magnitude of the problem. Exact information about the dynamics of the aquifers in the different regions of Oman need to be generated.

- Sand drifting represents serious problems especially over areas adjacent to Wahiba Sands and in the plains and wadis of Dakhliya, Wusta and Janubiya Regions.
- Type of agriculture practiced is characterized mainly with very large numbers of small farm holdings (1 farm about 1 ha each) cultivated to low yielding varieties, under-fertilized and over-irrigated traditional crops. The small holdings prevent farm mechanization which along with the low yield increases the cost of production. Productivity of crops is evaluated according to unit area (feddan or hectare) and neglecting the productivity of irrigation water used, which is given zero value. Soil fertility is expected to deteriorate after successive cultivation following single or double crop rotation system. The rate of mineral fertilizers applied is very low. This worsens the situation of soil fertility. The absence of organic manuring of soils with high rate of organic matter decomposition in Oman will indeed reduce the level of soil fertility.
- Overgrazing has become the general trend everywhere in Oman. This is true for the rangelands with low carrying capacity as in Wahiba Sands and for the forests of Dhofar Mountains in the Southern Region where two thirds of Oman's cattle graze. Increasing demand for red meat and milk products as a direct result of both the increase of population and the rapid improvement of the living standard of the Omanis during the last three decades has encouraged pastoralists to raise larger numbers of cattle, sheep and camels. This was much beyond the carrying capacities of the rangelands grazed. Desertification processes i.e. deterioration of vegetation composition and biomass productivity of rangelands were accelerated by providing pastoralists with subsidized feed. This encouraged pastoralists to keep larger numbers of animals. Increasing the availability of surface fresh water for the watering of livestock disturbed the balance between animals and plants, which existed for many generations .The current desertification in Dhofar Mountains is due to heavy over-stocking, little application of rangeland management practices, and significant deterioration in rangeland quality and productivity.

Socio-economic factors causing desertification in Oman

Due to limited data of Oman population, their distribution according to sex, age, trend of growth, labor force and their distribution according to area of activity, the evaluation of socio-economic factors affecting desertification processes in Oman is difficult. However, the following are the socio-economic factors that contribute to the desertification process in Oman :

- The type of farming in Oman which is characterized by very small holdings (about one hectare and less) operated traditionally becomes profitable only when cultivated to high water consuming corps i.e. vegetables and forage crops (alfalfa). It is quite evident that the type of farming is of crucial importance to Oman. Modern farming leading to reduction of water use (sprinkle and drip irrigation) to increase yields and hence leading to increased net profitability of agricultural lands can help combat desertification causes by traditional subsistence farming. The improvement will need however skilled labor, active extension service, financial supporting system and organized marketing of products.
- Employment in agriculture represents one of the major constraints for agricultural development. The number of Omanis employed in agriculture is unknown, however it was felt that young Omanis show unwillingness to work in agriculture because agricultural work is not a prestige, required hard working conditions and needs a long day work, and lower money reward as compared to governmental and other jobs.
- The number of foreign agricultural labors has therefore increased in recent years and many of them had no experience before. After one or two years training they usually return to their home countries. The continuity of acquired agricultural techniques is not sustainable unless Omanis get attracted to agricultural work.
- The zero value of water has encouraged farmers to the extent of overusing this scarce resource. This overuse has contributed to increasing salinization.

In addition of that the government decided to combat deterioration of rangelands of the Southern Region (Dhofar Region) through the destocking program in 1984 to protect national resource from overgrazing. Encouraged subsidized purchase of old Dhofari animals to reduce their numbers has, on the contrary, stimulated the livestock holders to increase the number of animals for higher prices and/ or profits. Al-Khuthairi (1992) found that the number of animals has nearly doubled (98% increase) within 6 years of applying this policy (1983-1989) The number of camel decreased by 12% while the number of goats remain unchanged high during the same period (see livestock population Table). In 2000, the number of cows, sheep and goats decreased while the number of camels increased as compared to the numbers in 1989. However, in 2004 the government approved another destocking program to reduce camel number by 35,000.

3.4 Livestock population and fodder crop demand

Rhodes grass and Alfalfa are the main fodder crops cultivated in Oman. It is cultivated and periodically cut and dried to sell as a fodder. The content of moisture in the green grass is 70-80%. The drying hay is carried out to give longer shelf life and to reduce transportation cost. The dried hay contents moisture levels of around 12-15%. Rhodes grass is grown for local consumption for animal like cows, camels, sheep and goats.

To estimate the fodder crop required to feed livestock in the country, we should know forage land available for grazing and the total forage needed to feed total livestock population (Feed demand). The animal unit (AU) concept is the most widely used way to determine the carrying capacity of grazing animals on rangelands. The AU provides us with the approximate amount of forage a 1000 lb cow with calf will eat in one year.

Table (2) Annual fodder requirement of animal based on AU Equivalent :-

Animal	Animal Unit	Fodder /ton	Ton/annum
Camels	1.00	3.2	3.20
Cows	0.70	3.2	2.24
Sheep	0.20	3.2	0.64
Goats	0.16	3.2	0.51

(source: FAO Report 2007, Oman).

It was standardized to the 1000 lb cow with calf when they were the most prevalent on rangeland. This AU was established to be 800 lbs of forage on a dry weight basis (not green weight). All other animals were then converted to an "Animal Unit Equivalent" of this cow. For example, a mature sheep has an Animal Unit Equivalent of 0.20, and 0.16 for a goat. The annual feed required for one animal unit is 3.2 tons. The above table shows annual fodder requirement of animal.

The total demand for fodder crop in Oman has a direct relation to the animal population of the country. The Ministry of Agriculture and Fisheries statistics for livestock population in 2011 is used as the basis for calculation demand for fodder crop in Oman.

However, Al-hag Bakhit et al. in 2007 (Country Pasture/Forage Resource Profiles –FAO Report 2007 – Oman) estimated the total feed requirement of about 1,455 Million tons and the deficit of feed of about 1,167 Million tons considering annual Animal Unit requirement of 2.2 ton per year.

Table (3) Livestock population trend (2001-2013) and fodder crop demand

Year	Cows	Camels	Sheep	Goats	Total AU	Demand/tons
2001	298783	121020	342483	978816	555275	1776881
2002	303265	122835	352757	1008180	566981	1814339
2003	307814	124678	363340	1038426	578964	1852684
2004	312431	91548	374240	1069579	556230	1779937
2005	317117	92921	385468	1101666	568263	1818443
2006	321874	94315	397032	1134716	580588	1857881
2007	326702	95730	408943	1168757	593211	1898275
2008	331603	97166	421211	1203820	606141	1939651
2009	336577	98623	433847	1239935	619386	1982035
2010	341625	100103	446863	1277133	632954	2025453
2011	339436	132151	396362	1753502	729589	2334685
2012	346225	134794	408253	1806107	747779	2392893
2013	359507	242832	548231	2085206	937766	3000851

(Source: calculated by Author).

Figure (2) : Livestock population (2001-2014) :

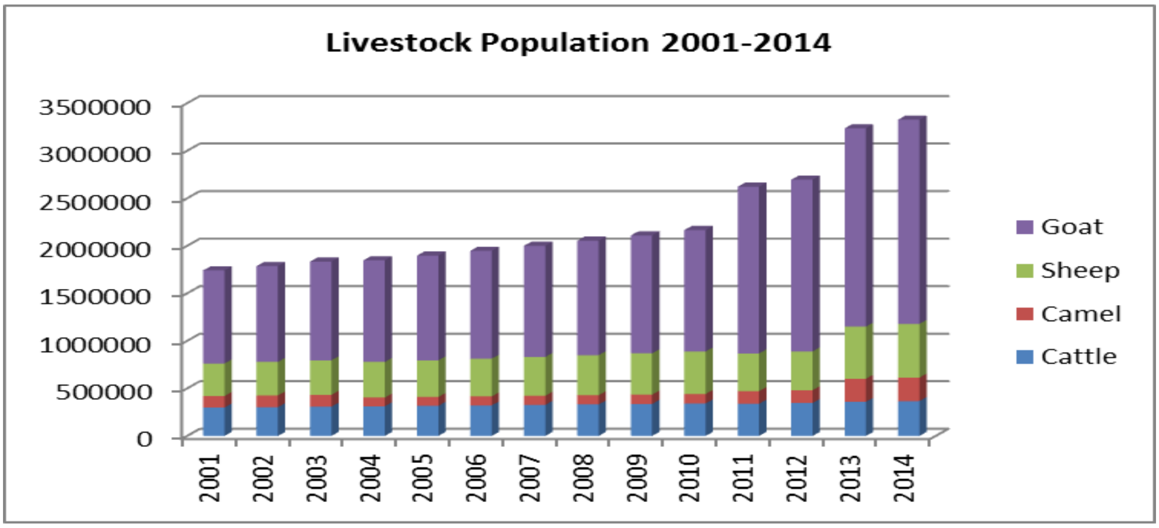


Figure (3) : Feed Demand, production and Gap (2001-2014) :

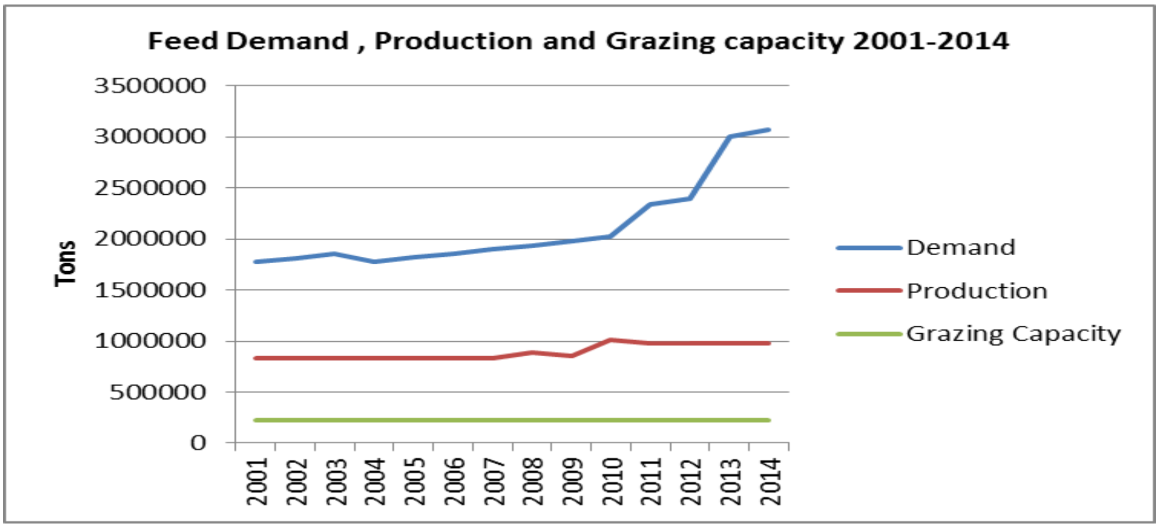


Table (4) Fodder crop demand, supply and gap per tons (2005-2014) :-

Year	Demand /tons	Fodder production	Grazing Capacity	Fodder gap
2005	1818443	610378	222000	986,065
2006	1857881	610378	222000	1,025,503
2007	1898275	610378	222000	1,065,897
2008	1939651	662539	222000	1,055,112
2009	1982035	630483	222000	1,129,552
2010	2025453	793718	222000	1,009,735
2011	2334685	755602	222000	1,357,083
2012	2392893	755602	222000	1,415,291
2013	3000851	755602	222000	2,023,249
2014	3075053	755602	222000	2,097,451

(Source: calculated by Author).

3.5 Cropping pattern and agricultural land allocation

The cropping pattern has been determined by socio-economical and physical factors such as water salinity and availability of irrigation waters. The results of statistics and detailed soil surveys carried out by the Ministry of Agriculture indicated the presence of more than 2.3 million hectares of arable land in the Sultanate. However, the size of the cultivated area is in fact 76,764 hectares (MAF, 2013*). Over half the agricultural area is located in the Batinah Plain in the north, which represents about 3% of the area of the country. Seasonal fruit crops occupy the first rank of the total cultivated area in Oman with 39,080 hectares of which 112,565 hectares are with date palm. The second cropped area is fodder crop with a total area of 20,481 hectares and field crop of 10,093 hectares and vegetables crops of 6,292 hectares. Rhodes grass cultivated area increased from 7,291 hectares in 2005 to 11,909 hectares in 2013. Alfalfa and Rhodes grass represent 8% of the total cultivated area in Oman. However, this may be explained by the relatively high profit from fodder crops. Cultivated area and crop production trend shows in (Table 1 & 2). In 2013 groundwater is used to irrigate about 68 thousand hectare cultivated to fruit trees including date palms (51%), vegetable crops (8%), fodder crops (23%), field crops (12%) and other crops (6%). The cultivated area is watered by wells is about 52,000 hectares, the remaining is irrigated by Aflaj and springs. The Falaj comprises a channel leading from the water source to the irrigation system. Qanat Al falaj (the channel) is fed by the water table and exploit the groundwater resource.

Table (5) Cultivated area in Oman in feddans 2008-2013 :-

Crops/year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Vegetables	14,163	14,720	18,517	14,982	14,152	27,574
Field crops	16,286	33,729	14,615	24,030	22,891	13,337
Fodder crops	40,219	38,628	48,607	48,764	43,216	48,750
Fruit crops	88,257	88,257	91,316	93,049	93,049	73,443
Total	158,924	175,334	173,054	180,825	173,307	163,103

*Ministry of Agriculture and Fisheries 2014.

It is apparent that there is an increase in agricultural production in 2011 as compared to previous years and the date palm occupies first in both area (31,348 ha) and production (268,011 tons). Date palm represents 80% of the total area planted with fruits followed by banana, mango, Omani lime, Omani coconuts. Al-Batinah region leads first in the cultivation of vegetables that cover highest of 79% of the area as compared to other regions. Besides, there are also other plant genetic resources such as indigenous grasses, medicinal plants, pastures, trees and shrubs, and forest resources.

Table (6) Crop production trend in Oman in tones 2008-2013 :-

	2008	**2009**	**2010**	**2011**	**2012**	**2013**
Vegetables	141,095	192,133	271,754	202,447	193,072	313,441
Field crops	24,576	48,448	42,672	56,395	46,037	28,140
Fodder crops	662,539	630,483	793,718	755,602	610,378	28,140
Fruit crops	327,625	319,880	365,508	362,112	312,065	35,278
Total	1,155,835	1,190,944	1,473,653	1,386,556	1,078,101	1,484,068

*Ministry of Agriculture and Fisheries 2014.

Farming systems include production of crops such as dates and fruits, vegetables, fodder and field crops, as well as livestock such as cattle, sheep, goats, and poultry. Farm holdings vary from less than 0.4 ha to more than 84 ha. Those less than 1.26 ha are about 11% of total farm holdings; those range between 1.26 to 2.60 ha are 65%, while those greater than 12.6 ha are about 23.8%.

Water plays a significant role in the development of Agriculture in Oman, which is largely dependent on groundwater. There are numbers of afalaj (falaj-singular), springs (oasis) and wells that provide the source of water for agriculture since ancient times. Recently, desalinized and treated waste-water also form non-conventional sources of water.

Figure (4) : Cropping Pattern 2005-2013 :

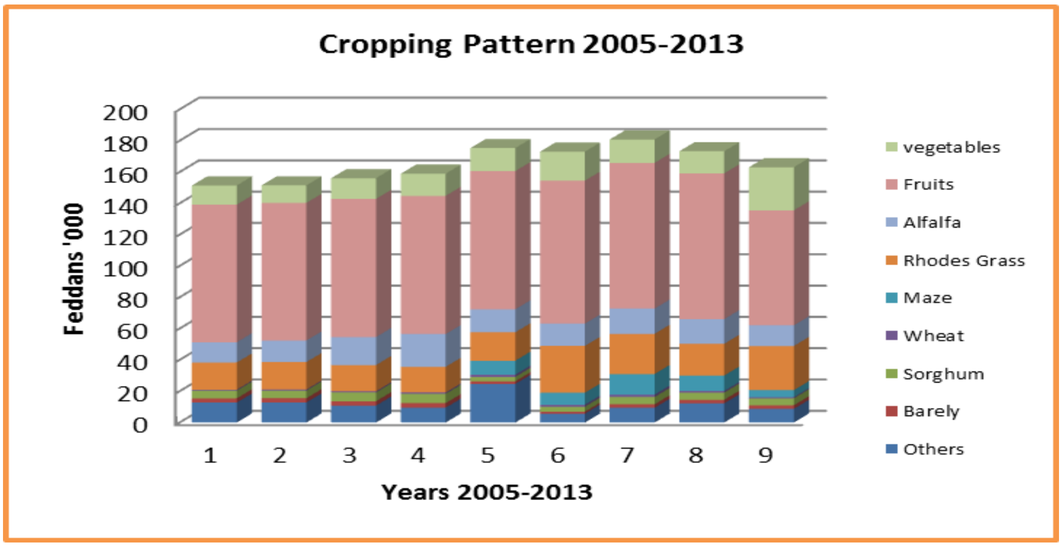
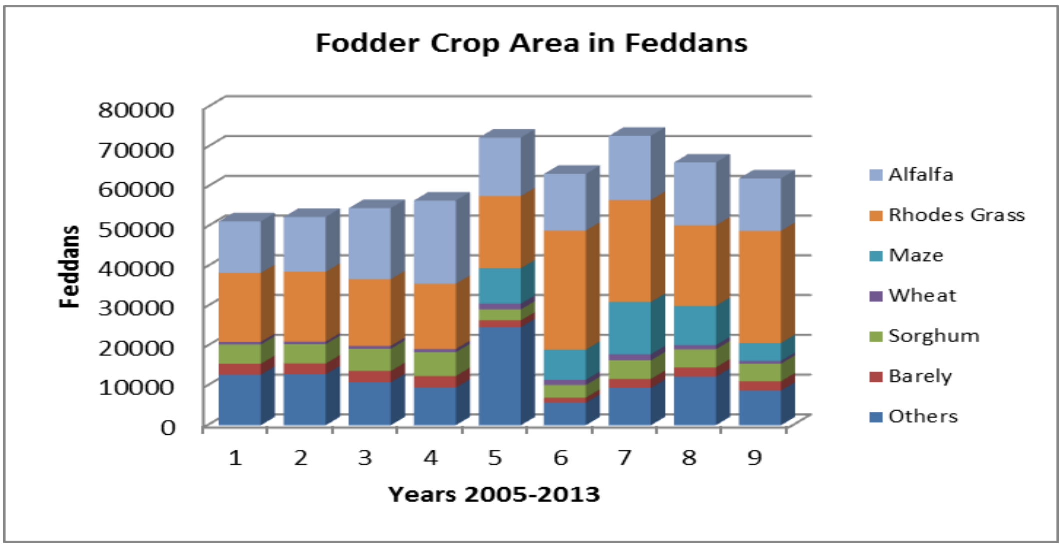


Figure (5) : Fodder Crop Area :



Sultanate of Oman is known for its distinctive irrigation systems of springs known as afalaj (falaj singular), which are one of the most important and oldest irrigation techniques established by the ancient Omanis thousands of years ago which is a vital part of the heritage of Oman. There are about 3,108 live falaj out of total 4,112 which contribute 404 million cubic meters of water to agriculture as per (MRMEWR). Most of the oases are used for irrigation through afalaj. The afalaj located near or adjacent to the stream wadis are often affected by water erosion.

Wells and springs play an important role in the life of the Omani society and are used to provide water to the population and farms for agriculture. There are 130,000 wells providing 720 million cubic meters of water needs of agriculture in the Sultanate. The government has established mega-projects for the maintenance and renovation and repair of wells and springs to reduce loss of water and increase the efficiency of irrigation for agricultural purposes. There are laws and regulations by the government to prevent indiscriminate drilling of water wells.

3.6 Identification of social-economic and ecological problems

Until early seventies the agricultural system in Al-Batinah and Salalah plains was called "The coastal Oasis" type. Oasis were located in low lying areas where regular floods from the mountains allowed considerable recharges as well as the leaching of salts from the soils. Dikes were used to improve the infiltration of floods. The farmer in choosing a location of his farm has to make a compromise between water depth and water salinity. With increasing distance from sea the ground water is sweeter and deeper. A deeper water table was a major drawback since lifting devices pulled by animals were used to extract irrigation water from the shallow dug wells. This type of irrigation system could only allow minimal water abstraction in most areas where aquifer recharge exceeded water abstraction.

Since the oil boom and the start of modernization of the country in early eighties a rapid expansion of the cultivation area took place. The availability of modern pumps made it possible to irrigate more land and created a large deficit in the aquifer recharge which is still compensated by sea water intrusion. This resulted in a considerable increase in ground water salinity and influence crop yield and production.

Moreover, the animal population of Oman had increased because of the requirement of dairy and meat products to support the increased population. Another reason was also the increased number of people taking to animal husbandry as a means of gainful employment. The development of the petroleum resources and the renaissance under the wise leadership of His Majesty Sultan Qaboos over the last three decades of the millennium gave great boost to the requirement of dairy and meat products for a more prosperous society putting pressure on the fodder requirements.

Agricultural farmers and landowners in the Al-Batinah and Salalah plains exploiting the good ground water resources took to wide scale cultivation of Rhodes Grass which is easy to grow and crop can be taken out at least six times a year. The excessive use of the precious freshwater has led to ingression of salinity in the area. This poses a grave threat to 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 concerned ministries apprised His Majesty of the situation and His concern for the environment is also reflected in the policy of the Government on fodder cultivation in Oman. It is decided by the Government to gradually stop the cultivation of fodder in Al-Batinah and Salalah plains and at the same time develop substitute areas in the Najed to meet the fodder requirement.

The 9th Gulf Water Conference organized in Muscat at 22-25 March 2010 by the Water Science and Technology Association and Oman Government the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) under title of "Water sustainability in GCC countries - The Need for a Socio-Economic and Environmental Definition" outline that the imbalance between supply and demand of water resources are mainly due to the lack of policies and strategies for managing water resources and the lack of an integrated approaches and supported by appropriate institutional structures and effective legislative framework in GCC countries. The Conference outline the most important challenges points facing GCC countries as under :

- Continuous reduction in per capita availability of fresh water in the region, increase competition on water resources by consuming sectors and deteriorate water quality.
- The increase in water requirement for population and food production and exceeding the GCC countries capacity in developing their water resources.
- The inadequate and inefficient water planning and management.

The conference urges GCC countries to consider the following recommendations: Implementation of national water strategies based on the principles of integrated water resources management in terms of economics efficiency, social equity and environmental sustainability.

- Setting compatible agricultural policies in line with the capacity of available traditional and non-conventional water resources.
- Design national plans and programs for the optimum utilization of water resources.

3.7 Water resources policy in Oman

Planning for development, especially in the agricultural sector, is based on availability of additional water resources. These resources could be: Surplus water in some regions due to rationalization of present uses; savings due to rationalization of present uses; new groundwater sources explored; and extensive use of TSE or recharge to groundwater.

Calculations made by JICA in (1990) indicated that there are few groundwater resources available for development (as shown in below table). General trends of regional balance of groundwater were, according to JICA (1990), as follows:

- Batinah Region indicated serious over drafting of groundwater amounting to 201.4 Mm3 per year over the available groundwater recharge (557.1 Mm³/year) or about 36% over drafting. The over drafting is mainly seen in salinization areas;
- Dhahira Region is reasonably balanced of 1.5 Mm³ ;
- Dakhiliya Region shows 14.4Mm³/year over drafting or about 9% of the rechargeable groundwater.
- Sharqiya Region is shown to have a positive balance amounting to 2401 Mm³/year of about 10.4% of the rechargeable groundwater; and
- Salalah Region (Dhofar region) is shown to also have a positive balance of 91.0 Mm³ per year. This is a considerable additional water resource, although salinization has unfortunately occurred in the central Salalah plains.

The regional assessments made by MRE are also presented in a map indicating the availability of groundwater to support additional agricultural development. In the late nineteen ninety (MRMEWR) published the balance status of water as presented in Table (7) to illustrate the water recharge, demand, and balance and to indicate the size of water problem.

Table (7) Water resources, demands and balance by region, status 1989 (Mm3/year)

Region	GW Recharges	Ground Water Demand			GW Balance
	Mm³	Agriculture	Domestic	Total Mm³	Mm³
N. Batinah	240.2	321.3	0.0	321.3	-81.1
S. Batinah	316.9	428.5	8.7	437.2	-120.3
Dhahira	136.6	134.5	0.6	135.1	+1.5
Dakhliya	157.4	168.6	3.2	171.8	-14.4
Sharqiya	232.0	206.8	1.1	207.9	+24.1
Musandam	30.0	13.4	0.2	13.6	+16.4
Dhofar	126.7	35.7	0.0	35.7	+91.0
Total	1,239.8	1,308.8	13.8	1,322.6	-82.8

*FAO Report Groundwater management in Oman 2009.

Assessment of water balance in Oman in 2000 revealed water deficits being 247 Mm^3 / year (annual water recharge (1,294 Mm^3) and total nationwide water use (1,217 Mm^3) (Master Plan, 2000). The suggested savings in irrigation water seems realistic as the present water consumption in Oman for irrigation growing crops in more than twice as much as the water requirements estimated for Northern Oman. Date palms receive 205 – 214% of the net water requirements. Alfalfa, the salt tolerant crop receives 175-207% and lime, as many other fruits in Oman, is irrigated with 206% of the required amounts of water. The surplus water applied is much beyond the leaching requirements of salts, usually about 25% of the water requirements. Tomato was the only crop with reasonable excess of water, only 41% over the water requirements. Probably this was due to the winter growth season. The Ministry of Regional Municipalities and Water Resources (MRMWR) expected water deficit to be (-606 Mm^3) in 2020.

Table (8) Water resources, demands and balance status in Mm^3/year (1990 - 2020)

Year	Ground Water	Recharge Water	Total Supply	Water Demand			Water Balance
				Agriculture	Domestic	Total	
1990	899	41	949	1152	73	1225	-285
1995	949	50	999	1152	156	1308	-309
2000	1004	100	1104	1250	185	1435	-331
2009*	1004	263	1267	1487	158	1645	-378
2020	1004	100	1104	1250	460	1710	-606

*FAO Report Groundwater management in Oman 2009.

Sultanate of Oman suffers from water scarcity with annual water deficit of as much as 387 million cubic meters. Recently, the Government of Oman is making efforts towards rationalization of water consumption, exploration of new water resources and recharging of barriers and dams and desalination of seawater and utilization of tertiary treated wastewater mostly in agriculture. Dams form another important source of water in the Sultanate. There are as many as 31 groundwater recharge dams which capture estimated 997 million cubic meters of water which is equivalent to 78% of the total annual amount of recharge groundwater in the Sultanate (1,295 million cubic meters), since their inception. In addition, there are surface storage dams, which are important sources of stored water at the time of floods flowing through wadis from the mountains. The Government of Oman has so far established 61 surface storage dams in its various regions with a total storage capacity of about 13,709 million cubic meters. In addition, the government has constructed 14 more dams- 11 in Muscat and 3 in Musandam, to protect especially against the risk of flooding.

In early 1970's, the development proceed and spread throughout the country using the same limited resources. The demand increases to meet the agricultural, industrial, commercial, and residential requirements. Water resources are faced by new challenges, represented by increased demand, pollution, low agricultural returns compared to water use, depletion of groundwater, reduction in aflaj flow, and saline water intrusion. To carry out its aim of planning a long-term strategy to develop the water resources of the Sultanate, the Ministry of regional municipalities, environment & Water Resources have completed a National Water Resources Master Plan that allowed a long term vision of this valuable resource. The National Water Resources Master Plan formed to meet the national goals of the vision 2020 and achieve the following goals :

- Balance water use and renewable resources
- Conservation of water resources
- Sustainable development of water resources
- Private sector participation in water resources projects
- Increase food security
- Economic diversification
- Employment and increase productivity

The water resources strategy implemented by (MRMEWR) considered the supply and demand management through :

- Resource Assessment and monitoring.
- Water harvesting.
- Well Permitting.
- Resource Augmentation through building dams.
- Aflaj Maintenance.
- Protection Zones - Well field Protection Zones.
- Conservation - Studies.
- Public Awareness Campaign.
- Conserving water use in agriculture through modem management methods.
- Emphasizing demand management for water.
- Emphasizing water supply management through water re-use, water harvesting and water transfer.

The current use of water in many areas where wells are used for agricultural purposes is unsustainable and agricultural production is being adversely affected. As a result, the Ministry of Agriculture and Fisheries (MAF) and (MRMEWR) formed new policies to improve situation through the following management of agricultural water demand.

- Improve irrigation systems to save water through small investments to provide simple water control structures and some channel lining in the distribution systems and irrigation infrastructure and by improving application efficiencies and water scheduling. Support activities training of farmers to improve water management through extension services will also be required.
- Introduce abstraction control through the introduction of water quotas, linked to well licenses and accompanied by well metering, monitoring and possible administration of penalties or fines for over abstraction (30 Lit/Second).
- Change cropping pattern, by extension services, taxes and market support for specific crops and crop area prohibition (MAF decision 25/2005).
- Crop area restriction, there is a scope to reduce the water use in agriculture through the prohibition of high water using perennial crops, mainly Rhodes grass and alfalfa.
- Change land use, by re-zone or re-classify the present land use.

As per the above recommendation the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) 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. Moreover, the (MRMEWR) determined 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. Along with this policy the Government decided to stop cultivation of Rhodes Grass in Al-Batinah and Salalah plains.

As a policy, the Government decided to reduce and stop cultivation of higher water consumption crop of Rhodes Grass in a gradual manner in Al-Batinah and Salalah plains. A Ministerial Decree No 25/2005 is already in place and Rhodes Grass area above 50 feddans has been stopped and gradually area above 10 feddans would be abandoning. This new policy will reduce the areas and production under cultivation of Rhodes Grass substantially and in line of this to compensate the reduction in fodder supply it is proposed to establish fodder cultivation farm at Najed area at Dhofar region. Four locations were selected and recommended by the consultant are (i) Hanfeet (878 hectares) (ii) Dawkha (770 hectares) (iii) Wadi Bani Khawater (770 hectares) (iv) Dimeet (330 hectares). The project will be implemented in phases through a joint stock private company and would cost RO 22.839 Million.

The Government decided to support and pay for external infrastructure like power supply and main road up to the farm gate. The Government also decided to grant for drilling and construction of water wells, installation of pump sets, internal roads and farm fencing. The total Government grant would be to the tune of RO 11.26 Million (RO 9.96 Million for farmers eligible on abandoning cultivation area under Rhodes Grass and RO 1.30 Million for Najed community).

3.8 Rhodes Grass crop water requirements

Crop water requirement is defined by FAO as “The depth of water needed to meet the water loss through evapotranspiration (ETC) of a disease free crop growing in large field under non restricting soil conditions to achieve potential production”. It is determined by climate, crop characteristics, local condition and agricultural practices.

Crop water requirement for different crops calculated in Agricultural Research Center at Ramais (South Al-Batinah) through many researches to identify crop factor (KC) from field experiments. The Radiation, Penmen and Pan Evaporation method are used to estimate crop evapotranspiration (ETC). The annual water requirement was calculated in as per the following equation :

$$ETC = ETO \times KC \times NA$$

- ETC is annual crop water requirement in (mm)
- ETO is evapotranspiration in (mm)
- KC is a crop factor calculated from research and field experiment.
- NA is total crop area

The annual Rhodes Grass crop water requirement for 1 square meter at ARC at Ramais is (2463) Lit/Year and for 1 hectare is equal :

2463 Lit/year X 10,000 Meters = 24,630,000 Lit/Year = 24,630 Mm^3/Year

Rhodes Grass crop water requirement calculated for different regions in Oman through Agricultural Research Center at Ramais (South Al-Batinah) according to evapotranspiration in each rejoin. South Al-Batinah has been taken as a reference value with (100%) value. The below table shows the Evapotranspiration Conversion Factor for each rejoin compared to South Al-Batinah :

Table (9) Evapotranspiration for each region compared to South Al-Batinah

No	Rejoin	Evapotranspiration % (Conversion Factor)
1	South Al-Batinah (ARC)	100
2	North Al-Batinah	85
3	Interior Oman	109
4	Al-Dhahira	111
5	Al-Sharqiya	125
6	Salalah plain	83
7	Thamrait & Najed Area	137

*Crop water requirement manual (Prof. Abd Al-Mohsin Al-Nadi, et al. -2001).

Crop water requirement for Rhodes Grass crop are calculated for deferent climate Zone in Oman through the following equation :

$$A = B \text{ X } C$$

Where :

A = water requirement at any rejoin.
B = water requirement at ARC at Ramais (South Al-Batinah).
C = Conversion Factor

From the above equation, we can obtain crop water requirement for Rhodes Grass crop at project area at Najed as :

$$24{,}630 \text{ Mm}^3\text{/Year X } 137\% = 33{,}743 \text{ Mm}^3$$

However, the (MRMEWR) and the consultant of the project (Al Baraka Economic Consultancy) calculated the total crop water requirement for Rhodes Grass crop at project area at Najed as 32083Mm^3 only with 5% less water requirement, which will affect the crop yield and project profitability. The irrigation system and pump flows at 30 Lits/Second are designed to apply a maximum of 12.2mm at 20 effective hours per day per hectare with peak requirement in June – August of 4450mm/annum. However, the pumps installed by contractor at Hanfeet (Phase one of the project) has a less capacity than the proposed ones which will also reduce the water flow needed to irrigate the Rhodes Grass plant. All these risk factors will be incorporated in the analysis.

Table (10) Monthly Rhodes Grass water requirement for sq. meter /mm :-

Month	S. Batinah	N. Batinah	Interior	Al-Sharqiya	Salalah	Najed
Jan	107	90	118	134	89	147
Feb	115	98	127	144	95	158
March	160	136	176	200	133	219
April	230	196	253	288	191	315
May	253	215	278	316	210	347
Jun	282	240	310	353	234	386
Jul	301	256	331	376	250	412
Aug	282	240	310	353	234	386
Sept	243	207	267	304	202	333
Oct	211	179	232	264	175	289
Nov	170	145	187	213	141	233
Dec	109	93	120	136	90	149
Total	2,463	2,096	2,709	3,081	2,044	3,374

*Crop Water Requirement Manual (Prof. Abd Al-Mohsin H. Al-Nadi et al. -2001).

3.9 Crop-water production function

We have estimated a crop-water production function that establishes the relationship between crop yield and water applied to Rhodes Grass crop. The crop-water production function is linear in the deficit irrigation section because all the applied water is used for evapotranspiration, and the production function is equal to the evapotranspiration production function.

Nevertheless, non-linear responses indicate that not all water is used by the crop, since some goes to deep drainage and the evapotranspiration production function is really a production function. The function becomes curvilinear as more of the applied water goes to deep drainage. Generally, a curvilinear function is expressed as a second order polynomial (Al-Jamal, 2000). This function is not unique and varies among crops and zones.

The signs and magnitude of the marginal effects indicate the effect of a particular input variable Xi over the crop yield. In this case, the coefficients of the model have to be interpreted as semi-elasticities because the model presents a semilogarithmic transformation. The interpretation is that semi-elasticity is responsible for the percent increase of yields produced by a unit change in the input variable.

Monte Carlo Simulations, yield water response

A yield production function can be estimated using data from field experiments, key informant interviews, expert knowledge, and empirical estimations. A sufficient number of observations for each input level, however, may not be available from the methods above (Effects of irrigation on the yield and water-use efficiency of Rhodes Grass (Chloris Gayana) in Batinah Region- Agricultural and Livestock Research, Annual Report 2007). Furthermore where farm level water measures are not developed, no precise information is available on the exact amount of water applied to achieve certain yields. In the case of too few observations or missing observations, stochastic simulation techniques can be a good method for establishing stochastic crop yield input response functions (Berg, 1998). For example, the Monte Carlo method is one such technique used for solving certain problems based on repeated random simulations.

The influence of irrigation water supply dominates yield response in irrigated agriculture. In Batinah region – research station showed that irrigation water availability is the most limiting factor to agricultural production in the region. Therefore, this study concentrates mainly on yield variance associated with water use levels and farm profitability. Water application is considered as the only controllable input, while other inputs, such as fertilizers, are not controlled by state order.

Data Analysis

To characterize the model we use research information from the paper (Effects of irrigation on the yield and water-use efficiency of Rhodes Grass (Chloris Gayana) in Batinah Region- Agricultural and Livestock Research, Annual Report 2007) An experiment research conducted to study the effect of different irrigation water applications on the Rhodes grass yield. The study tested four irrigation levels based on evaporation from class A pan (1.6 Ep, 1.2 Ep, 0.8 Ep and 0.4 Ep) on the yield and water use efficiency.

The results showed that Rhodes grass irrigation by 1.6 Ep produced highest dry mater yield of Rhodes grass with lower water use efficiency whereas irrigation by 0.4 Ep produced lower yield but higher water use efficiency. The results also showed that dry mater yield of Rhodes grass was reduced by 24.9% as the irrigation water was decreased 47.2% from actual water consumption, but it was increased by 4.9% and 12.7 % when irrigation water was increased by 49.8 % and 98.1 respectively. However, the effect of water reduction by 25% on Najed Project profitability is tested in model (3-4) and (5-6) in chapter 4 of this study with a probability of 10%, 30% and 50%.

The monthly water requirements calculated and maximum water consumption of Rhodes grass was in Jun-July periods when it reached 10.0 mm/day and minimum was 3.0 mm/day in Dec-Jan. Table (11) shows monthly water requirement at Batinah Region whereas Table (12) shows monthly water requirement at Najd area.

Rhodes Grass crop water requirement at Najed area is 137% of the crop water requirement at Batinah region. From scientific and research publication mention above and the above figures crop yield distribution was obtained. In defining the possible yield values and their probabilities for the stochastic values the program @Risk's functions "Fit distribution" and "Define distribution" have been used.

Table (11) Water requirement and application of 0.6, 1.2 and 1.6 at Batinah Region:

Month	m3/ha/day	m3/ha/month	m3/ha/year	0.8	1.2	1.6
Jan	3.30	102.30	1227.6	982.08	1473.12	1964.16
Feb	3.90	113.10	1357.2	1085.76	1628.64	2171.52
Mar	5.80	179.80	2157.6	1726.08	2589.12	3452.16
Apr	7.00	210.00	2520	2016	3024	4032
May	8.00	248.00	2976	2380.8	3571.2	4761.6
Jun	7.90	237.00	2844	2275.2	3412.8	4550.4
Jul	7.00	217.00	2604	2083.2	3124.8	4166.4
Aug	6.60	204.60	2455.2	1964.16	2946.24	3928.32
Sep	6.10	183.00	2196	1756.8	2635.2	3513.6
Oct	5.20	161.20	1934.4	1547.52	2321.28	3095.04
Nov	3.80	114.00	1368	1094.4	1641.6	2188.8
Dec	2.90	89.90	1078.8	863.04	1294.56	1726.08
Total	**67.5**	**2059.90**	**24718.8**	**19775.04**	**29662.56**	**39550.08**

(Source: calculated by Author).

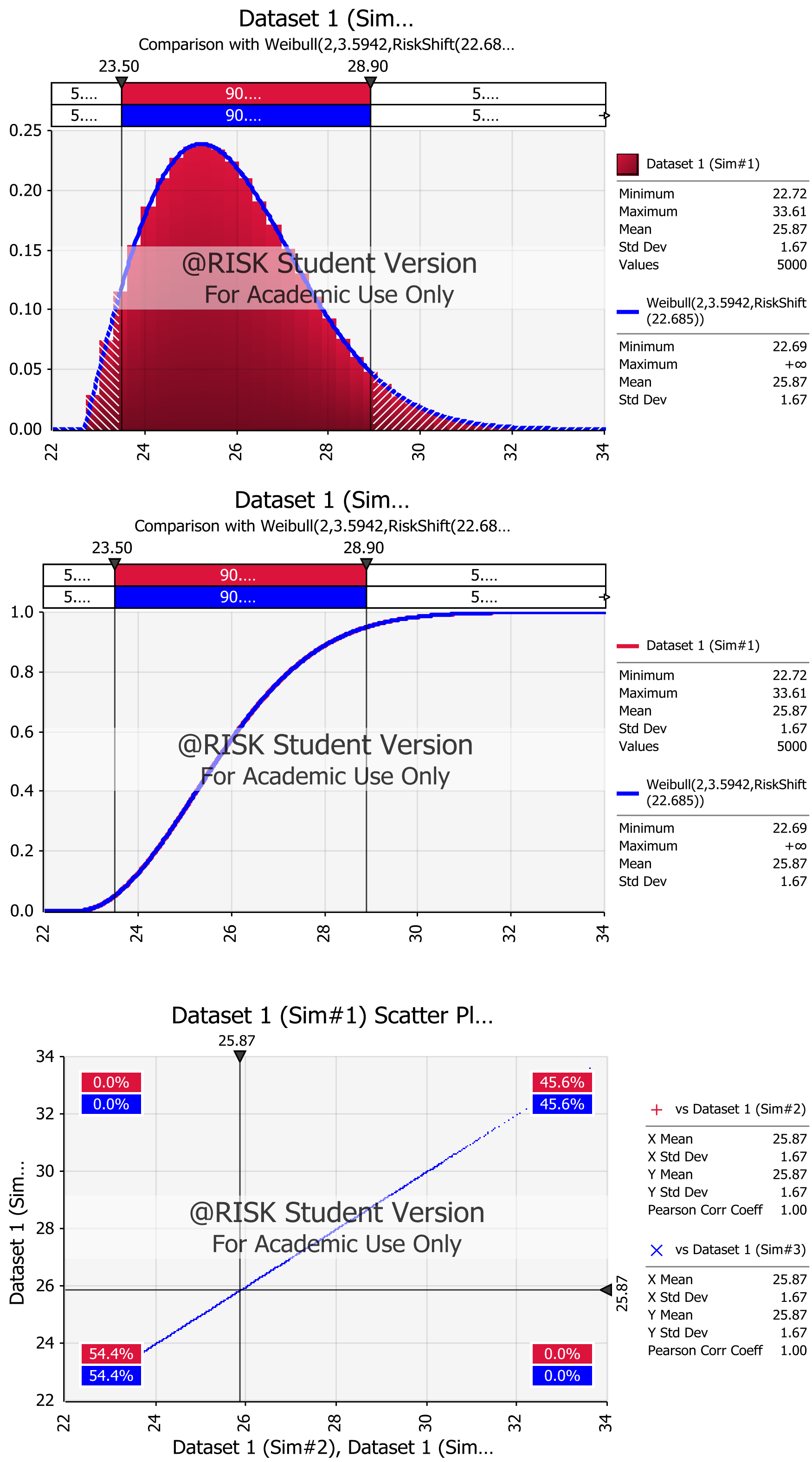
Table (12) Water requirement and application of 0.6, 1.2 and 1.6 at Najed Region:

Yield/ton				**46.5**	**48.8**	**52.4**
Month	**m3/ha/day**	**m3/ha/month**	**m3/ha/year**	**0.8**	**1.2**	**1.6**
Jan	4.74	147	1764	1345.45	2018.17	2690.90
Feb	5.45	158	1896	1487.49	2231.24	2974.98
Mar	7.06	219	2628	2364.73	3547.09	4729.46
Apr	10.50	315	3780	2761.92	4142.88	5523.84
May	11.19	347	4164	3261.70	4892.54	6523.39
Jun	12.87	386	4632	3117.02	4675.54	6234.05
Jul	13.29	412	4944	2853.98	4280.98	5707.97
Aug	12.45	386	4632	2690.90	4036.35	5381.80
Sep	11.10	333	3996	2406.82	3610.22	4813.63
Oct	9.32	289	3468	2120.10	3180.15	4240.20
Nov	7.77	233	2796	1499.33	2248.99	2998.66
Dec	4.81	149	1788	1182.36	1773.55	2364.73
Total	**110.55**	**3,374**	**40488**	**27091.80**	**40637.71**	**54183.61**

(Source: calculated by Author).

The expected loss of crop yield due to water shortage is estimated using best fit distribution command at @Risk Program. For the annual production the lowest value was set to 22.7 ton and the highest was defined as 33.6 ton. The (Weibull) distribution type is performed and generate the below graphs. The probability distribution for the stochastic variable "Annual crop yield" is generated for use in the model. The model run results provides data which are used to estimate inputs parameters in Model 5 and 6 to calculate the effect of water shortage on NPV and IRR.

Figure (6) : BestFit Rhodes Grass probability crop yield distribution Model outputs :-



3.10 Risk of water resources deficit in Najed Project profitability

The new water resources policy introduced recently at Najed project area cased many problems which can be summarized as under :

- The total project area Najed project is about 11,400 hectares and the planted area is 2,418 hectares constitute 21% of the total project area. This as per the requirements of the (MRMEWR) and the need to keep (10000 Meter) between wells, which leads to higher capital and operating costs. The financial capital and operation cost effect on profit will be calculated and presented in chapter 4 and 5.

- Due to the limited underground water in the region and (MRMEWR) restrictions and new water policy on the quantities of water withdrawn from wells, the project relied on the central pivot irrigation system cover only 22 hectares with 40 wells and 40 pump at Hanfiat area (878 hectares). This will increase the capital and operation cost. However, the central pivot system at Al-Batinah and Salalah plain could cover 50 hectares and needs 20 wells and 20 pumps only.

- Amount of water allowed by withdrawn as per (MRMEWR) should not exceed (81 million cubic meters) per year, less than the actual Crop Water Requirement of the plant which estimated at about (88 million cubic meters) per year. This will effect crop yield and reduce productivity per hectare or increase risk of drying wells in the future and reflect on project sustainability. The table blew shows the amount of water discharge authorized by (MRMEWR) and crop water requirement in million cubic meters per year. The figures in the table shows that the authorized water discharged is less than crop water requirement and that will affect Rhodes grass yield and project profitability. A detail analysis will be presented in chapter 4 and 5 of this thesis.

Table (13) Total Area, water discharge and Crop Water Requirement in Mm^3/ Year :-

Location	Cultivated area as (MRMEWR)	Authorized Water discharge Mm^3	Actual area	Water discharge in study Mm^3	CWR Mm^3
Hanfeet	958	31	878	28	31
Khawater	750	25	770	25	28
Dawkah	750	25	770	25	28
Total	**2458**	**81**	**2418**	**78**	**88**

(Source: calculated by Author).

- The technical feasibility study indicate the water extraction from wells should be 30 liters/sec only while the plant requirement needs pumping extraction of 40 liters/ sec to meet the CWR of the plant. Even if we take new water policy of (MRMEWR) (30 liters/sec) from well, the pumps should operate more than 22 hours / day which is not possible. Time is required for maintenance and pump should stop working at mid-day due to high temperature at desert.

- The efficiency of wells productions have been estimated through monitoring wells of the (MRMEWR) located at different area at Najed. However, the efficiency of wells at Hanfeet Area should be evaluated through well at the same area as monitoring well may not reflect the actual production of the wells at the project area.
- The expected productivity per hectare considered in technical study is high 35 tons/ha, especially with water restrictions (in terms of quantity and quality) in addition to the low temperatures at night in winter and height day temperature in the summer which will affect Rhodes grass growth. The productivity per hectare for local farms at the area range between (17 - 21 tons / ha) only. The risk MCS models take a triangle distribution ranges of (35, 30, 21) tons per hectares to test yield variation in the model.

- The technical study assumed low input of seeds and fertilizers which cannot get the productivity mentioned in the study 35 t / ha. The new input prices increased recently and this will affect project profitability. Risk analysis should incorporate inputs price increase and product sale price fluctuations.

- The relationship between the government and the partners are not clear, particularly with respect to project intensive and subsidy for beneficiary's (grant and soft government loans). The effect of project intensive on project profitability will be presented in chapter 5.

- The total project cultivated area (2418 ha) which assume to produce 84,630 tons (35 ton per hectar) is calculated based on total abandoned Rhodes Grass Farms at Al-Batinah plain (according to the Ministerial Decree 25/2005) equal of 2658 hectares. The project consultant did not take into account the areas of Rhodes Grass in Dhofar Region which is about 630 hectares (40 hectares of farms in Salalah plain in addition of 590 hectares of DCF Company). However, this will affect the estimation of demand and production of the fodder crop in Oman.

- Agricultural equipment in Najed Agricultural Development Project are less and needs to be increased as Desert farming required more and heavy duty equipment (number 3 four-wheel drive power of 100 hp) and grass tanker 2 each and grass collector 4 and Combine with 2 each project site. Where you cannot work with these equipment in the desert for a period of 20 hours.

- The cost irrigation system equipment (central axis) under estimated at RO 590 per Ha, where the actual costs increased to RO 900 per ha. However, (4 new pumps were replaced and additional cost of RO 62,000).

- Depreciation cost does not include pre expenses cost of RO 188,068 and contingency cost of RO 799,893.

- IRR of the project basis on total project costs RO 16.800 million is 10.5%, while the IRR reduced to 1.2% when it was recalculated on new capital cost of the project RO 22.839 million.

- NPV estimated of RO 2.6 million, while it reached (-2.57 million) when capital cost of the project increased to RO 22.839 million. B/C ratio of the project (0.83) only.

- Payback period after 7 years and increased to 9 years with new project capital cost.

- The capital cost of the project firstly estimated of RO 16.49 million. However, the capital cost increased to RO 22.839 million with 38% increase. Project cost overrun risk analysis should incorporate project cost overrun through Monte Carlo Simulation model analysis. Probabilistic analysis determines the risk of the total project by assigning a low, medium, and a high estimate to each project element, and computing the expected cost and variance of each element and of the total project. The Model will also combining risks from various sources and events using a simulation technique. In this way, the project contingency is determined with respect to a certain level of confidence that the actual cost will not exceed a given project cost estimated.

Chapter Four

Methodology and Empirical Model

CHAPTER 4
METHODOLOGY AND EMPIRICAL MODEL

This chapter gives a full description of data collection , methodology and mathematical programming model developed within this study. The methods of handling multidimensional risk in irrigated agriculture are presented. Incorporation of data on agro-ecological properties of the farms into mathematical programming is discussed. A description of the data sources used in the model is given.

4.1 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) :

- Historical data from Farmers in costal and new location area.
- Agricultural Research Center and JICA reports.
- 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.

4.2 Methodology :

The research will develop a project risk management tools model for risk analysis and risk assessment using data from existing scientific research publications, historical and cross section data in order to identify risky variables and improve risk assessment process and adoption of good water use policy. The new water policy will be evaluated under different underground water availability.

The different scenarios analyzed in this study are designed to improve our understanding of the potential economic and ecological impacts of different water policy measures. The simulations should improve our understanding of how farmers can increase their income and water use efficiency under the current as well as various future socio-economic and ecological situations, as well as identifying suitable risk reducing strategies.

The primary goal of this PhD is to develop enhanced methods for risk analysis to help decision-making in irrigation project management. Techniques for risk analysis have been theoretically established for a number of years and the most relevant to agriculture can be summarised as follows:

1. Sensitivity analysis.
2. Conventional project evaluation NPV and IRR
3. Probability analysis and Monte Carlo simulation.
4. Stochastic Efficiency with Respect to a Function (SERF) Analysis.

Three first techniques have been applied to evaluate Rhodes Grass Project at Najed area in different situations to different risk aversion degrees to compare project evaluation techniques and select the most appropriate techniques for risk analysis and water policy analysis.

Based on the viewpoints above, the present research focuses on risk analysis, emphasising water resources and financial risks in agriculture management, especially the quantitative aspects of risk analysis. A review of the treatment of risk and uncertainty in agriculture project management has been undertaken to identify the main areas of study and the overall objective of this investigation is to develop enhanced quantitative, probabilistic methods for risk analysis. The enhanced risk analysis methods can then be used to improve decision-making and encourage appropriate risk allocation, risk modification, mitigation or avoidance for highly uncertain investment projects.

This thesis aims to improve the understanding of current valuation practices for agriculture infrastructure developments. In particular, the thesis seeks to identify the optimal approach for the financial analysis of these projects, choosing between the following capital budgeting techniques: Net Present Value, Internal Rate of Return, and simulation Monte Carlo Analysis. The comparison will cover both the theoretical advantages and disadvantages of each approach as well as real-life implementation issues that may arise in a particular context. A stochastic efficiency model compares the NPVs under different scenarios and combinations of risk management strategies. Stochastic efficiency with respect to a function (SERF) is used to rank the risky alternatives for decision makers with different risk aversion preferences.

The primary goal of the PhD research is to test different techniques of risk and uncertainty analysis and enhanced methods for risk analysis to aid decision-making in project management. The research will also help to increase the level of understanding of how improvements in risk analysis can enhance the existing water policy and productivity of the project areas. The research will quantify the risk of implementation new water policy and calculate the additional capital and operation cost required to implement new water policy and the effect of these additional cost on Najed project profitability.

The study will investigate the hypothesis that NPV is inadequate for the evaluation of projects in uncertain environments and present the optimum way to evaluate investment decision-making under risk and uncertainty.
Typical enterprise budgets for Rhodes grass that are specific by MAF are constructed to generate net returns and NPV. Three budgets are prepared for Salalah Location, Hanfeet and Dawkah locations; one with government capital subsidy and one without government capital subsidy. Underground water level test also is also performed for each farm location.

This provides 12 enterprise budgets as alternatives to determine the most profitable enterprise and to rank the associated risk of each alternative. Average farm hectares in our model are fixed at 878 Ha. per farm according to the 2013 Census of Agriculture. The budgets assume no economies of size.

State level average annual producer price and yield of Rhodes grass for a period of 10 years were obtained from MAF Agriculture Statistics Department. However, the price is fixed by government of RO 1 for 10 KG ball.

4.3 Traditional project evaluation and risk analysis

Financial feasibility and project evaluation is the overall determination of whether the tangible value of project output will be sufficient to account for financial obligations such as interest of loans, operation and maintenance costs, and other such costs. Present and future cash flows of the project were calculated to measure financial feasibility of the project. The following few criteria were used to assess capital budgeting decisions in project investment and project planning.

1) **Net Present Value**

Net Present Value (NPV) is one of the oldest and best-known methods to rank financial feasibility of projects. It is also known as Discounted Cash Flow (DCF) method. For calculating the NPV, the annual difference between project benefits and costs is discounted back to the time at which NPV is being calculated and cumulatively added to a single sum. The highest NPV alternative is favored.

Net Present Value (NPV) is obtained by discounting both costs and revenues at a specified rate which is 12% (often the market rate of interest), and then subtracting the resulting present value of the cost stream from the present value of the revenue stream.

Alternatively, current expenditures can be subtracted from current receipts to give net revenue for each year. The net revenues are then discounted to the present and added. Ignoring risk (addressed later) it is financially acceptable to make any investment which results in a positive NPV. The mathematical equation shows as under.

The NPV value is an absolute measure of profitability. It can easily produce a high value simply because the investment is very large. This criterion does not measure the relative efficiency with which different size projects use resources. The result of NPV calculation for basic model run using conventional method showed a negative figure of (-2,570,705) Rial Omani.

$$NPV = (Ro - Co) + \frac{(R1 - C1)}{(1 + r)} + \frac{(R2 - C2)}{(1 + r)^2} + \ldots\ldots\ldots \frac{(Rn - Cn)}{(1 + r)^n}$$

$$\text{or } NPV = \sum_{t=0}^{t=n} \frac{Rt - Ct}{(1 + r)^t}$$

Where:	R	=	gross revenue
	C	=	gross cost
	R	=	discount rate expressed as a decimal
	T	=	time interval
0, 1, 2, 3, n		=	years of the project's life

This technique is mathematically and computationally simple but most importantly reduces financial and economic information about the project to a single value for the ease of decision-making. Table (14) summarizes some disadvantages of NPV by contrasting assumptions and realities.

Table (14) Disadvantages of NPV :-

Disadvantages of NPV (DCF) :	
NPV Assumption	**Realities**
Decisions are made now and cash flow streams are fixed for future.	Uncertainty and variability in future outcomes. Not all decisions are made today, as some may deferred to the future, when uncertainty resolves.
Once launched, all projects are passively managed.	Projects are usually actively managed throughout the project life-cycle, including check-points, decision options, budget constraints etc.
Future free cash flow streams are all highly predictable and deterministic.	It may be difficult to estimate future cash flows as they are usually stochastic and risky in nature.
Project discount rate used is the opportunity cost of capital, which is proportional to non-diversifiable risk.	There are multiple sources of business risk with different characteristics, and some are diversifiable across projects or time.
All risks are completely accounted for by the constant discount rate.	Project risk can change during the course of time.
All factors that could affect the outcome of the project are reflected in NPV.	Project complexity and so-called externalities make it difficult to quantify all factors in terms of incremental cash flows. Disrupted, unplanned outcomes can be significant and strategically important.
Unknown, intangible or immeasurable factors are valued at zero.	Many important benefits may be intangible assets or qualitative strategic positions.

Adapted from Mun [2002]

The fundamental flaw with NPV method is that it does not incorporate the risk of uncertainty by treating future cash flows in a deterministic manner. There is no definitive way to decide the discount rate to be used, so it is subject to question. Also NPV yields no information about the ratio of costs to benefits.

2) **Internal Rate of Return**

Internal Rate of Return (IRR) is that discount rate at which the net present value of the project is zero. Projects with an IRR higher (lower) than opportunity costs are accepted (rejected). The merit of this method is that it allows planners to determine financial feasibility of projects without having to choose a rate of discount as in DCF or NPV. The method has computational advantages when choosing between multiple projects with similar objectives. Apart from this, IRR suffers from all the flaws formerly noted in NPV in the above table.

Internal Rate of Return (IRR) is the discount rate which makes the present value of the cost stream equal to the present value of the revenue stream, or as is sometimes defined, the rate which reduces the discounted net profit to zero. To compute the IRR one solves the equation:

$$\sum_{t=0}^{t=n} \frac{Rt - Ct}{(1+r)^t}$$

In a riskless situation, it pays to invest if the IRR exceeds the rate of interest (or cost) at which capital can be borrowed or secured as equity to execute the project, or exceeds the rate (financial yield) that could be obtained from alternative investment opportunities, whichever of the two is higher. The IRR for the Basic rum model is 1.2%.

3) **Cost Benefit Analysis as decision making tool**

Since the 70's, Cost Benefit Analysis4 (CBA) has been the dominant decision support system adopted for economic and financial decision-making process involving large projects and infrestrusion projects [WCD 2000]. CBA estimates equivalent economic worth of a project costs and benefits to determine financial and economic feasibility [Fuquitt 1999].

Revenue/Cost Ratio (R/C) is obtained by dividing the (discounted) present value of the revenue stream by the present value of the cost stream. A variant of this criterion, the net revenue – cost ratio (NR/C), is obtained by dividing the present value of net revenues by the present value of costs. According to the revenue/cost ratio, a project is worth undertaking when the ratio is greater than one, the larger by which the ratio is greater than one, the larger the ratio, and the more efficient the project. Based on the net revenue/ cost ratio, a project is worthwhile when the ratio is positive. The B/C ratio of the project is (0.94) less than one which indicated that the project is not profitable.

Both the IRR and the revenue/cost ratio measure the efficiency with which resources are employed irrespective of the size of the investments. When projects are not mutually exclusive, ranking by efficiency will result in the largest overall financial gain. The revenue/cost ratio, however, is technically superior, since the IRR can give an incorrect result in special circumstances, i.e. multiple rates in the presence of a NPV function for which the stream of net revenues becomes negative more than once. The practical advantage of the IRR, and one that should not be ignored, is that (assuming it does give the correct result) it is more familiar to businessmen and administrators.

A common measure for expressing costs and benefits is chosen. The most convenient common unit is money. The monetary value of costs and benefits must be expressed in currency value at a particular time to account for time value of money and inflation. Time value of money implies that a Rial Omani or a dollar spent today is not equivalent to a dollar spent in the future. So, the net benefit of the projects is sum of present value of benefits less the present value of costs. The choice of discounting factor is not easy to justify. The most challenging aspect of CBA is quantifying all the intangible costs and benefits. The problem for using CBA can be summarized as under :

- All variables are not readily quantifiable: For instance displaced farmers have been known to suffer economic and cultural impoverishment, higher rate of sickness, malnutrition and deaths but these costs are not readily quantifiable [Morimoto 2001].
- All costs and benefits cannot be anticipated: For instance the construction of Dam led to change in the climatic pattern and silting of the downstream plains, thus affecting irrigation. These costs were completely unanticipated in the original CBA conducted by the Egyptian government to build Aswan Dam [Shibl 1971].
- Future uncertainty cannot be accounted for accurately: The estimated costs and benefits may change significantly. For instance the present cost of constructing Najed fodder project increased 1.5 times the initial estimates. Though construction delays are accounted for, the prolonged delay due to project finances delay.

Henceforth, the estimated costs (benefits) are higher (lower) than actual costs (benefits).

4) **Probabilistic Cost Benefit Analysis (CBA)**

All the methods presented so far disregard the risk of uncertainty. We can work and tackles uncertainty by way of probabilistic CBA. The use of probabilistic distributions for input parameters in CBA model and analyze the financial implications of implementing the Najed Project. The analysis reveals a potential outcome of constructing this proposed project. Using probabilistic distribution for input parameters allows computing a distribution of NPV. This captures more information about project feasibility than a single NPV value that is computed using the expected mean of input parameters. The model worked out by using Stochastic Mont Carlo Simulation Model to incorporate uncertainty and risk of variables such as product sale price, crop yield and cost of production per ton. The effect of underground water availability on crop yield will also be tested in these models.

Probabilities of the variables are used when considering future events with more than one possible outcome. In a given situation only one of these outcomes will occur but in advance we cannot say which. Such situations are called stochastic, as opposed to deterministic situations where the outcome is determined in advance. The probability of an event is a measure of the chance that it will occur and is measured as a value in the interval between 0 and 1. Something that is almost certain to happen has a probability close to 1, while an event that is extremely unlikely has a probability close 0. Probabilities are usually assessed and estimated by experience based data. In this model, we use normal and triangle distributions to predict variables future distributions.

4.4 Sensitivity analysis and risk factors identification

Project economic analysis tries to allow for existence of unknown future outcomes in the most basic sense by modeling the existence of uncertainty rather than dealing with risk.

Attempts to model the impact of uncertain outcomes and develop decision rules about what choices to make (for example, between different projects or alternative project designs) derive from the operations research (linear programming models) and game theoretic (von Neumann, Morgenstern) approaches of the 1960s and 1970s. In situations of different possible project alternatives and uncertain future events (“states of nature”), project would be chosen on the basis of various proposed criteria, according to decision-makers’ preferences. Such proposed criteria are:

a) Select the project or design alternative which yields the highest return, whatever the risk and “state of nature” obtains
b) Select projects or design alternatives which yield the best returns (e.g. the highest NPV) if the situation/”state of nature” turns out as badly as possible
c) Select the project which minimizes the maximum opportunity cost of having made a wrong choice by choosing s “state of nature” which does not in fact obtains.

It can be proven that such criteria are in fact all are irrational in different ways. The first criterion ignores uncertainty altogether, the second criterion assumes the risk “nature” to be as harmful as possible and the third criterion does away with normal assumptions about decision-makers’ preferences (because they are more concerned about minimizing losses than about maximizing returns).

The most used technique for describing uncertainty is sensitivity testing. In essence, it involves changing the value of one or more selected variables which affect the project’s costs or benefits and calculating the resultant change in the project’s NPV or IRR. There are recommended practices such as:

- Testing the effects of changes in aggregate project costs and benefits.
- Testing the effects of changes in individual underlying variables (irrigation water, crop yields, price of crop, operating costs of machinery in farming project).
- Testing variables one at a time, so as to be able to identify the ones with most impact on project NPV and IRR.
- Testing for delays in benefits or project implementation.
- Testing likely combinations of variables (especially if these may in practice be linked).
- Testing for changes in economic pricing adjustments (e.g. shadow wage rate factor, shadow exchange rate factor, standard conversion factor etc.) made by the analyst.

Sensitivity test calculates Switching Values (SVs) and Sensitivity Indicators (SIs):

1. **Switching Values** : Identify the percentage change in a variable for the project NPV to become zero (i.e. for the project decision to switch between accept or reject, average crop yields would have to fall by 20%); sometimes SVs are expressed in terms of the absolute value of a variable.

2. **Sensitivity Indicators**: Compare the percentage change in a variable (crop yield) with the percentage change in a measure of project worth (NPV or IRR).

The main benefit of sensitivity testing is that it leads to the identification of those variables to which a particular project design is most sensitive, and mitigating action can then be taken to minimize the consequences of such outcomes. Likely mitigating actions include changing Government policies, undertaking pilot projects, securing long-term supply contracts, increasing technical and financial assistance and training levels to support project implementation.

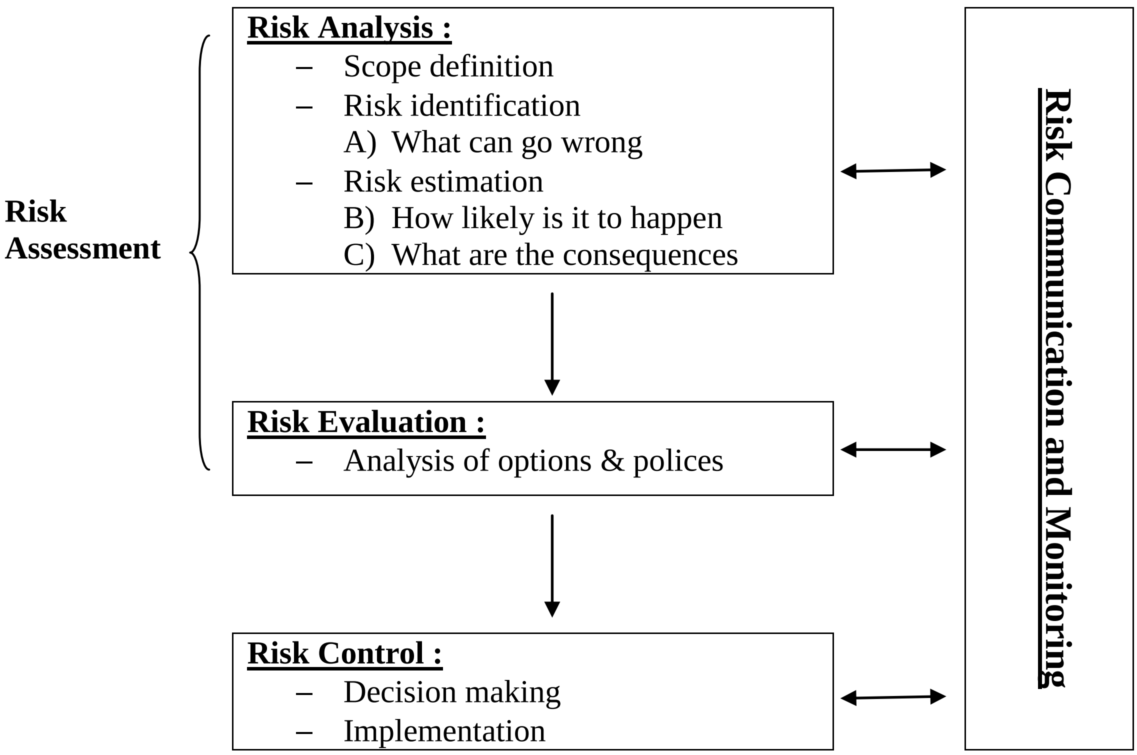
4.5 Risk Assessment Components :

Risk assessment is the activities for when a risk analysis (risk identification, risk estimation) and a risk evaluation (scenario and option analysis) are carried out.

Risk Control :

Risk control is the process of decision–making for managing and/or reducing risk. The risk is reduced by implementing a decision or new policy.

Figure (7) : Different Parts of Risk Management



Risk Communication and monitoring :
Risk communication and monitoring are important. Risk communication is exchanging or sharing information between the decision–maker and other stakeholders. Risk assessment should be monitored to make sure that expected results are achieved, assumptions of acceptable risk level are correct and that the risk methods are used properly. Figure (7) shows the flowchart of risk assessment and risk management.

The main risk and uncertainty variables identified in Najed Project are:

- Project capital increase (project overrun) 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 crop yield and NPV and IRR.
- Rhodes Grass crop yield variation at 3 proposed project locations.

In Najed Project the Government provided a grant of RO 11.26 Million to support internal infrastructure to compensate capital cost increased and reduce the effect of project overrun. Capital cost of the project increased from 16 Million Rials to 22.8 Million Rials. Project overrun risk performed to avoid implementation problems. The research also investigated if Government support sufficient enough and can cover the stochastic variations of future risk of project overrun. Different sensitivity test is performed to evaluate the effect of underground water reduction on crop yield and mitigate action to support water policy. The result of the analysis addressed within the simulation risk analysis models in chapter 4 and 5 of this study.

Sensitivity test technique is very easy to apply, as changes to one value in a spreadsheet will reflect instantly in values for NPV, IRR etc.

The sensitivity testing technique has a number of limitations :

a) It does not take into account the probability of the occurrence of the events it models
b) Deviations from project "base case" estimates are modeled in sensitivity testing, it is not clear whether the variations in values which are being modeled are changes from "expected" values or are deviations from

"most likely" (or modal) values; depending upon the characteristics of particular distributions, mean and mode values may be very different one from another, and what is being captured in the base case and its variation is not clear

c) The identification of appropriate groups of variables to vary together depends on specialist knowledge, and misunderstanding the nature and extent of correlation between variables can lead to erroneous results; and
d) because the distribution characteristics of different variables which determine project outcomes can differ very much (for example the variability in commodity prices is less than input prices, the variability in power demand is less than in generation etc.), the use of standard percentages for variations in sensitivity testing captures quite differential extents of likely variability. An impression of homogeneous variability is given, which is not warranted by reality.

We have to mention a very important issue regarding to modeling uncertainty in project economic analysis. It is sometimes suggested that uncertainty can be allowed for by either applying a different discount rate in the calculation of NPV or by using a higher cut-off rate for investment decisions. While there is a large theoretical literature on this point, in essence there is no justification for this approach – apart from any other consideration, it assumes that risk always increases with time, which is not necessarily true. The discount rate is a rate of decline in the numeracies of economic value, and has nothing to do with the source of risks facing an investment.

4.6 Traditional treatment of risk

The discussion so far has dealt with riskless cases only. There is no single correct method of allowing for risk. The Organization for Economic Cooperation and Development (OECD) classifies the risks of investment into three categories:

- Risks which can be measured in terms of a probability coefficient related to each possible situation, e.g. economic activities subject to climatic conditions (crop yield) are uncertain, but known in terms of probability.
- Risks relating to a future situation which cannot be measured in terms of probability, but which depend on a single event or limited number of events such as the outcome of political negotiations, scientific discovery, etc. This is what may be more properly called "uncertainty."
- Risks due to ordinary mistakes in forecasting and planning.

The inherent quality of risk is that it can be assessed quantitatively by expressing it in terms of the probability of a certain event (result) occurring. Uncertainty, on the other hand, is indeterminate. Not only is a certain event unreliable, but also its degree of unreliability is unknown.

The theory of choice under uncertainty remains one of the major subjects of controversy in economics, and there is considerable disagreement between economists and statisticians on quite fundamental issues. Therefore, it is difficult to determine the most efficient way of dealing with risk and uncertainty in project appraisal.

There is no unique approach to the treatment of risk and uncertainty in a theoretical context. There are, nonetheless, several popular methods that have been used successfully in project appraisal in the past. They include:

a) Adding a premium to the discount rate

Depending on the degree of risk involved, a premium may be added to the discount rate to reflect the uncertainty of future costs and benefits in present value terms. This is a popular method with the private sector, which is assumed, largely in the face of uninsurable risks, to function under conditions of greater uncertainty than the public sector. While the uniformity of this criterion has advantages in terms of preventing subjective and irrational preferences from biasing the result, there is the corresponding disadvantage that risks do differ between cash flow items and projects and that they can, to some extent, be broken down for separate consideration instead of being lumped together in an overall risk allowance.

b) Upward – downward revision of prices

Under conditions of uncertainty for specific project prices, a popular method to deal with risk is to adjust downward the expected future output prices and/or to adjust upward the expected future input prices.

c) Introducing subjective probability into the calculation

This is a common approach for evaluating investments. The procedure allows for risk and uncertainty by estimating, in addition to the most likely future price of each input and output, both an upper and lower limit. In this manner, a triplet of cost-revenue estimates can be obtained: a most optimistic, a most likely, and a most pessimistic estimate of the net revenues in each time period. This method, unfortunately, does not give a good idea as to the likely chance of each estimate occurring.

A more thorough approach to the informed guesses method is possible by attaching to each of the three price outcomes, the most optimistic, the most likely and the most pessimistic, the conjectured probability of them occurring. The resulting treatment of risk cannot, of course, be more accurate than the subjective estimates of price probabilities. However, it does bring out the full implications of the estimates.

4.7 More recent views on the treatment of risk

The literature review shows that economists have recently researched the treatment of risk in agriculture and come up with the following ideas:
According to Pukkala and Kangas
"Risk refers to a situation in which the probabilities of the possible outcomes of a decision alternative are known; if the probabilities are unknown one speaks of uncertainty. The main sources of risk in Rhodes Grass planting project planning include success of regeneration, growth, survival of crop at desert stress, and economic situation, especially raw material cost and crop selling prices. A planning approach that corresponds to the real-life situation is stochastic rather than deterministic. By using the distributions of outcomes of decisions, the risk associated with the various alternatives can be dealt with analytically.

Many approaches have been presented for dealing with risk in agricultural projects decision-making. However, the theoretical possibility of dealing with risk is not enough for supporting practical decision-making. If the decision alternative that maximizes utility is sought, the decision-maker's attitude toward risk has to be taken into account. A risk-avoiding person does not choose the same plan as a risk-seeking or a risk-neutral person.

• Klemperer [2] notes that the U.S. Office of Management and Budget (OMB) recommended that government projects and their expected values be appraised with a 10% real risk-adjusted discount rate. The figure is a reflection of the average before-tax rate of return on private capital in the United States at various risk levels. He warns, however, that not all U.S. agencies follow the OMB guide. For example, the U.S. Forest Service adopts a 4 percent real discount rate.

The OMB argues for higher discount rates on the basis that Government projects should earn as much as private ones. If that were not to occur, capital would shift from higher rates of return (more efficient use) to lower rates of return (more inefficient use). The problem with the OMB strategy is that the 10 percent real discount rate applies to investments of average risk

and average duration, and many projects are not average. In general, it would appear that the OMB's high discount rate would tend to be biased against low-risk investments and in favor of high -risk projects.
Klemperer addresses the risk premium question by employing certainty equivalents. He uses a simple algebraic formulation and demonstrates that for any given perceived risk level, the correct risk premium for the discount rate declines with increasing payoff periods. As a result he suggests that the further that revenue from a risky venture is in the future, the lower the correct risk-adjusted discount rate (RADR) should be, given the same degree of risk and risk aversion. Thus, he observes, that "projects with long production periods may often require lower RADRs than average short-term industrial RADRs".

Finally, Klemperer concludes that there is no such thing as the correct risk-adjusted discount rate (RADR) for agricultural projects expected values. "In reality, a different RADR should be used for each cash flow, depending on its probability distribution, on its time from the present, and on the decision-maker".

Given the difficulties in identifying the appropriate RADR, it seems appropriate that a process of explicitly modeling risk in the cash flows would be worthwhile pursuing.

- Pukkala [6] uses a scenario technique in conjunction with multi-attribute utility theory to integrate multiple risks in multi-objective of agricultural project. He divides the risk sources into three categories: risks related to growth and yield, risks arising from unknown future states of nature, and risks associated with the decision maker's preferences. Pukkala uses the novel approach of integrating the decision maker's attitude toward risk in planning by means of the distribution of a weighed utility index. The utility index is computed from an additive utility function and optimization is done using a heuristic algorithm. They show that the choice of a forestry plan is not only affected by risk but also by attitude toward risk.

- In a later publication, "Risk Analysis in Forest Management", Klemperer [10] suggests discounting risky cash flows in private projects using a weighted average cost of capital (WACC). When raising funds for investment, a private firm can borrow capital from lenders or issue new shares of stock. In the first instance, it will have to pay interest (cost of debt) and in the latter it will be required to pay dividends (cost of equity). Equity is the share of ownership which shareholders have in the firm. Thus, the cost of debt and equity combined is the cost of capital, which, when weighted by the firm’s percentages of debt and equity, yields the WACC.

- In his "Focus on the Treatment of Risk in Forest Valuations" in a New Zealand context, Liley [8] sponsors the view that:

"In an NPV environment, there are two broad alternatives for addressing risk:

(1) Including suitable allowance in the derivation of future cash flows, or

(2) Incorporating some extra margin in the discount rate.

A number of experts describe the issues involved. All acknowledge that in calculating the NPV for risk projects, it may be common practice to add a premium to the discount rate. Because decision-makers tend to be risk-averse, penalizing more risky investments would appear to be a valid means of adding extra stringency to the investment process. However, the user does need to be aware that this approach can distort the relative magnitude of immediate and future cash flows. The problem of including suitable allowance or adding extra margin in the discount rate can be summarized by pointing out the following :

(a) Use of a risk-adjusted discount rate assumes risk is compounding over time.

(b) No specific guidelines are available on how to determine the appropriate adjustment factor.

"Plus, frequently, the further into the future that the revenues arise, cash flows become less certain, however:

- Not all risks increase over time. (In New Zealand plantations, for instance, wind throw risk may be greatest between two years and four years old (toppling), and then after thinning operations which may occur before age 10 years).
- Where risks do increase through time, it may not be exponential as with compound interest.
- Market uncertainty is not a sufficient reason for discounting, as it may involve outcomes better or worse than expected."

- Peltola and Knapp [12] note that, while expected net present value (ENPV) is a commonly used criterion in optimal forest management, it only applies to risk neutrality. If the forest owner has other risk preferences, a utility function needs to be used. Expected utility is the most common way to handle stochasticity (randomness) in an a-temporal framework, but is problematic in in-temporal problems. Given that recursive preferences can overcome a variety of the difficulties associated with expected utility in stochastic control problems, they apply them to forest management. The experts weigh the effects of risk aversion and inter-temporal substitution on optimal forest management.

- Other experts comment that estimates of real risk-free rates of return (historic and anticipated) on U.S. Government bonds, range from 1-4 percent before tax, equivalent to the nominal risk-free rate less the inflation rate. Thus, they suggest that a 3 per cent risk-free real rate would be reasonable. The investment analyst would then need to add his own risk premium to come up with the applicable discount rate.

4.8 Proposed models and scenarios for investment & policy decisions :

The proposed models and scenarios will investigate how different risk models (well water drawdown and no water recharge/ well water drawdown and water recharge) and risk strategies (Government subsidy/ No subsidy) affect investment decisions. The proposed models consist of six parts. The different parts of the method are described in this section.

I) Scope definition: defines the study motivation, project locations, irrigation system and new water policy and define variable inputs.

II) Risk identification: identifies the risk factors affect project profitability and the consequences for the investors and other stakeholder.

III) Risk estimation: Estimate inputs data and its consequences for project. Form risk models and calculate Monte Carlo Simulation MCS Models and probability distribution for NPV & IRR for each risk model and scenario.

IV) Risk evaluation: analyzes the different result of the model for projects after risk estimation has been performed for each project and model. The decision-maker can use different risk strategies to see how the results vary for each model and proposal.

V) Risk control : is decision-making based on the results from the risk evaluation and the risk attitude of the decision-maker a reinvestment project is chosen and implemented. Risk reduction and mitigation can be perform through decision-maker and policy change.

VI) Risk communication and monitoring: is a parallel activity that exchanges information about risk between the parts such as decision-maker, economist, investors and other stakeholders. Risk assessments cover different areas of expertise such as irrigation and water system analysis, agriculture, engineering and economics. For a successful risk assessment, the parties involved must communicate. Risk communication is also about sharing information about risk between the decision-maker, government and other stakeholders such as private sector and investors. The detail proposed methodology and flowchart for investment and policy evaluation presented in Figure (8).

Figure (8) : Proposed Risk-based Methods for Investment & Policy Decisions :

1) **Scope Definition** :
- Define study areas (Salalah- Hanfeet- Dawkah).
- Define variable inputs (Yield- price-unit cost- sale Growth – 1st year Yield).
- Define new water policy and it is effect to yield & NPV.

2) **Risk Identification :**
- Increase of capital cost.
- Increase of operation and unit cost.
- Underground water drawdown & yield decrease.
- Sale price volatility, growth and price range.
- Annual increase in price & unit cost.

3) **Risk Estimation :**
- Estimate inputs data and its consequences for project.
- Risk Models (WR1st Year- WR & Recharge every Year).
- Monte Carlo Simulation MCS Models.
- Probability Distribution for NPV & IRR each risk model

4) **Risk Evaluation :**
- Analysis of the Models and Projects NPV & IRR
- Analysis of Locations Model (Salalah- Hanfeet- Dawkah).
- Test Risk Strategies

5) **Risk Control :**
- Risk reduction (Decision-making & form new water policy)
- Risk mitigate (Decision-making)
- Risk acceptance & management (G. Subsidy- MRG)

6) Risk Communication and Monitoring

* Source: Formed by the Author

4.9 Stochastic Monte Carlo Simulation techniques used for risk analysis

Because of the conceptual shortcomings of all approaches to modeling uncertainty, various attempts have been made to properly capture the impacts of unknown outcomes through modeling risk quantitatively in project economic analysis.

The purpose of quantitative risk analysis in essence is to provide 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 results of sensitivity testing can be used to consider which variable(s) may be appropriate to base a risk analysis upon (those that have major impacts on project outcomes). Having identified particular variables, a number of possible data points (i.e. values above and below the “base case”, upper and lower limits to data values, etc. are necessary to be specified, together with the frequency (or likelihood) of each of these values occurring. From such data points and associated frequency estimates, a probability distribution can be constructed for the variable(s) in question.
It should be noted that identical procedures to these can be applied to projects where expected NPV is not typically calculated (e.g. irrigation water projects which use measures of cost-effectiveness of outputs or impacts (e.g., cost per cubic meter of irrigation water) quoted together with distributions for those values. Risk analysis typically involves the choice of several variables (irrigation water, crop yield, crops sale price, variable and fixed operation cost) to be varied simultaneously, as project returns are generally subject to more than one source of risk. Because of the mathematical complexity involved in such calculations, the analysis of risk in this form is invariably undertaken by some kind of computer software. The process which is followed (and which is usually referred to as Monte Carlo or simulation analysis) is that values for individual variables are generated randomly according to their respective probability distribution, combined with other randomly-generated values for the other variables, and these figures are used to calculate an estimate of the project NPV. This process is repeated a large number of times (a number which is specified by the analyst – in effect equivalent to implementing the project again and again in different circumstances – and is usually at least 1000 times, and typically more than this) and an average (or expected) NPV is produced together with an associated probability distribution.

The early literature on risk modeling and also standard texts on project appraisal, all mention the fact that computer time and expertise is likely to be a major constraint to the use of this technique. In recent years this constraint has largely been overcome and more than adequate computational facilities and software are now available to practitioners.

In this study, the MCS were carried out using the @Risk (pronounced "at risk") simulation computer package 5.7.1. (Student Version). @Risk is a program package which allows analysis of technical and economic situations impacted by risk. It is software which "adds-in" to Microsoft Project & Excel or Lotus 1-2-3. @Risk uses a technique of 'simulation' to combine all of the uncertainties identified in a model. Both Monte Carlo and Latin Hypercube sampling are supported by the software, but Latin Hypercube sampling was used in this study.

@Risk provides over thirty probability distribution functions that allow the specification of nearly any type of uncertainty. The common distribution types such as Normal, Log-Normal, Beta, Triangular and Uniform, are all included. However, in this study we used normal, triangular and compound distribution.

Normal distribution : The best-known and most important probability distribution is the Normal distribution, also known as the Gaussian distribution. Historically, the Normal distribution has played a central role in the development of probability and statistics. The reasons for this pre-eminence are both practical and theoretical. Normal distribution provides a good representation for many physical variables such as crop yield variation.

Triangular distribution : describes a situation where one can estimate the minimum, maximum and most likely value. Values near the minimum and maximum are less likely to occur than those near the most likely.

During simulation the value of an operation is influenced by the effects of uncertainty by being chosen at random from a range of possibilities. The project profitability NPV and IRR are calculated from these randomly chosen values. This represents only one possible way in which the project may proceed. The whole process of choosing duration and cost under uncertain conditions is repeated and the result calculated to produce a different answer. Each calculation is known as 'iteration'. @Risk allows any number of iterations in a simulation. In this analysis, we run 5000 iterations and 3 simulations.

The results generated in a simulation are presented in histograms, cumulative curves, summary graphs for cell ranges and zooming. Statistical reports on generated distributions and probability of occurrence for target values in a distribution generated and displayed below. The table below shows how likely risk in inputs parameters happen. The minimum, maximum and most likely figures for model inputs and there type of distributions :

Table (15) Input parameters distribution used in MCS Models :

Variables	Distribution	Min	Mean	Max
1st year yield with water decrease	Normal	-	65,286	-
1st year yield without water decrease	Normal	-	84,630	-
Annual increase in yield	Triangle	2%	3%	5%
Sale price year 1	Triangle	90	95	100
Unit cost price year 1(% sale price)	Triangle	75%	79%	83%
Annual increase in price and unit cost	Triangle	1%	2%	3%
Water reduction effect % at any year	compound	8%	12%	15%

(Source: calculated by Author).

The study runs the Stochastic Monte Carlo Simulation Models to evaluate the following :

- The difference between conventional and stochastic MCS model techniques for project investment evaluation and risk assessment.
- The government subsidy and incentive program that can reduce risk and uncertainty impacts of Najed Agricultural Development Project.
- The effect of irrigation water policy on crop yield and project NPV and IRR.
- The effect of project location on crop yield and project profitability.

<u>The Study Run Stochastic MCS Models to calculate NPV and IRR probability distribution associated to critical variables outline below :</u>

1. Model (1)Basic model (without Gov. subsidy, without water reduction effect).
2. Model (2) Basic model (with Gov. subsidy, without water reduction effect).
3. Model (3) model (without Gov. subsidy, with water reduction effect-level1).
4. Model (4) (with Gov. subsidy, with water reduction effect-level1).
5. Model (5) model (without Govern. subsidy, with water reduction effect-level2).
6. Model (6) (with Gov. subsidy, with water reduction effect-level2).
7. Model (7) baseline Salalah location (without G. subsidy & water reduction effect).
8. Model (8) baseline Salalah location (with Govern. subsidy & water reduction effect).
9. Model (9) Hanfeet location (without Govern. subsidy & water reduction effect).

10. Model (10) Hanfeet location (with Govern. subsidy & water reduction effect).
11. Model (11) Dwakah location (without Govern. subsidy & water reduction effect).
12. Model (12) Dwakah location (with Govern. subsidy & water reduction effect).

Model (7-8-9-10-11) and (12) regarding Farm locations effects will be discussed in chapter five. The main risk and uncertainty variables identified in Najed Project and it is effect on project profitability NPV and IRR are calculated from each model run and summarized in table (16) and (17) as under :

Table (16) The results of the MCS models run for NPV in Million Rials :

Model No.	Min	Mean	Max	5%	95%	SD	Variance	Ranking
Model (1)	-52	-10	+28	-26	+6	9.9	9.978	(4)
Model (2)	-37	+1	+41	-15	+17	9.9	9.881	(1)
Model (3)	-52	-13	+21	-29	+4	9.9	9.887	(6)
Model (4)	-40	-2	+35	-17	+15	9.9	9.948	(3)
Model (5)	-44	-11	+16	-23	+0.77	7.1	5.01	(5)
Model (6)	-29.3	+0.122	+28.55	-11	+12	7.2	5.18	(2)

(Source: calculated by Author).

Table (17) The results of the MCS models run of probability distribution of IRR :

Model No.	Min	Mean	Max	5%	95%	SD	Variance	Ranking
Model (1)	-38.0%	-0.60%	+31.3%	-22.3%	+16.0%	11.5	0.0133	(4)
Model (2)	-37.3%	+13.10%	+66.5%	-15.0%	+37.0%	15.6	0.0244	(1)
Model (3)	-38.6%	-3.23%	+27.3%	-25.0%	+14.0%	11.6	0.0135	(6)
Model (4)	-38.6%	+9.45%	+58.8%	-18.4%	+33.7%	15.8	0.0248	(3)
Model (5)	-38.0%	-3.0%	+23.0%	-21.0%	+11.0%	10.0	0.0092	(5)
Model (6)	-38.0%	+10.0%	+48.0%	-14.0%	+29.0%	13.0	0.0120	(2)

(Source: calculated by Author).

Model (2) represents the project with Government subsidy, without water reduction effect has the highest profitability because of the combination of a high initial production with the lowest operating costs per ton among the six models. In contrast, because of its capital cost structure and a more evenly distributed production profile, Model (3) (The project without Government subsidy, with water reduction effect-level1) and Model (5) is significantly less profitable than the other models.

4.10 Monte Carlo Simulation techniques and Gov. subsidy program

The Government of Oman recommended a financial support to Najed Project. The Government will provide a grant of RO 11.26 Million to support internal infrastructure to compensate capital cost increased and reduce the effect of project overrun. Capital costs of the project increased from 16 Million Rials to 22.8 Million Rials at the stage of phase one of the project implementation. Project overrun risk analysis should be performed to avoid implementation problems and mitigate risk. The research will also investigate if Government support sufficient enough and can cover the stochastic variations of future operation risk and project overrun risk. The Government subsidy program evaluated and tested within 3 scenarios and 6 MCS Models runs. The statistics result of the probability distribution of NPV and IRR for each model presented in table (18) and (19).

Table (18) and (19) indicate statistical measures used to test different normal and non-normal risks associated with investing in Najed Project. The statistical analyses performed in this study are measure of central tendency which test the mean and mode of the NPV and IRR – measure of variability which test the stander deviation, variance and coefficient of variation of the models and the measure of Skewness and Kurtosis for each model. The skewness is a measure of the degree of asymmetry of a frequency distribution of investment return NPV and IRR, whereas, Kurtosis is a measure of the peakedness of the probability distribution or measures the degree of fat-tailness of the investment returns.

Table (18) Statistics of Models run results – without Government subsidy :-

Models Item	**Model (1) NPV**	**Model (3) NPV**	**Model (5) NPV**	**Model (1) IRR**	**Model (3) IRR**	**Model (5) IRR**
Mean	-10	-13	-11	-1%	-3.2%	-3%
Mode	-13	-17	-15	3%	2%	3%
SD	9.989	9.943	7.128	11.5%	11.6%	10.0%
CV	0.99%	0.76%	0.65%	11.5%	3.63%	3.33%
Variance	9.978	9.887	5.081	0.0133	0.0135	0.0092
Skewness	0.0575	0.0434	0.0788	-0.530	-0.436	-0.647
Kurtosis	3.142	3.069	3.175	3.220	2.955	3.531
Min	-52	-52	-44	-38%	-38.6%	-38.0%
Max	28	22	16	31.3%	27.3%	23.0%
Range	80	74	60	69	66	61
Expected loss ratio	0.65	0.70	0.73	0.55	0.57	0.62

(Source: calculated by Author).

Table (19) Statistics of Models run results – with Government subsidy:-

Models Item	Model (2) NPV	Model (4) NPV	Model (6) NPV	Model (2) IRR	Model (4) IRR	Model (6) IRR
Mean	1	-1.6	0.122	13%	9.45%	10%
Mode	3.5	-0.887	-0.889	11%	18%	12%
SD	9.940	9.974	9.511	17%	16%	13%
CV	9.94%	6.23%	79.26%	1.31%	1.70%	1.30%
Variance	9.881	9.948	9.046	0.024	0.028	0.0167
Skewness	0.046	0.0736	0.0929	-0.342	-0.274	-0.498
Kurtosis	3.094	3.095	3.210	3.097	2.958	3.430
Min	-38	-40	-29	-37.3%	-38.6%	-38%
Max	41	35	29	66.5%	59%	48%
Range	79	75	58	103	98	86
Expected loss ratio	0.48	0.53	0.50	0.36	0.39	0.44

(Source: calculated by Author).

Table (18) and (19) provide the detailed statistical summarized for results from Figure (11-12-13-15-16-18). The coefficient of variation is a useful summary measure of project risk. It is the standard deviation of the projected returns divided by the expected value. Assuming a positive expected NPV and IRR value, the lower the coefficient of variation the less the project risk. Model 5 and model 3 without Government subsidy present a low variation coefficient (CV) while model 1, 2 and 6 with no water reduction have a high variability. On the other hand, we observed that the skewness coefficient is positive and higher in models with Government subsidy, indicating that they have an elevated probability of obtaining results above the mean. Also, the skewness coefficient is greater than 0 in all models, indicating that there is no large probability of having a low yield. The kurtosis coefficient for every model is larger than 3, and we have a leptokurtic distribution that indicates that the probability distribution of the model have a narrow peak (a high probability than a normally distributed variable of values near the mean) and fat tails (a higher probability than a normally distributed variable of extreme values) especially for model (4) and (6).

Measure of central tendency:

The mean is a statistical term that describes the central tendency or average of a NPV and IRR probability distribution. Whereas, the mode (or modes because it is possible to have more than one of them) of a set of observations is the value that occurs most frequently, or the most commonly occurring outcome.

The mean and mode is calculated for each model and presented in table (18) and (19). We can observe that the means and mode figures increased and changed from negative figures (without subsidy in Model 1,3and 5) in table

(18) to positive figures (with subsidy in Model 2, 4 and 6) in table (19). The higher figure of mean and mode in in table (19) indicates that Government subsidy programs increased project profitability and project sustainability.

Measure of variability :

Variability is a statistical term used to describe and quantify the spread of data around the center, usually the mean. In most practical situations, knowing the average or mean is not sufficient to obtain an adequate understanding of the data. The two most frequently used measures of dispersion are the variance (The second moment around the mean) and its square root, the standard deviation.

The measured of variance and standard deviation in the study indicates less variation of the probability distribution of NPV and IRR with government subsidy program. The low standard deviation figures and the low variance indicate that government subsidy will reduce the risk and increase sustainability. The Coefficient of Variation also calculated to evaluate relative uncertainties. The smallest CV for IRR indicates reduction in in dispersion of returns with Government subsidy and shows good investment project opportunity. However, Standard deviation is not a good measure of return variability if the distribution of returns is skewed or otherwise non-normal.

Investor Perceptions of Risk

The investor's perception of risks between the two scenarios (with Subsidy and without subsidy) is evaluated by analyzing :

i) The mean expected of NPV, IRR to the investor and the CV of investor returns, and
ii) The cumulative probability distribution of NPV, discounted at 12% under each project. The result of the analysis presented in table (18) and (19).

Measure of Skewness and Kurtosis :

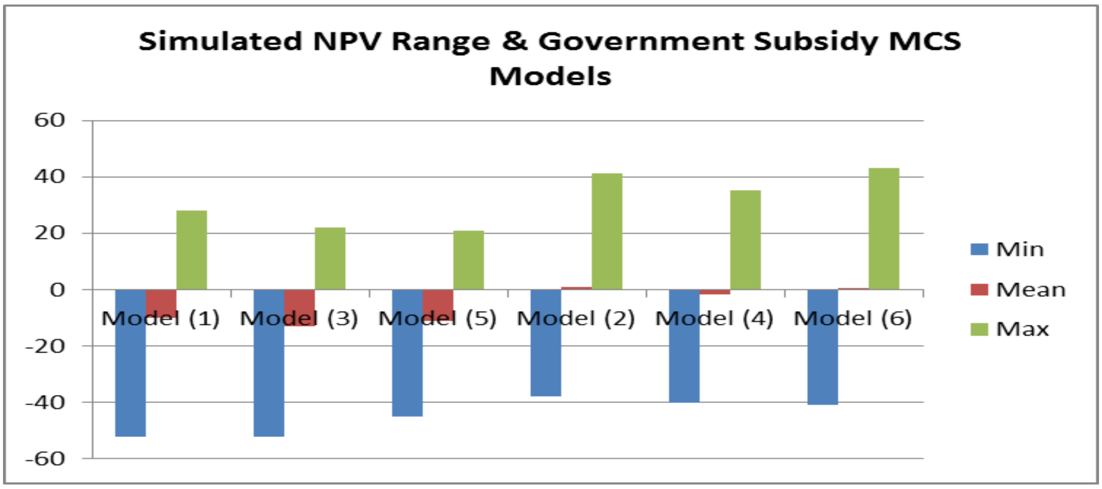
Two additional attributes of a frequency distribution that are useful are Skewness and kurtosis. Skewness is a measure of the degree of asymmetry of a frequency distribution of investment return NPV and IRR. It is often called the third moment around the mean or third central moment. When a distribution is right skewed, the mean is to the right of the median and mode (mean bigger than median and mode) and when distribution is left skewed the mean is to the left of the median and mode (mean smaller than median and mode).

The effect of government subsidy's program is tested using skewness and kurtosis analysis and indicates that NPV and IRR probability distribution stretches to the left more than it does to the right and it can be said that the distribution is left-skewed, or negatively skewed with Government subsidy program in scenario one and two which means (controlling large losses and offering downside protection). This means subsidy could eliminate downside risk, but the upside potential or (the opportunity to take advantage of a higher realized NPV/IRR) remains un-covered. For scenario three (with a possibility of underground water re-charge) the model shifted from left to right-skewed. However, this means government subsidy has more effect and can eliminate upside risk.

We can conclude that NPV distribution are skewed with an upper limits on output and high chance of occasional low Rhodes Grass yield. This is because of a capacity constraint on the full yield potential of a crop. Crop yield capacity is defined as the yield that would occur with efficient use of the given technology for controllable inputs and ideal weather. Extreme weather conditions and pest infestation are typical random events that have adverse effects on commodity and Rhodes Grass yields. Moreover, the crop can never achieve the biological potential of the plant in desert farming and with the limit of water use and hence there is an upper limit on crop yield and NPV. These types of events tend to pull the distribution's mean yield below the normal level, but outcomes above the mean level occur with greater probability (greater than 50% chance) than do outcomes below the mean level. Advance treatment of crop risk management strategies will be discussed later in this thesis.

Kurtosis is a measure of the peakedness of the probability distribution or measures the degree of fat-tailness of the investment returns. Sudden extreme positive or negative returns increase the kurtosis. For a normal distribution kurtosis equals 3. If the parameter is larger than 3 there is a clustering of points around the mean an indication of non-normal peakedness (Leptokurtic distribution) and if it is low than 3 (Platykurtic). The result of the analysis shows that kurtosis figures increased in table (19) which indicates that government subsidy program are useful and reduce future risk. Figure (9) showed that Government subsidy program reduce the range between Max and Min and shift the range (uncertainty) to positive side in model 2, model 4 and model 6.

Figure (9): shows NPV Ranges Minimum and Maximum levels with Government subsidies:-



4.11 Research displaying scenarios :

For our case evaluation of the Najed Project we use three different scenarios e.g. Basic model - farm production without risk of underground water reduction, farm production with the risk of water reduction at year one without underground water recharges and farm production with the risk of water reduction at any year with a possibility of underground water recharges. Each scenario tested with and without government subsidy. From these scenarios we build two models for each scenario.

Table (20) Research scenarios and models :

Scenarios	Water Risk level	G. Subsidy	Models
(1) Basic Model			
Scenario One	**No water risk**		
	Basic Model Najed Project	without	1
	Basic Model Najed Project	with	2
Scenario Two	**Water risk level 1**		
(No water recharge)	Basic Model Najed Project	without	3
	Basic Model Najed Project	with	4
Scenario Three	**Water risk level 2**		
(With water recharge)	Basic Model Najed Project	without	5
	Basic Model Najed Project	with	6
(2) Location Model	**Water risk level 2**		
Baseline model (No water policy)	Salalah Location	without	7
	Salalah Location	with	8
Water policy & low water risk	Hanfeet Location	without	9
	Hanfeet Location	with	10
Water policy & high water risk	Dwakah Location	without	11
	Dwakah Location	with	12

(Source: calculated by Author).

Scenario One: Basic Model (No risk of underground water reduction):-

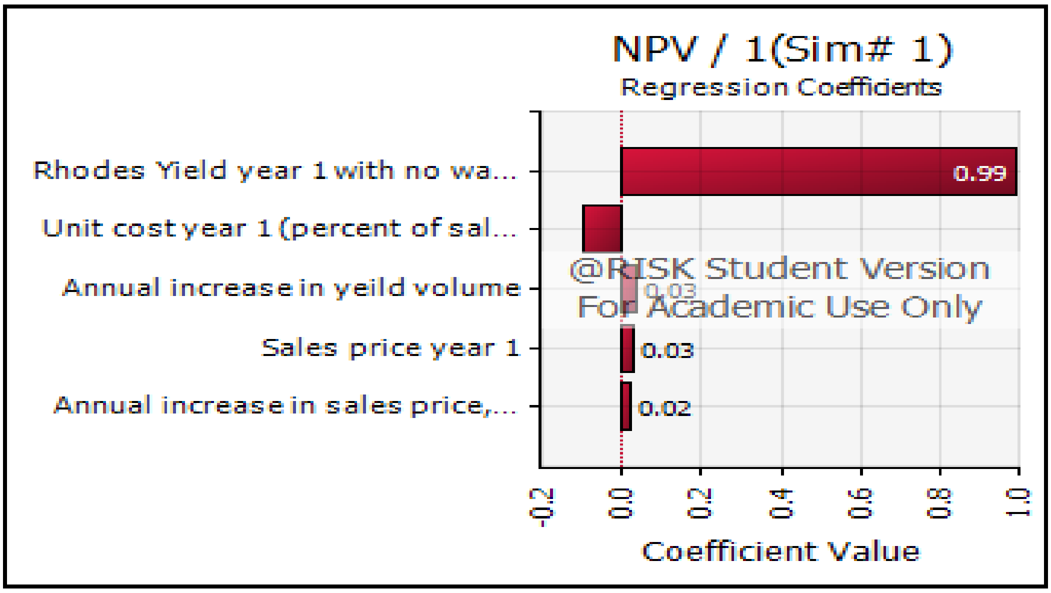
The scenario assumes no risk will affect the Rhodes grass crop yield and two models performed to test Government subsidy. Model (1) and (2) will be tested in this scenario.

Model (1) : The Basic model (without Government subsidy)
This model corresponds to scenario one of no risk of underground water reduction and a risk of other variables future uncertainty such as sale price at year one, unit production cost , annual increase in yield and sale price and unit cost.

The figure (11) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO (-10 Million) and a variance of RO 9.978. The IRR analysis shows negative figure of (-0.60%) with a variance of 0.0133. The cumulative probability distribution of NPV at figure (11) shows that NPV will be zero or negative is 80% in this model.
The 5th percentile, mean and 95th percentile of cumulative NPV and IRR is worked out as NPV is RO – 26.29, RO – 10.46 and 6.340 Million respectively. The cumulative NPV values show an improvement in NPV which reach 6.34 Million rials.

The sensitivities of the project to the variations in input parameters are shown on figure (10). From the graph we can see that the NPV is very sensitive to changes in crop yield in year one with a contribution to the variance of 99%, unit cost with a contribution to the variance of -0.09%, and annual increase in yield volume with a contribution to the variance of +0.033.The sensitivities of the project model (no risk of underground water reduction) shows the variations in input parameters are presented below in figure (10).

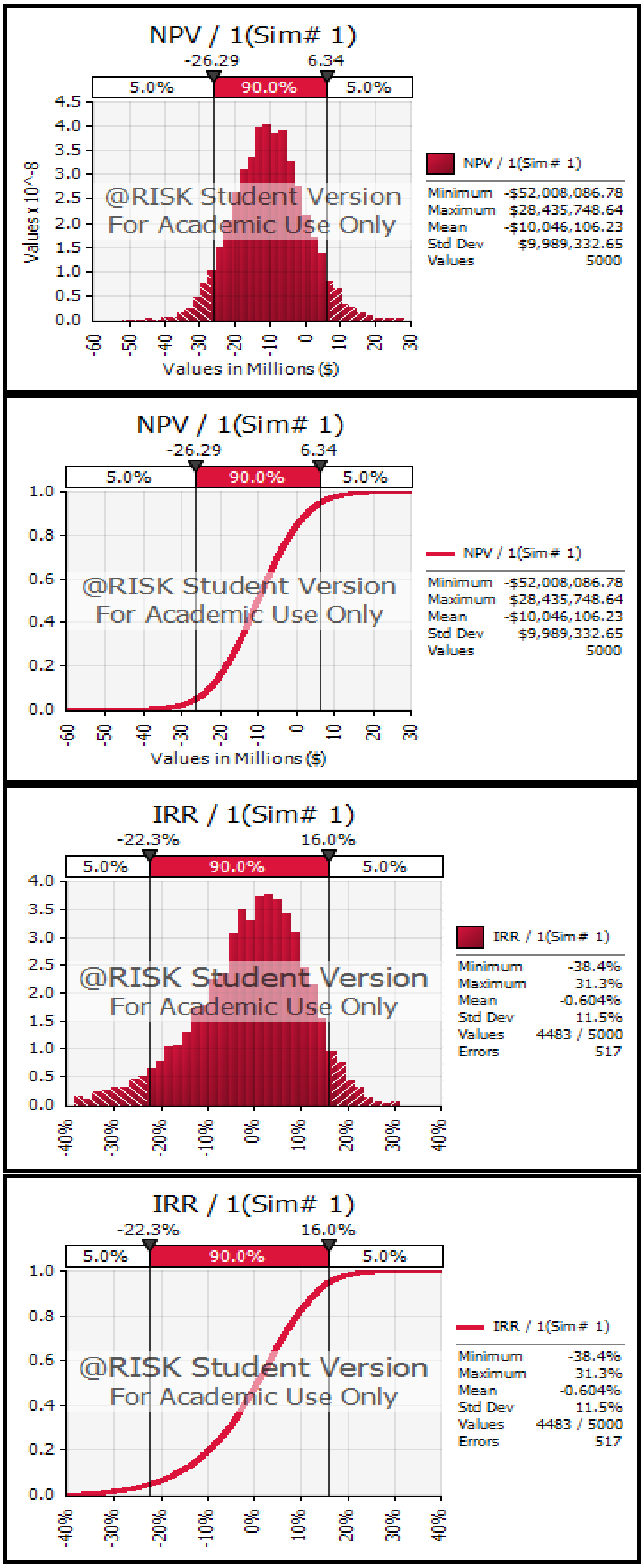
Figure (10) : Sensitivities analysis of Basic Model and Tornado diagram



The sensitivities of the project the variations in input parameters are shown on Tornado figure.

Figure (11) :

<u>Model (1) Result of Stochastic Monte Carlo Simulation Model (without Government Subsidy & without water reduction effect) :-</u>



Model (2) : The Basic model (with Government subsidy) and no risk of underground water reduction:

This model corresponds to scenario one of no risk of underground water reduction and a risk of other variables an future uncertainty such as sale price at year one, unit production cost , annual increase in yield and sale price and unit cost.

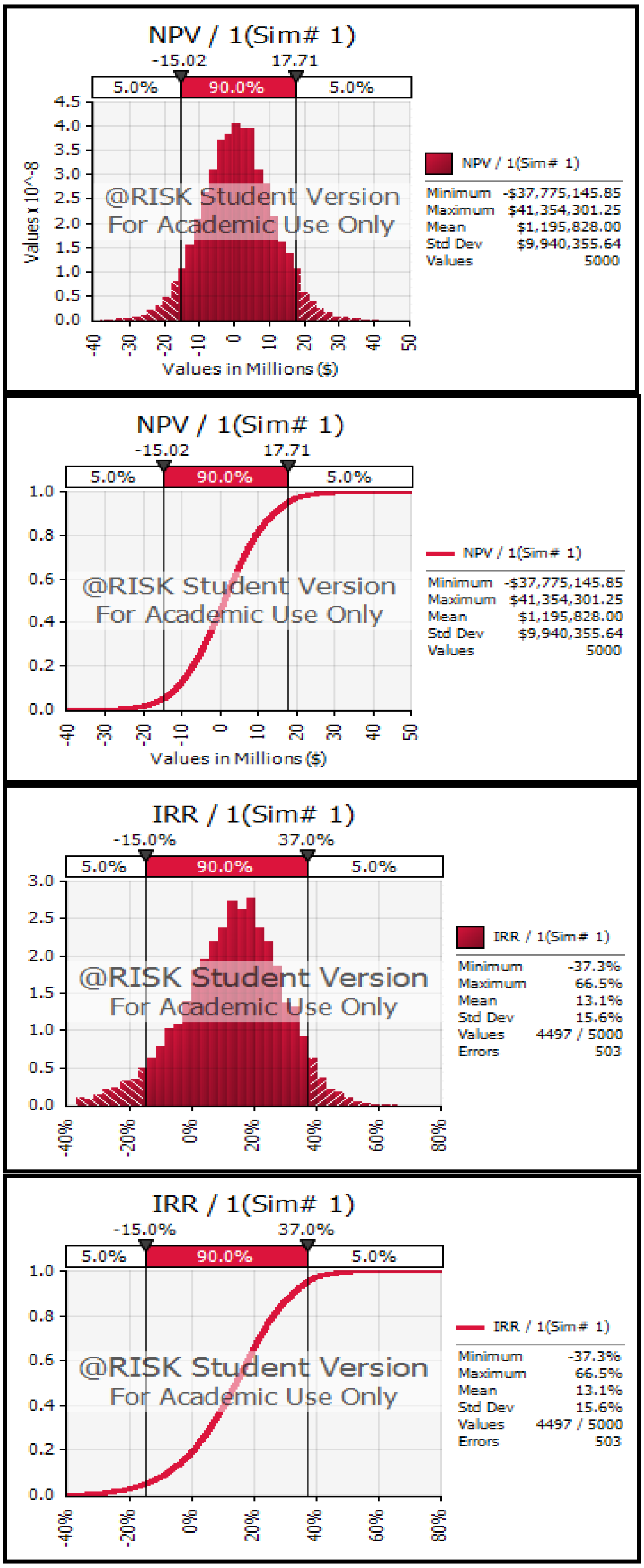
The figure (12) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO (+1 Million) and a variance of RO 9.88. The IRR analysis shows positive figure of +13.1% with a variance of 0.0244. The cumulative probability distribution of NPV at figure (12) shows that the probability of having NPV below zero in this model is about 40%. The cumulative probability distribution of IRR at the same figure shows that making a positive IRR is about 80%.

The 5th percentile, mean and 95th percentile of cumulative NPV and IRR is worked out as NPV is RO – 15, RO one million and 17.7 Million respectively. The cumulative NPV values show an improvement in NPV which reach 17.7 Million rials.

The sensitivities of the project to the variations in input parameters shows that the NPV is very sensitive to changes in crop yield in year one with a contribution to the variance of 99%, unit cost with a contribution to the variance of -0.100%, and annual increase in yield volume with a contribution to the variance of +0.034. The result shows that Government subsidy improves project profitability of about 60% in NPV and 80% in IRR.

Figure (12) :

<u>Model (2) Result of Stochastic Monte Carlo Simulation Model (with Government Subsidy & without water reduction effect) :-</u>



4.12 Monte Carlo Simulation techniques and water policy analysis

The study performed four models to assess the risk of underground water availability and its effect on crop yield. The objectives of this analysis outline as under:

Irrigation water reduction effect on NPV and IRR Stochastic MCS Models :

Two types of stochastic MCS models were performed to test the effect of irrigation water reduction on NPV and IRR. The first model will test water reduction from year one without any underground water recharge and the other models will test water reduction and recharged of underground water at any year of the project life.

1. The effect of water reduction at year one without any underground water recharges.
2. The effect of water reduction at any year and possibility of underground water recharges.

The effect of Government subsidy to NPV and IRR were also tested and two models test were performed (with Government subsidy and without Government subsidy). The result of these four models were summarized as under :

<u>Scenario Two : Test risk of underground water reduction :-</u>

This scenario assumes that the project will face risk of Rhodes grass crop yield reduction due to underground water reduction at year one and continued for all project life and affect NPV and IRR. Model (3) and (4) will used to be tested in this scenario to evaluate Government subsidy with risk of underground water reduction (level 1).

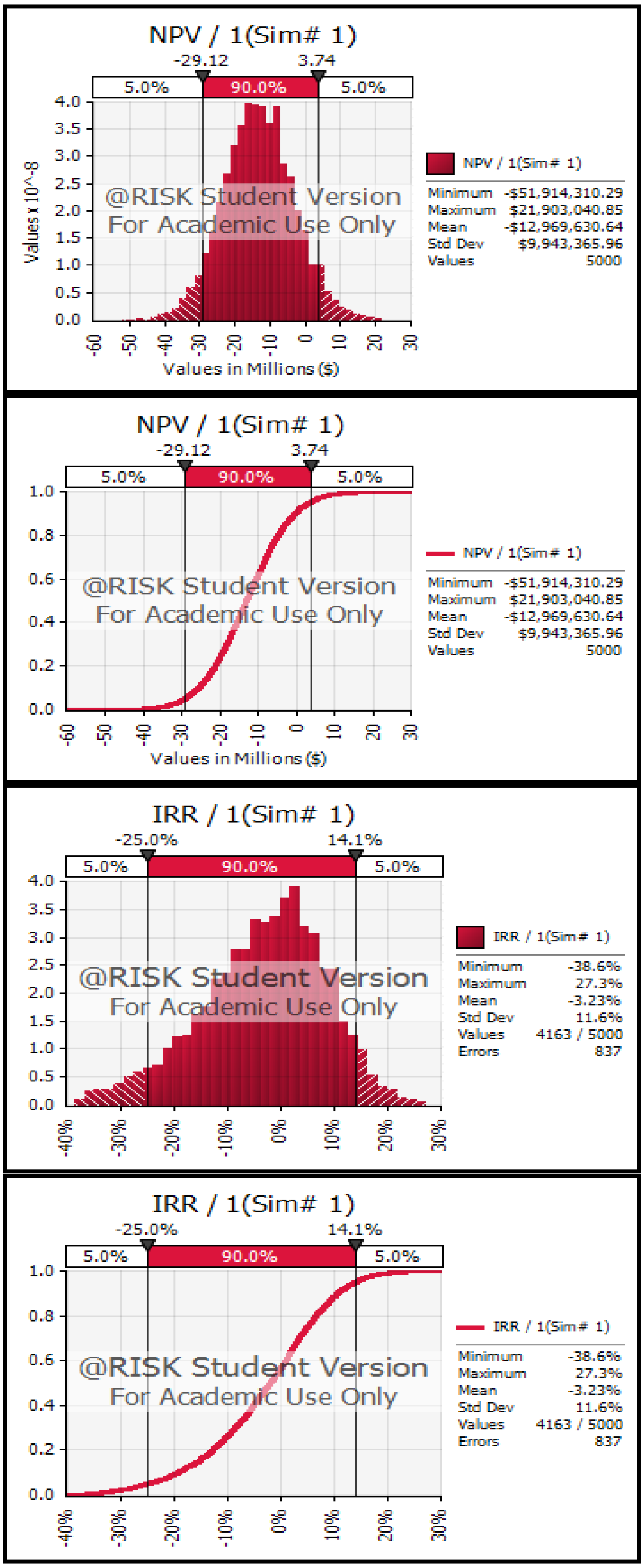
Model (3) : Risk of underground water reduction (without Government subsidy)

This model corresponds to scenario two which assumed the risk of underground water reduction at year one of the project, and a risk of other variables future uncertainty such as sale price at year one, unit production cost, annual increase in yield and sale price and unit cost.

The figure (13) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO (-13 Million) and a variance of RO

Figure (13) :

Model (3) Result of Stochastic Monte Carlo Simulation Model (without Government Subsidy) & with water reduction effect level 1 :-



9.887. The IRR analysis shows negative figure of (-3.2%) with a variance of 0.0135. The cumulative probability distribution of NPV at figure (12) shows that making a loss from this model is more than 93%. Whereas making negative IRR in this model is about 60%.

The 5th percentile, mean and 95th percentile of cumulative NPV and IRR is worked out as NPV is RO – 29, RO – 12 and 3.74 Million respectively. The cumulative NPV values show an improvement in NPV which reach 21 Million rials.

The sensitivities test of the project to variations in input parameters are calculated and shows that the NPV and IRR are very sensitive to changes in crop yield in year one and unit cost and annual increase in yield volume. However, project should look after these factors and put more concentration to mitigate the risk.

Model (4) : Risk of underground water reduction (with Government subsidy)

This model corresponds to scenario two which assumed the risk of underground water reduction at year one of the project, and a risk of other variables future uncertainty such as sale price at year one, unit production cost, annual increase in yield and sale price and unit cost with Government investment subsidy.

The figure (15) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO (-1.6 Million) and a variance of RO 9.948. The IRR analysis shows a positive figure of 9.45% with a variance of 0.028. Although, IRR is positive but still Government subsidy not enough to compensate underground water reduction risk. The cumulative probability distribution of NPV at figure (15) shows that making a loss from this model is about 60%. Whereas making negative IRR in this model is about 20%.

The 5th percentile, mean and 95th percentile of cumulative NPV and IRR is worked out and all NPV shows negative figures whereas IRR figures show a – 18.4%, 9.45%, and 33.7% respectively. The cumulative IRR figures show an improvement in IRR which reach 33.7%.

The sensitivities test performed to assess the variations in input parameters and its effect to NPV and IRR. The result shows that the NPV and IRR are very sensitive to changes in crop yield in year one due to underground water reduction with a variance of 0.99 and unit cost and annual increase in yield volume. However, project management should look after these factors and put more concentration to mitigate the risk. The blow figure (14) shows the effect of Government subsidy on NPV due to underground water reduction at year one and continued for all project life.

Figure (14) : shows the effect of Government subsidy on NPV for Model 4 &3 :

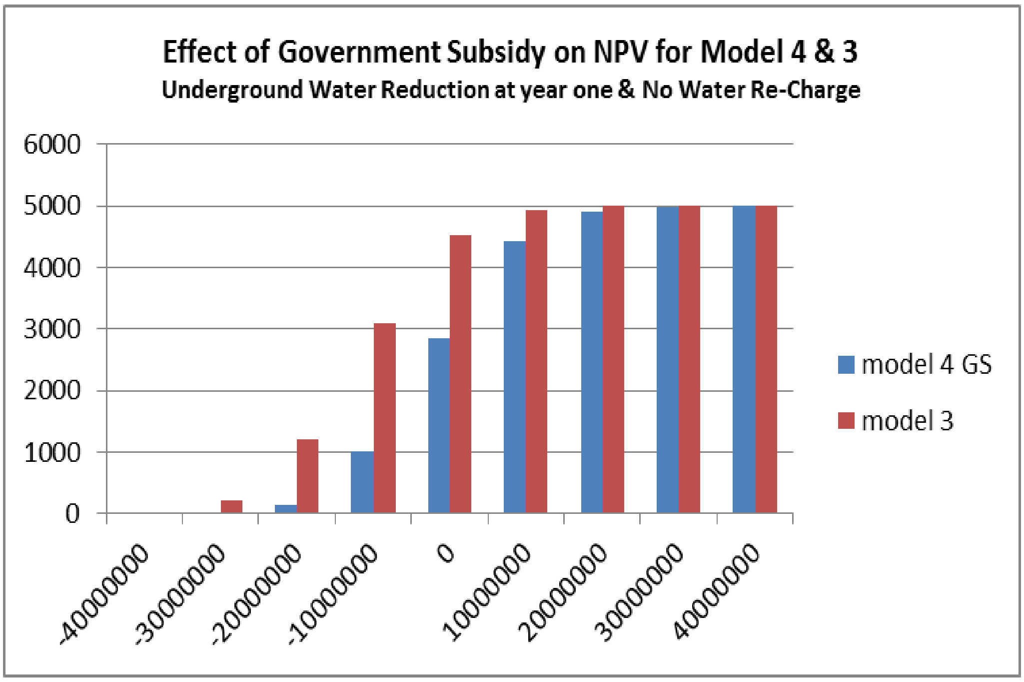
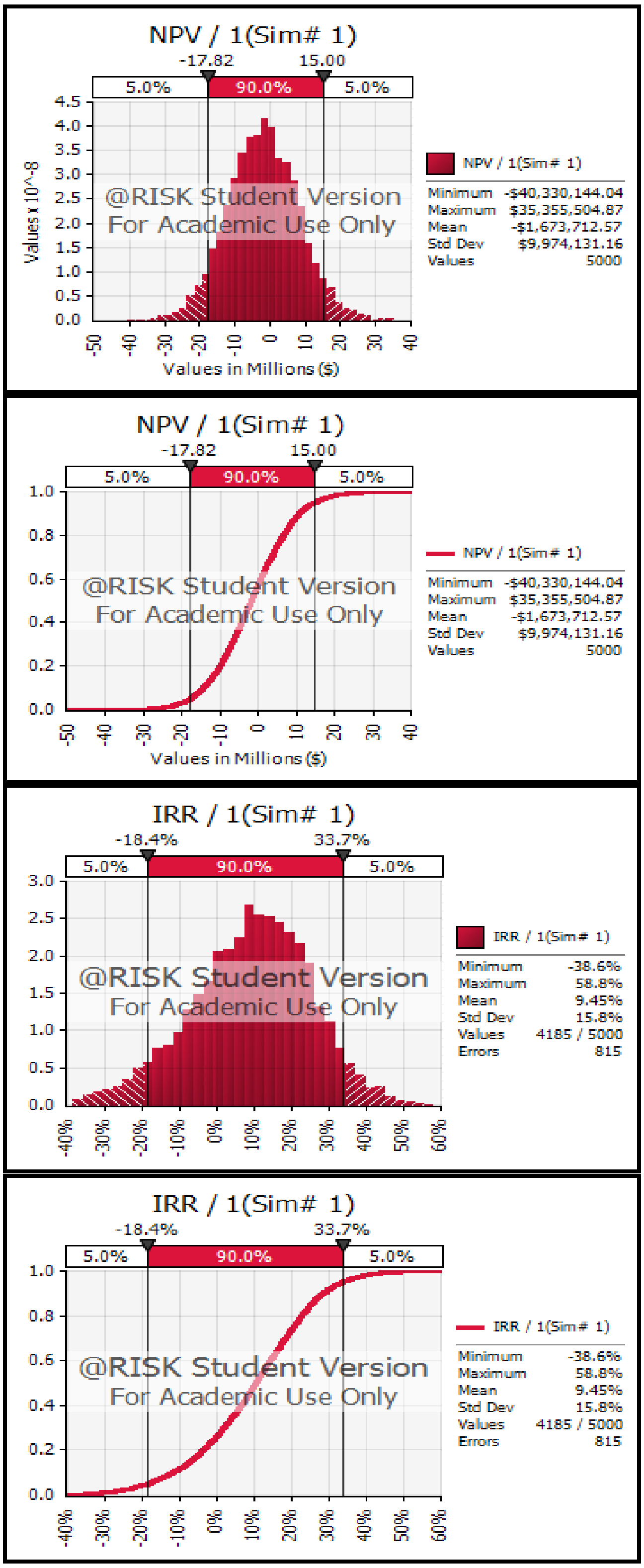


Figure (15) :

Model (4) Result of Stochastic Monte Carlo Simulation Model (with Government Subsidy) & with water reduction effect level 1:-



Scenario Three : Test risk of continues underground water reduction & re-charge :-

This scenario assumes that the project will face continues risk of Rhodes grass crop yield reduction due to underground water reduction at any year of the project and also a possibility of underground water re-charge. The water availability risk incorporated in the model and the effect of this risk on NPV and IRR are assessed. Model (5) and (6) will be tested in this scenario to evaluate Government subsidy.

Model (5) : Risk of continues underground water reduction (without Government subsidy)
This model corresponds to scenario three which assumed the risk of underground water reduction at any year of the project, in addition of the risk from other variables and future uncertainty such as sale price at year one, unit production cost, annual increase in yield and sale price and unit cost.

The figure (16) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO (-11 Million) and a variance of RO 5.081. The IRR analysis shows negative figure of (-3%) with a variance of 0.0092.

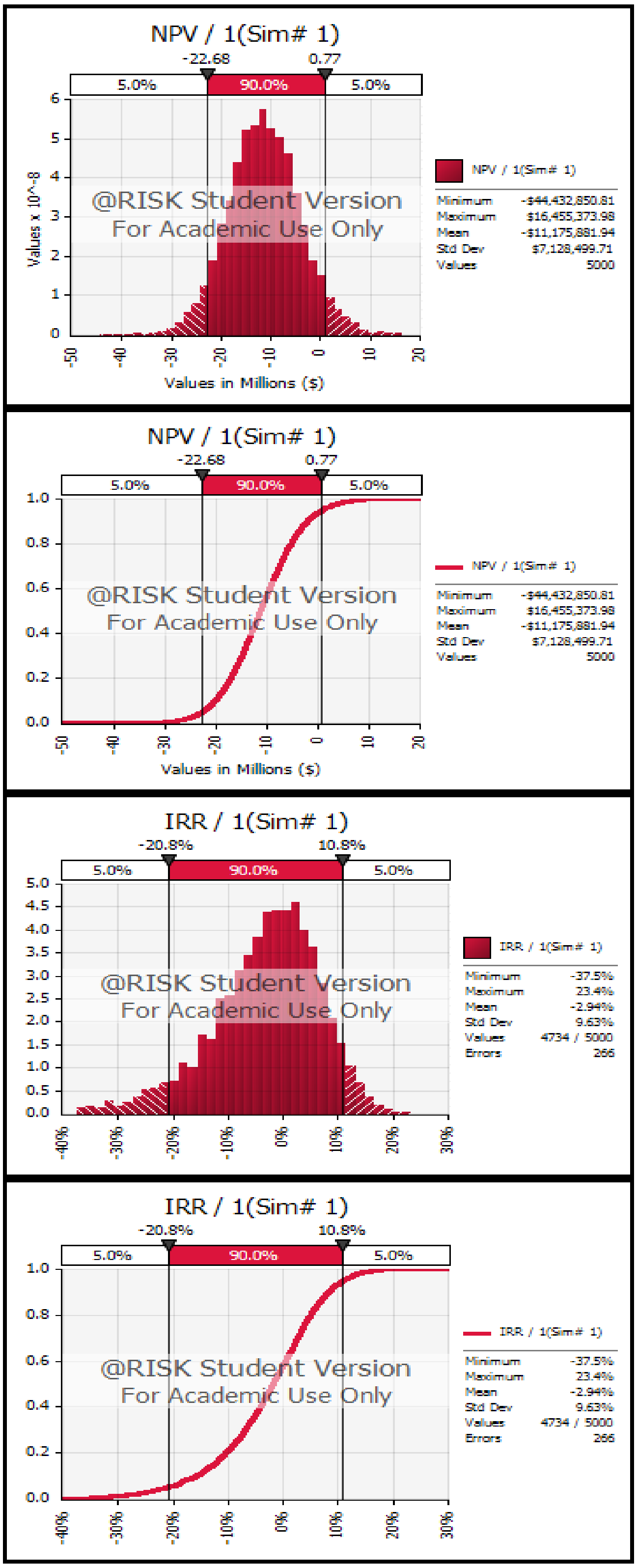
Table (21) Sensitivity analysis and risk factor ranking results for water reduction effect on NPV (without Government subsidy):-

Regression and Rank Information for NPV / 1			
Rank	**Name**	**Regr**	**Corr**
1	Total sales volume / 1	0.985	0.983
2	Unit cost year 1 (percent of sales price)	-0.125	-0.110
3	Annual increase in sales price, unit cost	0.040	0.022
4	Sales price/Ton year 1	0.035	0.058
5	Annual increase in sales volume	0.029	0.017
6	Crop yield reduction due to water/ 10	-0.018	-0.041
7	Crop yield reduction due to water/ 7	-0.018	-0.054
8	Crop yield reduction due to water/ 3	-0.016	-0.063
9	Crop yield reduction due to water/ 5	-0.016	-0.066
10	Crop yield reduction due to water/ 4	-0.014	-0.056
11	Crop yield reduction due to water/ 8	-0.013	-0.058
12	Crop yield reduction due to water/ 2	-0.012	-0.013
13	Crop yield reduction due to water/ 6	-0.011	-0.053
14	Crop yield reduction due to water/ 9	-0.010	-0.057

The sensitivities test of the model shows that project probability distribution of NPV and IRR are sensitive to 14 parameters and the most factor

Figure (16) :

<u>Model (5) Result of Stochastic MCS Model (without Government Subsidy & with water reduction effect - level 2) :-</u>



influences the project profitability is the total sale volume for year one. The sensitivity tables rank parameters according to their effects to NPV and IRR.

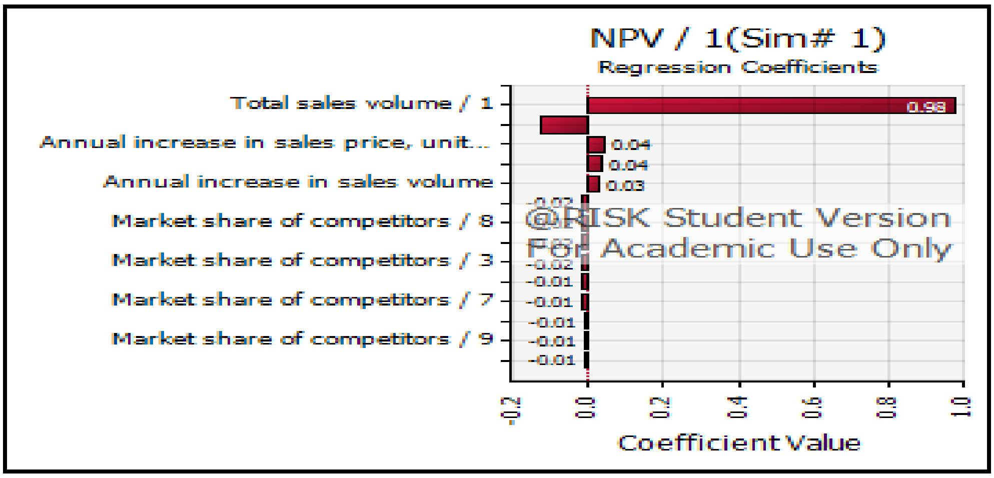
Model (6) : Risk of continues underground water reduction (with Government subsidy)

This model corresponds to scenario three which assumed the risk of underground water reduction at any year of the project, in addition of the risk from other variables and future uncertainty such as sale price at year one, unit production cost, annual increase in yield, sale price and unit cost.

The figure (18) shows the probability distribution of the NPV and IRR of Najed Project and the statistics of the result. The NPV of the project follows a normal distribution with a mean of RO 120,450 and a variance of RO 9.046. The IRR analysis shows a positive figure of 10% with a variance of 0.0167. Although, IRR is positive but still Government subsidy not enough to compensate underground water reduction risk. The 5th percentile, mean and 95th percentile of cumulative NPV and IRR is worked out and all NPV shows negative figures whereas IRR figures show a –16.3%, 11.2%, and 34.4% respectively. The cumulative IRR figures show an improvement in IRR which reach 34.4%.

The sensitivities test performed to assess the variations in input parameters and its effect to NPV and IRR. The (Tornado diagram) used to help to sort through the combination of relative risk and role in the model figure (17). The result shows that the NPV and IRR are very sensitive to changes in crop yield in year one due to underground water reduction with a variance of 0.99 and unit cost and annual increase in yield volume. However, project should look after these factors and put more concentration to mitigate the risk.

Figure (17) : The sensitivities test to assess the variations in input parameters



The sensitivities test performed to assess the variations in input parameters and its effect.

Figure (18) :

<u>Model (6) Result of Stochastic MCS Model (with Government Subsidy& with water reduction effect - level 2):-</u>

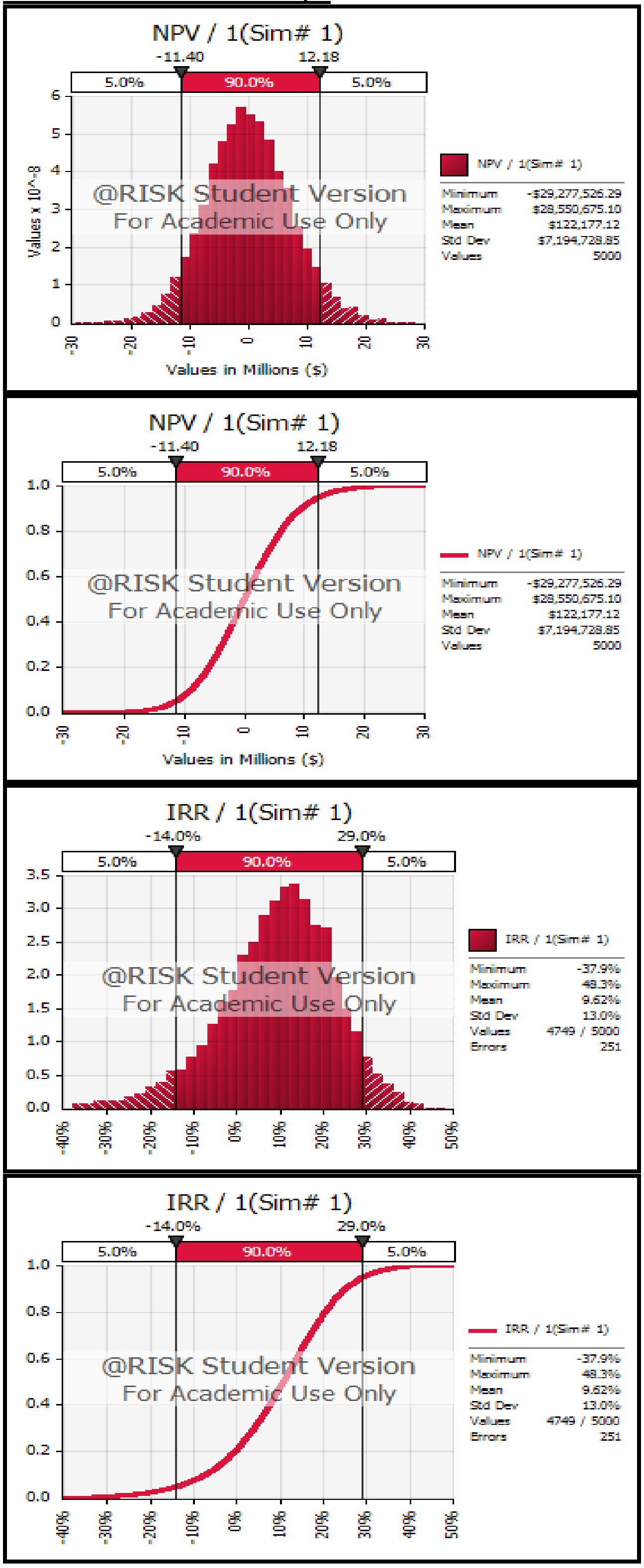


Table (22) Sensitivity analysis and risk factor ranking results for water reduction effect on NPV (with Government subsidy):-

Regression and Rank Information for NPV / 1			
Rank	**Name**	**Regr**	**Corr**
1	Total sales volume / 1	0.977	0.983
2	Unit cost year 1 (percent of sales price)	-0.127	-0.149
3	Annual increase in sales price, unit cost	0.043	0.048
4	Sales price/Ton year 1	0.035	0.013
5	Annual increase in sales volume	0.026	0.037
6	Crop yield reduction due to water /10	-0.017	-0.066
7	Crop yield reduction due to water /8	-0.017	-0.054
8	Crop yield reduction due to water /6	-0.016	-0.055
9	Crop yield reduction due to water /3	-0.015	-0.055
10	Crop yield reduction due to water /4	-0.015	-0.086
11	Crop yield reduction due to water /7	-0.013	-0.067
12	Crop yield reduction due to water /2	-0.012	-0.043
13	Crop yield reduction due to water /9	-0.012	-0.059
14	Crop yield reduction due to water /5	-0.010	-0.061

Nowadays there are drawbacks to using standard deviation as a measure of risk in project investment. It interprets any difference from the average, above or below, as bad, not how most investors feel about returns. No investors afraid about their investment to be doubled; they only worry about the downside their returns being below average. Investors think of risk as downside risk only.

Downside risk, as the name implies, measures risk below a certain point. For example, if an investor is worried only about losing money, that point would be zero and any NPV below zero is not acceptable, and the possibility of negative NPV returns would be viewed as risky. If an investor needs to earn IRR with 12% return in order to meet goals, any IRR return under 12% would be considered risky. The point or the line between good and bad outcomes, is called the Minimum Acceptable Return (MAR).

Figure (19) shows the effect of Government subsidy on NPV with underground water reductions possibility. The graph showed that Government subsidy reduces downside risk and difference between NPVs at downside the graph is big.

Figure (19) : Effect of Government subsidy on NPV :

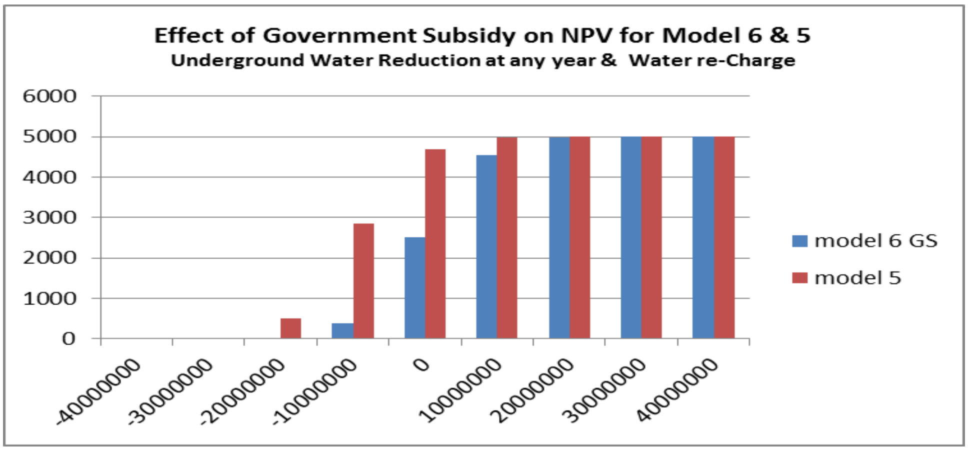
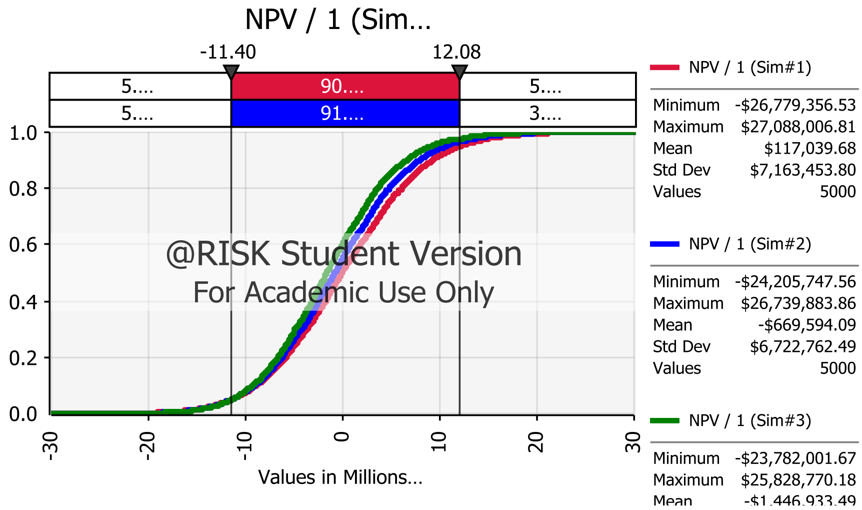
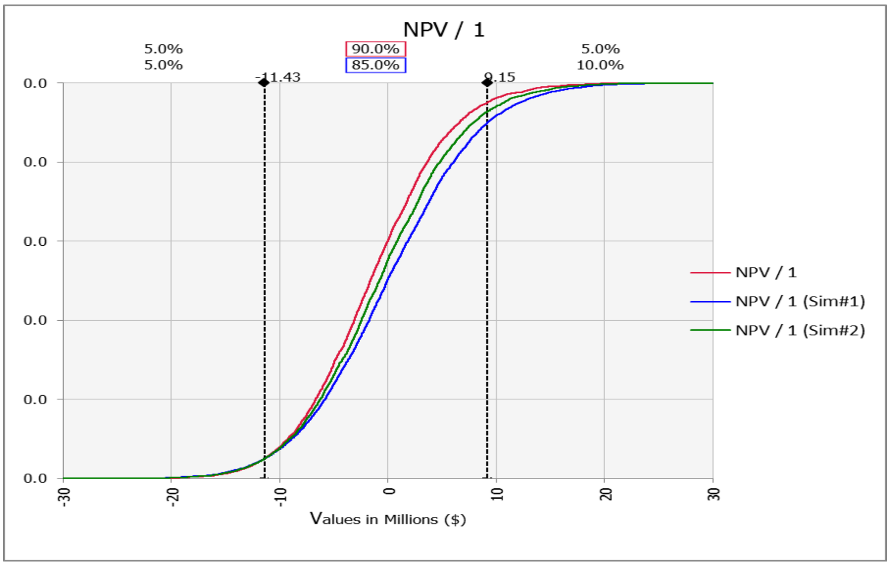


Figure (20) : The NPV cumulated distribution function :





Considerations on risk analysis in Najed project

Despite the overcoming of computational limitations to the application of such techniques, two major practical considerations remain as regards the extent to which such techniques as Monte Carlo simulation can be used in project preparation situations.

The first consideration : Is the issue of data availability (effect of irrigation water reduction on Rhodes grass crop yield), and the extent to which the situation can reasonably be defined as risk (as opposed to uncertainty) through the construction of a meaningful probability distribution of outcomes. The actual situation with data availability is likely to vary very much both between project situations and also across different sources of variability within any one project environment. At one extreme, large volume of reliable cross-sectional or time series data may be available from historical sources for the variable concerned (e.g., for rainfall, for underground water availability, for crop yield, for crop prices). At the other extreme may only be the existence of a few data points (e.g., most likely values, absolute minimum possible, maximum possible etc.) which are expectations of experts or analysts involved in preparing the project. Other possibilities lying within these bounds include the forecasting/specification of crop yield theoretical capabilities adjusted for a set of likely different water level and farm operating conditions, forecasts of cost of raw materials and commodity prices etc.

It is important to note that very large and complete data sets from empirical sources are not always necessary for the undertaking of risk analysis. Simplifying assumptions about variable distributions can be made – as a bare minimum, triangular distribution from three points (most likely, minimum possible, maximum possible) can be constructed based on "best guesses" of project preparation experts and/or team members. The minimum, maximum and most likely method are used to estimate yield and price in this study.

There is also often considerable expertise within the project preparation environment about the likelihood of variables or outcomes which may be not available from official sources but which can be elicited from potential project participants. The Delphi method of eliciting opinion from local experts is an example of this type of approach that could be used.

Well-tried empirical methods exist for developing probability distributions from such subjective sources. These include visual impact techniques (e.g., matches or stones piled up to represent frequency of value occurrence), structured questions to identify key points in a distribution (e.g., the median, quartiles, etc.) and the application of "smoothing" techniques in situations where a few real data points may be available. Rhodes grass crop yield distribution best fit test and curve smoothing techniques is used in this study to identify the relation between water application and yield.

Some proponents of probability-based risk analysis argue that the shapes of particular distributions of individual variables are less important than the choice of variables themselves, which are allowed to be modeled. Recent experience of preparation of agricultural projects suggests that the particular form of distribution matters less if a large number of simulations are run. Even when considerable effort is made to replace, for example, the quoted discrete distributions with relatively few values by continuous distributions based on large amounts of empirical data, there is little difference in resulting distributions of EIRR/ENPV outcomes (i.e., expected values and variance, minimum and maximum values, etc.).

This approach may not always be appropriate for all variables, and it still requires judgment on the part of the analyst about what ranges are acceptable for values to fall within. Also, to adjust the spreadsheet model to produce a normal distribution (as opposed to a uniform one) becomes very much more complex. It is also noted in the risk literature that there is no a priori case for the use of normal distributions as all variables are not always subject to relatively large number of random influences. However, this issue discussed in chapter 3 point number 3.9 of this thesis.

The techniques applied to develop definitions and derivations of probability distributions for individual variables in most cases is likely to depend upon some subjective judgment by a researcher – and inevitably the extent to which these design assumptions adequately reflect the reality of the project will vary from case to case. The suspicion that what appears as a full-scale risk analysis has in reality only a spurious precision can be ultimately only fully allayed if the data upon which the variables' probability distributions are constructed are believable.

The second consideration : When applying risk analysis in practice is the extent of covariance between those variables that are to be selected for risk analysis. Projects are rarely subject to only one source of risk, and therefore more than one variable at a time is modeled in the Monte Carlo simulation expertise. Statistical complexities can arise depending upon the relationship between the selected variables. Where variables are in fact statistically independent of one another there is no problem, as it is appropriate to treat them independently. Where variables may be thought to be related in some way, the extent of covariance between them needs to be taken account of when specifying the distribution of individual variables in some type of simulation.

For example, project revenues are typically products of both quantities sold (in tons) and prices obtained. If these underlying variables are correlated in some way (which may well be if project output is large relative to market volume, and negatively so in this case) the expected value of the product of two random variables (i.e. project revenue) is equal to the product of the individual expected values plus the covariance between the two variables. Another typical example of covariance may be that between area planted and average yield (i.e., with both variables as determinants of farm production volumes). There could be a negative correlation between the limited irrigation water availability and area planted with Rhodes grass at Najed Project. In practice, the approach to assigning particular levels of covariance between variables is quite pragmatic, and typically simple rank correlation coefficients between pairs of variables are sufficient for most purposes.

It is specifically recommended that disaggregation of individual variables be limited as much as possible so as to avoid including too much correlation in the analysis. For example, although individual construction cost items e.g., cement, cost of floor, cost of walls) may each be thought to vary individually, in reality the sources of this variability all arise from one point (e.g., cost of imported cement), and this could be most appropriately captured through some item such as "construction materials" rather than by introducing additional correlation between such items (which would tend to increase unnecessarily the estimate of overall variability). Akin to the nature of some subjective judgment being involved in the allocation of probability distributions, there is therefore a similar judgment to be made about the extent of disaggregation to be applied in individual circumstances.

It is clear that the quantitative modeling of risk is in principle preferable to the simple depiction of uncertainty, although it is obvious that data and time considerations and the difficulties in properly identifying and specifying covariance among variables, have often limited the extent of actual risk analysis practice. It is also the case that the present availability of computer software and easily process Monte Carlo-type simulations from data already available to the analyst within spreadsheets, plus the existence of statistical routines and computational processes to fit probability distributions to many data sets, helped us for application of quantitative risk analysis as a more commonplace part of project design, and water policy analysis.

Chapter Five

Farm Location Models Analysis

CHAPTER 5
FARM LOCATION MODELS ANALYSIS

5.1 Introduction

Location Problems :

Many feasibility studies do not incorporate alternative location choices for evaluation. This study differs as three location choices will be incorporated and analyzed to determine which location is preferred. It is important to understand how location science has evolved from deterministic to dynamic and how important choosing the right location is to the profitability.

Study in the field of agricultural economics in relation to location science has been minimal. Most research has been in the operation research and urban development fields. Operation research has developed mathematical programming models to represent and cover the wide range of location science problems. These problems have been formulated with multiple objective functions and various constraints to adapt these models to meet specific applications (Daskin 1998). Outlaw (1988) studied the location of agribusiness centers and how they were relatively new and do not fit into typical growth center studies. He identified eleven factors that affect a community's chances of attracting new businesses. They are industry infrastructure, population, transportation, business environment, development action, education, raw materials, financial development assistance, medical facilities, quality of life, and taxes.

The Stollsteimer model continues to be the most widely used complete enumeration method for analyzing plant location problems (Beck, 1980) with application to agribusiness. The Stollsteimer model requires data for location of plant sites, transportation cost, processing cost, volume for supply centers, and plant capacities. Fuller (1975) presented a modified version of the Stollsteimer plant location model. The Stollsteimer model determines the least-cost number and the size and location of sub-industry's marketing facilities with a guaranteed a global minimum. Fuller modified the Stollsteimer model to where the long-run cost function is discontinuous and formulates the computational scheme to enable researchers to lower total cost. The modified version does not attain a global minimum through simultaneous variations. The feasibility of the model diminishes as the number of potential sites increases. Klingman, et al. (1976) examined the plant location problem with cotton gins. Past decisions on location of cotton gins were intuitive ones without sound economic justification. A network problem was formulated and it was shown that the cotton industry could improve its profit by at least 10% and as much as 15% by using the cooperative blueprint specified by the optimal solution.

Recently, Isik, et al. (2002) presented a paper on entry-exit and capacity decisions under demand uncertainty for an agribusiness. Sambidi and Harrison (2003) surveyed U.S. broiler industry executives to determine site-specific factors related to broiler location problems. They find that total cost factors are the main drivers, noting that industries tend to locate in regions with high unemployment and low wage rates. It is difficult to determine whether location decisions are made by accident, as a function of history, or as a function of economic variables that can be measured, such as wage rates, tax rates, urban size, utility cost, or cost of inputs.

Industry Clustering

Many firms locate individually, but industries have been shown to cluster together. Industrial parks have emerged recently in the U.S., some 3 digit manufacturing industries such as agriculture machinery, automobile components, electronic computing, tend to locate together. It is interesting to note that most of the cities where industrial parks locate have minimal or zero employment in that industry before investment was made (Henderson 1992). Henderson attributes these static location economies to:

1. Economies of intra-industry specialization where increased industry size permits greater specialization among industry firms,
2. Labor market economies resulting from a larger pool of trained workers,
3. Scale for networking or communication among firms to take advantage of complementarities,
4. Scale in providing public goods and services tailored toward specific industries.

Barkley, et al. (2001) created a probabilistic modeling approach to determine if manufacturing plants cluster across rural areas. They measured clustering tendencies based on a “dispersion parameter” of the negative binomial distribution and found nearly all-manufacturing industries cluster establishments in non-metro areas. Some cases of concentration come from natural advantages that include such things as climate, topography, proximity to inputs, etc. Many of the studies in the field of clustering industries have been limited to case studies of specific industries.

Industry clustering will normally provide greater economic benefits to the community and firm. Barkley and Henry (2001) show that clustering will strengthen localization economies, facilitate industrial reorganization, encourage networking among firms, and permit greater focus of public resources. The downside to clustering is that communities will have difficulty picking the proper firms and later investors may not be competitive in the market as the earlier firms gain an advantage.

Historically, it was believed that manufacturing products close to demand is optimal to reduce transportation cost, offer maximum coverage of demand, and maximize profitability with respect to controlling cost. Increased transportation cost from being located farther from demand points have forced businesses to operate at the highest level of efficiency and take advantage of economies of scale to reduce cost. Almost all location studies focus on three major factors important to location, assembly of the plant, processing, and distribution of products.

Location Study Literature Review

Looking back in time, Emperor Constantine was first interested in the problem of location and distance in the 4^{th} Century AD for strategic placement of Roman legions. In 1826, von Thunen studied the forces that affect agricultural prices and land use in the central city. Variation of cost was determined to be due to land rent and transportation cost. The 17^{th} century mathematicians, Fermat and Torricelli, developed the first formal problem of location and distance, which is known as the Weber Problem or Euclidean minisum problem today. Studies then move forward into the 19th century where Sylvester, a mathematician, studied the infinite solution space minimax Euclidean distance problem (Sylvester, 1857). In the 20^{th} century, Steiner expanded the three-node Weber problem into a general problem where multiple nodes were connected together with the shortest distance.

Location science then moves into modern economics. Weber (1909), Hotelling (1929), and Hoover (1948) have all contributed a great deal to economics and location science. Weber was an economist studying the location of industry and Hotelling and Hoover continued this idea. In the past, mathematicians were concerned with solving the problem of minimizing distance or maximizing coverage. Weber considered the positioning of a single warehouse to minimize the total distance between it and several customers. Hotelling's problem, known as "ice cream vendor on a beach," looks at capturing market share on a beach against a vendor who is located in the center of the beach. Today, this type of problem is known as a "competitive location" problem where companies compete for maximum market share. Hoover in 1948 expanded the Weber problem from a single source and demand to multiple demand and multiple supply locations.

Baumol and Wolfe (1958) were the first known economist to use a computer to solve a location problem. They solved a mathematical programming model for warehouse location on a network. Following this, in 1963 and 1964, Hakimi presented proofs of nodal sufficiency for optimal citing in a minisum problem on a network. These proofs became a foundation for location science. Hakimi concentrated on the location of switching centers in a communication network and police stations in a highway system. Since this time, location study has flourished and expanded to many fields of study.

Location science can be broken down into two different areas of study, static location models and dynamic location models. Static or deterministic models take constant known quantities of inputs and derive a solution to be implemented. The solutions to these static problems are solved according to certain criteria or objectives. In both cases, the goal is the same, to determine the number of facilities to be located, the size and location of the facility, and the market responsibilities of each facility (Randhawa, 1995). In the following pages, static or deterministic problems will be discussed followed by dynamic models. Both types of models fall into four broad categories: median, covering, capacitated, and competitive (Church, 1999).

5.2 Deterministic and Dynamic Location Models

Static/Deterministic Location Problems

Static or deterministic problems have been made easier with the invention of the branch and bound method (Lang and Dolg, 1960). Church and ReVelle (1974) present new techniques that enhance the performance of the branch and bound algorithms called branch and peg algorithms.

Distance from the selected location is a major factor; there are inbound cost, in plant cost, and outbound cost for delivery of products to demand (Dohse, 1996). Hakimi first invented this problem, known as the P-median problem, where demands are not sensitive to the level of service. ReVelle (1986) presented a modified version of the P-median problem for locating retail facilities in the presence of competing firms.

Facility locations have fixed costs that are involved which must be accounted for. Neebe and Khumawala (1981) and Holmberg (1994) all present models that incorporate fixed cost associated with plant assignments in addition to transportation costs. Harkness and ReVelle expand on this problem saying that with every decision to invest in a new plant, there is a simultaneous location decision.

Averbakh (1998) consider a generalization of the traditional plant location problem where the setup cost of a facility is demand dependent, meaning that it depends on the number of customers served by that facility. The capacitated plant location problem includes a set of potential locations for plants with fixed costs and capacities and a set demand from customers from these plants (Sridharan, 1995; Sankaran and Raghavan, 1997). A simple capacitated problem using an econometric model could be used to determining the location of individual industries (Henderson, 1992).

Eiselt (1998) and Rhim, et al. (2003) look at a model where two competitors locate simultaneously to capture an unknown demand. Locations consider the positive effects of pulling the facilities toward demand or the negative effects of pushing the facility away from the places affected by the facilities nearness (Krarup, 2002, Zhou, 1998. ReVelle (1997) states that many of these formulations can be expanded to other industries, specifically industrial, environmental, and geographic industries.

Dynamic Location Problems

Dynamic location problems have moved into the forefront of location science problems, as static problems do not capture many of the characteristics of real world location analysis. Static models require that future information is given but in the real world sense of location science, future information such as demand and supply, crop yield and price are uncertain, i.e. there is imperfect information (Murray, 2003). However, the underground water availability at study area, yield, sale price and cost per unit are input variables used in location model in this study to test the effect of Farm location on profit.

Ballou in 1968 was the first paper that recognized the limited application of static or deterministic location models and used a set of suitable locations dynamic programming to determine the optimal subset of locations. Taperio (1971) extends the model to include capacities and shipping cost. In his model, supply and demand values are known and minimum cost is found. Sweeney and Tatham (1976) present a model that determines the location, size, and timing of plant facility construction.

Drezner in 1995 reformulated the P-median problem to a dynamic problem. Drezner and Wesolowsky (1991) and Wang et. al. (2001) considered a planning horizon where demand and population shift. Ermoliev and Leonardi (1982) also included stochastic features into a facility location problem to describe both demand for facilities and the trip pattern of customers. They show stochastic programming may be useful although difficult to solve. Wesolowsky (1973) and Wesolowsky and Truscott (1976) expand this idea to take into account predicted changes in demand.

Stochastic problems represent real world systems where parameters in a system are uncertain, such as cost of production, capital and construction cost, demand locations and quantity, and supply location and quantities. The objectives of these models are to find robust facility locations under a number of possible parameter realizations. There are probabilistic models, which consider probability distributions of the parameters, and there are scenario-planning models, which generate a future set of random variables.

One of the earliest works with stochastic inputs was by Manne in 1961. Bean (1992) expands this problem with stochastically growing demand and an infinite planning horizon. Mirchandani and Odoni (1979) showed that the previously stated proofs by Hakimi's can be applied to stochastic location problems. They evaluate the previous stated P-median problem and uncapacitated warehouse location problem with stochastic distances, supply patterns, and demand patterns.

Another approach to the facility location problem is presented by Hanink (1984), which uses portfolio theory from finance economics to solve a class of multiple plant location problems. This was followed with an option-value model (Isik, 2002).

Schilling (1982) uses scenario planning to analyze the problem of locating a number of facilities over time. Scenarios depict a range of future states through a quantitative characterization of various values for a problem's input parameters (Vanston, 1977). The difficulty is determining which solution is robust. Three common selection criteria are (Owen and Daskin, 1998); optimizing the expected performance over all scenarios, optimizing the worst-case performance scenario, and minimizing the expected or worst-case regret across all scenarios

Location Incentives

Incentive packages can directly influence location decisions of agribusiness and firms. Incentive packages are widely used by governments to attract business in investing in the local economy. With government involvement, the investor and community must recognize economic and social goals as well as private profit targets. Historically, it is believed that the attracting of businesses is a method of improving employment and income to the community or reduces the risk of miss-use of water resources and will have an overall positive economic impact (Barkley, et al., 2002). Many cities and regions forced companies to relocate and invest in their community. The effectiveness of giving these incentives is up for debate and has been the center of many economic studies (Peters, 1995). Dye (2000) states that there are four general reasons why incentives are offered; market failure, blighted areas, bidding wars and intergovernmental revenue shifting. However, given incentive to manage water resources is now taking more institution attentions and covered in this study.

Difficulty arises in how to measure the benefits from the business investment against the cost of attracting that business to the community. The true costs are difficult to measure, as the business will change the welfare distribution patterns of individuals in the community and among different classifications of residents. Some individuals may experience a positive effect from the agribusiness project while others may bear the cost of this gain (Reinschmiedt, 1976). In this study, we will calculate and compare cost of attracting business to Najed area and benefit from investment in 3 farm locations.

The Government of Sultanate of Oman spent 11.7 Million rials as capital incentives to subsidy cost of wells, fencing and irrigation systems. In addition of that free shares are given to farmers in Najed Agricultural Development Project. Rhodes Grass production facility has strict environmental constraints in Salalah and Government stop large scale farms at costal area to reserve underground water at costal area and subsidies farming in desert area.

5.3 Typology of Risks in Najed Project

During its life cycle, Najed project will expose to various risks that, if not mitigated, may cause financial distress for the project stakeholders and investors. The risks in Hanfeet and Dawkah projects have been categorized in various fashions which can be classified as under :

1. Technical risk, the failure to meet yield and performance criteria due to irrigation system design and engineering issues.
2. Construction risk, because of faulty construction techniques and cost escalation and delays in construction for more than 5 years;

3. Operating risk, due to higher operating costs, raw material and electricity costs;
4. Revenue risk, e.g. due to yield reduction and sale volume shortage or yield volatility which can lead to revenue deficiency;
5. Policy change risks, due to legal changes and unsupportive government policies;
6. Environmental risks, because of adverse environmental impacts and hazards;
7. Force majeure risk, involving underground water reduction (well water level drawdown) and other calamities and acts of God.
8. Project default, due to failure of the project from a combination of any of the above.

These risks can also be classified according to timing of their occurrence in the project life-cycle as presented under :

- Design and construction phase (Technical, construction, financial and economic risk).
- Operation phase (operation and revenue risk).
- Residual risks that exist throughout the project life-cycle (environment, Regulatory and policies, project default risk).

Location models in this study will incorporate the above mention risks at three project locations and evaluate the project investment at each location and recommend solutions to mitigate those risks. The study will identify the types of Government Share (or Support) that can be extended to the project through the sharing of the cost and risk of implementing and/or operating in the project, and also specific instruments that should be used to affect the support and subsidy. The study will also identify issues involved in the budgeting, monitoring and management of such support at study area to ensure a successful long term partnership between the private and public sector.

Risk and Simulation Modeling

Risk analysis is a tool that can be used to deal with risk and uncertainty in decision-making (Pouliquen, 1970). Most investments and decisions are made under the conditions of risk and uncertainty. Uncertainty in input variable prices, underground water availability or future demand states can cause an investment to go from favorable to unfavorable depending on which state of nature occurs. However, most analyses assume perfect knowledge for simplicity in modeling.

Several examples in location science realized perfect knowledge is not feasible and incorporated uncertainty through the use of dynamic programming, portfolio analysis, and scenario analysis to account for risk. Difficulty arises when there are multiple sources of input risk and uncertain future states are incorporated into the model. Stochastic simulation is an alternative tool for analyzing investment and location problems under conditions of uncertainty and risk. Simulation allows for evaluation of risk from stochastic input variables and alternative scenario choices.

Ragsdale (1998) states that simulation is a technique that is helpful in analyzing models where the value to be assumed by one or more independent variables is unknown. Because of unknowns, simulation is a useful tool for analyzing risky decisions (Hardaker, 2004; Jones, 1972). According to Richardson (2003), the purpose of simulation in risk analysis is to estimate distributions of economic returns for alternative strategies so the decision maker can make better management decisions. Decision and policy makers can use an analytical model to make optimal business decisions based on given input and control variables (Winston, 1996).

Law and Kelton describe techniques for simulating operations of various real world systems. Simulation has been used at the firm level for farms since the early 1970s (Eidman, 1971). Richardson and Nixon (1986) describe the basic equations required to simulate a farm or agribusiness enterprise. Their basic equations were defined to simulate financial statements for a given planning period. Gray (1998) described a similar framework for simulation of an agribusiness enterprise. His model did not include evaluation of alternative location choices affecting the probability of return which we are going to do at this study.

Monte Carlo simulation can be used to evaluate location problems and investment decisions when information is available regarding the sources of variability for a business at multiple locations. Simulation can be done deterministically or stochastically. Deterministic results only give “on average” results, meaning the best case, worst case, median case results can be compared ignoring all aspects of risk. A deterministic simulation would be equivalent to a static location model where each simulation returns a representation of the outcomes without the likelihood or probability of the outcome.

5.4 Risk and Dynamic Simulation Models in Farm Location Models

Barry, Hopkin, and Baker (1983) show four methods for evaluating potential profit: simple rate of return, payback period, net present value, and internal rate of return. The net present value is the most comprehensive method, using the discounting formulas for a non-uniform or uniform series of payments. Richardson and Mapp (1977) suggest the use of probabilistic cash flows as an approach for analyzing investments under conditions of risk and uncertainty. They define the probability of economic success as the probability of returning a positive net present value (NPV). Stochastic dynamic simulation model is used in this study to incorporate uncertainty in the analysis. The model will estimate the distribution for outputs i.e. NPV rather than using a single value of NPV and IRR alone.

Ragsdale (1998) lists three methods used to analyze risk, best case/worst case, what if analysis, and simulation. With deterministic models, ranking alternatives is based on a single output. To maximize profitability, the highest value would be chosen. To minimize risk, the scenario with the lowest standard deviation would be chosen. By applying simulation to evaluate alternative scenarios with stochastic variables, the analysis will show a complete representation of possible outcomes. Ranking alternative location choices under risk can be difficult. Simulation estimates an empirical distribution for key output variables (NPV, IRR) that can be compared across locations. Each location and Farm can be compared and ranked to determine which is most viable.

The location models used in this study tested three location and 6 scenarios (Salalah- Hanfeet- Dawkah) according to unknown risk factors effects such as underground water scarcity and irrigation water availability, capital cost, operation cost, location incentives and crop yield variables. Salalah location represents coastal area with old water policy, whereas Hanfeet- Dawkah represent desert area with new water policy. The models will test the effect of the new water policy on probability distributions for output NPV, IRR.

The methodology for building a stochastic feasibility model with probability distributions defined for variables where risk factor incorporated in the model. This type of analysis requires estimating a range of possible risks together with their probabilities of occurring, and the maximum and minimum project costs for the different scenarios. The model can use probabilistic cash flows to calculate NPV and IRR. Stochastic variables are incorporated into a deterministic capital budgeting model to generate probability distributions for key output variables. Random sampling is used to estimate empirical cumulative distributions for the key variables. The probability distribution is a distribution of all possible values associated with a stochastic variable. A probability density function (PDF) represents the complete distribution of a stochastic variable and empirically measures values of the random variable producing a histogram depicting relative frequencies of output ranges, this histogram resembles the random variable's probability density. Table (23) shows uncertain input incorporated in location models.

Table (23) Stochastic variables effect project NPV and IRR at different locations:-

Location	**Salalah**	**Hanfeet**	**Dawkah**
Farm Location	Costal Farming	Desert Farming	
Total Farm Area/Ha	1500	4200	3600
Cultivated Area/Ha	878	878	770
Total Capital Budget RO	4,791,524	7,596,000	7,430,000
Government Incentive RO	-	2,599,000	2,543,000
Yield range /Ton	24-22	24-22	22-20
% yield reduction due water level reduction	1-3-5	1-3-6	2-5-7
Operation cost RO/ton	58	75	79
Unit cost year1/(% of sale price) triangle dist.	65-68-70	75-79-83	80-84-88
Annual increase in sale price & unit cost %	1-3-5	1-3-4	1-3-5
Sale Price /ton (triangle distribution) RO	90-95-100	90-95-100	90-95-100
Authorized Water discharge Mm³	Un-limit	31	25
Water discharge in study Mm³	Un-limit	28	25
No Wells	20	40	35
No central Pivots	20	40	35
Area per Central Pivots/ha	40	22	22

5.5 Risk factors and Risk Assessment in Farm Location Models

One of the main question to be answered in this study is to investigate the sufficient of Government incentives and capital subsidy given to the project to compensate the risk associated with change in water resources policy and farm location. Risk associated with input availability and costs were analyzed for the proposed three farm locations so each location resulted in different levels of economic viability and risk that would not have been observed with a traditional deterministic analysis.

The large–scale irrigation infrastructure projects such as Najed Project are almost inevitably risky. The risks arise at each stage of the project’s life cycle and have to be divided carefully between the public and private sector partners. If the allocation is misjudged, that could have severe consequences – on the one hand, inadequate incentives for the private investor; on the other, bankruptcy or costly bail-outs.

The allocation of risks between public and private sectors often tends to follow a generic pattern (construction, operations and maintenance should be allocated to the private sector, site risk and policy risks to the public sector). The allocation and transfer of the risk should be to the party who is the most capable of efficiently managing these risks and to achieve the best project value for money.

The following section describes the stochastic variables used in the model. The stochastic variables used in the farm location evaluation models are: Water level drawdown – increase in capital cost of the project due to new water policy at Najed project area- increase in operation cost (unit cost as a % of sale price) – sale price – annual % increase in unit cost / sale price- annual % yield reduction due to water level drawdown- the range of the crop yield per hectare and 1st year crop yield. The estimation of each input variable and probability distribution at each location identified and incorporated in the analysis.

To achieve well-balanced risk allocation, we can divide the work into three broad sections: identifying and assessing the risks; determining the party best able to manage the risk; and reassuring investors by taking measures to mitigate and share risks. Accordingly, the risk associated with farm location model can be grouped to three main groups as under :

(1) Risk due to change in water resources policy :

- Well water level drawdown.
- Crop yield reduction due to insufficient irrigation water.
- The first year yield volume.
- Annual yield growth.
- Increase in total capital cost of the project.

(2) Risk due to operation cost increase :

- Raw material cost increase.
- Electricity cost increase due to water level drawdown.
- Per unit cost for year one (Ton/cost).
- Annual increase in unit cost.

(3) Risk due to sale price control :

- Demand and supply of fodder crop fluctuation and sale price per ton.
- Annual increase in sale price.
- Risk due to sale price control.

(1) Risk due to change in water resources policy :

Well water level drawdown.

The wells water level data at study area (Hanfeet, Dawkah) and the effect of water level drawdown on crop yield at each location are tested. Water level drawdown especially coupled with pumping data were tested and provide useful information can be used in determining wells performance and aquifer conditions, including the presence or absence of hydrologic connection between different wells. When referring to water level data one should look at both static and dynamic (Pumping) levels to estimate water level drawdown.

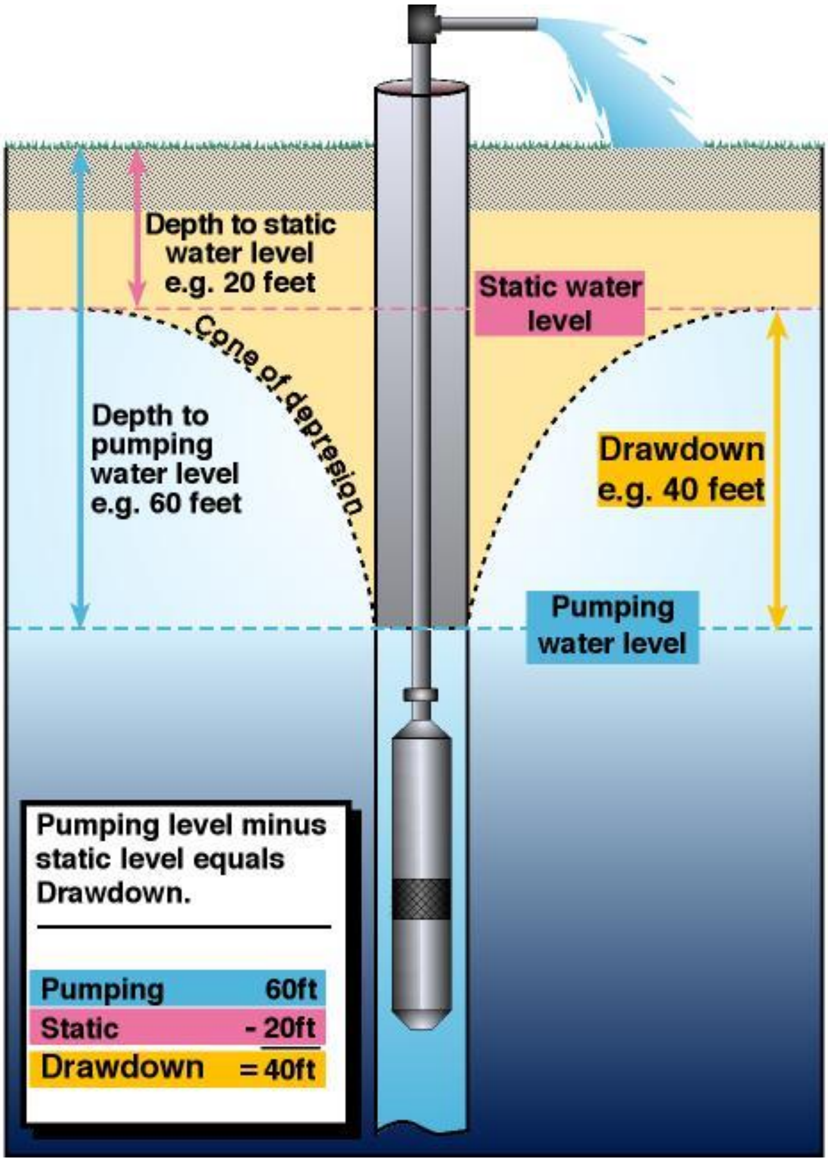
- Static water level refers to the water level in a well when it is not being pumped.
- Dynamic water level refers to the water level in a well when it is being pumped.

The first year yield volume and annual yield growth.

The first year yield at Hanfeet Farm location was low due to implementation of new irrigation system, new water resources policy and Failure to meet performance criteria due to design issues. The first year yield for Salalah and Hanfeet locations incorporated in the model with normal distribution (RiskNormal) and a range of yield between 24-22 ton per hectares, whereas, for Dawkah location the first year yield range between 22-20 ton per hectares.

The model assume annual increase in yield/sale volume variable, which incorporated in the model by triangular distribution (RiskTriang) i.e. 1%-2%-5% for Salalah location and 1%-3%-5% for Hanfeet and 1%-2%-5% for Dawkah location.

The difference between static and dynamic (pumping) water levels is referred to as drawdown. Understanding drawdown is important in well use because when pumping (dynamic) results in drawdown that brings the dynamic water level to depths near the pump and the well will lose the ability to produce water and crop yield will be affected. Moreover, drawdown is commonly coupled with pump damage and a total number of 12 pumps were damaged at Hanfeet location due to water drawdown.



Crop yield reduction due to insufficient irrigation water.

The effect of water level drawdown on Rhodes Grass yields incorporated in the model by introducing three scenarios probabilities i.e. 10% 30% and 50% at each location model. The model allows water level drawdown each year and also allows water level re-charges in any years with triangular distribution (Risksimtable). The total yield reduction each year formed with a (RiskCompound) function.

Hanfeet Farm started the operation on December 2011. The water level drawdown significantly as showed in Table (24) and 12 pumps were damaged due to water drawdown and additional RO 127,930 capital cost was used to repair pumps.

Table (24) Water level drawdown in meters Dec.2011–Feb.2013 Hanfeet Farm:-

Pivot No.	Well No.	Dec 2011	Feb 2013	Static level Differ. In Meters	Feb 2013	Dynamic Head
		Static Level SL	Static Level SL		Dynamic Level DL	DL-SL
1	11	45.72	57	11.28	66.00	9.0
	12	44.50	56	11.50	61.00	5.0
2	9	50.60				
	10	47.39	69.10	21.71		
3	7	76.16	114.40	38.24		
	43	76.11				
4	6	73.50	108	34.50	117.30	9.3
	44	74.77	112.70	37.93	117.50	4.8
5	4	70.76	107.50	36.74	109.50	2.0
	5	72.40	108	35.60	111.60	3.6
6	2	69.55				
	3	70.41				
7	1	67.96	102	34.04	104.40	2.4
	45	70.16	105	34.84	108.80	3.8
8	13	48.48	60	11.52		
	42	85.19	56	-29.19	60.00	4.0
9	14	48.75	60.6	11.85	63.60	3.0
	15	48.35	61.5	13.15	82.00	20.5
10	18	75.75	112.5	36.75		
	19	80.64	119.2	38.56		
11	20	79.21	117.5	38.29	119.50	2.0
	21		116		118.80	2.8
12	22	76.47	115	38.53	118.00	3.0
	23	75.52	112.7	37.18	116.50	3.8
13	24	75.15	113	37.85	115.60	2.6
	25	73.73	111	37.27	114.00	3.0
14	26	72.63	109.6	36.97	113.00	3.4
	46	74.87	111.9	37.03	118.00	6.1
15	40	55.80	66.4	10.60	67.60	1.1
	41	52.41	64	11.59	65.00	1.0
16	38	51.83	65	13.17		
	39	54.05	65	10.95		
17	33	84.23	121	36.77	123.50	2.5
	34	85.19	123	37.81		
18	31	82.22	120	37.78	122.20	2.2
	32	83.22	112	28.78	122.00	10.0
19	29	80.45	118	37.55		
	30	81.73	118.3	36.57	121.50	3.2
20	27	78.45	115.7	37.25	117.00	1.3
	28	79.12	117	37.88	118.70	1.7

- Source Najed Agri. Development Company's technical report January 2013.

Increase in total capital cost

The new water resources policy introduced recently at Najed project area increase capital cost of the project by 60% and cased risk of project cost overrun needs to be mitigated. The new water policies in project area increase capital cost of irrigation system, fencing, building and inside roads as summarized under :

The total project area of Najed project is about 11,400 hectares and the planted area is 2,418 hectares constitute 21% of the total project area. This as per the requirements of the (MRMEWR) and the need to keep (10000 Meters) between wells, which leads to higher capital and operating costs. The increase in total capital and operation cost effect on profit will be calculated and presented later.

Due to the limited underground water in the region and (MRMEWR) restrictions and new water policy on the quantities of water withdrawn from wells, the project relied on small central pivot irrigation system can cover only 22 hectares with 2 wells and pumps. As a result, the new water policy increase the numbers of well and pumps at Hanfeet and Dawkah farms to 40 wells and pump to irrigate area of (770 hectares). However, the central pivot system at costal area (Al-Batinah and Salalah plain) could cover 50 hectares and needs 20 wells and 20 pumps only. Table (25) indicates capital cost and Government incentive and subsidy for each farm location.

Table (25) Capital cost and Government subsidy of the farm in each Location:-

Location	**Hanfeet**		**Dawkah**		**Salalah**	
	No	Cost RO	No	Cost RO	No	Cost RO
Pivots	40	798,182	35	798,182	20	400,000
Wells	40	751,887	35	761,881	20	376,800
Pumps	40	356,992	35	356,992	20	178,496
Agri. machineries		666,939		586,945		666,939
Total irrigation & Machineries		**2,574,000**		**2,504,000**		**1,622,235**
Control Room		250,000		250,000		125,000
Roads		650,561		650,560		325,281
Buildings		2,500,000		2,387,440		1,250,000
Fencing		255,000		200,000		127,500
Total Building cost		**3,655,561**		**3,488,000**		**1,827,781**
Vehicles		305,000		306,000		305,000
Furniture & Office Equipment		47,100		48,000		47,100
Total fixed cost		**6,581,661**		**6,346,000**		**3,802,116**
Contingency		257,400		257,000		162,224
Pre-Operation cost		66,550		66,000		66,550
Working capital		760,635		761,000		760,635
Total project cost		**7,666,246**		**7,430,000**		**4,791,524**
Government subsidy RO		2,599,000		2,543,000		No subsidy
Government subsidy %		34%		34%		-

- Calculated by the Author.

The above table shows that new water policy increased the capital cost of the Hanfeet and Dawkah farms by about 60% compare with Salalah farm at costal area. The cost of irrigation systems, farm fencing, roads and building were the main cost affected by the new water policy introduced at project area. The Najed Project cost overruns are the results of several key factors which can be summarized in three areas:

Cost estimations:

- Incomplete initial design or further development of design prior to secondary costing.
- Inadequate contingencies to accommodate level of project design maturity at tender.

Fluctuating market pressures:

- Significant increases in capital equipment and other raw material costs.
- Escalation in civil and equipment costs due to inflation and price increase.
- Labour shortages and supply cost increase.

Inadequate ongoing governance and risk management:

- A lack of appropriate governance and decision making.
- Inadequate risk management, including poor transparency of information and remediation activities.
- Failure to disclose downside risk leading to under-forecasting of potential cost exposures.
- Failure to monitor use of contingency budget.

The conventional project evaluation method such as net present value NPV and internal rate of return IRR were used to evaluate each farm location. Stochastic simulation model are also used in this study to analyze risk and uncertainty in the investment and to estimate the distribution for NPV and IRR.

(2) Risk due to operation cost increase :

Raw material and electricity cost increase.

The technical study assumed low input of seeds and fertilizers which cannot get the productivity mentioned in the study 35 ton/ha. The new input prices increased recently from RO 431 to RO 577 and this will affect cost of production and project profitability. The operation costs of wells at Najed area is high compared to the Costal area, as a result cost of electricity per hectare is high and reach RO 198 at Hanfeet and Dawkah farms compared to Salalah location of RO 150. The risk of unit cost (ton) increase for each farm location incorporated in the location model by triangle distribution ranges presented in table (23). Risk analysis also incorporated annual inputs and sale price increase.

Crop yield and per unit cost

The expected productivity per hectare considered in Najed Project technical study is high 35 tons/ha and difficult to achieve, especially with water restrictions (in terms of quantity and quality) in addition to the low temperatures at night in winter and high day temperature in the summer which will affect Rhodes grass growth. The crop yield per hectare for local farmers at the project area ranges between (21-28 tons/ha) only. The risk MCS models take a triangle distribution ranges of (30, 28, 25) tons per hectares to test yield variation in the model, as shown in table (23).

One of the main constrains of Rhodes Grass cultivation at new location, is the amount of water withdrawn allowed by (MRMEWR). The water withdrawn should not exceed (81 million cubic meters) per year, which is less than the actual Crop Water Requirement of the plant which estimated at about (88 million cubic meters) per year. This constrain will effect crop yield and reduce productivity per hectare or increase risk of drying wells in the future and reflect on project sustainability. The table below (26) shows the amount of water discharge authorized by (MRMEWR) and crop water requirement in million cubic meters per year. The figures in the table show that the authorized water discharged is less than crop water requirement and that will affect Rhodes grass yield and project profitability. A detail analysis will be presented later in this chapter of this thesis.

Table (26) Total Area, water discharge and Crop Water Requirement in Mm³/Year:-

Location	Cultivated area as (MRMEWR)	Authorized Water discharge Mm³	Actual area	Water discharge in study Mm³	CWR Mm³
Hanfeet	958	31	878	28	32
Khawater	750	25	770	25	28
Dawkah	750	25	770	25	28
Total	2458	81	2418	78	88

(Source: calculated by Author).

The technical feasibility study indicate the water extraction from wells should be 30 liters/sec only while the plant requirement needs pumping extraction of 40 liters/ sec to meet the CWR of the plant. Even if we take new water policy of (MRMEWR) (30 liters/sec) from well, the pumps should operate more than 22 hours/day which is not possible. Time is required for maintenance and pump should stop working at mid-day due to high temperature at desert.

The efficiency of wells productions have been estimated through monitoring wells of the (MRMEWR) located at different area at Najed. However, the efficiency of wells at Hanfeet Area has been evaluated through measuring well water production and water level drawdown. 5 pumps are not working at Hanfeet due to low capacity and insufficient electricity power which reflect the actual crop production at the project area.

(3) Risk due to sale price control :

Demand and supply of fodder crop fluctuation and sale price per ton.
The total project cultivated area (2418 ha) which assume to produce 84,630 tons is calculated based on total abandoned Rhodes Grass Farms at Al-Batinah plain (according to the Ministerial Decree 25/2005) equal of 2658 hectares. The project consultant did not take into account the areas of Rhodes Grass in Dhofar Region which is about 630 hectares (40 hectares of farms in Salalah plain in addition of 590 hectares of DCF Company). However, this will affect the estimation of demand and supply and accordingly sale price of the fodder crop in Oman.

Annual increase in sale price.
The product sale price fluctuations considered in the model with a triangle distribution range of (90, 95, 100) rials per ton in the study. The percentage annual increase in sale price at Salalah and Dawkah incorporated in the model by triangle distribution range of (1%, 3%, 5%) and for Hanfeet location by a triangle distribution range of (1%, 3%, 4%).

Risk due to sale price control.
The Government wants to control sale price of Rhodes Grass and to keep the price per ton below RO 100. As a result, the location model assumed the range of the sale price per ton (90-95-100) RO per ton.

The relationship between the government and the private sector partners are not clear, particularly with respect to project incentive and subsidy for beneficiary's (grant and soft government loans). Risk evaluation and risk allocation is one of the greatest challenges in designing, construction and operation of Najd Project due to great uncertainty in many parameters at each stage of the project implementation. The private investors often ask for the government support in the form of subsidies, grants or guarantees in order to mitigate the negative consequences of overestimating these parameters. The effect of project incentive and subsidy on project profitability for each location (Salalah, Hanfeet and Dawkah) performed by using dynamic models and presented in next section.

5.6 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. The main principles to keep in mind in risk allocation and sharing are :

- Risk is bound up with expected profit. Imposing too high a risk on the private sector implies that the public sector will eventually have to pay an excessive payment.
- The risk must be of a suitable size and under reasonable control of the party which bears it.
- Whatever risk is allocated, part of it (even a small part) might be borne by each partner as an incentive.
- Risk allocation must be made at the outset and before project start. If this is not so, the chances of disagreement are high and moreover, if any serious problems arise, the private sector will be in a stronger position to pass the burden on to the public sector.
- If the duration of the project is long it is wise to set up a clause to adjust the contract on a predetermined basis.
- Risk magnitude and money at stake are not the same thing, i.e. the risk of a project collapsing is very different to the risk of losing money on it.

The potential private investors are not prepared to bear some of the risks related to the development and operation of the Najed Project. 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 the potential private investors 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 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 very low levels of yield.
- **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 very low levels of income and cannot offer high fodder crop price.

- **Cost per ton increase risk:** The risk that the raw material cost and operation and maintenance cost will be increased.
- **Hydrology risk:** The risk that there is not enough water and water level drawdown from wells. The new water policy of (MRMEWR) 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.

The private company's invested in Najed Project would not be willing to invest more capital in the project, because they consider that the risk of recovering this capital plus an adequate return on it is too high.

The risk allocation principles is about allocating the responsibilities for, and risks of, Rhodes Grass production at Najed Project between the government and the private investors. In some cases risks may also be transferred to consumers. This is the case if crop sale price, for example, increase in line with operation cost increase or inflation-customers bear risks associated with a rising general level of sale prices. But if Government wants to control sale price, the Government bear risks associated with operation and raw material cost increase. Each risk should be allocated to the party who can best manage it. The means of 'managing' a risk varies depending on its nature. According to best-practice risk management principles, risks should be allocated to the party that is best placed to either:

- Influence the risk factor, if possible (increase sale price).
- Influence the sensitivity of total project value to the risk factor (anticipate or respond to risk factor), if possible, or
- Absorb the risk.

One party to the contract may have direct influence over the risk factor. For example, in the case of Najed Project, the government has the power to stop Rhodes Grass cultivation at costal area in Batinah and Salalah and support Najed Project to bear part of the risk if crop yield reduced due to new water policy implementation.

Finally, there may be some risks that neither party has the ability to influence, anticipate or respond to. In these cases, to 'manage' the risk simply means to absorb its impact. The government may have a greater ability to absorb the impact of some risks than the private operator. The government has a variety of sources of revenue - income taxes, import duties, and profits of state-owned enterprises, for example. The private operator typically has only one source of revenue because it is typically a special-purpose vehicle designed to develop the specific project to achieve specific objective. Thus, if revenue to the project falls for reasons outside the control of the government or the private party, the government may be best-placed to absorb this loss. Alternatively, these types of risks may be shared, to reduce their impact on any one party.

For the risk allocation to be effective, and acceptable to all concerned, the party that bears a risk should also have control over decisions related to the risk factor. For example, the party that bears construction-related risks should be able to select the construction materials, equipment and techniques to be used in irrigation system. This allows that party to react to changes in relative prices of materials by choosing the best-value alternative. In this way, the party both mitigates its own exposure to the risk of construction cost increases, and in turn minimizes the overall project cost.

Determine the party best able to manage the risk, and allocate the risk accordingly, we need understand the following :

– Allocate the risk to the party that is best able to control the likelihood of occurrence, to limit the risk's impact, and to absorb the risk at the lowest cost. To make this allocation accurately, analyse the risk's correlation to other risks, and the private sector's ability to pass the risk on (for example, through insurance, sub-contracting or hedging). Also, we need to study the skills and tools that the candidate contractors have to manage each identified risk – that is, to minimize the likelihood and impact of the risk (for instance, through project management or technical solutions such as growing drought resistant crop varieties).

–Start with the accepted and common standards of risk allocation and evaluate the need for project-specific adjustments. For example, if crop yield is affected by new water policy decisions issued by government, the yield reduction risk should be assigned to the public sector and government. But if yield reduction are due to technical inefficiency and team management and can be influenced strongly by the project operator's marketing or operations, the risk should be allocated to the private sector.

– Assess the implications of transferring risk from the public sector to the contractor, i.e. the increase in cost of capital and its effect on the project's bankability.

–Consider the limits of risk allocation. Often, risks have to be bundled – that is, allocated in groups – as the cost of identifying and allocating each individual risk is excessive. So in practice, only a few particularly significant risks are separated from a bundle of risks and singled out for specific allocation (for example, hydrology risks would be treated separately from general construction risks). And bear in mind that risk transfer to the private party is mostly limited by that party's equity exposure.

–Attract investors by pre-emptively sharing and mitigating risks that are difficult to manage. If the perception is that the project's risks outweigh the opportunities, potential investors will stay away. For the more formidable risks, such as yield reduction risk, the project's promoters need to understand that assigning such risks to the private sector will increase the price they are paying. As a consequence, government may apply various techniques to reduce these risks for the private sector. Besides direct government support (such as co-financing, subsidies or administrative support), these techniques involve various risk-sharing and mitigation mechanisms which will be discussed later in this study. The various categories of risk involved in Najed Project contracts, and guidelines for thinking about how to allocate them, are described in Table (27). The table shows how the key risks associated with the project will be allocated among the Government and the private investors.

Table (27) Risk allocation and responsibilities for each partner at Najed Project

Risk	Description	Allocation
Designs & Construction	Site risk and availability of water. Inadequate planning, substandard design VS project technical requirements. Failure to meet performance criteria due to design issues. Time delays, completion risk, cost overruns, irrigation system quality issues, sub-contractor underperformance, untried and complex technologies, design change requests, and this means the operator receives revenue later than forecast, reducing the project's net present value.	Assumed by the party that has responsibility for design, building and monitoring the project. Government, contractors and MAF should bear this risk. Government may transfer this risk to the private sector if it wishes to ensure that construction is completed on time and within budget and project technical standard. However, pumps installed at Hanfeet were in lower power capacity and not matching the requirement and specifications. Government should bear risk due irrigation system design restricted wells numbers & distance between wells.
Operational	Risk that Najed Project unable to produce grass efficiently : - Fails to meet project objectives & specifications. - Has higher operations cost than expected. - Operational inefficiency, irrigation system underperformance, reduced asset availability and capacity, service & production interruptions, innovation risk	Usually assumed by the private operator because it has responsibility for operating project to provide grass. However, where inputs are controlled by the government, the government may take on risks related to the provision of this input (electricity). For example, in Hanfeet electricity power where not enough to operate all pumps simultaneously due to connection & supply problems from Stat Electricity Authority. The Government may be penalized for interruptions in operation caused by delayed electricity supply.
Commercial	The risk that operating revenues differ from expected Revenues. Commercial risk is often broken down into: -Yield risk: The risk of low production yield less than expected. -Sale price risk: The risk that customers & livestock owners do not pay the expected sale price or sale price control by government. -Lower demand than forecast, higher price elasticity.	If the project operates by a private operator and there is well-established crop yield and sale price payment, this may be borne completely by the private operator. But If the Project with uncertain crop yield, sale price and demand, serving customers whose payment capacity has not been tested, or if yield and sale price payment risks are quite high, these risks may be shared between the public party and private operator or borne completely by the public party by Minimum Revenue Guarantee System (MRG).

Continue of table (27) Risk allocation and responsibilities for each partner at Najed Project

Risk	Description	Allocation
Financial	The risk of the project failing to obtain financing, or that financing terms (tenors and borrowing rates) will differ from forecasts. Risk raise from inadequate revenue streams to cover operation cost.	Allocation depends on whether the project is financially viable (expected revenue covers expected costs) on its own or requires government subsidies to be financially viable. If it is financially viable on its own, the private operator should be able to obtain financing with little difficulty, and financial risk is borne by the private operator. If it requires government funds to be financially viable, the government needs to bear some degree of financial risk.
Regulation and policy	The risk that changes in policy regulations affecting the project's cash flows. Includes control of water extraction from wells (30 liters/sec) risk, where water extraction is control by government and the risk that will not be upheld or enforced at a cost-recovery level the Government must bear this risk.	Government policy usually borne by private operator, unless tightly specified in contract. However, the project contract may also include penalties to the government for not receiving the crop water requirement at farm location. In this case government should borne the risk
Hydrology	In all of the options, the Government bears Hydrology risk. This is the risk that there is not enough water (or lake) to supply the quantity of water needed for irrigation in the project.	The Government should bear this risk because it is better placed than the private operator to absorb it. In addition of that, Government introduced new water policy and stopped Grass cultivation at costal area and asked farmers to locate at Najed area.

5.7 Evaluation criteria and indicators for farm location models

Three key evaluation criteria and indicators are used to evaluate farming at different farm locations. The technical water used evaluation is performed as the first performance indicators. The Rhodes grass produced, crop water requirement CWR, cost of production and returns per ton for each farm location are calculated and summarized in table (28).

The second key evaluation criteria and indicators used in this section are Net Present Value (NPV). The NPV is used to understand project profitability and risk analysis methods and processes. The NPV analyses were performed in static model and dynamic model for each farm location to test key performance indicators.

The Net Present Value (NPV) is a common method to evaluate different projects. It is the sum of the all future cash flows discounted to their present value and a standard method to assess long-term project where the “time value of money is involved.

- **Water use efficiency and return :**

The technical water used evaluation is performed as the one of performance indicators. The Rhodes grass produced, crop water requirement CWR, cost of production per ton and returns from each farm location are calculated and summarized in table (28).

The term "Water Use Efficiency" as a widely used concept in irrigation management is highly controversial and can be clarified only according to one's perspective and purpose within the context of several interrelated factors. When generally defined as the total benefits (material goods, services, crop yields or financial returns) produced by each unit volume of water diverted or consumed beneficially or nonbeneficially, it can be directly linked to water productivity, demand water management, opportunity cost of water uses, comparative production advantages of agricultural crops and other macroeconomic manipulations.

Water Use Efficiency (WUE) is used and defined in this report as the ratio of volumetric crop transpiration (m3) to the volume of total water supply diverted to irrigate the crop (m3). But since it is impossible to separate crop transpiration and measure it directly under field conditions the numerator of the ratio is replaced by volumetric crop evapotranspiration (ET) which can be easily estimated or directly measured by several available methods and techniques. WUE measures the total water used to produce one ton of Rhodes Grass at each farm locations. Table (28) shows that Salalah location is more efficient and consumed less water to produce one ton of Rhodes Grass. Hanfeet and Dawkah farm locations consumed more water than Salalah farm location by 64% and 96%, respectively.

Water Productivity (WP), is defined as the ratio of economic yield of a crop in kilograms (Kg) to total water supply diverted to irrigate the crop (m3). The water productivity analysis for three farm locations indicates the Salalah location is more productive than Hanfeet and Dawkah farms. These two concepts as defined here are selected because they are easier to calculate fewer than two field conditions and reflect the total water losses for beneficial water use from both the engineering and agronomic perspectives. Thus, they provide a wider spectrum for manipulations and interventions towards real savings in irrigation water supplies. Salalah farm indicates higher water productivities than Hanfeet and Dawkah farms as shown in below table.

Table (28) Water used and return for each M³ of water at three farm locations :

Item	Salalah	Hanfeet	Dawkah
	Coastal Area	New Location at Najed	
Cultivated area/ha	878	878	770
CWR/ha/M³	24719	40488	40488
Total CWR/M³	21,703,282	35,548,464	31,175,760
Yield/ha/ton	24	24	20
Total yield/ton	21,072	21,072	15,400
Water used M³/ton	1029.96	1687.00	2024.00
Cost/ton	58	75	79
Price /ton	95	95	95
Return/ton	37	20	16
Return per ton/M³/RO	0.036	0.012	0.008
Water productivity Kg/M³	0.971	0.593	0.494

Table (29) Cost of production per year of Rhodes Grass for three farm locations :

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%**

(Source: calculated by Author).

– Static Location Model :

The second indicator is static and deterministic model, which used to calculate the NPV of a project and quantifies if the project will add value to the firm. In financial theory, if there is a choice between two exclusively independent alternatives, the one with the higher NPV should be selected. The NPV and IRR calculated for three farm locations to compare coastal farm and new farm locations at Najed area. A summary of the three farm locations and the relevant values of NPV are given in Table (29).

The second performance indicators used in this section are IRR or equity provider. The equity providers (also called sponsors) are generally focused on the project internal rate of return (IRR) which represents the yield of a project regardless of the financing structure.

Internal Rates of Return provide evaluation of the desirability of projects; the higher the IRR for a project, the better from an equity provider's perspective. Therefore equity provider use risk management policies to mitigate the potential impacts on this internal rate of return (IRR). The results of IRR analysis for three farm locations are given in table (29). The analysis tests the Government capital subsidies to Hanfeet and Dawkah farm locations. The Government subsidy and grants for Hanfeet and Dawkah locations are deducted from project capital cost to test subsidy effect on NPV and IRR. Salalah Farm location is tested with tow deferent raw materials cost (with subsidy and without subsidy).

As discussed earlier, the base case Salalah Location Model will be a benchmark for different project proposals at new Farm location. The basic Salalah Location Model is compared with Hanfeet and Dawkah locations Model to assess the new farm location proposed by Government and evaluate the best value for money. The DCF and NPV are calculated to measure the long-term value for money for each farm locations project.

– **Dynamic Location Models and Risk Evaluation :**

Dynamic location problems have moved into the forefront of location science problems, as static problems do not capture many of the characteristics of real world location analysis. Static models require that future information is given but in the real world sense of location science, future information such as irrigation water available to crop, crop yield and price are uncertain, i.e. there is imperfect information (Murray, 2003). However, the underground water availability at study area, yield, sale price and cost per unit are input variables used in location model in this study to test the effect of Farm location in profit.

One of the main purposes of this research was to evaluate and compare the long-term project NPV trends with risk impact between the desert farm location proposals against base case farm at costal area. Therefore, this research investigated and identified the risks which would impact Nejd project performance in the first instance. The physical risk interdependencies (cause-effect interrelationships) were addressed based on scenarios cases and quantitative simulation dynamic models to evaluate risk effects on the project NPV.

As discussed in Chapter 4, the risk factors for Nejd Project were collected from the secondary data including two major sources: empirical studies and official publications. The collected data were then summarized into a set of risk factors with explanations of how the risk factors would interact in the construction and operation stages.

Monte Carlo simulation is used to study outcome variability. Each risk event triggered by one or more causes and got result in one or more consequences. Once the probability for each main event and any sub-events is estimated and determined, the likelihood for these causal sub-events is combined to calculate the occurrence likelihood for the main event. Monte Carlo simulation 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 best method for economic feasibility analysis is Monte Carlo simulation because it gives the probability of success, probability of positive returns, and ending cash reserves. These three variables help stakeholders make a decision based on probabilities instead of worst, best, and average estimated outcomes.

Monte Carlo simulation has been used extensively in economic analyses (Bise 2007; Fumasi 2005; Ray et al. 1998) and ethanol and bio-fuel feasibility studies (Outlaw et al. 2007; Ribera et al. 2007a; Ribera et al. 2007b; Richardson et al. 2007a; Richardson, Lemmer, and Outlaw 2007b; Lau 2004; Herbst 2003; Gill 2002) to account for risk in business decisions. Advances in risk modeling have increased the accuracy of the forecasts to make Monte Carlo simulation more popular. All of the above authors, with the exception of Ray et al. (1998), used Latin hypercube sampling. The modification to the Monte Carlo method by using Latin hypercube sampling requires fewer samples to get an accurate estimate of the empirical probability density function (PDF) for the key output variables (KOVs) (Hardaker et al. 2004a). Latin hypercube sampling ensures that samples are pulled from each interval (1/number of iterations) in the uniform distribution. The Monte Carlo method may pull samples from a concentrated area under the uniform distribution creating bias in the sampling processes and results. Bias will prevent the model from reproducing the parent distribution and can only be detected by applying statistical validation tests (Richardson 2007). Using Latin hypercube sampling reduces this bias and gives an output that is much more accurate than using Monte Carlo sampling (Hardaker et al. 2004a).

Richardson et al. (2007a) demonstrated the benefit of using Monte Carlo probabilistic simulation with Latin hypercube sampling over deterministic estimation. The study modeled 50 million gallon ethanol plant in Texas over 10 years. Stochastic 26 variables were simulated from historical data using the multivariate empirical (MVE) distribution to account for correlation among the variables. In this study Latin hypercube is sued as sampling type to perform location models and analyze economic feasibility for each farm location.

Risk can be evaluated in two complementary ways, qualitative and quantitative. The qualitative approach deal with the evaluation of single risk issues, while quantitative approach deals with the evaluation of all risk combined.

In qualitative evaluation information is relatively descriptive and based on expertise and results presented in descriptive form (Risk register) or graphic forms and matrix (Risk mapping). Qualitative approaches deal with the evaluation of single risk, while quantitative approaches deal with the evaluation of all risks combined through modeling.

In quantitative evaluation information is based on numerical forms and results can be presented as probabilistic curves or histograms etc. the quantitative risk analysis approaches provide a global picture of risk exposure of the project and hence we will concentrate and focus in this study on quantitative risk analysis.

The purpose of qualitative risk analysis in this study is to provide a high level of understanding of risks of the project. Such analysis may increase attention of management and team members to the top risks they need to manage effectively.

Qualitative risk assessment should identify risk and estimate :

- Risk probability

- Risk impacts on one or more project objectives such as capital cost-operation cost – project time and duration - project financing and revenue. The risk impact can be built in a probabilistic model during quantitative evaluation.

The quantitative risk analysis is a numerical analysis of the probability and consequence of all individuals risk combined on parameters affecting the project financial performance and cash flows as shown in table (30). The result of the analysis includes a probability that a project will meet its quantitative objectives and cash flow projection. All probability distribution of the parameters are incorporated in to Monte Carlo Simulation Model which allows evaluation and quantified risks.

Table (30) Risk Parameters Affecting Project DCF in Dynamic Location Models:

Risk	affects	Distribution	Absolut/ percentage	Impacts Min	Most likely	Max
1st year Sale volume	Revenue	Normal	Percentage	19667		21072
Increase in sales ton	Revenue	Triangular	Percentage	1%	2%	5%
Sale Price/ton	Revenue	Triangular	Absolut	90	95	100
Unit cost/ton	Cost	Triangular	Absolut	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	

Location Models Description and Scenarios

This section presents the model results in the baseline as well as the results from different scenarios simulations. In addition to the baseline scenario (Salalah), there were four scenarios tested. Parameters used in the baseline scenario and Najed area scenario reflects an expected water policy and/or crop yield, total sale volume, sale price and per unit cost of production for each farm location.

The results of each scenario contribute to the decision making process as they shed light on the potential positive and negative economic and ecological implications of proposed water policy changes. The main parameters changed among the different simulations are presented in Table (31) and a full description of each scenario is presented in the subsequent sections. Each scenario was ultimately designed to understand two primary effects: firstly, changes to project yield and income and the risk of Rhodes Grass production. Secondly, changes in underground water availability and its effect on yield and NPV. Three Probabilities of water reduction of (10%-

Table (31) Short description of Location Models and different Scenarios :

Model No.	Scenario name	Scenario description
	State order and new water policy not in place (Location without water risk)	
1- Basic Model	Salalah : Without subsidy	The baseline examines the expected yield, income, income variance of crop and water allocation under *usual farming conditions*. The base run reflects the actual situation of Rhodes Grass cultivation at coastal area without raw material subsidy. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.
2- Basic Model	Salalah : With subsidy	The baseline examines the expected yield, income, income variance of crop and water allocation under *usual farming conditions*. The base run reflects the actual situation of Rhodes Grass cultivation at costal area with raw material subsidy. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.
	State order and new water policy in place (Location with low water risk)	
3- Water scarcity and new water policy state order	Hanfeet : without subsidy	This scenario is relevant to the case where Rhodes Grass farms moved to new location at Najed. Project want to secure and gain profit when *insecurity related to water supply* is higher and the expected amount of water in the area is lower than in the baseline scenario. Simulations were carried under new water policy state order and Government subsidies on inputs were removed. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.
4- Water scarcity and new water policy state order	Hanfeet : with subsidy	This scenario is relevant to the case where Rhodes Grass farms moved to new location at Najed. The project wants to secure and gain profit when *insecurity related to water supply* is higher and the expected amount of water in the area is lower than in the baseline scenario. The simulations were carried out under existing state order situation and subsidy. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.
	State order and new water policy in place (Location with high water risk)	
5- Water scarcity and new water policy state order	Dawkah : Without subsidy	This scenario is relevant to the case where Rhodes Grass farms moved to new location at Najed. Investors want to secure their profit when *insecurity related to water supply* is higher and the expected amount of water in the area is lower than in the baseline scenario and Hanfeet area. The simulations were carried out under existing state order situation. However, the other model parameters such as input-output prices are also adjusted for the situation, where state subsidies on capex were removed. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.
6- Water scarcity and new water policy state order	Dawkah : With subsidy	This scenario is relevant to the case where Rhodes Grass farms moved to new location at Najed. Investors want to secure their profit when *insecurity related to water supply* is higher and the expected amount of water in the area is lower than in the baseline scenario and Hanfeet area. The simulations were carried out under existing state order situation with Government subsidy. Three Probabilities of water reduction (0.10-0.30-0.50) tested by suing Risksimtable Function.

30%-50%) were tested by suing Risksimtable Function. The yield reduction of each water level is presented by a Trianguler distribution form (8%-12%-15%). The water policy use for each location (Coastal Area & Desert Area) and its implications and effect on yield and NPV were tested for each location.

The model simulation produces a range of possible outputs NPV and IRR represented in cumulative probability distributions addressing a level of confidence for each different outcome.

Table (32) Statistics of Location Models run results – without Government subsidy:-

Models	Model (7)	Model (9)	Model (11)	Model (7)	Model (9)	Model (11)
Location	Salalah	Hanfeet	Dawkah	Salalah	Hanfeet	Dawkah
	RiskSimtable Function Models test probability of 0.10 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	62,181	(4,441,315)	(5,554,459)	13%	-4%	-11%
Mode	219,762	(3,604,714)	(6,093,243)	11%	1%	-11%
SD	4,553,273	2,971,229	1,765,989	16%	11%	9%
Variance	2.073	8.828	3.115	0.0267	0.0122	0.0085
CV	73.22%	-0.67%	-32%	1.23%	-2.72%	-0.82%
Skewness	0.0222	0.0539	0.10046	-0.2989	-0.4624	-0.4613
Kurtosis	3.0568	3.0840	3.1518	2.9637	2.9907	2.9372
Min	(17,598,320)	(17,647,894)	(11,754,193)	-38%	-39.0%	-39.0%
Max	18,037,151	6,286,159	1,488,082	67%	25.0%	14.0%
Range	35.635,471	23,934,053	13,242,275	105	64	53
	RiskSimtable Function Models test probability of 0.30 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	(15,290)	(4,491,916)	(5,602,738)	12%	-5%	-12%
Mode	(432,601)	(3,895,384)	(5,277,770)	19%	0%	-11%
SD	4,481,585	2,876,585	1,720,489	16%	11%	9%
Variance	2.008	8.275	2.960	0.0266	0.0121	0.0085
CV	-293.11%	-0.64%	-0.31%	1.33%	-2.20%	-0.75%
Skewness	0.0245	0.05623	0.0998	-0.2957	-0.4596	-0.4558
Kurtosis	3.0608	3.0867	3.1558	2.961	2.9881	2.9279
Min	(17,037,473)	(17,082,710)	(11,717,834)	-38%	-39.0%	-39.0%
Max	17,037,475	5,937,167	1,354,218	66%	25.0%	14.0%
Range	34,074,948	23,019,877	13,072,052	104	64	53
	RiskSimtable Function Models test probability of 0.50 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	(93,259)	(4,542,541)	(5,649,017)	12%	-5%	-12%
Mode	156,536	(4,395,684)	(5,661,661)	11%	-1%	-11%
SD	4,408,356	2,876,585	1,677,563	16%	11%	9%
Variance	1.943	8.828	2.8142	0.0264	0.0120	0.0083
CV	-47.27%	-0.63%	-0.30%	1.33%	-2.20%	-0.75%
Skewness	0.0248	0.0562	0.1027	-0.2948	-0.4602	-0.4490
Kurtosis	3.0626	3.0868	3.1518	2.9607	2.987	2.9172
Min	(17,376,785)	(17,648,710)	(11,584,988)	-38%	-39.0%	-39.0%
Max	16,795,482	5,937,167	1,115,979	65%	24.0%	13.0%
Range	34,172,267	23,585,877	12,700,967	103	63	52

The analysis in Scenarios 9, 10, 11 and 12 are carried out under the conditions of existing state order and new water policy. The situation of increased water scarcity at new farm location at Hanfeet Farm without Government subsidy presented in (Scenario 9) and the introduction of Government subsidy presented in (Scenario 10). These scenarios are all considered under the existing state order and new water policy system. In model 11 and 12 the proposed scenarios perform under severe water shortage at Dawkah Farm location under the existing state order and new water policy system. Model 11 present the farm without subsidy and model 12 present Government capital subsidies. The results of the model analysis are presented in table (32) and (33) below.

Table (33) Statistics of Location Models run results – with Government subsidy:-

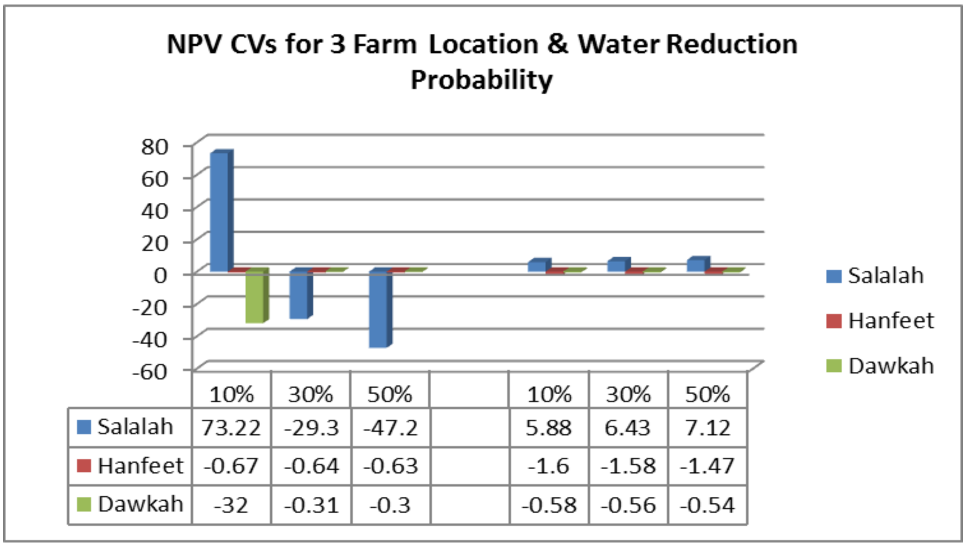
Models	Model (8)	Model (10)	Model (12)	Model (8)	Model (10)	Model (12)
Location	Salalah	Hanfeet	Dawkah	Salalah	Hanfeet	Dawkah
	RiskSimtable Function Models test probability of 0.10 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	915,448	(1,846,437)	(3,013,694)	17%	3%	-6%
Mode	(978,750)	(2,961,350)	(3,193,633)	22%	7%	-1%
SD	5,381,799	2,962,446	1,755,468	18%	13%	11%
Variance	2.8964	8.7761	3.0817	0.0322	0.0172	0.0115
CV	5.88%	-1.60%	-0.58%	1.06%	4.33%	-1.83%
Skewness	0.0531	0.0421	0.0830	-0.2074	-0.4137	-0.4724
Kurtosis	3.1052	3.1004	3.1494	2.9531	3.0201	3.0419
Min	(20,210,996)	(15,903,188)	(10,219,702)	-39%	-38.0%	-50%
Max	21,888,561	9,520,626	4,483,129	78.0%	41%	26%
Range	42,099,557	25,423,814	14,702,831	117	79	76
	RiskSimtable Function Models test probability of 0.30 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	823,547	(1,846,369	(3,061,089)	16%	2%	-6%
Mode	1,258,069	(1,592,900)	(3,032,016)	21%	6%	-1%
SD	5,295,892	2,916,386	1,711,808	18%	13%	11%
Variance	2.8964	8.5053	2.9303	0.03201	0.0172	0.0115
CV	6.43%	-1.58%	-0.56%	1.13%	6.5%	-1.83%
Skewness	0.0550	0.04387	0.0840	-0.2040	-0.4126	-0.4621
Kurtosis	3.1080	3.0994	3.1538	2.948	3.0189	3.0112
Min	(20,011,929)	(15,718,503)	(10,219,702)	-38%	-39.0%	-39%
Max	21,286,238	9,220,672	4,132,694	77.0%	41%	25%
Range	41,298,167	24,939,175	14,352,396	115	80	64
	RiskSimtable Function Models test probability of 0.50 Water reduction					
Item	**NPV**	**NPV**	**NPV**	**IRR**	**IRR**	**IRR**
Mean	731,184	(1,946,346)	(3,108,686)	16%	2%	-6%
Mode	(1,103,699)	(1,579,694)	(3,238,805)	21%	6%	-6%
SD	5,209,000	2,869,409	1,667,992	18%	13%	11%
Variance	2.714	8.23351	2.7822	0.0318	0.01698	0.0112
CV	7.12%	-1.47%	-0.54%	1.13%	6.50%	-1.83%
Skewness	0.0547	0.04614	0.0850	-0.2023	-0.4117	-0.4548
Kurtosis	3.1097	3.0981	3.1563	2.9506	3.0165	2.9956
Min	(19,786,265)	(15,688,367)	(9,957,601)	-39%	-39.0%	-39%
Max	21,250,039	9,107,868	3,951,119	77.0%	41%	25%
Range	41,036,304	24,796,235	10,352,720	116	80	64

(Source: calculated by Author).

Table (32) and (33) show NPV and IRR analysis for three farms locations and indicates statistical measures used to test different risks associated with investing in three locations. The statistical analyses measure central tendency such as mean and mode, measure variability test such as SD and variance of the models and also measure Skewness and Kurtosis for each model. Table (32) shows farm location outputs without Government investment subsidy. Salalah farm got the highest NPV and IRR while Dawkah farm got the lowest. The required level of confidence is the acceptable level of risk that the investor would take in each project. The probability Salalah farm model to be profitable (NPV>0) is 40% without subsidy and increased to 60% with Government capital subsidy. The spread among minimum and maximum NPV for Salalah farm is higher than other farm locations. The models also test 3 probabilities of water reduction of 10%, 30% and 50% and its effect to NPV. The NPV decreased with the increase of the probability of water reduction in each model.

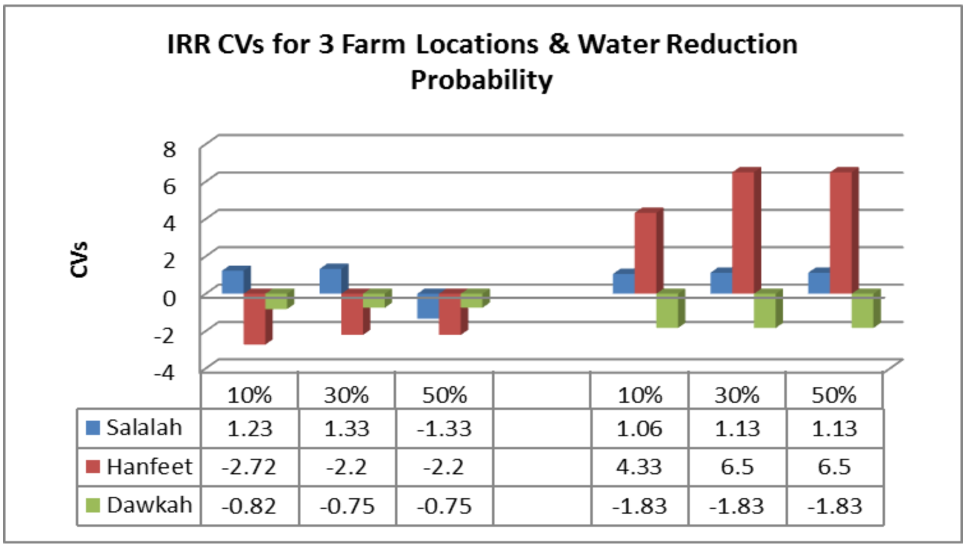
The Coefficient of Variation or risk degree was calculated to compare NPVs of different location models. It will be used to represent the degree of risk. The larger the CV is the greater the risk is. The CVs of NPVs for Salalah Farm Model increased with the increased of probability of water reduction without Government Capital subsidy. Table (33) shows CV increase with water reduction probability increase in Government subsidy scenarios. The Government Capital subsidies reduce degree of risk as presented in Figure (21). Figure (21) shows CV for NPV which represent investor perceptions of risk. It could be stated that all locations are less risky after Government subsidy. However, the variance, SD and CV analysis shows the limitation of using one of these analyses alone as a measure for risk evaluation. Consider two normal distributions of outcomes i.e. NPV and IRR with identical CV and variances but different means. Everyone will prefer the one with the positive and higher mean such as Salalah Farm Location.

Figure (21) :NPV Coefficient of variation for three farm Location :



	10%	30%	50%		10%	30%	50%
Salalah	73.22	-29.3	-47.2		5.88	6.43	7.12
Hanfeet	-0.67	-0.64	-0.63		-1.6	-1.58	-1.47
Dawkah	-32	-0.31	-0.3		-0.58	-0.56	-0.54

Figure (22) : IRR Coefficient of variation for three farm Location :



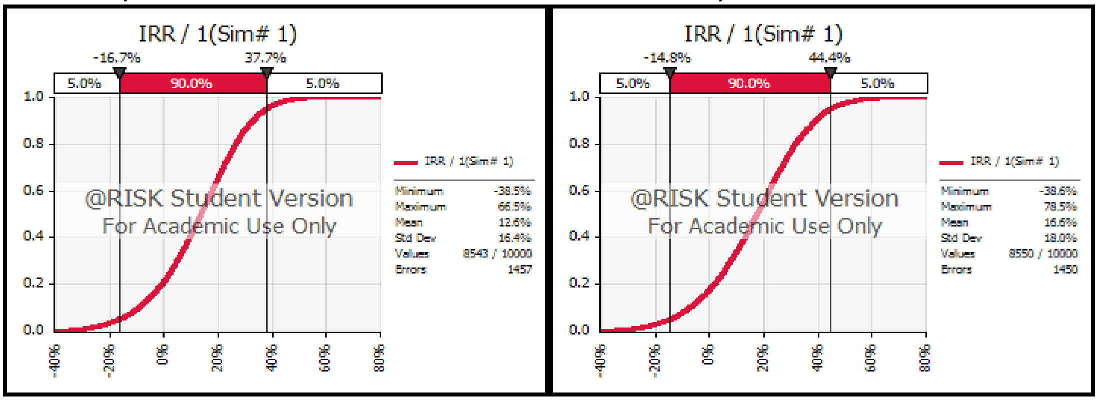
	10%	30%	50%		10%	30%	50%
Salalah	1.23	1.33	-1.33		1.06	1.13	1.13
Hanfeet	-2.72	-2.2	-2.2		4.33	6.5	6.5
Dawkah	-0.82	-0.75	-0.75		-1.83	-1.83	-1.83

Figure (23) presents IRR analysis for three farm locations with and without Government subsidy. Farm location and underground water shortage parameters are tested at Hanfeet and Dawkah location. The cumulative distribution of IRR for Hanfeet farm indicates that probability of getting IRR ≤ 0 is 60% without subsidy and 40% with subsidy. Dawkah farm model shows IRR ≥ 0 with a confidence of 40%. The models analysis shows that IRR are affected with yield reduction and insufficient irrigation water at Hanfeet and Dawkah farms.

Figure (23) : IRR for three Farm location with and without subsidy :

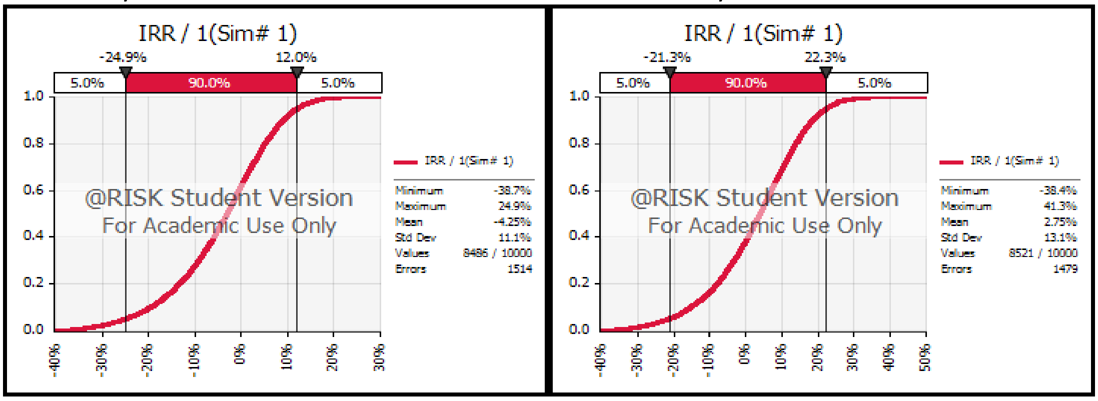
Salalah

No subsidy with subsidy



Hanfeet

No subsidy with subsidy



Dawkah

No subsidy with subsidy

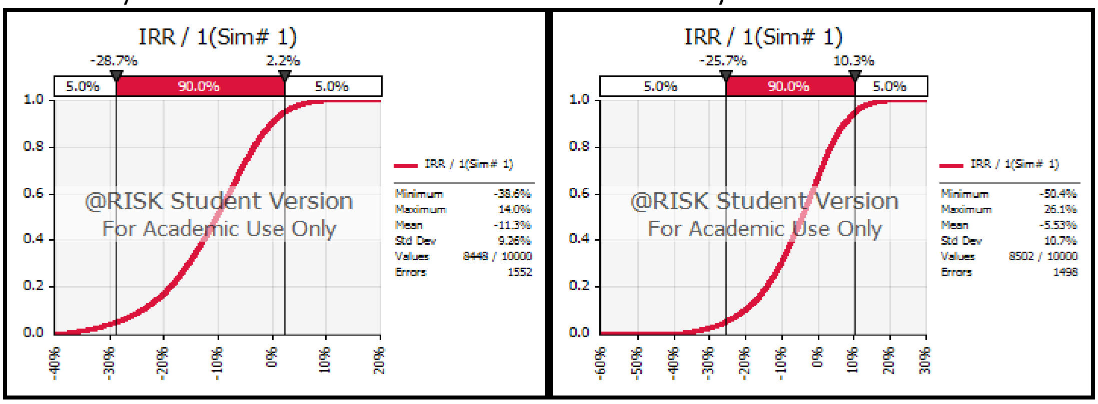


Figure (24) presents NPV analysis for three farm locations with and without Government subsidy. The NPV of each Farm location improved with Government subsidy. The analysis shows that the new locations recommended by Government Authorities at Najed Area such as Hanfeet and Dawkah are still getting a negative NPV and Government subsidy could not recover losses (Figure 25). However, this shows additional support should be given to farms at new location at Najed.

Figure (24) : The NPV analysis for three farm locations with and without Government subsidy.

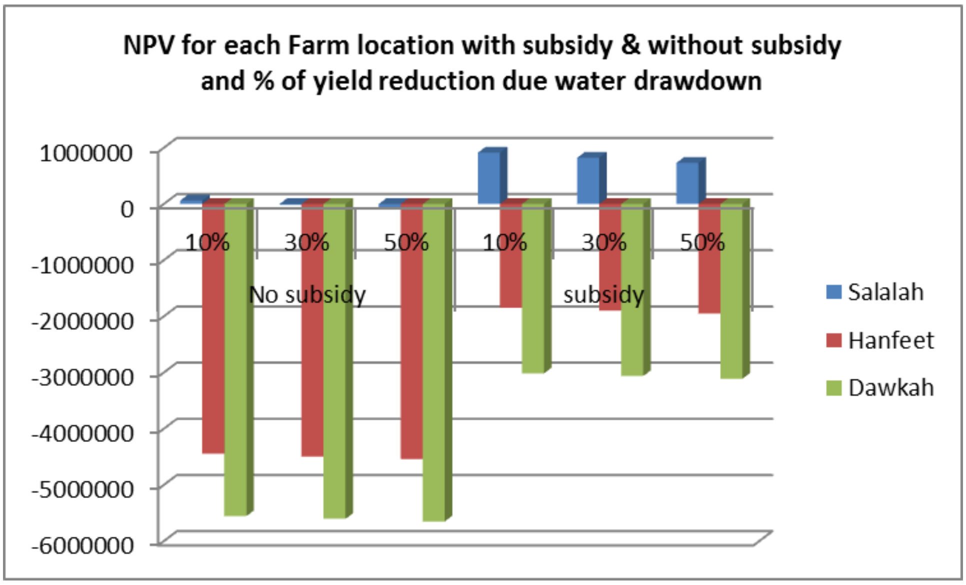
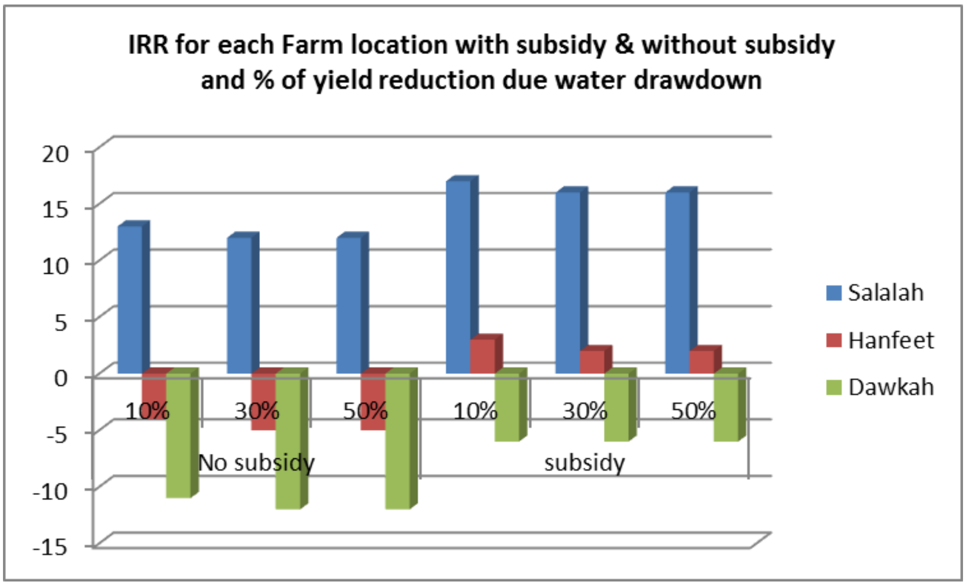


Figure (25) : The IRR analysis for three farm locations with and without Government subsidy



5.8Interpretation of Dynamic Location Models Results

The quantitative risk analysis results provide an overall picture of Najed Project investment risk exposure and project NPV. Dynamic analysis provides decision makers with a basis to discuss relevant project risks and management strategies that could be implemented to understand significance and sensitivities of risk. The quantitative risk analysis also used to provide information on the following :

- Implication to project revenue, sale price, NPV, IRR, capital cost and operation cost.
- Distribution of all output and range between minimum and maximum output value.
- Measurement of the NPV, IRR and impact of a risk mitigation plan (G. subsidy).
- The most sensitive parameters and variable driving the output (NPV).
- Level of confidence calculated for each single value in the distribution, i.e. P50 is the value of NPV at 50% confidence or value that has 50% chance to be superseded.

The Dynamic Location Models perform in this study consist of two main scenarios :

- The Baseline Scenarios at Salalah Location (with and without Government subsidy).
- The New Location Scenario at Hanfeet and Dawkah Farms (with and without Government subsidy).

5.8.1 The Baseline Scenario (Salalah Farm)

Model results reveals that Salalah farm location gains highest NPV and IRR under the scenarios with and without Government subsidy and relaxed state order for moving Rhodes Grass farms from costal area to Najed area. Farmers had more flexibility in their farming decisions and adjusted their farming activities according to their comparative advantages in the local markets when the Government and state order system was not issued. More freedom in crop allocation or permition of growing other fodder crops may increase the risk-coping strategy of farmers, which is argued to be very limited under the current political system. The highest NPV and expected income could be obtained with the introduction of water saving irrigation technologies and introduction of fodder crops with low irrigation water requirement.

The cumulative distribution of NPV of Salalah farm location (calculated with 25% raw material subsidy) is reported in figure (27) of this study. The probability of project be profitable (NPV>0) increased from 55% to 60% with raw materials proposal subsidy. The range between minimum and maximum NPV increased and moved to positive side with subsidy as shown in figure (27).

5.8.2 The New Location Scenario (Hanfeet and Dawkah Farms)

The recommended new farm locations at Najed Area were tested for Hanfeet and Dawkah locations. The risk analysis shows that the probability of getting (NPV>0) for Hanfeet Farm is only 4% as shown in figure (28). The Government has taken steps to control risk and subsidized the project with capital cost grantee by RO 2,599,000 for Hanfeet farm and by RO 2,543,000 for Dawkah farm. The Government mitigation actions are considered in dynamic simulation models analysis to understand and see how the quantitative approach would function after government capital cost subsidy. The probability of getting (NPV>0) for Hanfeet Farm after Government subsidy increased to 22% and range of 90% result moved to positive side as shown by figure (29).

Figure (26) :

Model (7) Result of Stochastic Monte Carlo Simulation Location Model (Salalah without Government Subsidy & with probability of 0.10 water reduction effect) :-

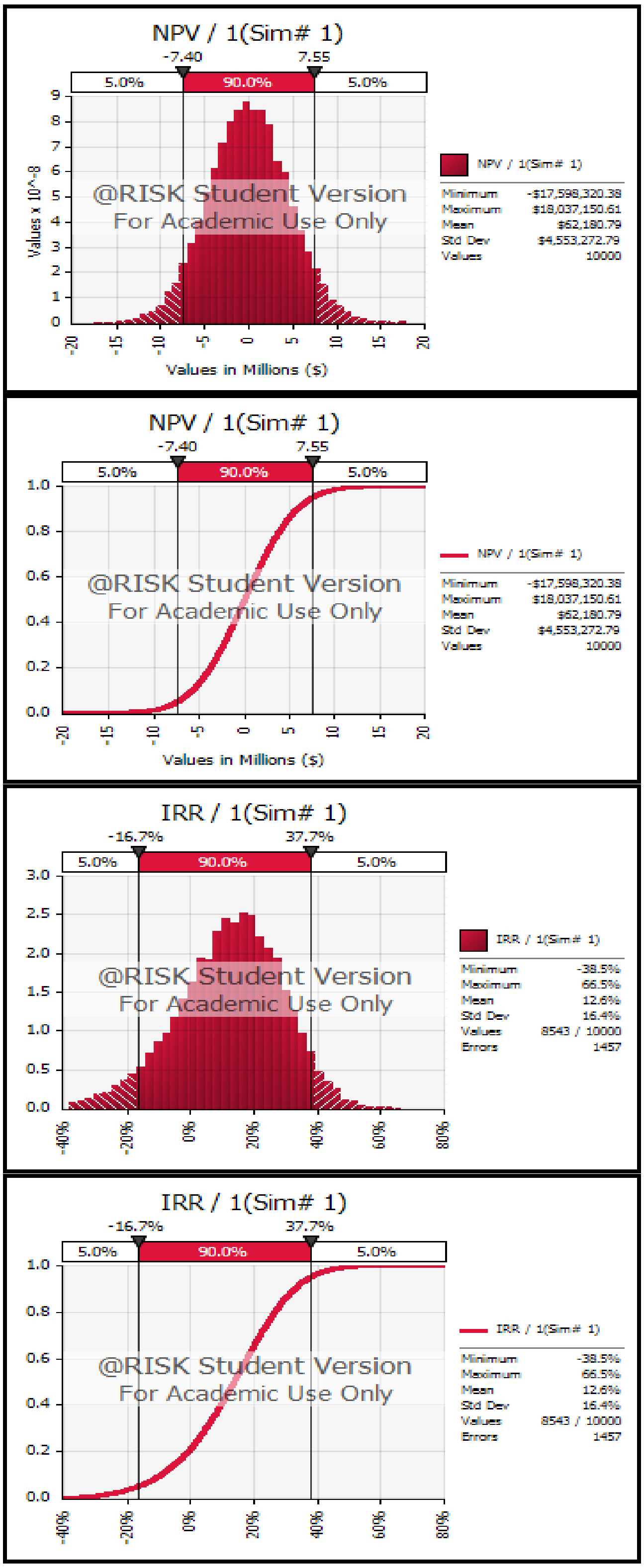


Figure (27) :

<u>Model (8) Result of Stochastic Monte Carlo Simulation Location Model (Salalah with Government Subsidy & with probability of 0.10 water reduction effect) :-</u>

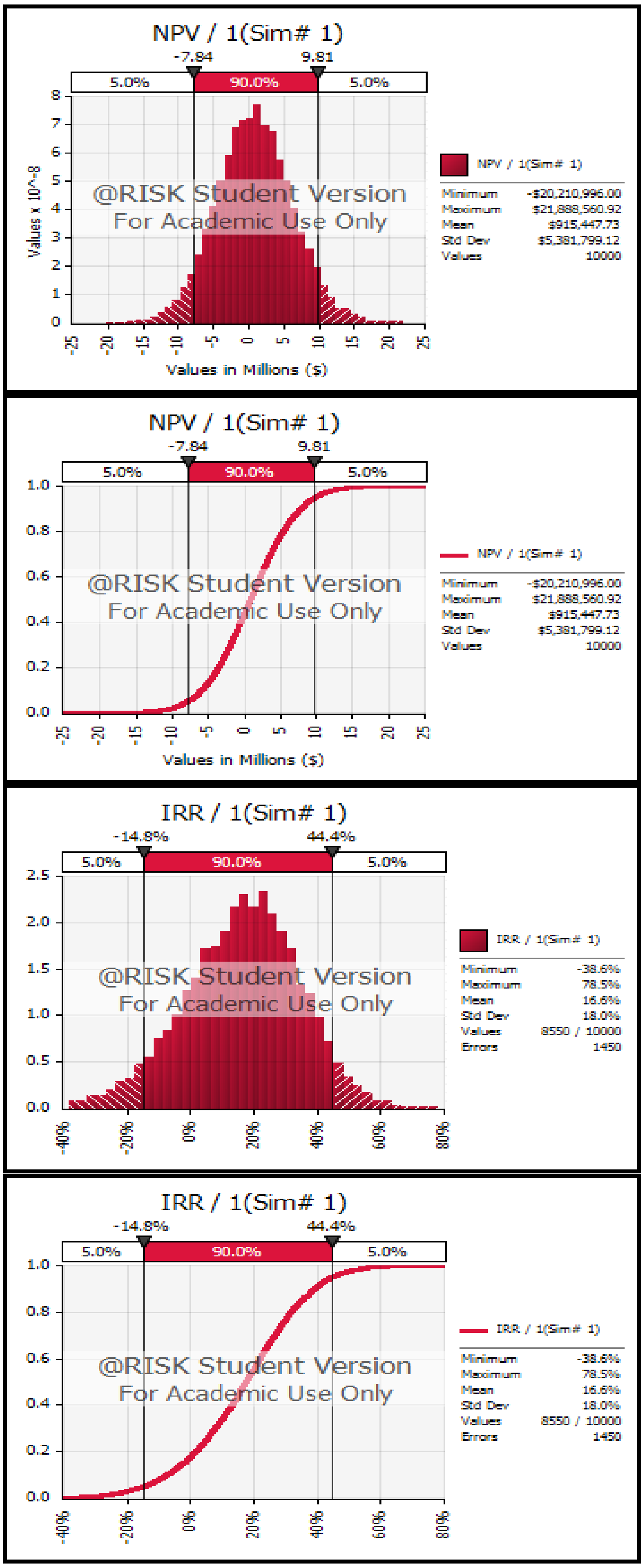


Figure (28) :

Model (9) Result of Stochastic Monte Carlo Simulation Location Model (Hanfeet without Government Subsidy & with probability of 0.10 water reduction effect) :-

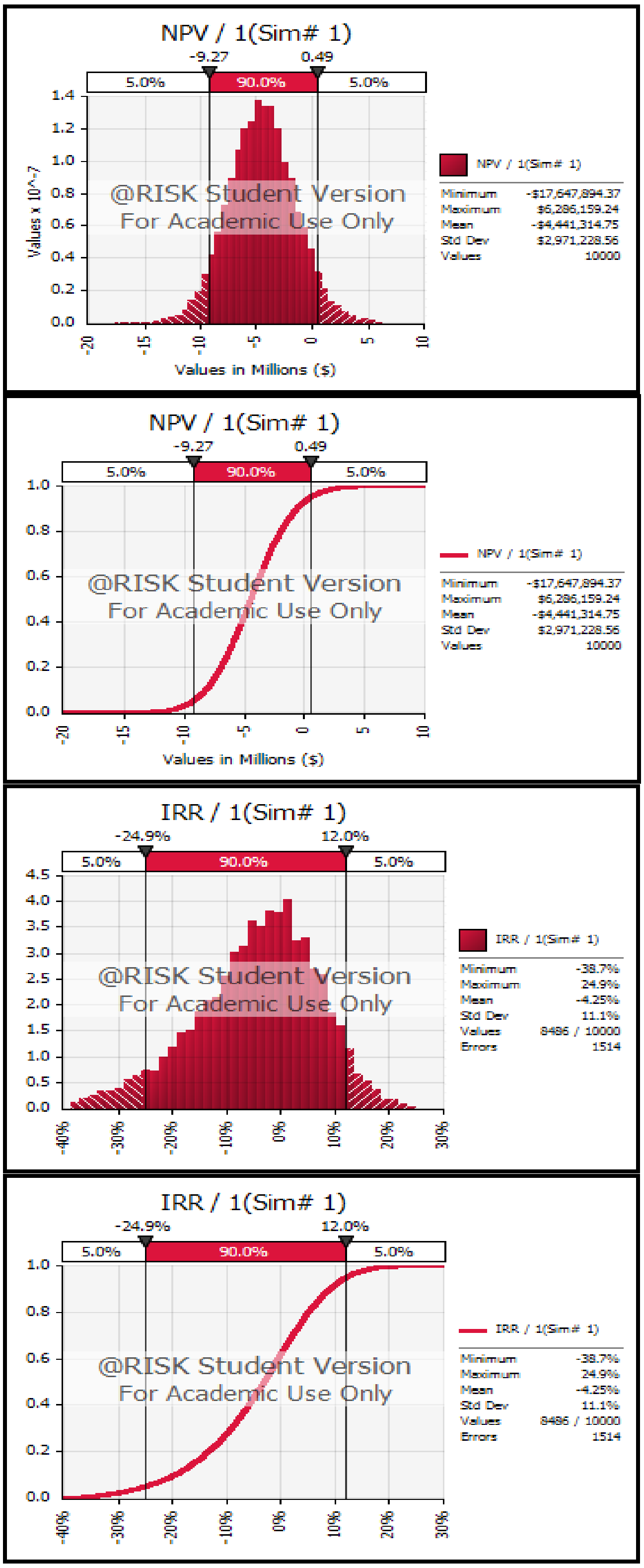


Figure (29) :

<u>Model (10) Result of Stochastic Monte Carlo Simulation Location Model (Hanfeet with Government Subsidy & with probability of 0.10 water reduction effect) :-</u>

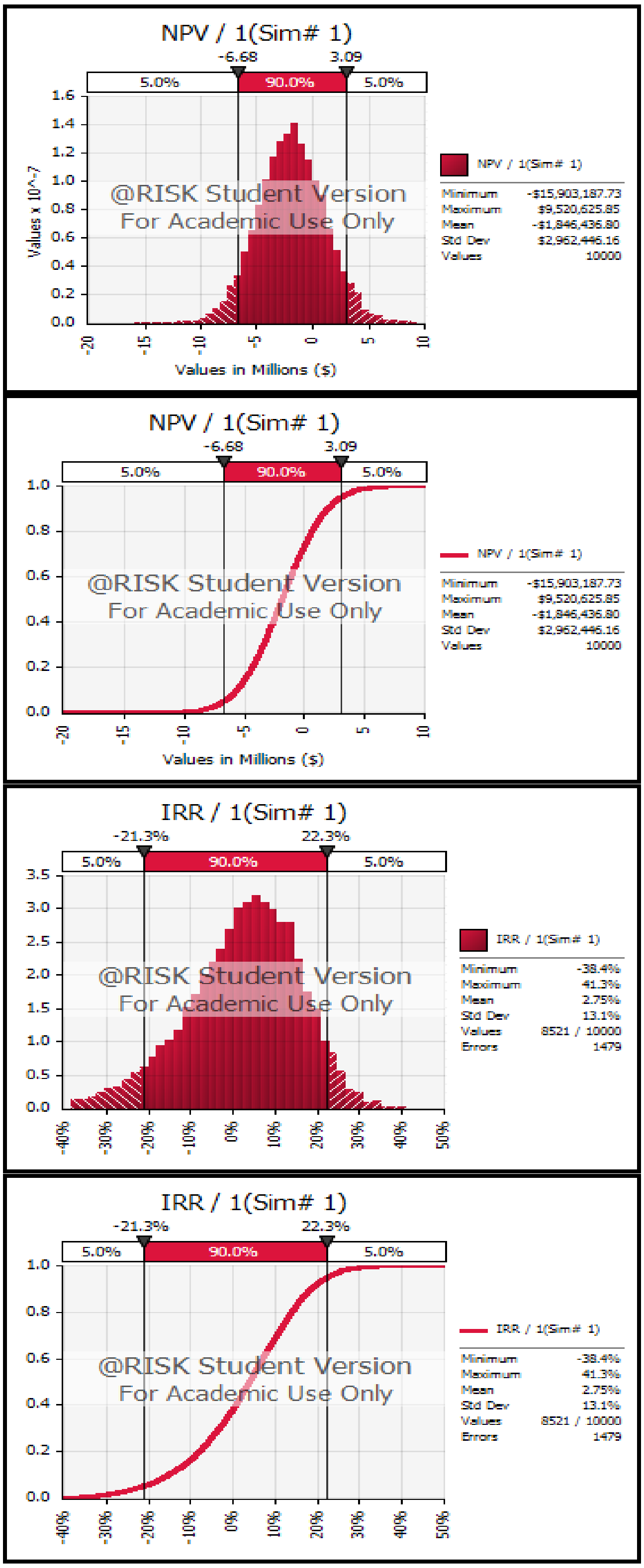


Figure (30) :

<u>Model (11) Result of Stochastic Monte Carlo Simulation Location Model (Dawkah without Government Subsidy & with probability of 0.10 water reduction effect) :-</u>

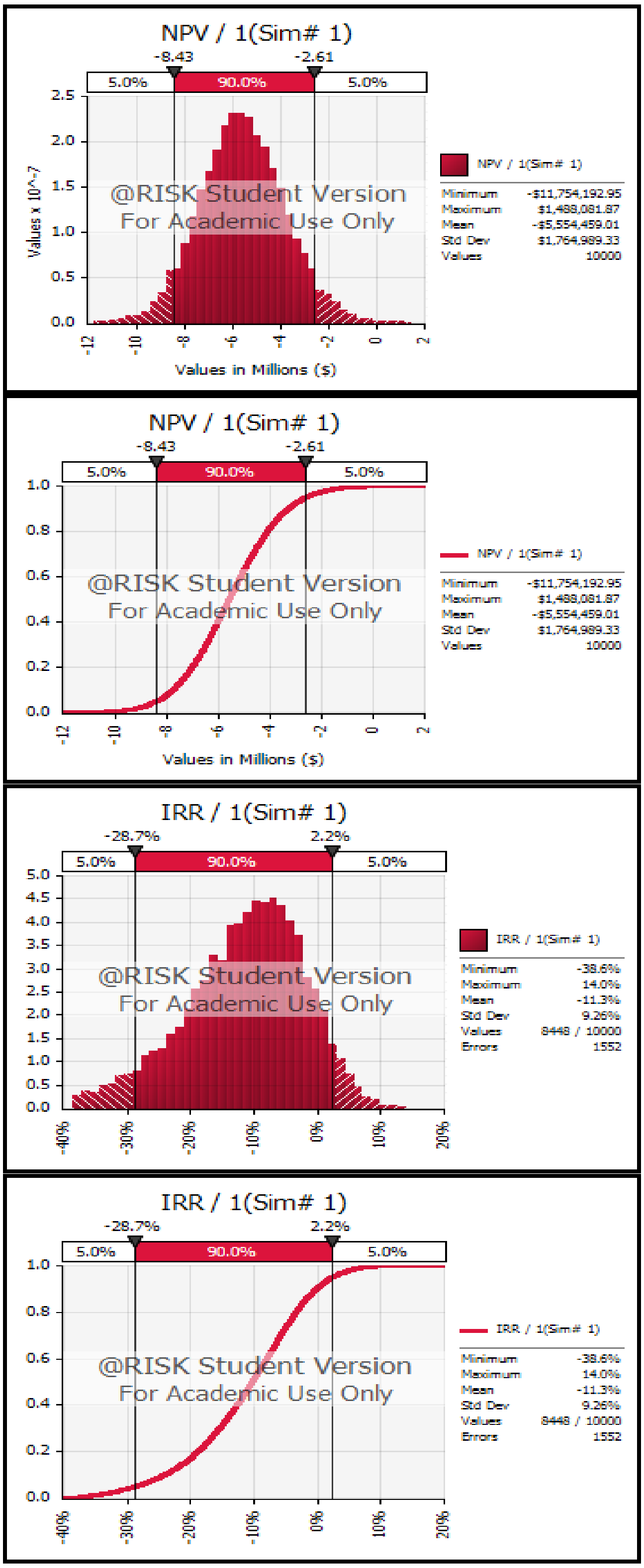


Figure (31) :

Model (12) Result of Stochastic Monte Carlo Simulation Location Model (Dawkah with Government Subsidy & with probability of 0.10 water reduction effect) :-

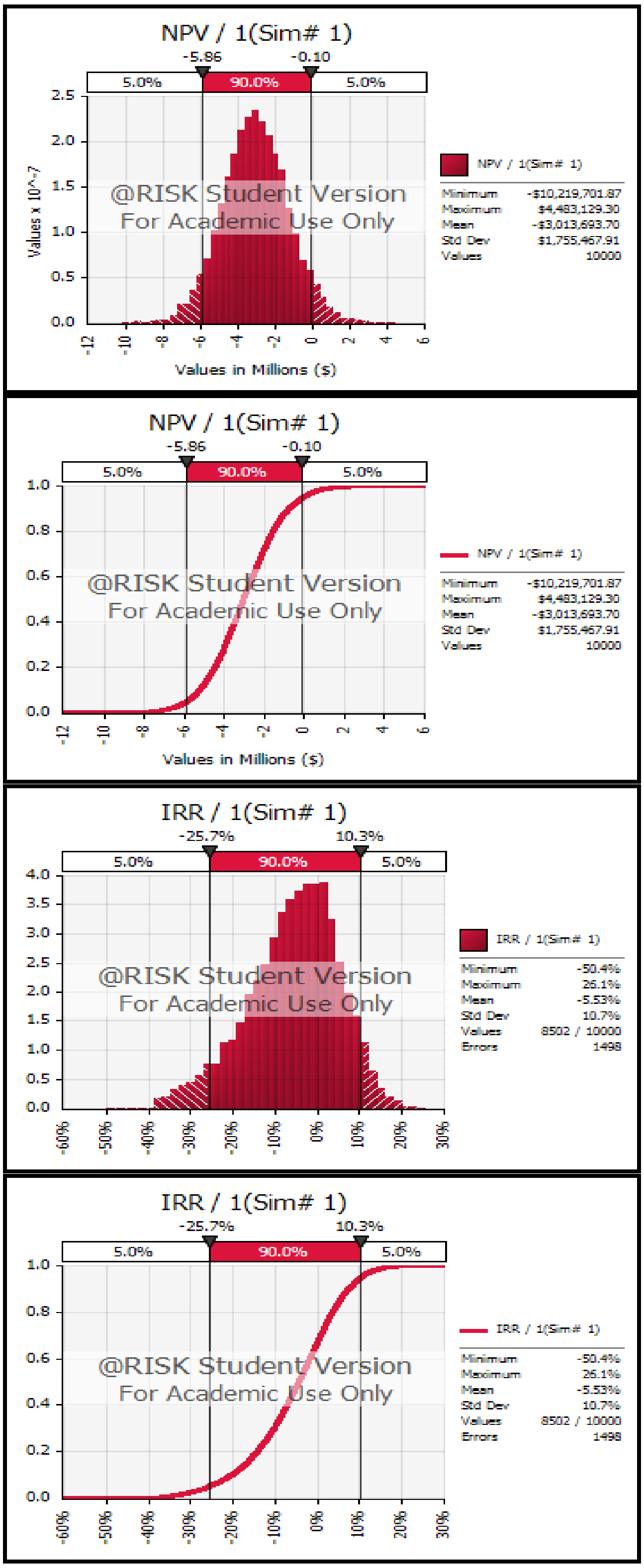


Table (32) and (33) provide the detailed statistical properties for Location Models number (7-8-9-10-111-12). Models number 7, 9 and 11 show farm Location without Government subsidy and present a low variation coefficient (CV) while model 8, 10 and 12 show farm location with Government support and probabilities of water reduction of 10%, 30% and 50%. The Government supported farms show low variation coefficient (CV) of NPV and low risk. The negative correlation between (CV) and increase of the probability of water drawdown reveal the importan of irrigation water to crop yield. On the other hand, we observed that the skewness coefficient is positive and higher in models without Government subsidy, indicating that they have an elevated probability of obtaining results above the mean. Also, the skewness coefficient is greater than 0 in all models, indicating that there is no large probability of having a low NPV. The result also shows skewness are positive and decrease with Government subsidy and NPV distribution turn to symmetrical distribution with Government subsidy.

With positive skewness result in Location Models, there is greater than a 0.5 probability (greater than 50% chance) that realized outcome (NPV) will be below the mean value of the distribution. In the case of a positively skewed distribution, the median value will lie to the left of the mean value and is a better measure of central tendency than the mean of the distribution. This case results from the fact that values on the upper (right side) portion of the distribution use influence and pull the mean toward its long tail and Government subsidy increase the mean of NPV and pull it toward the long tail of the distribution.

The kurtosis coefficient for every model is larger than 3, and we has a leptokurtic distribution that indicates that the probability distribution of the model (NPV) have a narrow peak (a high probability than a normally distributed variable of values near the mean) and fat tails (a higher probability than a normally distributed variable of extreme values). However, the detailed statistical figures for Location Models indicate Government support reduced losses for farming at new location.

A dynamic simulation location models results show that risk at Hanfeet and Dawkah location are high and the generated NPV is negative even with Government capital cost subsidy. This situation needs to create a public-private strong partnership with the principle of risk sharing. The private players are willing to take some of the project risks, provided that the nature of the risks relates to their expertise so that they will be able to properly assess the consequences. However, the private investors at Najed Project are specifically interested in limiting their exposure to the downside revenue risk. This will reduce the overall project risk and allows the investors to enjoy the benefits of having higher leverage and lower interest rates to finance phase two and three of the project.

The risk management at Najed Project should be built in a principle that can help every party to take risks that he can actively manage and control. All parties who are involved in the project should understand and share responsibilities and risks. The government should establish incentive structures to encourage private investors to participate in the project. However, asking the private sector to bear un-controllable risk or risks that could best be handled by the Government or public sector will usually result in:

- Withdrawal of the private partners who refuse to take the risk.
- Excessive risk premiums to be paid, thus losing some or all of the benefit of project.
- Project restructuring if the risk materializes and the private players cannot handle the associated losses in the foreseen conditions and project goal to provide fodder will not be achieved.

In any case, it could lead to an inefficient use of public money because the risk premium is high due to excessive profits expected by the private sector as compensation and if the risk materializes it would actually not be borne by the private sector because its magnitude would result in the incapacity of the private party to further deliver and produce Rhodes Grass to local farmers. Moreover, the economic return of the project as shown in the analysis is reduced due to the high cost paid by private sector.

Risks normally are allocated between the public and private sectors and also between private partners among themselves through the project contractual framework and agreements. In some sense, project agreements can be viewed as a mechanism for equitable and effective sharing of the risks, which are traditionally borne by the public sector, to the private sector. The success of the Najed projects depends upon the appropriate allocation of the risks among the project stakeholders. The risk allocation process for the project should help in determining which party or parties should bear the consequence of each specific project risk. Throughout this process, the ultimate goal is to create an arrangement that satisfies the stakeholders' goals in enhancing their value and income. Some risks cannot reasonably be controlled by any of the public or private parties. As a result, allocating these risks to the private entities would be counter-productive as shown above. On the other hand, having those risks borne entirely by the public sector might eliminate incentives for the private sector to operate the project and perform efficiently.

All project risks should be assessed to the finest possible degree prior to initiating the project. Each risk must be assessed under the responsibility of the entity which will incur risk. Reasons of efficiency and equity require risks to be taken by entities which will obtain the greatest benefit from the operation, or those whose line of business is concerned, namely technical risks by contractors and operators, and economic and financial risks by the government, and MAF who was supervising project construction.

Chapter Six

Risk Management Tools and Strategies

CHAPTER 6
RISK MANAGEMENT TOOLS AND STRATIGIES

6.1. Risk Management Tools and Strategies

Project risk analysis and management is a process which enables project management to mitigate risks associated with a project. Proper undertaking 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. However, no two projects are the same. Often things go wrong for reasons unique to a particular project, technically or working environment. 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.

Recently Public Private Partnership (PPP) is being used as an important tool of financial engineering. The objective of this mechanism is to create conditions so that the private sector can participate in the construction and operation of public projects, which look infeasible in the first instance. Governments can make such projects viable by offering guarantees and subsidies under certain conditions and offering tax incentives under other conditions. The government is likely to make better decisions about guarantees and subsidies when its advisers have an overview for judging if support is justified, when they know how to estimate the cost and when they evaluate carefully the costs and benefits in each situation (Irwin, 2007).

The Government guarantees and subsidies have been used in many countries, especially in public and soci-economic projects, but deciding on this course of action is not an easy task. One of these mechanisms is the guarantee involving minimum and maximum levels of revenue which has been proposed and valued by many projects in different ways, using analytical solutions, binomial tree methods and the Monte Carlo Simulation.

An additional benefit of the proposed guarantee is to minimize an implicit abandonment option. In high leveraged projects involving project finance structures such as Najed Project, the private investors could decide to pay the debt service or to abandon the project in each period or project stage. In this case, the government should look at the guarantee option additionally to minimize the probability of abandonment. In this study, we will evaluate the project and present Monte Carlo Simulation Models to evaluate government capital investment subsidy and possibility of using Minimum Revenue Guarantee (MRG) as a mechanism to share the project risk to avoid project failure.

6.2. The Cost of Agricultural Risk

Farmers are not unlike other investors: they invest in annual operating inputs (land rent, seed, fertilizer, fuel, and chemicals), machinery, and land in the hope that they will earn enough from the sale of their crops to cover their operating costs and payments on their machinery and land. If they do, then they earn a profit. If not, then they must call on their own assets to cover the loss or ask forbearance from their lenders.

Economists measure the cost of risk as the difference between the amount of money that an investor expects to make on average from a risky investment and the smallest amount of money that the same investor would accept to sell the risky investment. If the investment has low risk, then this difference will be small. However, very risky investments such as Najed Project can lead to a high cost of risk because of a large probability that the investment will be lost. The government should subsidies Najed Project as most investors will not take on such as high-risk investments unless the payback when the investment is not lost is substantial. This gives rise to the risk/return trade-off. To induce investment in risky assets, the returns when the investment pays out must be large enough to compensate investors for the high probability that the investment will be lost. The feasibility study submitted to the investors indicates good return for Najed Project IRR of 9.8% payback of 7.8 years and ROI 10.8%. The study has not incorporate risks of yield, sale price and raw material cost uncertainties in the analysis.

The cost of risk is a real production cost. And because the cost of risk is greater for riskier crops and in riskier regions such as Najed area, farmers who grow these crops or who farm in these regions have higher costs of production than farmers who do not.

Farmers in developed countries treat risk just as they treat any other production input, such as fertilizer, seed, and machinery, by balancing the returns from its use with the associated increased cost. For example, in years in which the returns to corn are expected to be higher than the returns to soybeans, farmers can increase expected profits by planting more corn crop and less soybeans. But the increase in expected profits only comes about by taking on more risk, because growing more corn typically reduces diversification. Farmers that have a high tolerance for risk (which means that risk imposes a low cost on them) will tend to plant more corn than will farmers with a lower tolerance of risk. But in Najed Project diversification are limited as Government force investors to grow Rhodes Grass crop only. Moreover, if investors and farmers are fully understand the risks they face they could not obtain and pay appropriate risk reduction tool from private markets in Oman as risk management tools do not exist in private market. As a result, agricultural activities cannot be increased through subsidized risk management only.

6.3. Risk-Sharing Mechanisms

Risk allocation should be made by an upfront analysis of the causes of the risks. When this is not possible, a mechanism can be worked out for sharing the consequences of the risk (cost) in proportion to what each player can reasonably bear.

The governments have considered a range of revenue risk mitigation mechanisms to encourage the private investment in crucial environmental and social projects such as Najed Project. Concession and project duration extension, Revenue enhancement, Sale price subsidy and Minimum Revenue Guarantee (MRG) are examples of the revenue risk mitigation mechanisms that governments can consider for the Najed projects. Apart from the revenue risk, the government and the private investors may also negotiate other forms of guarantees such as raw material and electricity rate subsidy, debt and equity guarantees. These guarantees enhance the private investors' ability to develop, operate and maintain the project facility to the desired standard performance and maintaining the project to produce and sale fodders at levels affordable to livestock breeders.

Among the aforementioned mechanisms for mitigating the low revenue risk, the Minimum Revenue Guarantees (MRG) is the frequently chosen alternative. Based on the MRG arrangement, the government partially assumes the low revenue risk and compensates the project in cash if the sale revenue falls below a specified minimum level or threshold. Hence, MRG is a mechanism for sharing the "downside" revenue risk between the project management and government in the operation phase of the project.

It should be noted that the threshold for the Minimum Revenue Guarantee must be set in a way that provides the private investors with financial incentive for investing in the project by sufficient coverage to support the debt component of the project capital structure and, provide an attractive return on their equity. It should also minimize the government exposure to the possibility that revenue may fall below the guaranteed minimum. The Minimum Revenue Guarantees (MRG) should be taken at Najed Project is the revenue level which farmers were getting at costal area (Batinah-Salalah) before new water policy announcement. The farms forced to stop Rhodes Grass cultivation in coastal area through Government decision. Governments later develop substitute areas in Najed area and encourage farmers to move to new location and grow Rhodes Grass to meet the fodder requirement.

Salalah Farm location model is taken in this study as a basic and reference model to be compared with Hanfeet and Dawkah farm locations. In this study, we will take Salalah location as an estimate of the hypothetical model, with whole-of-life cost and revenue and NPV of a private sector project if implemented at new Government proposed location in desert. The Salalah location reference model is developed in accordance with the required output specification NPV, the proposed risk allocation and is based on the most efficient form of project delivery, adjusted for the new location risks of the project. This is referred to as the Reference Project.

The purpose of the Salalah location reference model is to provide governments and stakeholders with a quantitative measure of the value for money and NPV expected from new locations. The investors and a private sector plan to deliver the output specification such as NPV will be compared to NPV of the new location. The reference model is also a valuable tool for government in determining value for money and investment subsidy and MRG could be given to Najed Project. As a result, it is important that the model should be prepared carefully and comprehensively. The reference model provides government with an approximate measure of the range of outcomes NPV and IRR that Government is likely to face in delivering subsidy and MRG can be given to Najed Project.

The good value for money is achieved through the efficient transfer of risk to the private sector. Optimal risk management allocates risks to parties that are able to manage them. The project advisers should recognize the importance of a sensible allocation of risks within an adequate risk management framework and contracts for the overall project. A commonsense approach is required to ensure that the project can be constructed in a timely and cost-effective manner.

Comparing the two models i.e. reference model with new location model enables Government to assess whether project delivery by private sector at new proposed location yields the best value for money to Government and society. The three criteria are affordability, risk transfer and value for money.

Risk is inherent in every project. Conventional public sector projects analysis has tended not to take risk into account adequately, often resulting in unbudgeted cost overruns. In a dynamic simulation model analysis, the risks inherent in the project are managed and costed differently by the private party. The treatment of risk in the project is a key aspect of the value assessment.

Affordability is whether the cost of the project over the whole project term can be accommodated in Government's budget, given its existing commitments. Value for money means that the provision of Government function by a private party results in a net benefit to the society, defined in terms of cost, price, quality, quantity, or risk transfer, or a combination of these. Value for money is a necessary condition for socio-infrastructure project, but not a sufficient one. Affordability is the driving constraint in these projects because underground water availability is uncertain and Government has to compensate losses due to limitation of these resources at new location.

As a preliminary analysis of affordability, the risk-adjusted new location model is compared with the Government's budget and Salalah reference model. If the project is not affordable, the Government may modify the new water policy and output specifications or may have to abandon the project. The value-for-money test is only conducted before contract signing and when private sector disclosed finance of the project. The risk-adjusted Salalah model provides the benchmark for value for money when compared with the new location model.

The Government imposed new water resources policy and control irrigation water at Najed Project area and determines quantities of water to be extracted out in Najed Project area. The total water to be extracted is restricted to 112 million cubic.M/year and water extraction per well restricted to 30 Lit/Sec only. Moreover, the (MRMEWR) determined 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. However, the new water policies affect the irrigation system design and impose risk of capital and risk of operation cost increase. The low yield and revenue due to uncertain parameters should be borne by Government.

6.4. Fixed Government investment subsidy

Fixed investment subsidies are given as incentives to Najed Project in order to induce earlier investment on such a large scale project, i.e. to induce investment in a moment when it is not yet optimal for a private sector to exercise its option to invest. In fact, under the government public welfare perspective, it can be optimal to start immediately the construction of the project. However, this may not be in accordance with the private value maximization perspective. In such a context, a PPP can arise and the government can give the private sector some incentives, in order to make the immediately investment an optimal decision. Model 9 & 10 were performed to calculate NPV of Hanfeet Farm without and with Government investment subsidy. Figure (28) & (29) show that Hanfeet Farm profitability IRR was -4.0% and increased to 2.75% with government capital.

6.5. Salalah Reference Model Valuation

Salalah reference dynamic model was performed to evaluate costal location and calculate project profitability i.e. NPV and IRR. The valuation of Salalah reference model and Hanfeet model was carried out with the below assumptions in Table (34).

Table (34) Salalah and Hanfeet Location Models Parameters Assumptions :-

Location	**Parameters**	
Farm Location	**Salalah Location**	**Hanfeet Location**
Total Farm Area/Ha	1500	4200
Cultivated Area/Ha	878	878
Total Capital Budget RO	4,791,524	7,596,000
Government Incentive RO	-	2,599,000
Yield range /Ton	24-22	24-22
% yield reduction due water level reduction	0.1-0.3-0.5	0.1-0.3-0.5
Operation cost RO/ton	58	75
Unit cost year1/(% of sale price) triangle dist.	65-68-70	75-79-83
Annual increase in sale price & unit cost %	10-30-50%	10-30-50%
Sale Price /ton (triangle distribution) RO	90-95-100	90-95-100
Authorized Water discharge Mm^3	Un-limit	Limit
Water discharge in study Mm^3	Un-limit	Limit
Quantity of Water available Mm^3	Un-limit	Limit
No Wells	20	40
No central Pivots	20	40
Area per Central Pivots/ha	40	20
Total Capital cost	4,791,524	7,596,000
Revenue	2,502,300	2,502,300
Net profit	**795,549**	**468,014**
Conversional calculation NPV	**2,878,601**	**-2,895,923**
Conversional calculation IRR	**18%**	**3%**

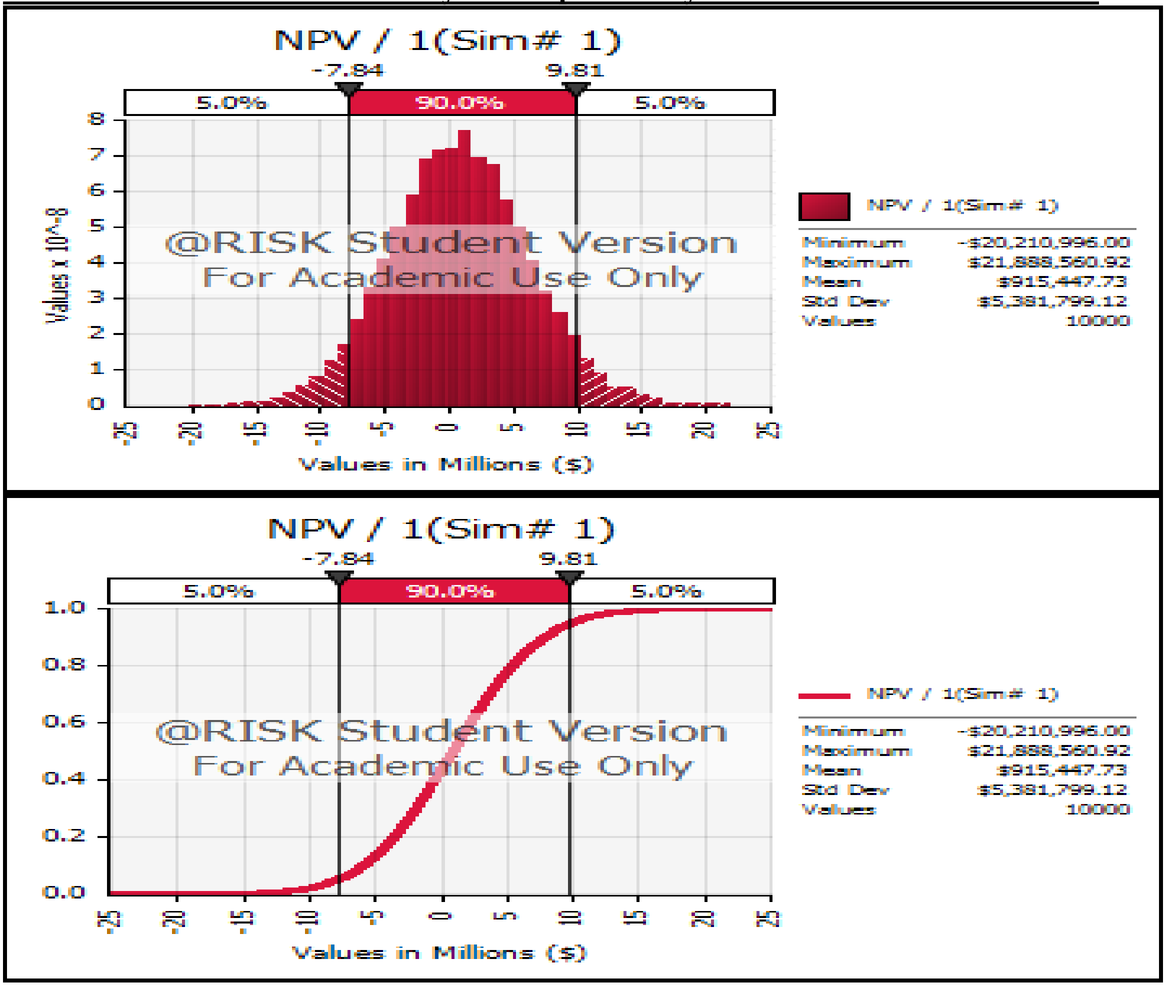
(Source: calculated by Author).

The yield per hactar range between 24-22 tons for 1st year and increase by 3% annually. The unit cost range between 65-70 RO per ton and sale price ranged between 90-100 RO per ton. The results such as net profit, NPV and IRR are tabulated below.

The results of the Salalah reference dynamic model compared with new location Hanfeet and Dawkah location and introduction of new water policy and it is effect to NPV and IRR. The quantitative risk analysis provide an overall picture of investment risk exposure and project NPV before implementing new water policy. It is then possible to provide investors and decision-makers with a basis to discuss project risks at new locations. Figure (32) shows Probability distributions and cumulative probability of the NPV of Salalah reference model. The analysis shows that the probability of getting (NPV>0) for Salalah reference model is 60%. Government subsidy for new farm locations is awarded if the NPV below zero and IRR are found to be equal or less than 12%.

Figure (32) :

<u>Salalah Reference Model Results Probability Distributions and Cumulative Probability of NPV - with Government Subsidy & with probability of 0.10 water reduction effect :-</u>



6.6. Application of Minimum Revenue Guarantee at (Hanfeet & Dawkah Location)

The use of government minimum revenue guarantees can also be used to help persuade private investors to finance phase two and three of Najed Project at desert is appealing because it can allow the government to get the Najed Project built without much payment. The Government can also benefit from the skill and enterprise of private firms to manage and operate the project. But it can cause problems as when the project started in 2012, the project revenue turned out to be less than the forecast at the technical feasibility study. As a result, the government has had to pay a lot of money to compensate private investors and to cover operation cost.

It is difficult for government to make good decisions about guarantees. To start with, there is no agreement among advisers about which risks governments should bear in PPP projects such as Najed Project. Should they bear crop yield reduction risk in desert farming projects? Or should they give soft loan by Government when investors borrow for capital investment? Or should they shield investors from raw material cost increase risk by increasing the price of the fodder sale price when the local yield decreases? Should they protect creditors from losses in the event that the project is terminated? Should they compensate investors for changes in government water resources policy? All changes? Some changes but not others? No changes? Opinions on these subjects are plentiful, but there is no agreement.

There is no simple solution to bad guarantee decision taken by Government, but good decisions are more likely if three conditions are met:

1. The government's decision makers should have a framework for judging when a guarantee is likely to be justified.
2. The government's advisers should know how to estimate the cost of a guarantee.
3. The government's decision makers should follow rules that encourage careful consideration of a guarantee's costs and benefits.

It is critical for the project stakeholder to measure and value their exposure to the project revenue risks in the presence of Minimum Revenue Guarantee and revenue sharing mechanism. It helps the private investors make better choices about investing in the project based on their expectation about the project costs, the extent of parameters risks and the level of guarantees should offered by government. Naturally, the private investors commit to invest in project only if the offered risk and revenue sharing mechanism improves the likelihood that their investment will be profitable. Pricing and value the MRG mechanism would also help the government avoid overinvestment or underinvestment of phase two and three of Najed Project. The government can make better choices about the MRG thresholds based on the expected costs and risks and decide if other support instruments would serve its goals for developing and moving Rhodes Grass cultivation from coastal area to Najed location at a suitable area and lower water pressures at coastal area. It also helps the government monitor its fiscal status and avoid making early commitments to different stages and development of the project, which may jeopardize its financial flexibility for investing in development programs in the future.

The Discounted Cash Flow (DCF) techniques and specifically the deterministic Net Present Value (NPV) analysis have been used to evaluate Hanfeet Location Projects. These conventional methods are inadequate to properly evaluate Najed Projects since they do not explicitly capture and treat uncertainty about underground water and desert farming, which are the most important sources of revenue uncertainty during the operation phase of this project.

Moreover, the uncertainty about the future project’s revenue streams of the Hanfeet Location impacts the private investor’s return on investment ROI. However, there is no systematic approach in the conventional NPV analysis to describe how the discount rate should be adjusted to reflect the risk of projected crop yield and revenue. The choice of exogenous discount rate is absolutely critical in the proper evaluation of agri-business projects since the project NPV is very sensitive to changes in the value of discount rate.
The NPV approach is also unable to address and properly evaluate the impact of the risk and revenue sharing mechanisms between the private and public sectors as an integrated part of the financial valuation of Najed Project. In other words, the NPV approach is unable to determine the correct market value of the government support option such as Capital cost subsidy. Therefore, there are many concerns about the validity of the results and reliability of using the conventional NPV analysis approach for economic evaluation of such a project. However, the conventional NPV approach applied as a basis of decision making in Najed Project gave a miss leading information to private investors and Government as the financial solvency of the project and creditworthiness of the investor would be in trouble in future and will result in the possible project failure.

The described limitations of the conventional NPV approach can be overcome by using a different approach for evaluating investments under uncertainty. The Monte Carlo Simulation Models Analysis is used for

Hanfeet and Dawkah Locations and the model result discussed earlier in chapter five. There were low probability to get (NPV≥0) i.e. 4% for Hanfeet Location and negative NPV for Dawkah location.

The Monte Carlo Simulation Models Analysis is used for Hanfeet and Dawkah Locations by suing advanced simulation model analysis techniques with NPV of RO 350,000 (Salalah's location NPV). Goal Seek analysis available in @Risk Program allows the Analyst to find a specific simulated statistic for a parameter cell such as annual sale volume increase (for example, the mean or standard deviation) by adjusting the value of another cell and output such as the recommended and acceptable level of NPV.

To achieve NPV of Salalah reference model the annual sale volume growth rate should be increased to 15.36% which is not possible in Hanfeet. As a result, Government has to implement MRG approaches to compensate farm losses. Table (35) shows annual MRG required to obtain Salalah Location NPV of RO 350,000 at Hanfeet Location.

Table (35) Basic and Goal Seek Model Results of Hanfeet Farm Location – with Government subsidy and MRG Required (NPV = 350,000 RO) :-

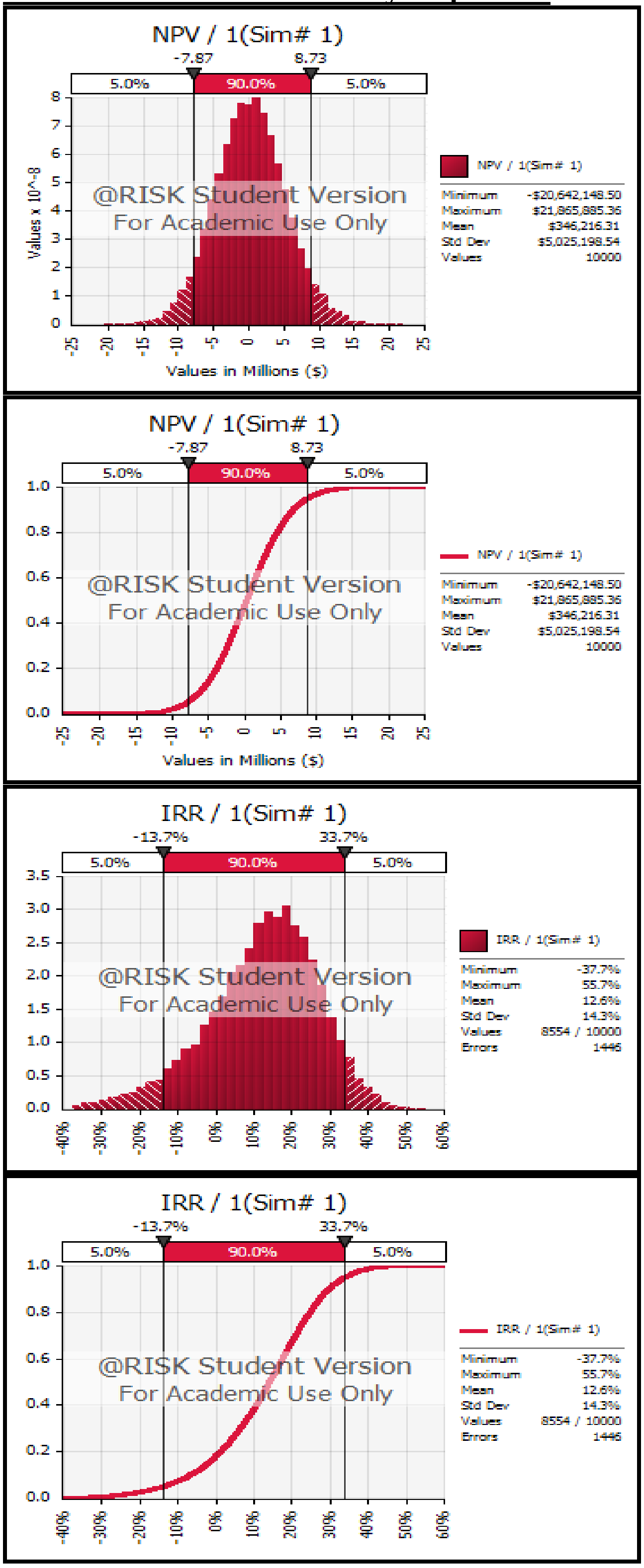
	Basic Model HLGS			**Goal Seek Model**		
Year	Yield/Ton	Price/Ton	Revenue RO	Yield/Ton	MRG	G. Subsidy
1	20440	95.00	1,941,800	20440	1,941,800	0
2	21053	97.53	2,053,299	23580	2,299,757	246,458
3	21685	100.13	2,171,319	27201	2,723,636	552,317
4	22335	102.80	2,296,038	31380	3,225,864	929,826
5	23005	105.60	2,429,328	36200	3,822,720	1,393,392
6	23695	108.40	2,568,538	41760	4,526,784	1,958,246
7	24406	111.30	2,716,388	48175	5,361,878	2,645,490
8	25138	114.20	2,870,760	55575	6,346,665	3,475,905
9	25893	117.30	3,037,249	64112	7,520,338	4,483,089
10	26669	120.40	3,210,948	73960	8,904,784	5,693,836
NPV	(1,872,771)			289,781		21,378,560
IRR	1%			12.6%		

(Source: calculated by Author).

The MCS Goal Seek Model Result of Hanfeet Farm Location showed an increase in NPV and the probability of getting NPV ≥ 0 (with Government Subsidy) increased to 55%. The MRG and Government Subsidy Required each year presented in table (35). The Minimum Revenue Guarantee increased every year due to the increase in the probability of underground water reduction. The IRR ratio also increases from 1% without MRG to 12.6% with MRG, Figure (33).

Figure (33) :

MCS Goal Seek Model Result of Hanfeet Location Farm (with Government Subsidy) and MRG and Government Subsidy Required :-



The Goal Seek Model test performed with NPV = 0 at Hanfeet Farm Location. The results showed that the NPV probability of getting NPV ≥ 0 (with Government Subsidy) is 48%. The MRG and Government Subsidy Required each year presented in table (36). The Minimum Revenue Guarantee for ten years can be reduced to RO 17.79 Million instead of RO 21 Million. The IRR ratio for this model reached 11%.

Table (36) Goal Seek Model Results of Hanfeet Farm Location – with Government subsidy and MRG Required (NPV = 0 RO):-

	Basic Model HLGS			Goal Seek Model		
Year	Yield/Ton	Price/Ton	Revenue RO	Yield/Ton	MRG	G. Subsidy
1	20440	95.00	1,941,800	20440	1,941,800	0
2	21053	97.53	2,053,299	23273	2,269,816	216,517
3	21685	100.13	2,171,319	26499	2,653,345	482,026
4	22335	102.80	2,296,038	30172	3,101,682	805,644
5	23005	105.60	2,429,328	34355	3,627,888	1,198,560
6	23695	108.40	2,568,538	39117	4,240,283	1,671,745
7	24406	111.30	2,716,388	44539	4,957,191	2,240,803
8	25138	114.20	2,870,760	50713	5,791,425	2,920,665
9	25893	117.30	3,037,249	57743	6,773,254	3,736,005
10	26669	120.40	3,210,948	65747	7,915,939	4,704,991
NPV	(1,872,771)			(301)		17,976,955
IRR	1%			11%		

(Source: calculated by Author).

The effect of three water reduction probability i.e. 0.10, 0.30 and 0.50 on crop yield, revenue and model outputs NPV and IRR are tested and summarized in table (37). The result shows that Government subsidy and Minimum Revenue Guarantee increase the project output NPV and IRR to an acceptable level and compensate investors' losses even with a probability of 50% underground water level drawdown.

Table (37) NPV and IRR of Goal Seek Model of Hanfeet Farm Location – with Government subsidy and with probability of 0.10 – 0.30 – 0.50 water reduction effect :-

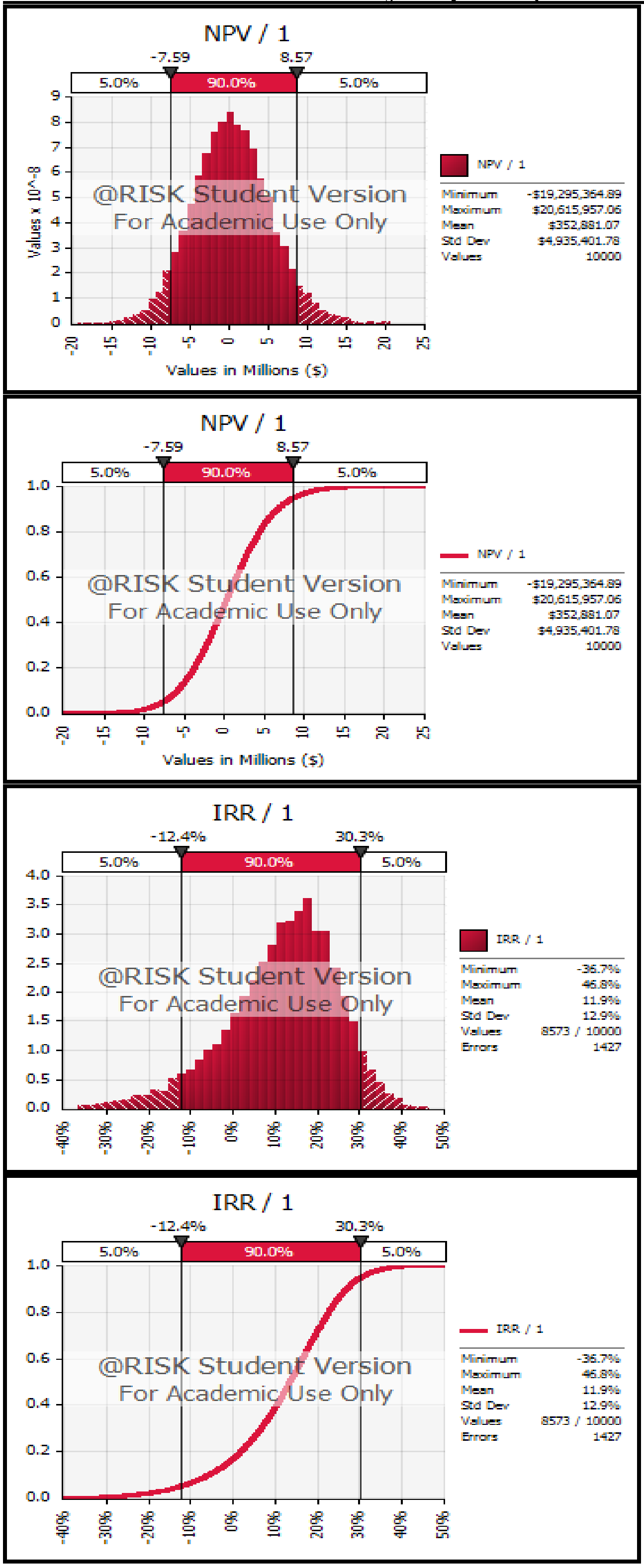
	NPV of Goal Seek Model			
Water Reduction Probability	**Min**	**Mean**	**Max**	**Range**
Water Reduction Probability 0.10	(20,642,150)	346,216	21,865,890	42,508,040
Water Reduction Probability 0.30	(20,527,600)	245,196	21,596,020	42,123,620
Water Reduction Probability 0.50	(20,396,510)	145,358	21,596,020	41,992,530
	IRR of Goal Seek Model			
Water Reduction Probability	**Min**	**Mean**	**Max**	**Range**
Water Reduction Probability 0.10	-38%	13%	56%	94%
Water Reduction Probability 0.30	-38%	12%	55%	93%
Water Reduction Probability 0.50	-38%	12%	55%	93%

(Source: calculated by Author).

The Monte Carlo Simulation Models Analysis is also used for Dawkah Locations by suing advance simulation model analysis techniques with NPV of RO 352,881 (which close to Salalah location's NPV).

Figure (34) :

<u>MCS Goal Seek Model Result of Dawkah Location Farm (with Government Subsidy) and MRG and Government Subsidy Required (NPV= 352,881) :-</u>



The Goal Seek analysis also used for Dawkah location with NPV of RO 352,881 by using @Risk Program and advanced analysis tools. The analysis runs to find a specific simulated statistics for a parameter cell of annual sale volume growth with adjustment value of NPV at a recommended and acceptable NPV for private investors.

Table (38) Basic and Goal Seek Model Results of Dawkah Farm Location – with Government subsidy and MRG Required (NPV = 350,000 RO) :-

	Basic Model DLGS			Goal Seek Model		
Year	Yield/Ton	Price/Ton	Revenue RO	Yield/Ton	MRG	G. Subsidy
1	15856	95.00	1506320	15856	1506320	0
2	16279	97.85	1592900	19975	1954554	361,654
3	16713	100.79	1684503	25163	2536179	851,676
4	17158	103.81	1781172	31700	3290777	1,509,605
5	17616	106.92	1883503	39935	4269850	2,386,347
6	18086	110.13	1991811	50309	5540530	3,548,719
7	18568	113.43	2106168	63377	7188853	5,082,685
8	19063	116.84	2227321	79840	9328506	7,101,185
9	19572	120.34	2355294	100581	12103918	9,748,623
10	20093	123.95	2490527	126708	15705457	13,214,929
NPV	(3,040,474)			256,383		43,805,422
IRR	7%			11%		

(Source: calculated by Author).

The analysis shows that to achieve this level of NPV RO 352,881 the annual sale volume growth rate should be increased to 25.98% which is not technically possible in Dawkah Location. As a result, Government has to implement MRG approaches to compensate farm losses. Table (38) shows annual MRG required to achieve Salalah's Location NPV at Dawkah Location.

The MCS Goal Seek Model Result of Dawkah Farm Location shows that the NPV increase and the probability of getting NPV ≥ 0 (with Government Subsidy) increased to 56%. The MRG and Government Subsidy Required presented in table (38). The Minimum Revenue Guarantee increased every year due to the increase in the probability of underground water reduction. The IRR ratio also increases from 1% without MRG to 11% with MRG.

6.7. Application of Government sale price subsidy

The Goal Seek Model test also performed with NPV = 0 at Dawkah Farm Location. The results showed that the NPV probability of getting NPV ≥ 0 (with Government Subsidy) is 48%. The MRG and Government Subsidy Required each year presented in table (39). The Minimum Revenue Guarantee for ten years can be reduced to RO 39 Million instead of RO 44 Million. The IRR ratio for this model reached 10%.

Table (39) Goal Seek Model Results of Dawkah Farm Location – with Government subsidy and MRG Required (NPV = 0 RO):-

	Basic Model DLGS			Goal Seek Model		
Year	Yield/Ton	Price/Ton	Revenue RO	Yield/Ton	MRG	G. Subsidy
1	15856	95.00	1506320	15856	1506320	0
2	16279	97.85	1592900	19740	1931559	338659
3	16713	100.79	1684503	24576	2477015	792512
4	17158	103.81	1781172	30597	3176275	1395103
5	17616	106.92	1883503	38093	4072904	2189401
6	18086	110.13	1991811	47424	5222805	3230994
7	18568	113.43	2106168	59043	6697247	4591079
8	19063	116.84	2227321	73507	8588558	6361237
9	19572	120.34	2355294	91515	11012915	8657621
10	20093	123.95	2490527	113934	14122119	11631592
NPV	(3,040,474)			1		39,188,197
IRR	7%			10%		

(Source: calculated by Author).

The Monte Carlo Simulation Models Analysis is used to test Government sale price subsidy for Hanfeet and Dawkah Locations. The model use advanced simulation model analysis techniques with NPV of RO 350,000 (Salalah's location NPV). Goal Seek analysis available in @Risk Program allows the Analyst to find a specific simulated statistic such as mean, SD and CV for NPV by adjusting the value of the price. The analysis shows that Rhodes grass sale price should increase to RO 161.085 per ton for the first year.

Government sale price subsidy for Hanfeet Location

The Goal Seek Model performed with simulation techniques to combine all uncertainties identified in the model. The model keep the NPV = 350,000 as a constant variable and ask changes in sale price should be obtain to get NPV of RO 350,000 at Hanfeet Farm Location. The results showed that the NPV probability of getting NPV ≥ 0 (with Government Subsidy) increased from 48% in Minimum Revenue Guarantee model to 55% in Government price subsidy model. The Government Price Subsidy required each year presented in table (40). The Government price subsidy cost for ten years can be reduced to RO 17.588 Million instead of RO 21 Million in MRG model. The IRR ratio for this model increased from 11% to 14% as shown in Figure (35).

Table (40) Basic and Goal Seek Model Results of Hanfeet Farm Location – with Government Capital Subsidy and Price Subsidy Required at (NPV = 353,059 RO) :-

	Basic Model HLGS			**Goal Seek Model**		
Year	Yield/Ton	Price/Ton	Revenue RO	Price/Ton	MRG	G. Subsidy
1	20440	95.00	1,941,800	161.08	3,292,475	1,350,675
2	21053	97.53	2,053,299	165.38	3,481,745	1,428,446
3	21685	100.13	2,171,319	169.79	3,681,896	1,510,577
4	22335	102.80	2,296,038	174.31	3,893,214	1,597,176
5	23005	105.60	2,429,328	178.96	4,116,975	1,687,647
6	23695	108.40	2,568,538	183.73	4,353,482	1,784,944
7	24406	111.30	2,716,388	188.63	4,603,704	1,887,316
8	25138	114.20	2,870,760	193.66	4,868,225	1,997,465
9	25893	117.30	3,037,249	198.83	5,148,305	2,111,056
10	26669	120.40	3,210,948	204.13	5,444,943	2,232,995
Total						17,588,298
NPV	(1,872,771)			353,059		
IRR	1%			14%		

(Source: calculated by Author).

The expected Hanfeet location project NPVs are RO 289,781 and RO 353,059 for the MRG and price subsidy models, respectively. In other words the expected NPVs are more with price subsidy model. The coefficients of variation (CVs) are 14.51 and 14.26 for the MRG and price subsidy cases respectively. A higher CV means higher risk, so the price subsidy case is less risky for Hanfeet location farm. The probability of a loss is reduced from 73% with capital investment subsidy to 45% with sale price subsidy. The variance on sale price subsidy model is also lower the variance with capital investment subsidy. The analysis shows that capital investment subsidy alone is not sufficient and Government should provide and support desert farming with sale price subsidy.

Government price subsidy for Dawkah Location

The Goal Seek Model performed with NPV = 350,000 at Dawkah Farm Location. The results showed that the NPV probability of getting NPV ≥ 0 (with Government Capital Subsidy and price subsidy) increased 57% with Government price subsidy model. The Government Price Subsidy Required each year presented in table (41). The Government price subsidy cost for ten years will reached RO 35.214 Million instead of RO 39.188 Million in MRG model. The IRR ratio for this model increased from 10% to 11% as shown in Figure (36).

Figure (35) :

<u>MCS Goal Seek Model Result of Hanfeet Location Farm (with Government Capital Subsidy) and Government Price Subsidy Required at (NPV= 353,059 RO) :-</u>

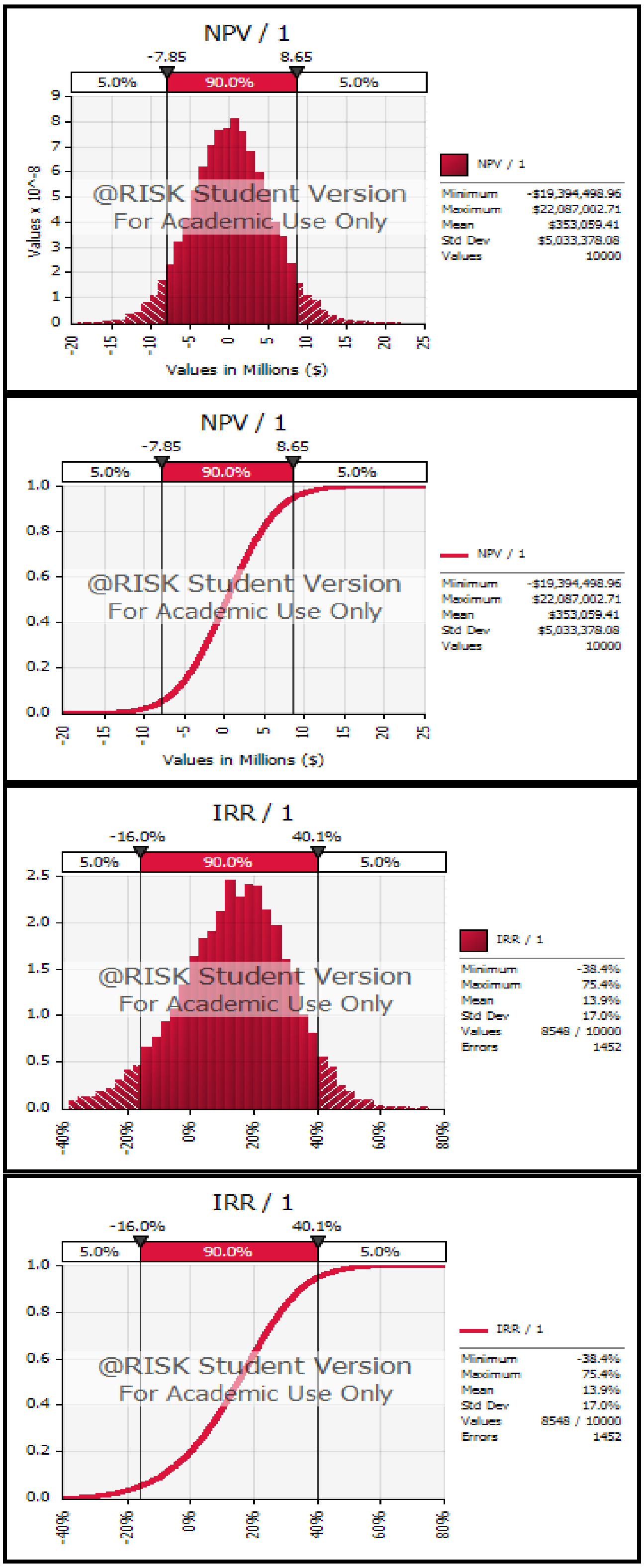


Table (41) Basic and Goal Seek Model Results of Dawkah Farm Location – with Government Capital Subsidy and Price Subsidy Required at (NPV = 273,756 RO) :-

	Basic Model HLGS			Goal Seek Model		
Year	Yield/Ton	Price/Ton	Revenue RO	Price/Ton	MRG	G. Subsidy
1	15856	95.00	1506320	265.51	4,209,927	2,703,607
2	16279	97.85	1592900	273.48	4,451,981	2,859,081
3	16713	100.79	1684503	281.68	4,707,710	3,023,215
4	17158	103.81	1781172	290.13	4,978,053	3,196,879
5	17616	106.92	1883503	298.83	5,264,189	3,380,687
6	18086	110.13	1991811	307.80	5,566,871	3,575,060
7	18568	113.43	2106168	317.03	5,886,613	3,780,445
8	19063	116.84	2227321	326.54	6,224,832	3,997,511
9	19572	120.34	2355294	336.34	6,582,846	4,227,552
10	20093	123.95	2490527	346.43	6,960,818	4,470,291
Total						35,214,325
NPV	(3,040,474)			273,756		
IRR	7%			11%		

(Source: calculated by Author).

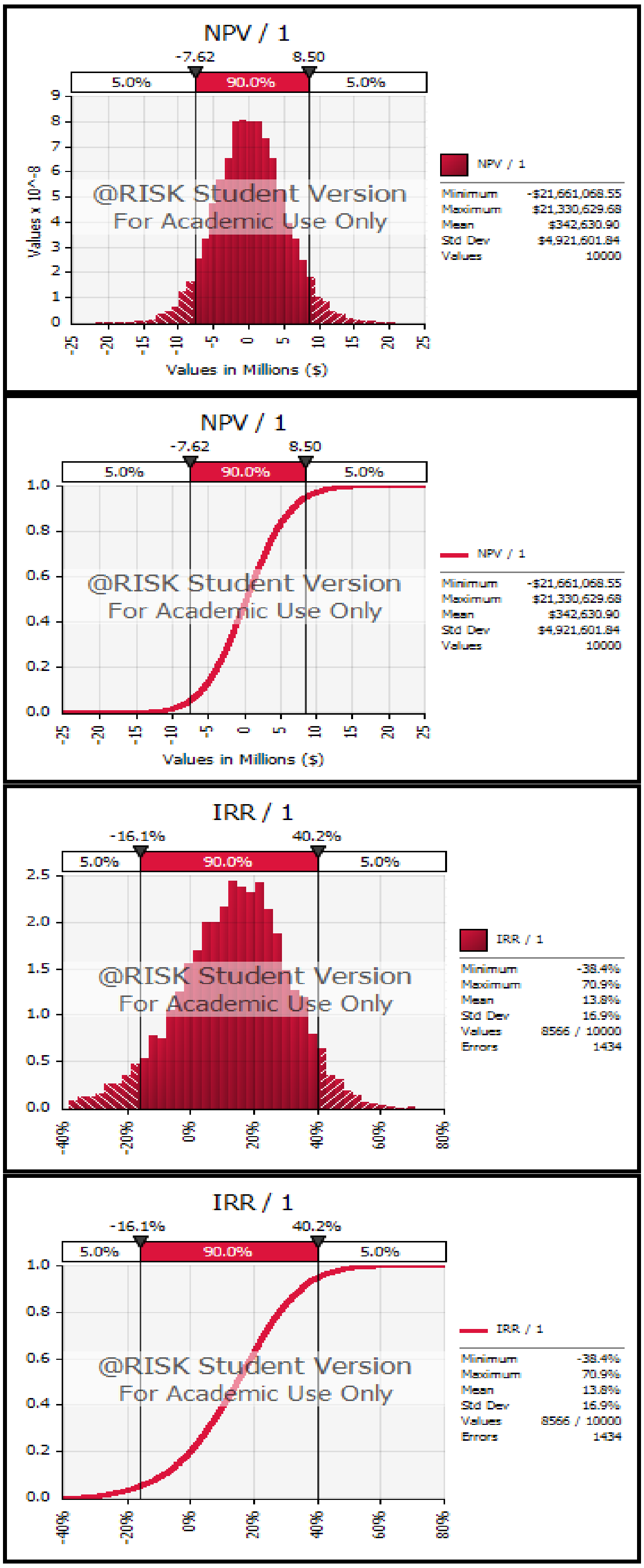
The expected Dawkah location project NPVs are RO 352,881 and RO 342,631 for the MRG and price subsidy models, respectively. In other words the expected NPVs are high with price subsidy model. The coefficients of variation (CVs) are 13.99 and 14.36 for the MRG and price subsidy cases, respectively. A higher CV means higher risk, so the MRG subsidy model is less risky for Dawkah location. The probability of a loss for sale price subsidy for Dawkah farm is lower than probability of a loss with capital investment subsidy alone. The cost of price subsidy for the both farms location Hanfeet and Dawkah are lower than MRG subsidy.

Table (42) Government subsidy analysis results of Hanfeet and Dawkah Farm Location – Statistics for NPVs for each policy :

Models	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**
Location	**Hanfeet Location**			**Dawkah Location**		
Subsidy	**Capital**	**MRG**	**Price**	**Capital**	**MRG**	**Price**
Mean	(1,846,437)	346,216	353,059	(3,013,694)	352,881	342,631
SD	2,962,446	5,025,199	5,033,328	1,755,468	4,935,402	4,921,602
CV	-1.60%	14.51%	14.26%	0.582%	13.99%	14.36%
Skewness	0.0421	0.0516	0.0583	0.0830	0.111	0.0819
Kurtosis	3.1004	3.0722	3.091	3.1494	3.205	3.172
Min	(15,903,188)	(20,642,149)	(19,394,499)	(10,219,702)	(19,295,365)	(21,661,069)
Max	9,520,626	21,865,885	22,087,003	4,483,129	20,615,957	21,330,630
Range	25,423,814	42,508,034	41,481,502	14,702,831	39,911,322	42,991,699
Cost	2,599,000	21,378,560	17,588,298	2,543,000	43,805,422	35,214,325

Figure (36) :

MCS Goal Seek Model Result of Dawkah Location Farm (with Government Capital Subsidy) and Government Price Subsidy Required at (NPV= 342,631 RO) :-



6.8. Application of minimum raw material subsidy required

The MCS Models Analysis performs to test the minimum government raw materials subsidy required for Hanfeet and Dawkah Locations. The advanced simulation model analysis techniques are used to calculate minimum raw materials subsidy required to get NPV of RO 300,000 at Hanfeet and NPV of RO 273,000 at Dawkah location. Goal Seek analysis available in @Risk Program allows the Analyst to find a specific simulated statistic such as mean, SD and CV for NPV by adjusting the value of the raw materials. The analysis shows that Rhodes grass raw material cost should be decreased from 79% to 64% of sale price per ton at Hanfeet location. The raw material cost for Dawkah location should be decreased from 84% to 55% of sale price per ton.

- **Raw material subsidy for Hanfeet Location**

The Goal Seek Model is performed with simulation techniques to combine all uncertainties identified in the model. The model keeps the NPV = 301,479 as a constant variable and asks changes and reduction in raw material cost to be obtain to get NPV of RO 301,479 at Hanfeet Farm Location. The minimum government raw material subsidy required each year presented in table (43). The total raw materials subsidy for ten years will cost the Government RO 4.012 Million as shown in table (43).

Table (43) Basic and Goal Seek Model Results of Hanfeet Farm Location–with Government Capital Subsidy and Raw Materials Subsidy Required at (NPV = 301,479 RO) :-

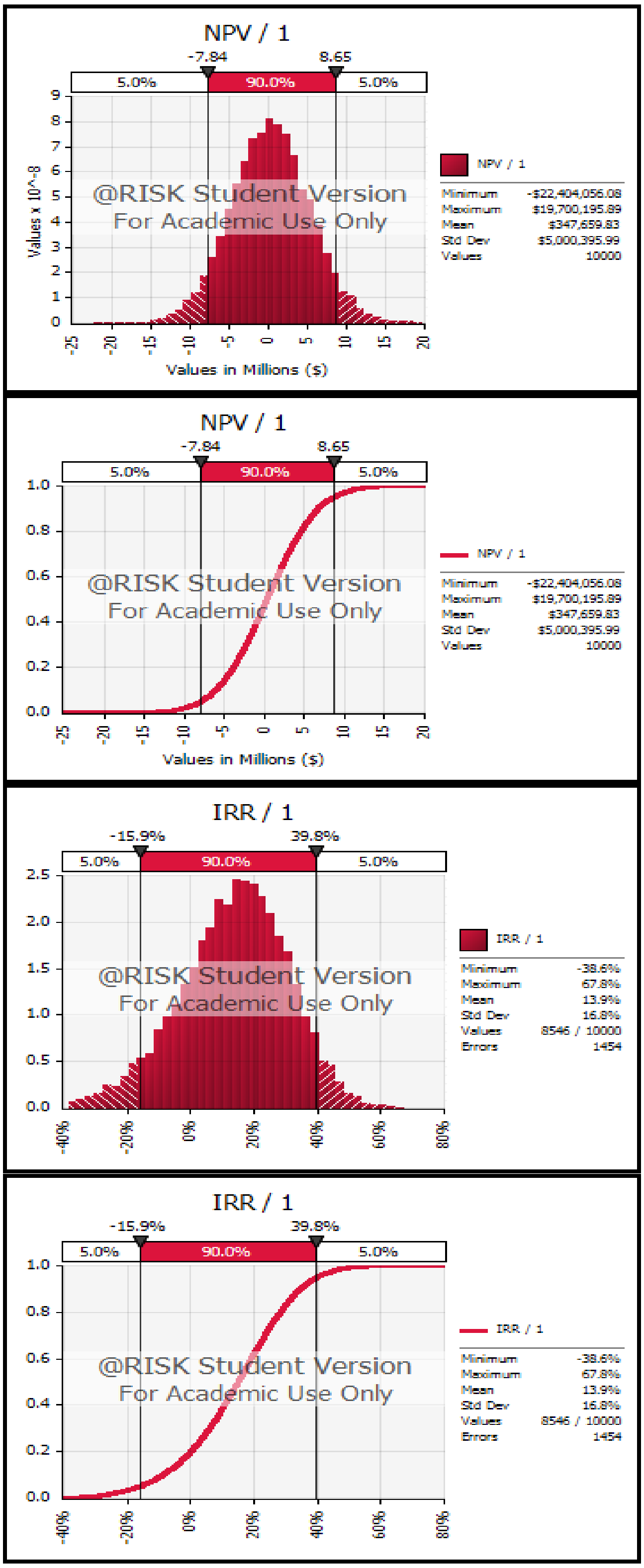
	Basic Model HLGS			**Goal Seek Model**		
Year	Yield/Ton	%RM/Ton	Total Cost RO	%RM/Ton	Total Cost RO	G. Subsidy
1	20440	75.05	1,457,321	61.17	1,187,799	269,522
2	21053	77.05	1,582,067	62.80	1,289,472	292,595
3	21685	79.11	1,717,731	64.47	1,399,849	317,881
4	22335	81.22	1,864,842	66.19	1,519,748	345,095
5	23005	83.38	2,025,574	67.96	1,650,971	374,602
6	23695	85.60	2,198,669	69.77	1,792,069	406,600
7	24406	87.89	2,387,433	71.63	1,945,749	441,685
8	25138	90.23	2,590,286	73.54	2,111,157	479,130
9	25893	92.64	2,813,707	75.50	2,293,123	520,584
10	26669	95.11	3,053,932	77.51	2,488,805	565,127
Total			21,691,562		17,678,742	4,012,820
NPV	(1,872,771)			301,479		
IRR	1%			11%		

(Source: calculated by Author).

The coefficients of variation (CVs) of NPV with raw material subsidy policy is 14.383 which is higher than price subsidy 14.26 and lower than MRG 14.51. A higher CV means higher risk, so the RM subsidy for Hanfeet farm

Figure (37) :

<u>MCS Raw Material Subsidy Model Result of Hanfeet Location Farm (with Government Capital Subsidy) and Government Raw Material Subsidy Required to get NPV = 301,479 :-</u>



- **Raw material subsidy for Dawkah Location**

The Goal Seek Model is performed with simulation techniques to combine all uncertainties identified in the model. The model keeps the NPV = 273,803 as a constant variable and asks changes and reduction in raw material cost to be obtained to get NPV of RO 273,803 at Dawkah Farm Location. The Government raw material subsidy required each year presented in table (44). The total raw materials subsidy for ten years will cost the Government RO 6.218 Million as shown in table (44).

Table (44) Basic and Goal Seek Model Results of Dawkah Farm Location–with Government Capital Subsidy and Raw Materials Subsidy Required at (NPV = 273,078 RO) :-

	Basic Model HLGS			Goal Seek Model		
Year	Yield/Ton	%RM/Ton	Total Cost RO	%RM/Ton	Total Cost RO	G. Subsidy
1	15856	79.80	1,202,043	52.52	791,119	410,924
2	16279	82.19	1,309,205	54.10	861,759	447,446
3	16713	84.66	1,426,100	55.72	938,605	487,495
4	17158	87.20	1,553,182	57.39	1,022,215	530,967
5	17616	89.82	1,691,762	59.12	1,113,527	578,235
6	18086	92.51	1,842,625	60.89	1,212,814	629,811
7	18568	95.29	2,006,968	62.72	1,320,989	685,979
8	19063	98.14	2,185,893	64.60	1,438,849	747,043
9	19572	101.09	2,380,967	66.54	1,567,213	813,754
10	20093	104.12	2,593,137	68.53	1,706,758	886,379
Total			18,191,882		11,973,848	6,218,034
NPV	(3,040,474)			347,803		
IRR	7%			14%		

(Source: calculated by Author).

The coefficients of variation (CVs) of NPV with raw material subsidy policy is 13.996 which is equal to CV of MRG and lower than price subsidy 14.36. A lower CV means less risk, so the RM subsidy for Dawkah farm model is less risky than price subsidy policy. Figures (39) shows NPV and IRR histograms and cumulative curves indicating that raw material subsidy policy increases Dawkah Project profitability and reduce risk.

Figure (38) : Government subsidy cost for Hanfet and Dawkah Farms :

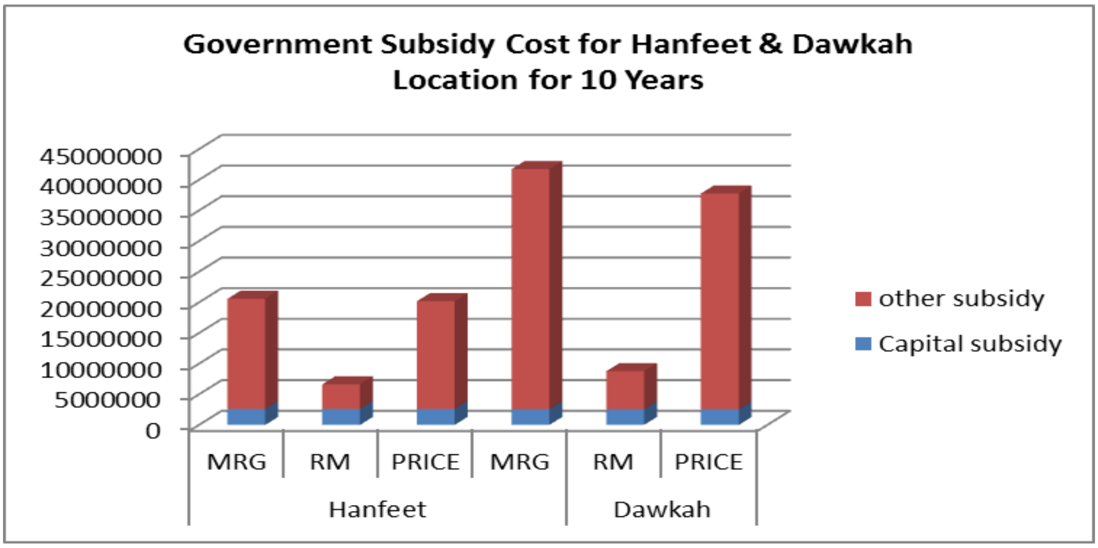
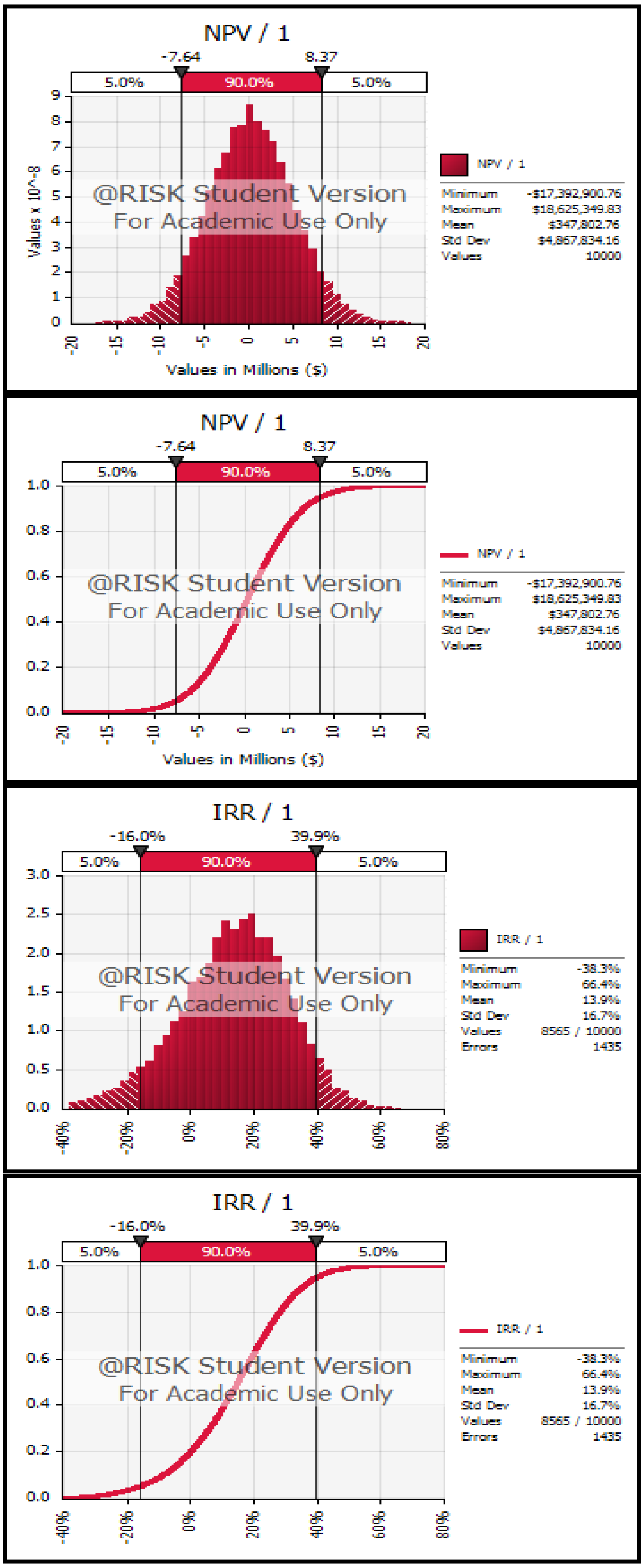


Figure (39) :

MCS Goal Seek Raw Material Subsidy Model Result of Dawkah Location Farm (with Government Capital Subsidy) and Government Raw Material Subsidy Required :-



model is more risky than price subsidy and less risky than MRG policy. Figures (37) shows NPV and IRR histograms and ascending cumulative frequency curves for raw material subsidy which shows the probability of NPV being less than or equal (zero) 45% and probability of achieving a positive NPV 55%. The ascending cumulative frequency curves for raw material subsidy shows the probability of IRR being between 0%-20% is 40%. The analysis indicates that raw material subsidy policy increases the Hanfeet Project profitability and reduces risk. Risk efficient analysis (SERF) over a range of risk aversion is performed in chapter seven to evaluate raw material subsidy policy for different Farm location at Najed Area.

Table (45) Government subsidy policies analysis results of Hanfeet and Dawkah Farm Location – Statistics for NPVs for each policy :

Models	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Location	Hanfeet Location			Dawkah Location		
Subsidy	**MRG**	**RM**	**Price**	**MRG**	**RM**	**Price**
5%	(7,867,168)	(7,836,935)	(7,847,095)	(7,586,845)	(7,642,260)	(7,624,740)
10%	(6,040,646)	(6,043,943)	(6,039,246)	(5,859,314)	(5,851,980)	(5,856,811)
15%	(4,828,496)	(4,821,096)	(4,830,385)	(4,684,134)	(4,677,335)	(4,682,068)
20%	(3,861,206)	(3,860,572)	(3,865,737)	(3,761,670)	(3,740,161)	(3,739,823)
25%	(3,033,629)	(3,040,660)	(3,049,745)	(2,966,753)	(2,942,438)	(2,920,248)
30%	(2,299,862)	(2,264,379)	(2,281,593)	(2,251,465)	(2,187,985)	(2,218,599)
35%	(1,614,053)	(1,577,215)	(1,614,156)	(1,579,776)	(1,538,124)	(1,575,561)
40%	(973,942)	(929,653)	(979,925)	(937,246)	(879,907)	(969,500)
45%	(306,439)	(273,096)	(309,678)	(318,459)	(257,197)	(372,476)
50%	311,635	310,120	327,454	289,947	329,236	286,297
55%	936,003	958,886	914,702	869,178	954,884	894,740
60%	1,552,564	1,610,303	1,574,843	1,511,914	1,546,507	1,510,047
65%	2,233,344	2,254,136	2,253,916	2,158,167	2,173,805	2,155,499
70%	2,920,274	2,950,086	2,954,615	2,811,053	2,859,336	2,851,878
75%	3,673,507	3,685,935	3,680,734	3,561,297	3,610,752	3,545,122
80%	4,509,868	4,572,336	4,557,734	4,404,892	4,426,485	4,360,391
85%	5,504,671	5,533,913	5,536,014	5,354,123	5,370,991	5,350,783
90%	6,729,670	6,707,888	6,820,858	6,650,209	6,576,013	6,727,497
95%	8,725,064	8,647,243	8,645.423	8,568,675	8,374,810	8,503,146
Mean	346,216	347,660	353,059	352,881	347,803	342,631
SD	5,025,199	5,000,396	5,033,328	4,935,402	4,887,834	4,921,602
CV	14.514%	14.383%	14.26%	13.986%	13.996%	14.364%
Skewness	0.0516	0.0058	0.0583	0.1114	0.02714	0.0819
Kurtosis	3.0722	3.0239	3.091	3.2054	3.031	3.1725
Min	(20,642,149)	(22,404,056)	(19,394,499)	(19,295,365)	(17,392,901)	(21,661,069)
Max	21,865,885	19,700,196	22,087,003	20,615,957	18,625,350	21,330,630
Range	42,508,034	42,104,252	41,481,502	39,911,322	36,018,251	42,991,699
Gov. Cost	17,976,955	3,696,280	17,588,298	39,188,197	5,633,129	35,214,325

(Source: calculated by Author).

The Government subsidy analysis performed to evaluate subsidy policies and estimate the cost of each policy. The Government subsidy analysis shows that raw material subsidy is more cheaper and cost 4.012 Million Rials for Hanfeet farm and 6.218 Million Rials for Dawkah farm as shown in table (45) and figure (38).

Government subsidy analysis for Hanfeet location farm shows that sale price subsidy is less risky than other subsidy as CV is lower for price subsidy model which is equal to 14.26%. However, for Dawkah location farm MRG Minimum revenue guarantee subsidy is less risky than other subsidy. The risk efficient and SERF analysis will be presented in chapter seven.

Regression Tornado Graph analyses were performed to see what factor has the most influence to NPV. The analysis show raw material cost is the second factor influencing NPV with negative coefficient parameters of (-0.110). The Government subsidy analysis show that raw material subsidy is cheaper and cost the Government 4.012 Million Rials for Hanfeet farm and 6.218 Million Rials for Dawkah farm for ten years as shown in table (45) above. The Government subsidy analysis for Hanfeet farm shows that sale price subsidy is less risky than other subsidy as CV is lower for price subsidy model which is equal to 14.26%. However, for Dawkah farm MRG Minimum Revenue Guarantee subsidy is less risky than other subsidy, but the cost of implementing this policy is high.

The NPV conventional approach is unable to address and properly evaluate the impact of the risk and revenue sharing mechanisms between the private and public sectors as an integrated part of the financial valuation of Najed Project. In other words, the conventional NPV approach is unable to determine the correct market value of the government support option such as capital cost subsidy. Therefore, there are many concerns about the validity of the results and reliability of using the conventional NPV analysis approach for economic evaluation of such a project. However, the conventional NPV approach applied as a basis of decision making in Najed Project did not gave a complete picture and enough information to private investors and Government as the financial solvency of the project and creditworthiness of the investor would be in trouble in future and will result in the possible project failure.

The described limitations of the conventional NPV approach can be overcome by using a different approach for evaluating investments under uncertainty. The Monte Carlo Simulation Models Analysis is used for Hanfeet and Dawkah Locations with Government capital subsidy and the model result showed unviable results. There were low probability to get

(NPV≥0) i.e. 4% for Hanfeet Location and negative NPV for Dawkah location.

The Monte Carlo Simulation Models Analysis is used for Hanfeet and Dawkah Farms by using advanced simulation model analysis techniques with NPV of RO 350 000 (Salalah's location NPV). The raw material subsidy determined by using the goal seeks technics by add-in from Excel to set NPV equal to Salalah's location NPV. Goal Seek analysis available in @Risk Program allows the Analyst to find a specific simulated statistic for a parameter cell such as raw material unit cost increase (for example, the mean or standard deviation) by adjusting the value of another cell and output such as the recommended and acceptable level of NPV.

To achieve NPV of Salalah reference model the annual sale volume growth rate should be increased to 15.36% which is not possible in Hanfeet area. As a result, Government has to implement MRG, Raw material subsidy or price subsidy program approaches to compensate farm losses. Table (46) shows distribution statistics of raw material subsidy program required to obtain Salalah Location NPV of RO 350 000 at Hanfeet Location.

Government raw material subsidy program will reduce expected loss probability from 95% to 47%. The chance of getting acceptable positive NPV is also increased to 47% with raw material subsidy compared to 95% of negative NPV without raw material subsidy as shown in Figure (40) below.

Figure (40) : NPV of Hanfeet Farm with & without Raw Materials Government Subsidy Programs

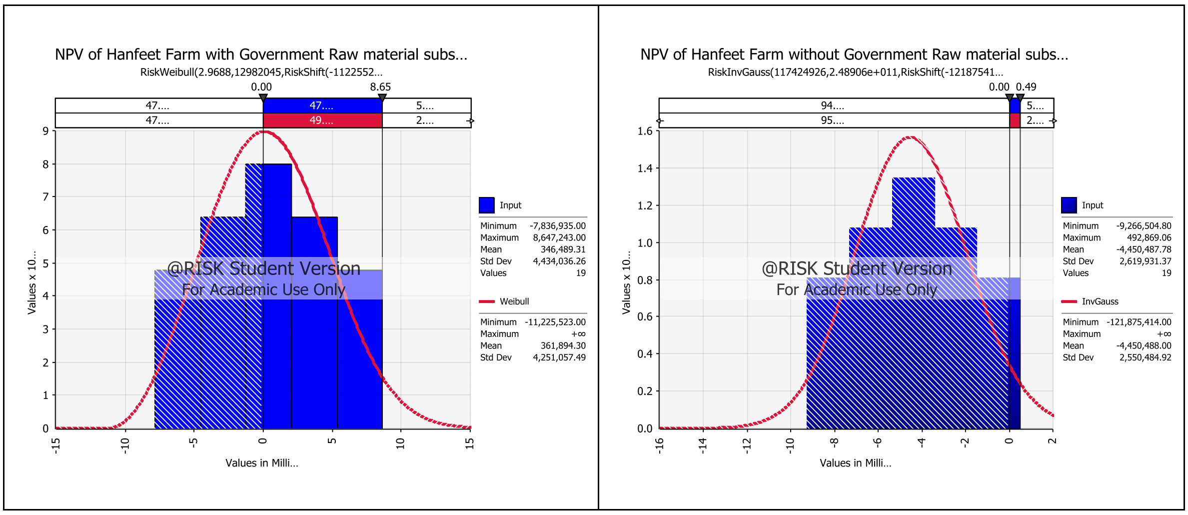


Table 46 : Distribution statistical analysis of NPV of Hanfeet Farm with & without RM Government Subsidy

Scenarios	Hanfeet With Government Subsidy	Hanfeet Without Government Subsidy
NPV Mean	346 489	-4 450 488
Mode	959 769	-5 210 144
Median	310 119	-4 468 505
Std. Deviation	4 434 036	2 619 931
CV	12.798	0.589
Skewness	0.0014	0.062
Kurtosis	3.004	3.006
Exp. Loss Ratio	0.475	0.949

(Source: calculated by Author).

For Dawkah Farm raw material subsidy required to maintain and achieve NPV of Salalah reference model will cost Government RO 6 Million in ten years. This financial incentives program will reduce expected loss ratio from 83% to 48% and increased the chance of getting acceptable positive NPV to 47% as shown in Figure (41) below. Table (47) shows distribution statistics of raw material subsidy program required to obtain Salalah Location NPV of RO 350 000 at Hanfeet Location.

The fat tail Kurtosis at Dawkah Farm model without raw material subsidy of 5.4 and Skewness of 1.139 indicates more risk will face farmer without Government raw material subsidy. The introduction of raw material subsidy program results in spreading NPV observation around the mean symmetrically and keeping Skewness near to (0) figure. The analysis also shows risk reduction as Kurtosis reduce from 5.4 to 4.2 as shown in table (47) below.

Figure 41 : NPV of Dawkah Farm with & without Raw Materials Government Subsidy Programs

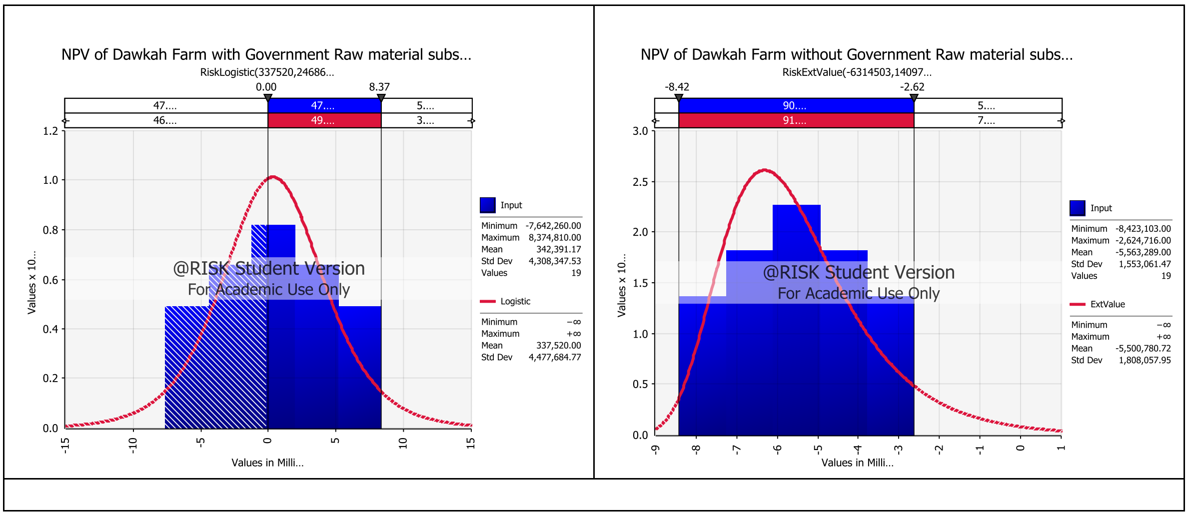


Table 47 : Distribution statistical analysis of NPV of Dawkah Farm with & without RM Government Subsidy

Scenarios	Dawkah With Government Subsidy	Dawkah Without Government Subsidy
NPV Mean	347 803	-5 556 191
Mode	202 750	-5 070 682
Median	329 236	-5 581 467
Std. Deviation	4 887 834	1 762 995
CV	14.053	0.317
Skewness	0.0071	1.1390
Kurtosis	4.231	5.420
Exp. Loss Ratio	0.483	0.826

(Source: calculated by Author).

6.9 SERF Analysis and Risk Management Strategies Ranking

There are many ways of uncovering a decision makers preferences in respect to outcome and risk and define them mathematically. This is called the decision makers utility function (Hardaker et al, 2004, 35). But defining a utility function is a difficult task and an impossible one if there are more than one decision maker (Hardaker et al, 2004 140). Another method for ranking risky alternatives is to use a so called efficiency criteria. This is a method that can be used when no utility function can be defined for the DM (Hardaker et al, 2004, 140).

There are several different methods for efficiency analysis, one of them being stochastic efficiency with respect to a function (SERF). This method is based on comparing the certainty equivalents (CE) of alternatives for different levels of risk aversion where the alternative with the highest CE is preferred. The method has its strength in that all alternatives can be compared at the same time in contrast to the more commonly used stochastic dominance in respect to a function (SDRF) (Hardaker et al, 2004, 155). In SDRF the comparison is done pair wise thus often resulting in a larger pool of efficient alternatives than the SERF does

In order to use an efficiency criteria assumptions must, however, be made about the form of the utility function to be used as well as the boundaries of the amount of risk aversion that will be analyzed (Hardaker et al, 2004, 140). Though there are many different utility functions, experience has shown that in practical application the choice of utility function has little effect on the result of the efficiency analysis (Hardaker et al, 2004, 153). Therefore a negative exponential utility function is often chosen due to that it is easy to use in mathematical applications. The range for the risk aversion should be defined so it is relative for the analysis. For example the boundaries for risk

aversion from normally from 0,5 to 4 proposed by Andersson and Dillon could be used where 0,5 is very risk averse and 4 is risk lover.
By varying the absolute risk aversion coefficient within the predefined range the CEs of each alternative are calculated corresponding to each level of risk aversion. The CEs are then compared to each other revealing which alternative has the highest value and thus is the most efficient for a particular level of risk aversion (Hadaker et al*, 2004, 258). The preferred choice can vary between levels of risk aversion giving different efficiency sets for DMs with different risk attitudes (Hadaker et al, 2004, 154-155). Stochastic efficiency with respect to a function (SERF) analysis is used in chapter seven to compare and rank the alternative 5 models and policy options.

Chapter Seven

Ranking of Risky Alternatives and Strategies

CHAPTER 7
RANKING OF RISKY ALTERNATIVES AND STRATERGIES

The use of a stochastic simulation model helps the Analyst to generate a distribution of results for risky alternative management decisions. These scenarios allow the analyst to compare outcomes (NPV) across alternative management decisions while considering the uncontrolled possibilities captured through the stochastic nature of the key input variables. A challenge arises when attempting to determine which of the given scenarios is preferred, as both the preferences for the outcomes and the probabilities of each outcome will affect the decision maker's preferred alternative.

Given the problem of not knowing a decision maker's utility function or their risk and income preference, analysts have a tool that can be used to determine the "best" alternative. Ranging in complexity can be based upon the mean, standard deviation, mean-variance, stochastic dominance, certainty equivalence, and stochastic efficiency which can be used to rank alternative scenarios. Rankings based solely on the mean outcomes and the standard deviation of the scenarios results in a loss of valuable information obtained by using a simulation procedure. Mean only rankings ignore the risk for each scenario and standard deviation based rankings of scenarios ignore the income and NPV generated by each scenario.

7.1 Performance indicators and Farm Location Models

The Monte Carlo simulation model created follows the style of simulation models done by Gill (2002), Herbst et al. (2003), Lau (2004), and Richardson et al. (2007). The model is completed by using the Excel add-in, @Risk and Simetar (Richardson, Schumann, and Feldman 2011). One of the distinguishing features of these models was that they incorporated probability distributions on the quantity of ground water level at each farm location i.e. Hanfeet and Dawkah compared to Salalah with sufficient water availability. Ground water level at each farm location is a stochastic function of stochastic model. Six scenarios were formed and each scenario was ultimately designed to understand two primary effects: firstly, changes to project yield and income due to water shortage risk at new developed area and its effect on NPV. Secondly, changes in different levels of underground water availability and its effect on yield and NPV. Three Probabilities of water reduction of (10%-30%-50%) were tested by using Risksimtable Function. The yield reduction of each water level is presented by a Trianguler distribution form (8%-12%-15%). The water policy use for each location (Coastal Area & Desert Area) and its implications and effect on yield and NPV were tested for each location. The model simulation produces a range of possible outputs NPV and IRR represented in cumulative probability distributions addressing a level of 90% confidence for each different outcome.

The analysis shows Dawkah Farm had the lowest NPV range while Salalah Farm had the highest NPV range of all three locations. The simulated relative risk is comparable in Hanfeet and Dawkah locations. The relative risk is higher without Government subsidy in all farms locations because there is greater variability in the capital and operation cost and yield per hectare of Rhodes grass. The analysis reveals that expected loss ratio reduced with Government capital subsidy from 74% to 63% at Hanfeet location and from 89% to 69% at Dawkah location. However, more government support and incentives are required to maintain financial sustainability.

7.2 Interpretation of dynamic Location Models Results

Dynamic location model was performed for three location, Salalah, Hanfeet and Dawkah area. Salalah location represents base model with sufficient water and Hanfeet and Dawkah with water shortage and water level risk and uncertainty stochastic variables. By taking a closer look at the differences between Hanfeet2 scenarios and Dawkah2 relative to the base scenario Salalah, we can get a better indication of the differences between the distributions. Figure 43 shows a comparison of the differences between NPV in scenario Hanfeet2 and scenario Dawkah2 relative to NPV for the base scenario. Salalah location will get positive NPV with a probability of 53%, whereas, Hanfeet location with 21% and Dawkah with 4% only. Government raw material subsidy can improve project success probability to 43% and 49% to Hanfeet and Dawkah locations respectively.

Figure 43 also shows a comparison of the differences between NPV in Hanfeet2 scenario and Dawkah2 scenario relative to NPV for the base scenario Salalah. It was found that NPV of Hanfeet2 scenario is approximately 32% of the time is less than Salalah base scenario, while NPV of Dawkah2 scenario is 49% of the times is less than Salalah location NPV.

SERF used in this study to provide an ordinal ranking of the three alternative location choices for Rhodes grass cultivation facility within feasible risk aversion boundaries. A complete evaluation of alternative locations and water policy presented in this study to help policy maker. The analysis can give the decision maker a cardinal ranking to determine which location and water policy is most suitable for investment based on their risk preferences defined by the risk aversion coefficient (RAC). Figure (44) reveals Salalah location is preference up to 0.000004 risk aversion coefficient (RAC) and after that Dawkah farm location is the most preferred investment. This situation is continued even with minimum raw material subsidy scenarios. Farm location preference changed with additional raw material subsidies of RO 19.67 per ton at Hanfeet and RO 35.47 per ton at Dawkah and new developed area at Najed became a preferred investment option. The decision maker has to compare the cost of risk mitigation and social benefit of new water policy implementation.

The important conclusions we can outline from this study is that although many of the studies in location science emphasize the importance of minimizing cost or maximizing coverage of a given location. However, this study focus on analyzing long-term profitability by considering the effects of stochastic inputs, outputs, and alternative water policy scenarios and incorporate risk and uncertainty into location evaluation model. The study also allows for sensitivity analysis and comparison of key control variables which directly affect the probability of economic success of the project.

7.3 Simulation run model and risk & uncertainty incorporations

Monte Carlo techniques have been extended to the arena of financial analysis. In a World Bank paper, the use of simulation in financial statement models was first proposed by Reutlinger (1970) as a means to estimating the net present value (NPV) of a proposed investment. Richardson and Mapp (1976) proposed utilizing probabilistic cash flows in a stochastic simulation setting as a preferable method to analyzing investment decisions under conditions of uncertainty.

Building on Reutlinger’s (1970) suggestion of using NPV as a key output variable, Richardson and Mapp (1976) defined a summary statistic called the probability of economic success, which refers to the probability that NPV is larger than zero. An investment with a NPV less than zero indicates that the project is not generating a return larger than the investor’s discount rate and is, therefore, not a “successful” investment.

One of the primary benefits to using simulation in this study is the ability to use ground water level as stochastic variables that represent variables with a significant amount of uncertainty, which is characteristic as a new environmental variable could affect project economic sustainability.

At varying levels of complexity, there are many approaches to incorporating risk into a decision model, including dynamic programming, non-linear programming, and scenario analysis. The approaches used for analyzing a decision under risk are referred to as decision analysis (Hardaker et al. 2004a). Challenges often arise when dealing with multiple sources of risk in a given analysis. Monte Carlo simulation has been used extensively for addressing multiple sources of risk and uncertainty. Simulation model offers the primary advantage of having the potential to analyze complex and realistic models. Simulation model also can reflect human behavior in decision making.

Using a simulation approach for decision analysis involves building a model that represents the farming system being described by the model. Within the model, stochastic variables are used to represent "significant" variables in desert farming that are uncertain such as underground water level. Stochastic variables are variables that are thought to have a key impact on the overall project outcome NPV and IRR, thus having a significant impact on the investment decision under study. Simulation model in this study include prices of the inputs and outputs are often included as stochastic variables in addition to crop yields as those variables directly impact the profitability of a farm. Stochastic variables are specified by the modeler as following a particular probability distribution.

Incorporation of stochastic variables is fundamental to the Monte Carlo simulation process. Monte Carlo simulation involves generating a random value for each of the stochastic variables based upon the probability distribution specified by the modeler. The draws of the input variables are aggregated into the output variable of interest based on the relationship specified in the model. This process of generating draws of stochastic input variables is repeated and a probability distribution for the output variable is developed.

7.4 Water policies model and project profitability impact

Water policy model considers the impact of alternative strategies, water level changes for each farm location and region (be it in a particular aquifer or water conservation district). The overall affect (net present value) is left uncertain; however, a regional approach does provide a detailed analysis of the particular region under study. In addition, another justification for the use of a regional analysis is for the policy implications of the model. Rather than looking at the overall result, typical water management and policy team are interested in just the impact of water policy on each location area. While the overall impact may be uncertain, having a complete understanding of the water implications at each location and water level will allow water management team to make good decisions.

The water policy imposed at new cultivated area at Najed increased capital cost of the project and affect project profitability. Operation cost also increased due to new water policy. The Government decided to support farmers and investors and give a grant of 11 Million Rials. The study investigated Hanfeet and Dawkah Location with and without underground water recharge. A dynamic stochastic simulation model of a Rhodes Grass farming was developed in three locations to evaluate the economics of investments in farming and water policy implementation. The model was designed to characterize agriculture risky parameters and economical complexities of a Rhodes Grass farming within a partial budgeting framework by examining the cost and benefit streams coinciding with investment in desert farming and high risk areas.

The simulation models test :

- Underground water level without water re-charges (Hanfeet1 and Dawkah1).
- Underground water level with water re-charges (Hanfeet2 and Dawkah2).
- Underground water level, water re-charges and RM subsidy(Hanfeet3 and Dawkah3).
- Underground water level, water re-charges and sufficient RM subsidy(Hanfeet4 and Dawkah4).

The Monte Carlo dynamic model used in this study not only shows the expected and mean NPV but also gives an expression for the amount of risk that is associated with the investment. There are two measures of risk that are revealed by the simulation models results. The first is the probability of getting negative NVP, which is the measure of the likelihood of the investment being unprofitable (Persson & Nilsson, 1999, 168). The smaller the probability is, the less the risk in the investment (Figure 43). The second measure of risk is the standard deviation which quantifies the variation of the possible NVPs from the mean. The larger the standard deviation is, the more risky the alternative is in that the most likely outcomes are spread on a large range (Figure 42).

The model result shows high probability of negative NPV for Hanfeet and Dawkah Location without Government capital support. With government support the project loss reduced and reached (1.8) Million Rails at Hanfeet location. The government subsidy and support increased NPV and IRR of

Salalah location model to RO 915,448 and 17% respectively. However, the existing government capital subsidy could not made farming at Hanfeet and Dawkah location attractive due to low yield and higher investment and operation cost compared to Salalah location.

The statistical analyses measures of central tendency such as mean and mode, measure of variability such as SD and variance of the models and also measure of Skewness and Kurtosis for each model were performed and shows that Salalah location got the highest NPV and IRR while Dawkah location got the lowest NPV and IRR. The analysis revealed that government subsidy increase project viability for all locations.

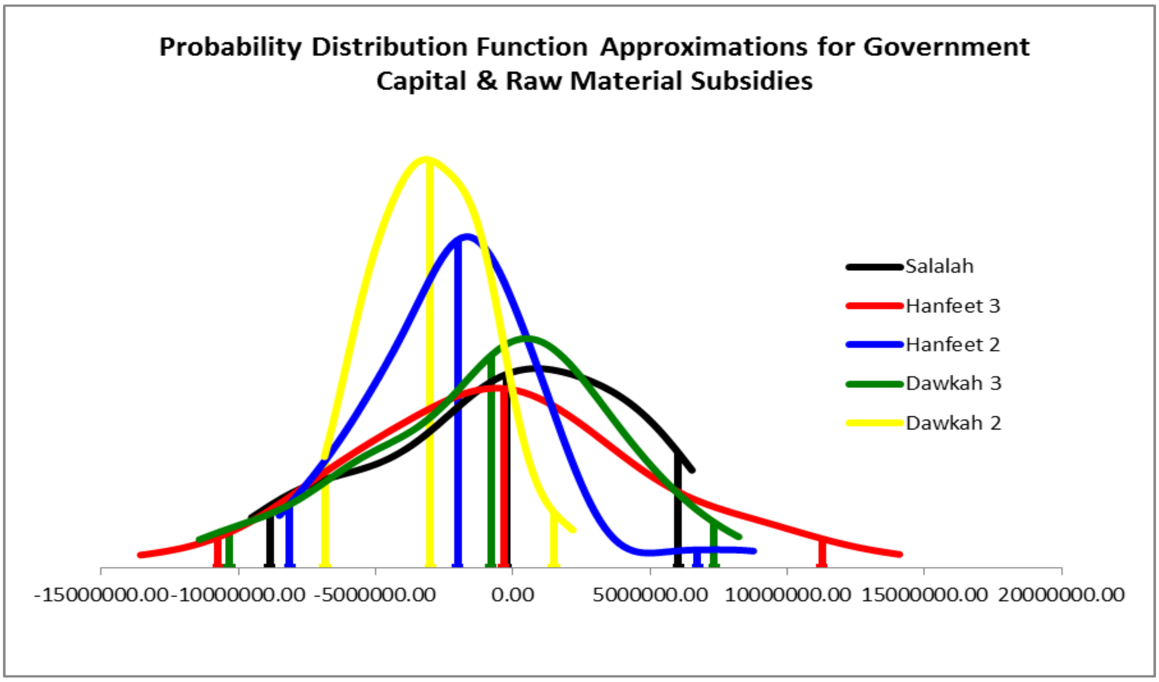


Figure 42 : Comparison of five Probability Distribution Function for Government capital and raw material subsidies.

Government raw material subsidy for Hanfeet and Dawkah Location area were tested by forming Probability Distribution Function (PDF) for Hanfeet and Dawkah with and without minimum raw material subsidy. Figure (42) shows that raw material subsidy (Hanfeet3 and Dawkah3) increased project NPV for Hanfeet and Dawkah Locations to near Salalah's Location NPV, but standard deviation for raw material subsidy models are higher than un-subsidized models (Hanfeet2 and Dawkah2), which mean raw material subsidy will be more risky. Although the Government subsidy (capital & raw material) makes NPV distribution more symmetric for all level of water reduction at Hanfeet and Dawkah Location, but government should introduce more subsidy programs to make desert farming more attractive investment and less risky investment.

Figure (43) shows the probability of having positive NPV of Hanfeet Farm Location increased with minimum raw material subsidy from 21% (Hanfeet2) to 43% (Hanfeet3) and for Dawkah Farm Location from 4% (Dawkah2) to 47% (Dawkah3). However, with the aim of evaluating both the economic and financial results of the model analysis, it is necessary to take into consideration the compromise that should be made between project policy with a high financial risk but also high social benefits and on the contrary, project with a low financial risk but reduced social and environmental benefits.

7.5 Stochastic Efficiency & Stochastic Dominance

Stochastic dominance (SD) is a statistical method for comparing probability distributions in order to identify risk efficient action choices. Thus, SD analysis is a set of decision rules for obtaining a partial ordering of risky alternatives. Use of SD methods overcomes the need to elicit a single-valued utility function. There are three forms of SD analysis: ordinary stochastic dominance (FSD and SSD), stochastic dominance with respect to a function (SDRF), and stochastic efficiency with respect to a function (SERF).

Stochastic dominance is a relationship between pairs of probability distributions. It involves comparison of the relative positions of the cumulative distribution functions (CDFs). The FSD provides the efficient set for all decision makers with utility functions increasing in wealth. The SSD provides the efficient set for all the subset of decision makers having increasing utility functions and risk aversion.

For First- order Stochastic Dominance (FSD) the dominant distribution lies everywhere to the right of the other alternatives without intercrossing and, therefore, it is preferred by decision makers as it is maximized the utility function. For Second- order Stochastic Dominance (SSD) the dominant distribution has a smaller area under the curve for any alternative and preferred by decision makers.

Stochastic dominance with respect to a function (SDRF) allows for the setting of more specific bounds on the risk aversion coefficient. Hardaker et al. (2004) show that SERF orders alternatives in terms of the certainty equivalents (CE) as the coefficient of absolute (or relative) risk aversion is varied over a defined range. It is assumed that the decision maker’s exact risk aversion over stochastic wealth lies somewhere in the range of utility function. Then the function for utility can be defined as either a continuous function or a discrete function.

7.6 First and Second Degree Stochastic Dominance

The use of a stochastic dominance criterion is more appropriate to provide partial ordering of risky alternatives for farmers and decision makers whose preferences fit the specified conditions about their utility functions (preferences for consequences). There is an important trade-off to be made in conducting a stochastic dominance analysis. Hadar and Russell (1969) and Hanoch and Levy (1969) presented the concepts of first-degree stochastic dominance (FSD) and second-degree stochastic dominance (SSD).

When using FSD, it is possible to rank alternatives for decision makers who prefer more wealth to less and have absolute risk aversion with respect to wealth, ra(w), between the bounds - ı<ra(w)<+ı (King and Robison 1984; Hardaker et al, 2004). For SSD it is assumed that decision makers are not risk preferring, therefore absolute risk aversion bounds are 0< ra(w)<+ ı. in of first-degree stochastic dominance (FSD) and second-degree stochastic dominance (SSD) the cumulative distribution functions (CDFs) for each alternative is used to rank alternatives for decision makers who prefer more NPV to less and have absolute risk aversion with respect to wealth (NPV) between bounds – I <ra (NPV) < +I for FSD and absolute risk aversion bounds are 0< ra(NPV)<+ I for SSD.

In this study CDF’s chart drown for NPV return for the five models under the baseline scenario of with and without government capital subsidy. Although specific risk preferences will vary from individual to individual, the CDF’s can be used to identify the treatments that would be preferred by individuals within a range of preferences using stochastic dominance analysis (Meyer, 1977). The simplest form of stochastic dominance is first-degree stochastic dominance. If a CDF ‘A’ lies entirely below and to the right of another CDF ‘B’, then ‘A’ dominates ‘B’ in the first-degree sense. ‘A’ would be preferred by any individual who prefers more of the performance measure (in this case net present value) to less, regardless of whether they are risk averse.

The study used @RISK program is a spreadsheet add-in to test different scenarios, there is considerable flexibility in setting up different scenarios to be evaluated within the spreadsheet. Five different scenarios are presented in this analysis: [1] Salalah Location and no government capital subsidy (baseline), [2] Hanfeet Location without underground water re-charged (Hanfeet1) and with government capital subsidy program, [3] Hanfeet Location with underground water re-charged and government capital subsidy program (Hanfeet2), [4] Dawkah Location without underground water re-charged (Dawkah1) with government capital subsidy program, [5] Dawkah Location with underground water re-charged and government capital subsidy program (Dawkah2), In each scenario, both yields and water level were stochastic. All five scenarios were run simultaneously using 10,000 random samples from each of the yield and price distributions. Even with 2000 random samples, the simulation only took 11 seconds to run on a computer with a 1.6 GHz Pentium 4 processor and 256 MB RAM.

To test risk management appropriate strategy the Cumulated Distribution Function CDF graphs performed to illustrate the range and probabilities of net present value for combinations of risk management strategies. If the lines on the graph do not cross, then the combinations of strategies can be ranked using first degree stochastic dominance and distribution on the right is preferred to those on the left. Hanfeet1 and Dawkah1 represent option (Farm Location with no water recharge), Figure (43 -A) indicate option could manage downside risk but were not dominated models and replaced by Hanfeet3 and Dawkah3 (Farm Location with water recharge and minimum raw material subsidy) in the model and the result presented in Figure (43 -B). Figure 43 shows the CDF lines for alternatives crossing each other and then there is no clear ranking for the Decision Makers under different RAC and more integrated stochastic efficiency ranking tools must be used for further clarification.

A more powerful form of stochastic dominance is second-degree stochastic dominance. Second degree stochastic dominance is based on the area under the CDF. If the area under CDF ‘A’ is less the area under CDF ‘B’ at every point along the x-axis, then ‘A’ is said to dominate ‘B’ in the second-degree sense. Activity ‘A’ would be preferred by any individual who is risk-averse for all values of the performance measure. Table (48) indicates the results of FSD and SSD analysis for different farm location with government capital subsidy.

Table (48) shows the first and second-degree stochastic dominance (FSD and SSD) analysis result for ranking irrigation systems and farm location basis on NPV for various levels of risk avoidance. Cumulated Distribution Function (CDFs) also performed for all alternatives and shown in Figure

(43) and Salalah Farm location is preferred as it is CDF is below and to the right of the CDFs of other strategies.

Since the CDFs intersect each other at multiple points, including intersection on the negative tails, first-degree stochastic dominance is inconclusive and the decision maker would require additional information (based on the area underneath each point of the CDF) offered by second-degree stochastic dominance (SSD). The ranking result for second-degree stochastic dominance (SSD) shows Hanfeet2 dominates Hanfeet1 and Dawkah Farm location with and without underground water re-charges. The result also shows that Salalah Farm dominates Hanfeet and Dawkah Farm location with and without underground water re-charges.

Table 48 : First and Second Dominance analysis of NPV of Salalah, Hanfeet and Dawkah Farm location with & without underground water re-charge

FDD Scenarios	Salalah	Hanfeet1	Hanfeet2	Dawkah1	Dawkah2
Sahalah		FDD		FDD	
Hanfeet1					
Hanfeet2		FDD		FDD	
Dawkah1					
Dawkah2				FDD	

Farm Location and underground water level

SSD Scenarios	Salalah	Hanfeet1	Hanfeet2	Dawkah1	Dawkah2
Sahalah		Hanfeet1		Dawkah1	Dawkah2
Hanfeet1					
Hanfeet2		Hanfeet1		Dawkah1	Dawkah2
Dawkah1					
Dawkah2		Hanfeet1		Dawkah1	
Area under CDF	90 902	131 196	108 531	148 185	118 24

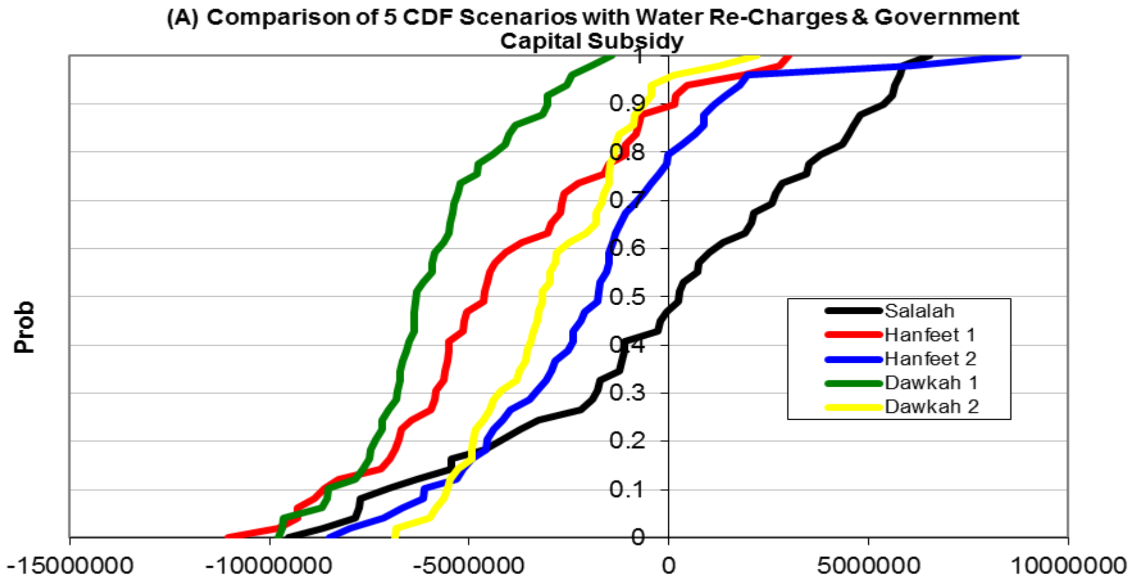
Farm Location underground water level and Government Raw material subsidy

SSD Scenarios	Salalah	Hanfeet3	Hanfeet2	Dawkah3	Dawkah2
Salalah		Hanfeet3	Hanfeet2	Dawkah3	Dawkah2
Hanfeet3			Hanfeet2	Dawkah3	Dawkah2
Hanfeet2					Dawkah2
Dawkah3			Hanfeet2		Dawkah2
Dawkah2					
Area under CDF	144 499	145 560	162 199	150 083	172 193

The CDF of all alternatives in figure (43) indicates that Salalah Farm location is a preferred by all risk averse decision makers as area under CDF of this alternative is smaller than others, table (48) and always below and to the right of the CDF of other strategies. However, SSD analysis is not conclusive because SSD doesn't rigorously discriminate between distributions at all levels, which is a problem in economic scenario in agriculture as most risk is usually at the distribution tails and have low level of net return and NPV.

7.7 Stochastic Dominance with Respect to a Function

Meyer (1977) developed a methodology to extend first and second degree stochastic dominance (GSD) techniques to order risky prospects while considering a distinct set of risk attitudes.



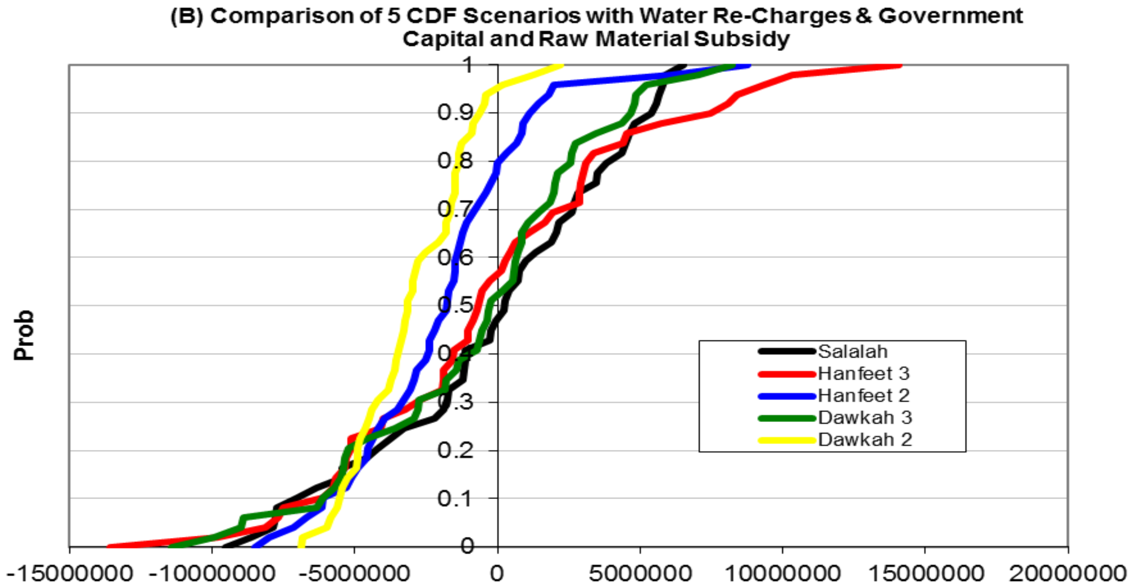


Figure 43 : Comparison of 5 CDF Scenarios for risk management strategies of capital and raw material subsidies.

This Generalized Stochastic Dominance (GSD) concept - also known as Stochastic Dominance with Respect to a Function (SDRF) - does not impose the assumption of normality on the distributions being compared as does mean-variance analysis, and does not assume a specific risk preference as do first and second degree Stochastic Dominance. The GSD ranks risky prospects from most preferred to least preferred through sequential pair wise comparisons of each prospect's expected utility.

The expected utility is a product of a prospect's cumulative distribution curve and the marginal utility of a particular class of decision makers.

To improve the discriminating power of SSD, SDRF is proposed as it is a more general notion of stochastic dominance. The SDRF helps to identify risk-efficient options for the class of decision makers whose risk aversion coefficients are bounded by lower and upper values. The smaller the range of risk aversion coefficients, the more powerful is the criterion. The SDRF criterion orders the strategies and alternatives by defining intervals using the (ARAC) absolute risk aversion coefficients. These risk-preference intervals are bounded by a lower risk aversion coefficient, and an upper risk aversion coefficient, which characterize the general degree of risk aversion for decision maker. A risk-efficient set of strategies will include the choices preferred by each DM and manager having risk preferences consistent with the restrictions imposed by the lower to upper interval. SDRF analysis performed to investigate ranking the preferred Farm location under water policy alternatives and results shown in table (49). Proposed Government raw material subsidy at different Farm location and underground water level were tested and results are summarized in table (50).

The relationship between absolute and relative risk aversion is ra(w) = rr(w)/w where w is wealth. Anderson and Dillon (1992) proposed a rough classification of risk aversion degrees, based on the relative risk aversion with respect of wealth, rr(w), ranging from 0.5 (almost no risk averse at all) to approximately 4 (high risk averse). In this study the absolute risk aversion coefficients (ARAC) was large relative to size of data and calculated as under :

ARAC = 4.0/absolute vale of the largest average value of NPV (3,000,000)

ARAC = 4.0/3,000,000 = 1.3333

Table 49 shows Salalah Location is the most preferred location at the lower risk averse coefficient (risk neutral condition) followed by Hanfeet Location with underground water re-charges. Dawkah Location with underground water re-charges was the 3rd most preference Farm location. Under upper risk averse coefficient (hardly risk averse condition) Dawkah Location with underground water re-charges was the most preferred scenario followed by Hanfeet Location with underground water re-charges. Salalah Location ranked as the 3rd most reference Farm location.

Table 49 : Analysis of SDRF of NPV of Salalah, Hanfeet and Dawkah Farm location with & without underground water re-charge

Efficient set based of SDRF at Lower RAC = 0		Efficient set based of SDRF at Upper RAC RAC = 1	
Scenario	Reference level	Scenario	Reference level
1 Salalah	Most Preferred	1 Dawkah2	Most Preferred
2 Hanfeet2	2nd Most Preferred	2 Hanfeet2	2nd Most Preferred
3 Dawkah2	3rd Most Preferred	3 Salalah	3rd Most Preferred
4 Hanfeet1	4th Most Preferred	4 Dawkah1	4th Most Preferred
5 Dawkah1	Least Preferred	5 Hanfeet1	Least Preferred

Raw material subsidy policy was evaluated by SDRF analysis and results presented in table (50). The analysis indicates Salalah Location is the most preferred location at the lower risk averse coefficient (risk neutral condition) followed by Hanfeet Location and Dawkah Location with underground water re-charges and raw material subsidy.

Under upper risk averse coefficient (hardly risk averse condition) Dawkah Location with sufficient underground water was the most preferred scenario followed by Hanfeet Location with underground water re-charges. The 4th and 5th preference policy was raw material subsidy policy for Dawkah and Hanfeet Farm location. However, this analysis shows raw material subsidy policy are preferred at lower risk averse coefficient and not preferred at upper risk averse coefficient.

Table 50 : Analysis of (SDRF) of NPV of Salalah, Hanfeet and Dawkah Farm location with underground water re-charge and Government raw material subsidy

Efficient set based of SDRF at Lower RAC = 0		Efficient set based of SDRF at Upper RAC RAC = 1	
Scenario	Reference level	Scenario	Reference level
1 Salalah	Most Preferred	1 Dawkah2	Most Preferred
2 Hanfeet3	2nd Most Preferred	2 Hanfeet2	2nd Most Preferred
3 Dawkah3	3rd Most Preferred	3 Salalah	3rd Most Preferred
4 Hanfeet2	4th Most Preferred	4 Dawkah3	4th Most Preferred
5 Dawkah2	Least Preferred	5 Hanfeet3	Least Preferred

7.8 Stochastic Efficiency with Respect to a Function

A more recent method of stochastic dominance, called stochastic efficiency with respect to a function (SERF), orders a set of risk-efficient alternatives instead of finding a subset of dominated alternatives and uses the concept of certainty equivalents (CEs) instead of cumulative distribution functions (CDFs) for each alternative (which used in the case of FSD and SSD). Hardaker et al. (2004), state that SERF provides an approach consistent with the subjective expected utility (SEU) hypothesis, in such way that SERF narrows the choice to an efficient set and thus has stronger discriminating power than conventional stochastic dominance techniques (SDRF). A major hypothesis of SERF is that the decision-maker would be risk averse enough to accept a sure lower expected NPV value versus a high unsure expected NPV value.

Sustainability of new water policy and farming at Najed area is also measured in this study by the probability of financial survival to the planning horizon. The negative value of NPV of farming at Hanfeet and Dawkah area shows that irrigation schedules for a risk averse farmer may include those with high production risk, due to the interaction of resource use between deficit irrigation alternatives when underground water is limited.

Sustainability measurement should not only be by economic criteria such as (NPV) value and used it to make a choice between farming at different farm location. As high NPV value focuses only on the lower tail of the distribution, implying an extreme aversion to risk. To supplement the sustainability criteria the Stochastic Efficiency with Respect to a Function (SERF) is used. The SERF method ranks the alternative risky farming systems in terms of the certainty equivalent (i.e., risk-discounted value) of current wealth (NPV) over a plausible range of risk aversion levels.

The SERF method calls for calculating 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 0.0 (risk neutral) to 0.00000133 (extremely risk averse). The upper ARAC value was calculated using the following formula proposed by (Hardaker et al. 2004: 2)

$$ARACrw = \frac{rr(w)}{w} = 4/Wealth \text{ (Absolute value of the largest average NPV= 3,000,000)}$$

where : rr(w) is the relative risk aversion coefficient with respect to wealth (w).

For example the boundaries for risk aversion from 0,5 to 4 as proposed by Anderson and Dillon 1992 rr (w) was set equal to 4 (extremely risk averse risk lover). Wealth (w) was calculated based on the respective net present value means from alternatives under test.

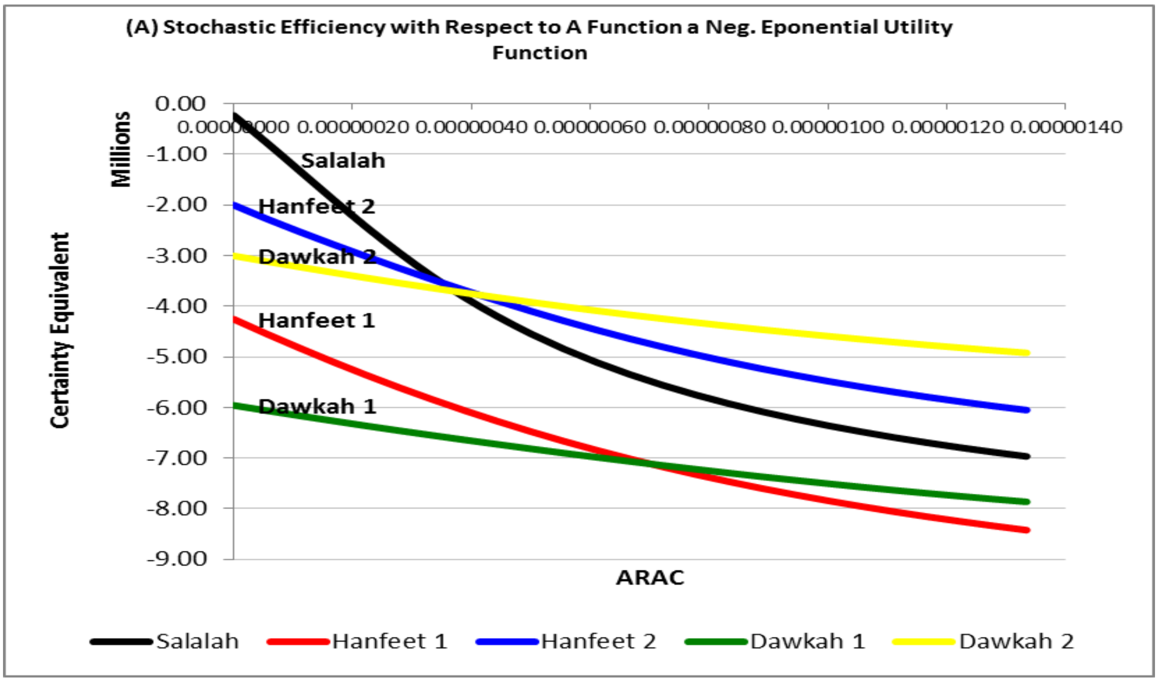
The Excel Add-In Simetar program was used to conduct the SERF analysis based on a negative exponential utility function. Certainty equivalent graphs were constructed to display ordinal rankings of NPV across the specified range of ARAC values. The risk premiums were also calculated for each risk management strategies by subtracting alternative NPV CE values from preferred NPV CE values at given ARAC values (Salalah Location). Positive RP for an alternative policy indicates that it is preferred over the base Salalah model by the given amount in Rials Omani, whereas negative RP indicate that the base Salalah model is preferred over the selected alternative.

The study performed (SERF) analysis over a range of risk aversion from (risk neutral to extremely risk).Table (51) shows that Salalah Location is the preferred alternative under risk neutral and moderate risk level followed by Hanfeet Location with water recharges. With minimum government raw material subsidy Salalah location is preferred followed by Hanfeet and Dawkah Locations as shown in figure (44-B). The break even risk aversion coefficient (BRAC) is obtained to show the point in which the preferences between risky alternatives are same and farm locations preference change. At a break even risk aversion coefficient (BRAC) point the decision makers are indifferent between the risky alternatives and farm location. Figure (44) shows (BRAC) point at 0.0000004 risk level at which three farm locations Neg. Exponential Utility Function (Salalah, Hanfeet2 and Dawkah2) intersect each other. The figure also shows that the minimum government raw material subsidy (Hanfeet3 and Dawkah3) are not dominate and would not be enough to compensate 3.7 Million Rials loss. The SERF analysis indicate that minimum government raw material subsidy would not be satisfied to neutral risk farmers at Hanfeet and Dawkah Location, and it will not be satisfactory to extreme risk averse and government should increase raw material subsidy to satisfy famers needs and make farming at Najed area profitable. The vertical distance between two alternatives at a specified level yields a utility weighted risk premium, which is defined as the minimum sure amount NPV that has to be paid to a decision-maker to justify a switch between a preferred (Salalah) and a less preferred alternative.

Table (51) revels the result of SERF analysis which is used to compare five risk management alternatives simultaneously for all ARAC values in a 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 analysis alternative Hanfeet1 and Dawkah1 are not utility-efficient as it is dominated by one of the other alternatives at every level of risk aversion and all classes of risk aversion with RAC ranging from -0.0000008 to 0.0000008.

Table 51 shows raw materials subsidy introduced to the model and 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 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 if decision maker are risk preferring. However, those who are slightly more risk averse would prefer Salalah location and decision maker with very risk averse would prefer Dawkah2 as it is keeping dominant and risk-efficient at extremely risk aversion level.

Moreover, farmer and decision maker with very risk averse would not prefer raw material subsidy and prefer other tool of risk mitigation such as insurance or final product price support. The analysis also shows that Risk averse farmers at Dawkah location may need substantial incentives to adopt new water policy and invest in costly irrigation system and technologies required at new area.



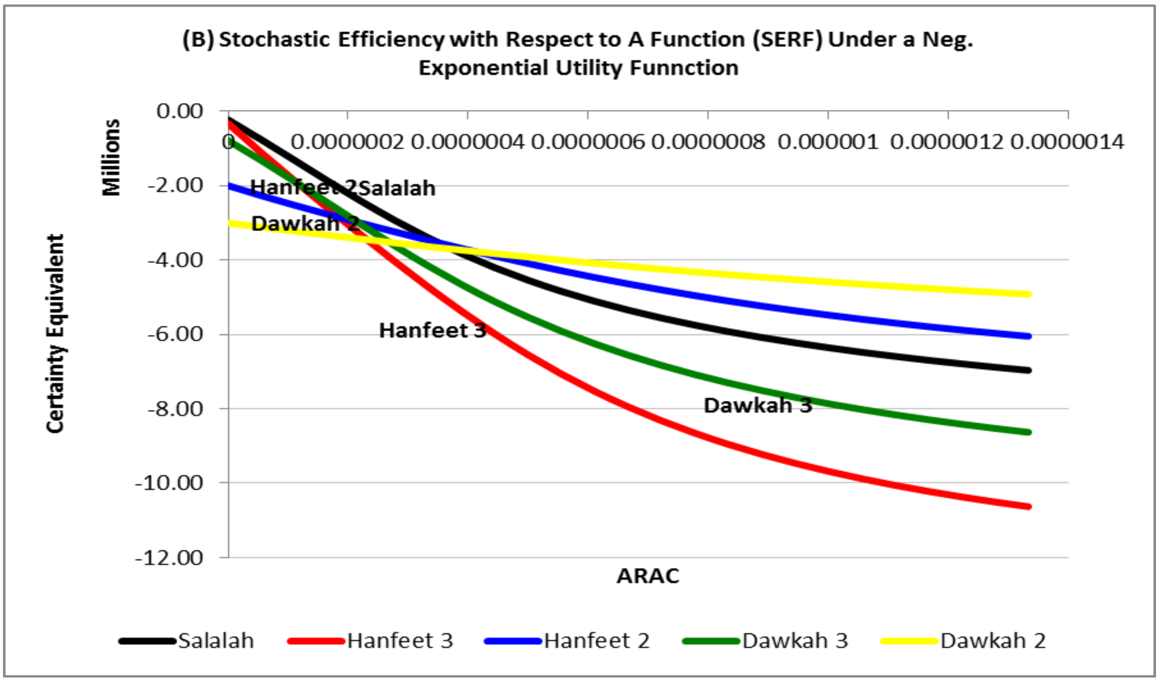


Figure 44 : SERF for NPVs of three farms with capital & raw material subsidy (A) No RM (B) with RM subsidy.

Table 51: Ranking of Risky Alternatives by Risk aversion using CE for NPV (000) of Rhodes Grass Farms

Risk level	Preferred Risk		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

(Source: calculated by Author).

A negative exponential utility function conforms to the hypothesis that managers prefer less risk to more given the same expected return and assumes managers have constant absolute risk aversion. Under this assumption, managers view a risky strategy for a specific level of risk aversion the same without regard for their level of NPV. The study used SEFR analysis and Simetar program to re-calculate CE with different ARAC range from (0) to (0.00000133) as the maximum ARAC should not exceed (4/3,000,000). The result of the new calculation presented in table (52) and figure (44).

The benefits of irrigation 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.

Table 52: Ranking of Risky Alternatives by Risk aversion using CE for NPV (000) of Rhodes Grass Farms

Risk level	Preferred Risk		Normal Risk		Rather Risk		Extremely Risk	
ARAC	0.00		0.0000039		0.0000083		0.0000013	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Salalah	-232	Hanfeet2	-3,686	Dawkah2	-4,393	Dawkah2	-4,920
2	Hanfeet3	-329	Dawkah2	-3,735	Hanfeet2	-5,101	Hanfeet2	-6,051
3	Dawkah3	-789	Salalah	-3,828	Salalah	-5,925	Salalah	-6,966
4	Hanfeet2	-2,002	Dawkah3	-4,661	Dawkah3	-7,304	Dawkah3	-8,633
5	Dawkah2	-3,005	Hanfeet3	-5,377	Hanfeet3	-8,955	Hanfeet3	-10,631

(Source: calculated by Author).

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.

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 Figure 45 and numerically in table (51-52). Table (51) reveals that under normal risk aversion raw material subsidy are required for Salalah location and new area at Hanfeet and Dawkah. Figure 45 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, which means more subsidy has to be given.

7.9 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. Figure (45) represent the difference 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) :

WTP = CEpreferred - CEalternative

Table 53: Utility Weighted Risk Premiums RO (000) relative to Salalah Location.

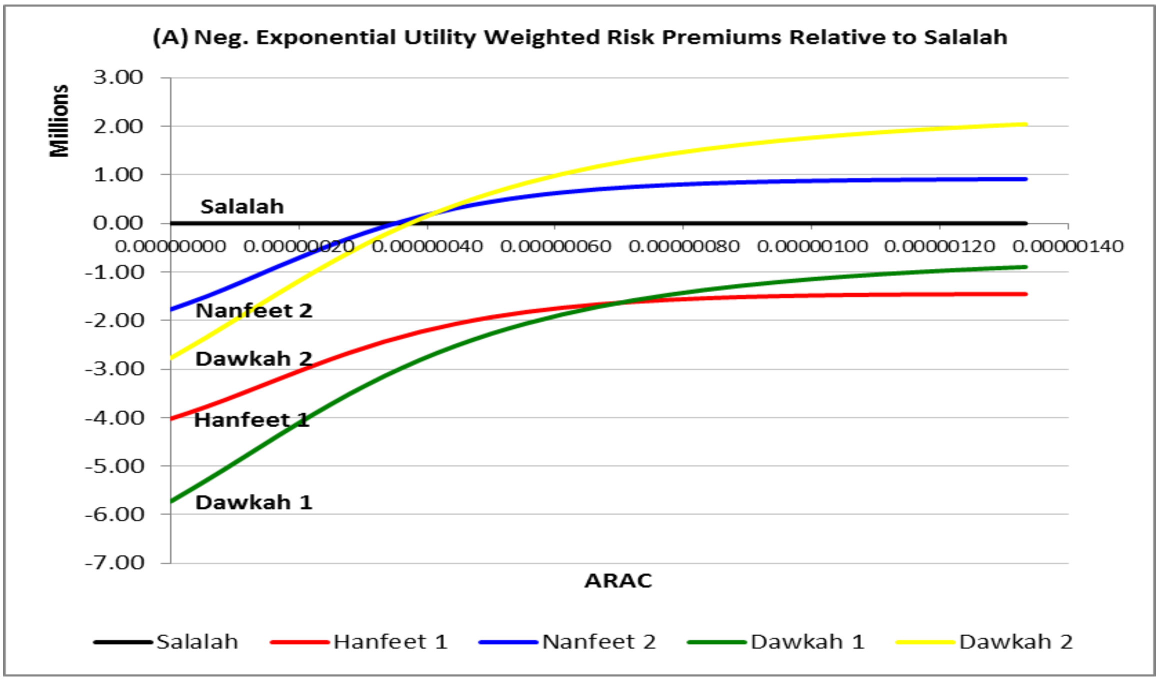
Risk level	Risk Preference		Normal Risk		Rather Risk		Extremely Risk	
ARAC	-0.0000008		0.0000000		0.00000033		0.0000008	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Hanfeet3	5,671	Salalah	0	Salalah	0	Dawkah2	1,473
2	Dawkah3	453	Hanfeet3	-97	Hanfeet2	-63	Hanfeet2	807
3	Hanfeet2	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

(Source: calculated by Author).

The SERF rankings and WTP are used to analyze risk management strategies for fodder crop re-allocation at Najed Area. Figure (45) shows how the alternative scenarios examined in the study rank relative to the preferred base scenario (Salalah) at various RACs. Table (53) shows the numerical risk premiums for four risk aversion levels.

SERF analysis is done assuming a negative exponential utility function for which Absolute Risk Aversion Coefficient (ARAC) range is set to be 0.0 and +0.0000013. SERF uses Certainty Equivalents (CE) to rank risky alternatives. Certainty equivalent value shows the amount of money that the decision maker would have to be paid to be indifferent between the particular scenario and a no risk investment. We also estimated confidence premiums for each alternative. Confidence premium indicates how much a decision maker has to be paid to switch from the preferred strategy in this case (Salalah). Hanfeet and Dawkah locations were tested with and without ground water re-charge and compared with Salalah location (Base Model). Certainty Equivalents (CE) for Hanfeet1 (No water re-charge) reached 4.2 million and Dawkah1 (No water re-charge) reached 5.9 million and Hanfeet2 (with water re-charge) reached 2 million Omani Rials. With minimum raw material subsidy Hanfeet3 (with water re-charge) reduces to RO 97,000 and Dawkah3 RO 557,000.

From table (53), it is evident that DMs for the risk aversion levels examined have a small risk premium value between the preferred scenario (Salalah) and the second place alternative (Hanfee3) with capital and minimum raw material subsidy options at normal risk level with (-97,000) risk premium and (-557,000) risk premium for (Dawkah3) at third place alternative. (Hanfeet2) alternative recorded (-1.769) million risk premium at fourth alternative. 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.



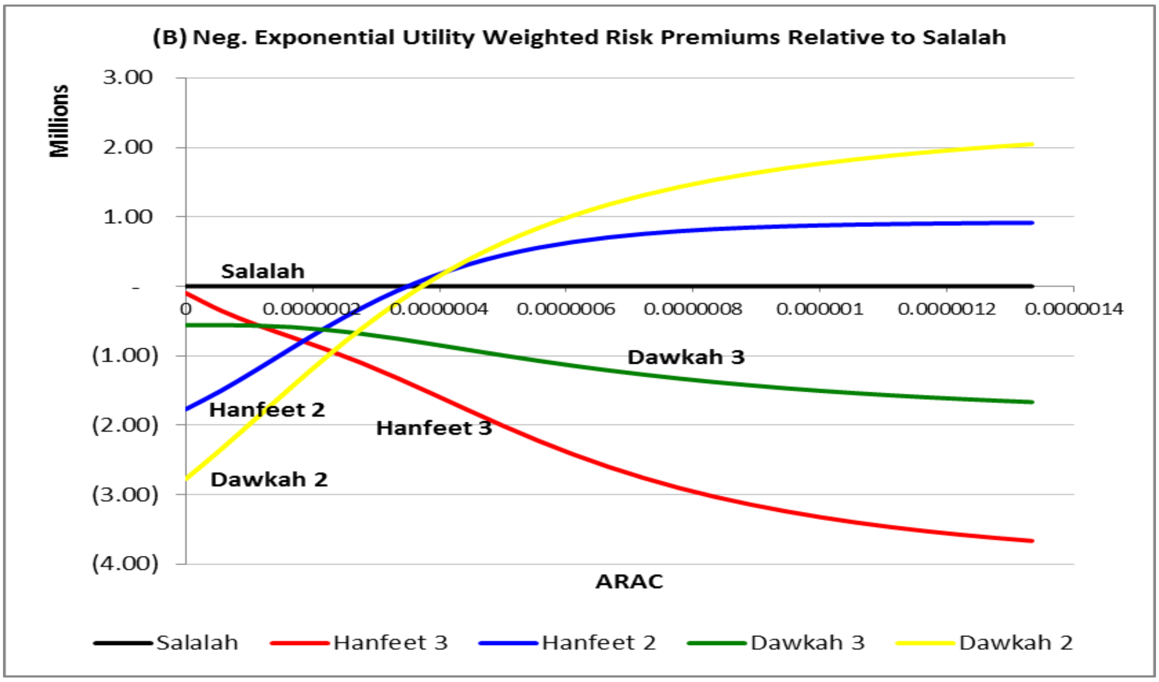


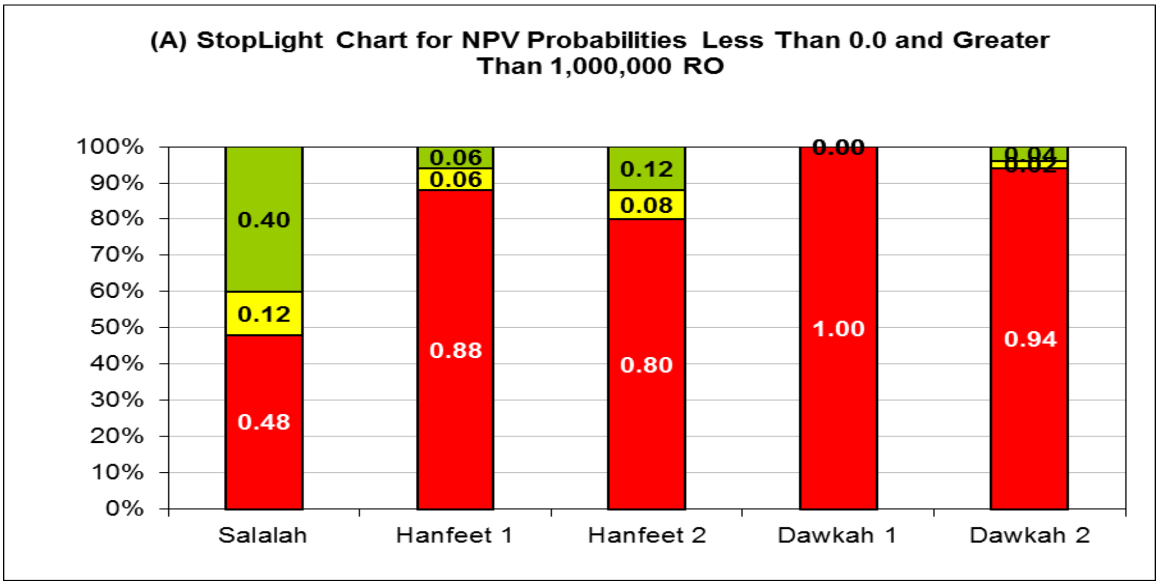
Figure 45: Neg. Exponential Utility Weighted Risk Premium relative to Salalah Location with RM subsidy.

The CDF Figure shows the probability of having positive NPV of Hanfeet Farm Location increased with optimum raw material subsidy from 20% (Hanfeet2) to 67% (Hanfeet4) and for Dawkah Farm Location from 4% (Dawkah2) to 57% (Dawkah4). However, with the aim of evaluating both the economic and financial results of the model analysis, it is necessary to take into consideration the compromise that should be made between project policy with a high financial risk but also high social benefits and on the contrary, project with a low financial risk but reduced social and environmental benefits.

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).

7.10 Government Raw Material Subsidy and StopLight Graph Analysis

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 i.e.(one Million and 0 NPV). The Stoplight graph in figure (46) illustrates the probability of NPV being less than zero and greater than RO 1,000,000.



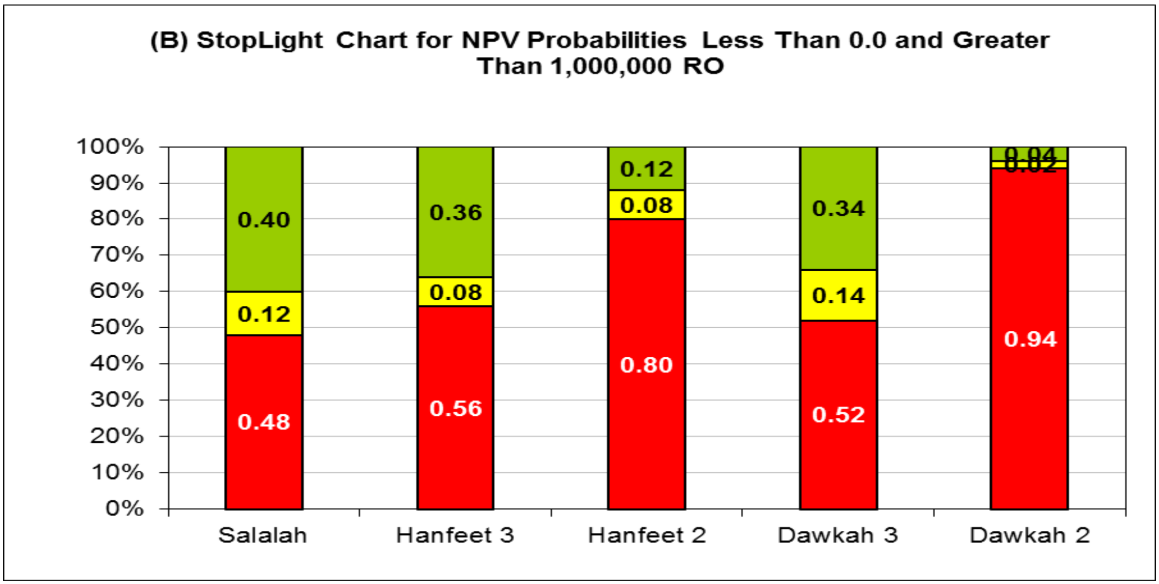


Figure 46 : StopLight chart for NPVs of Three Farms with (B) & without (A) minimum RM subsidies.

Figure (45-B) reinforces the results found in the NPV CDFs in Figure (43). For example, Hanfeet1 and Dawkah1 (with no water recharge) in Figure (46-A) has more than 88% chance of negative NPV (i.e., red area) and are replaced by Hanfeet3 and Dawkah3 (with water recharge) in Figure (46-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.

7.11 The Optimum Government Raw Material Subsidy Required

The minimum raw material subsidy required to obtain same level of NPV of basic reference Salalah Farm Location of RO 301,479 was calculated in Chapter 6 and recorded as RO 10.12 per Ton for Hanfeet Farm and RO 27,28 per ton for Dawkah Farm. Stochastic efficiency with respect to a function (SERF) analysis was performed to rank risky alternatives in terms of CE across a range of RACs. The calculated CEs are displayed on Figure 45 and table 52, and shows that Salalah and Hanfeet2 and Dawkah2 are the most preferred over risk level range ARAC of (0.0 – 0.0000013). The analysis indicates minimum raw material risk management policy is not favorable.

The study tested the increase of raw material subsidy from RO 10.12 to RO 19.67 per ton for Hanfeet Farm and from RO 27.28 to RO 35.47 per ton for Dawkah Farm. The analysis reveal that NPV for Hanfeet increased to RO 1,796,959 and for Dawkah increased to RO 1,268,085. Stochastic efficiency with respect to a function (SERF) analysis was performed to rank risky alternatives in terms of CE across a range of RACs. The result of rankings five alternative risk management strategies indicates Hanfeet4 is the most preferred scenario over the range of risk preference from (0.0-0.00000013). Results were presented graphically in Figure 47 and numerically in table (54) below.

Table 54 : Ranking of Risky Alternatives by Risk aversion using CE for NPV (000) of Rhodes Grass Farms with 10% Additional Raw Material Subsidy

Risk level	Preferred Risk		Normal Risk		Rather Risk		Extremely Risk	
ARAC	0.00		0.0000039		0.0000083		0.0000013	
Rank	Alternative	CE	Alternative	CE	Alternative	CE	Alternative	CE
1	Hanfeet4	2,681	Hanfeet4	1,976	Hanfeet4	1,213	Hanfeet4	423
2	Dawkah4	1,361	Dawkah4	642	Dawkah4	-127	Dawkah4	-927
3	Salalah	-232	Salalah	-604	Salalah	-1,044	Salalah	-1,57
4	Hanfeet2	-2,002	Hanfeet2	-2,193	Hanfeet2	-2,402	Hanfeet2	-2,628
5	Dawkah2	-3,005	Dawkah2	-3,083	Dawkah2	-3,171	Dawkah2	-3,268

(Source: calculated by Author).

Because the distributions of NPV with regard to scenarios do cross, we are not able to tell which one would be preferred by a risk adverse individual just by looking at the CDF, therefore making the use of a SERF analysis a necessary tool to determine the preferred alternative. A SERF analysis was run on NPV for each of the analyzed scenarios, Figure 47 shows a SERF chart under a power utility function. Clearly, Hanfeet4 is preferred under all reasonable levels of risk aversion. From the SERF analysis, it is clear that all raw material subsidy scenarios are preferred to the base scenario (Salalah).

Figure 49 revealed that (Hanfeet4) is dominated over a range of risk aversion. The figure also shows a Break Even Risk Aversion Coefficient BARAC, where the preference changes and intersected at (0.00000033) Risk averse level at 3.4 Million loss. Therefore, Break even risk aversion coefficient (BRAC) method is used to identify risk preference interval reflecting unique preference ranking. Using BRAC procedure we can calculate the actual range of RACs where raw material alternative is preferred and the range over which another alternative is preferred.

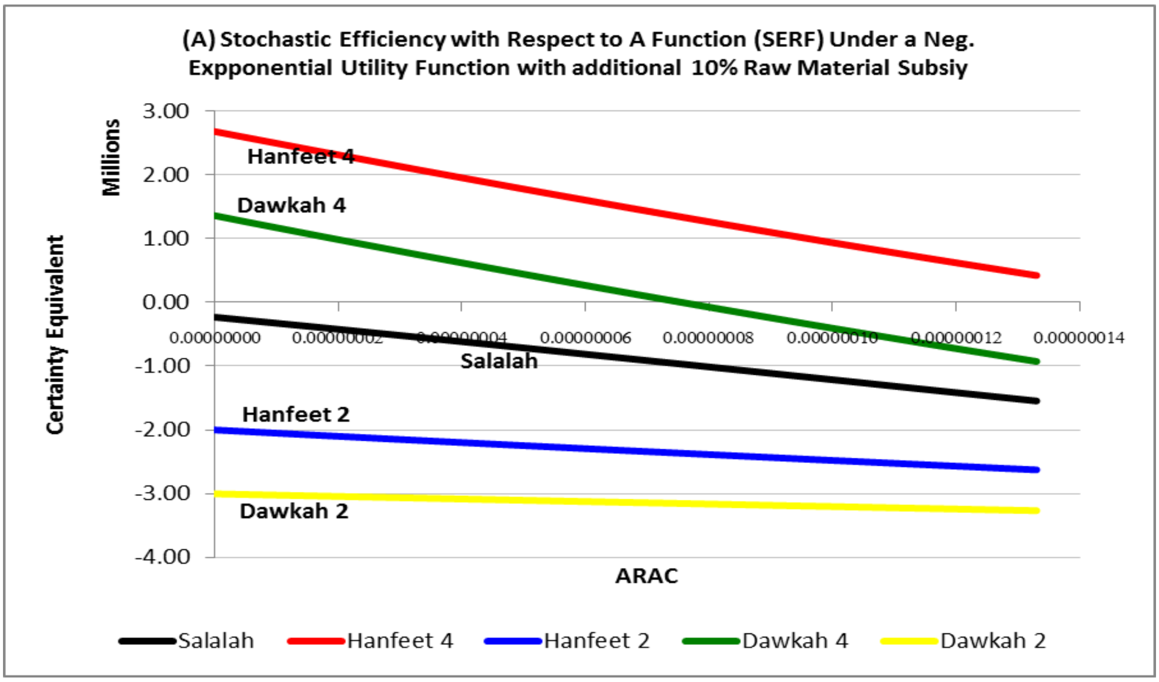


Figure 47 : SERF for NPVs with capital subsidy & 10% additional raw material subsidy.

Risk premium analysis was performed using Neg. Exponential Utility Weighted Risk Premium for each alternative. The NPV for Salalah are considered as the base location while calculating RP. Positive RP for an alternative (Hanfeet4) indicates that it is preferred over the base location Salalah by 3 Million Rials Omani, whereas negative RP (Hanfeet2) indicate that Salalah base location is preferred over the selected alternative.

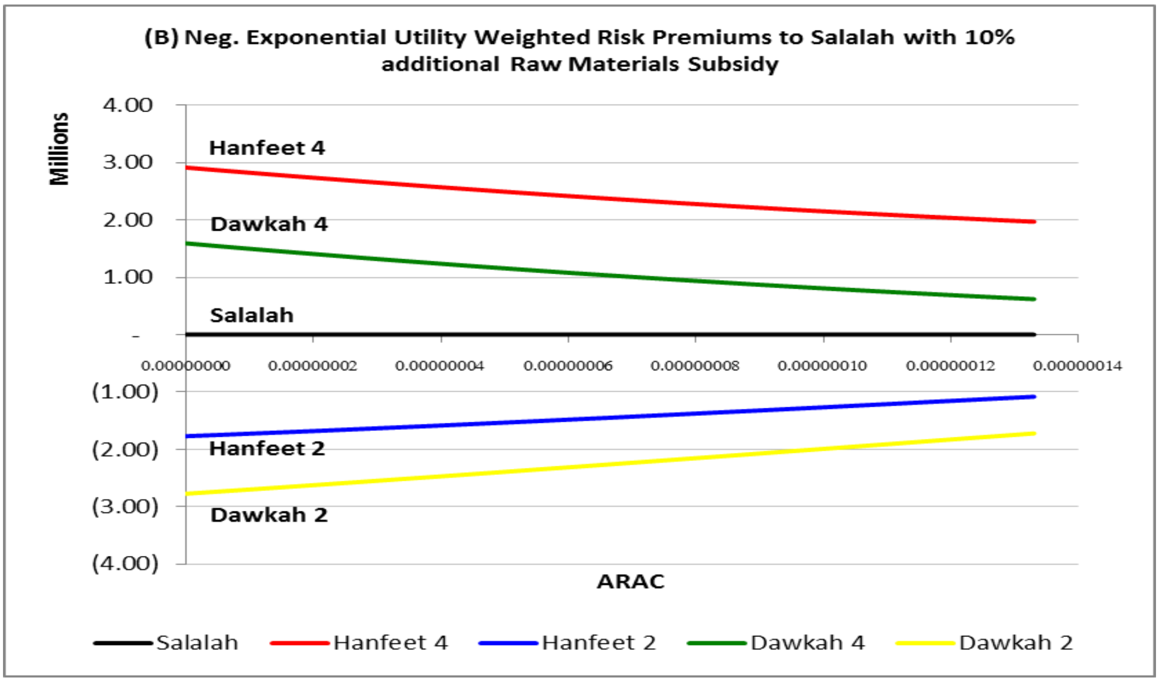


Figure 48: Neg. Exponential Utility Weighted Risk Premium relative to Salalah Location with additional 10% RM subsidy.

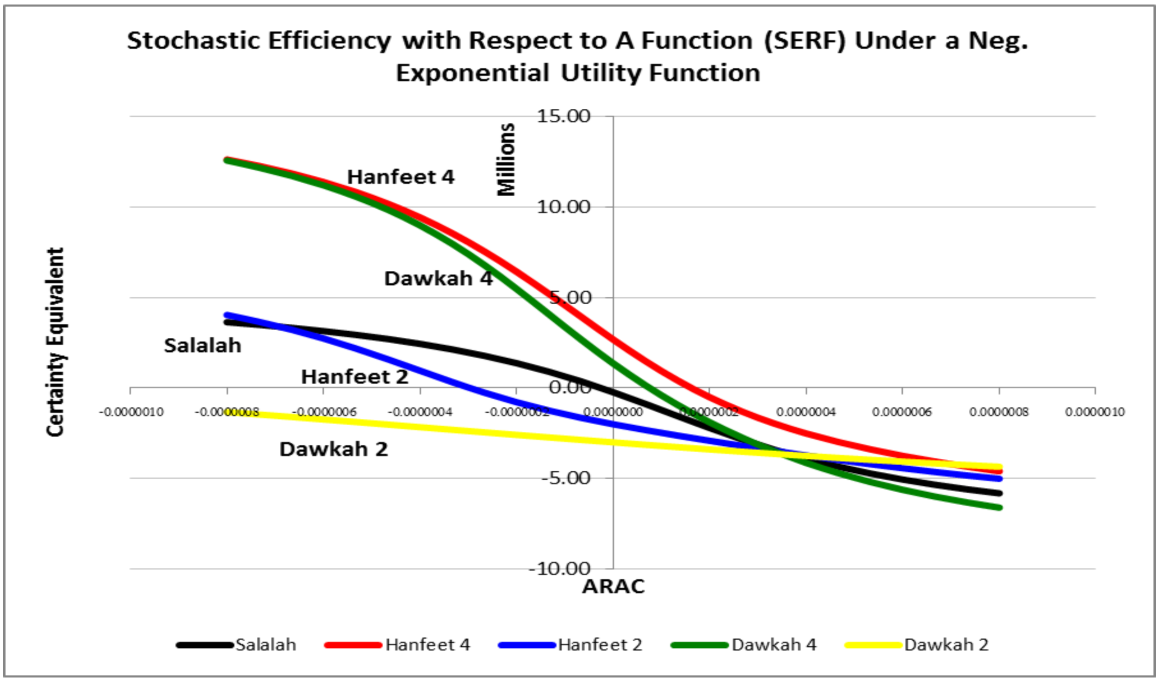


Figure 49 : SERF for NPVs with capital subsidy & 10% additional raw material subsidy.

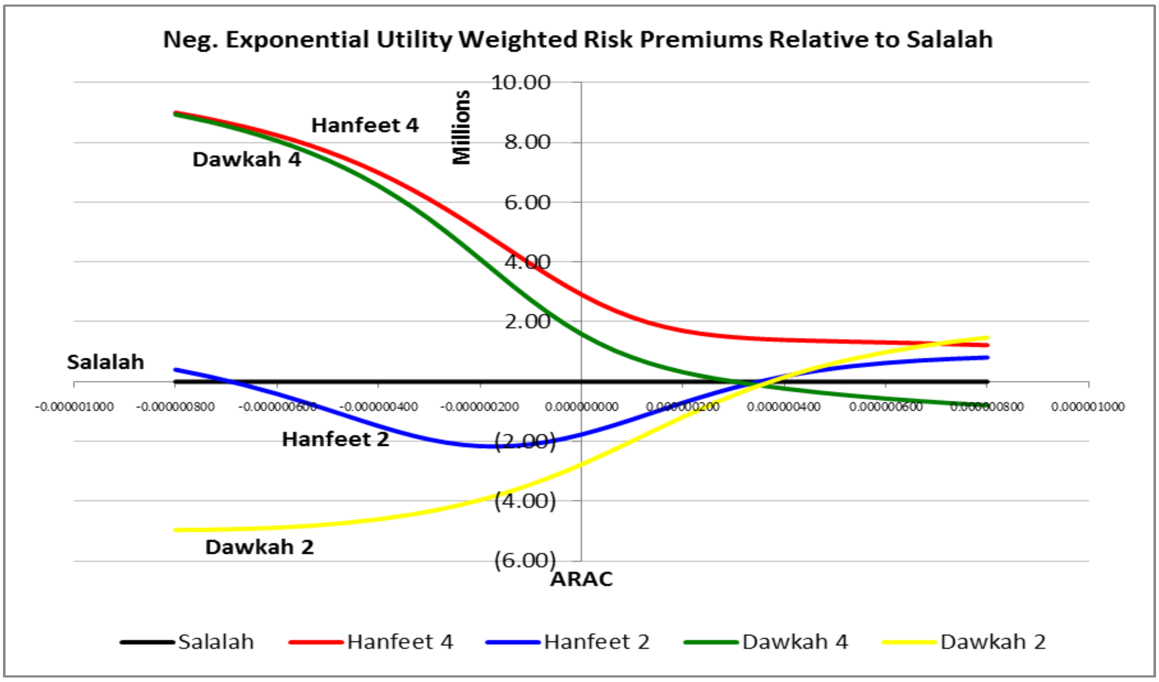


Figure 50: Neg. Exponential Utility Weighted Risk Premium relative to Salalah Location with additional 10% RM subsidy.

SERF analysis is done assuming a negative exponential utility function for which Absolute Risk Aversion Coefficient (ARAC) range is set to be -0.0000008 and +0.0000008. SERF uses Certainty Equivalents (CE) to rank risky alternatives. Certainty equivalent value shows the amount of money that the decision maker would have to be paid to be indifferent between the particular scenario (Salalah & Najed) and a no risk investment. We also estimated risk premiums for each alternative. Risk premium indicates how much a decision maker has to be paid to switch from the preferred strategy. Figure 50 shows Salalah Location is preferred than Hanfeet2 by 1.78 Million and by 2.77 Million to Dawkah location if raw materials subsidy policy are not implemented.

The additional raw material subsidy model (Hanfeet4) dominated Salalah by 2.91 Million, whereas (Dawkah4) dominate Salalah by 1.59 Million. Preference ranking based on generalized stochastic dominance indicate that (Hanfeet4) can be stable alternative and is ranked high throughout the range of the ARAC.

Table 55: Raw material cost and subsidy and NPV for each Model

Hanfeet			Dawkah		
Model	RM cost/ton	NPV (000)	Model	RM cost/ton	NPV (000)
Hanfeet2	71.290	-1.846	Dawkah2	79.800	-3.014
Hanfeet3	61.170	300	Dawkah3	52.520	273
Hanfeet4	51.620	1.797	Dawkah4	44.330	1.268

(Source: calculated by Author).

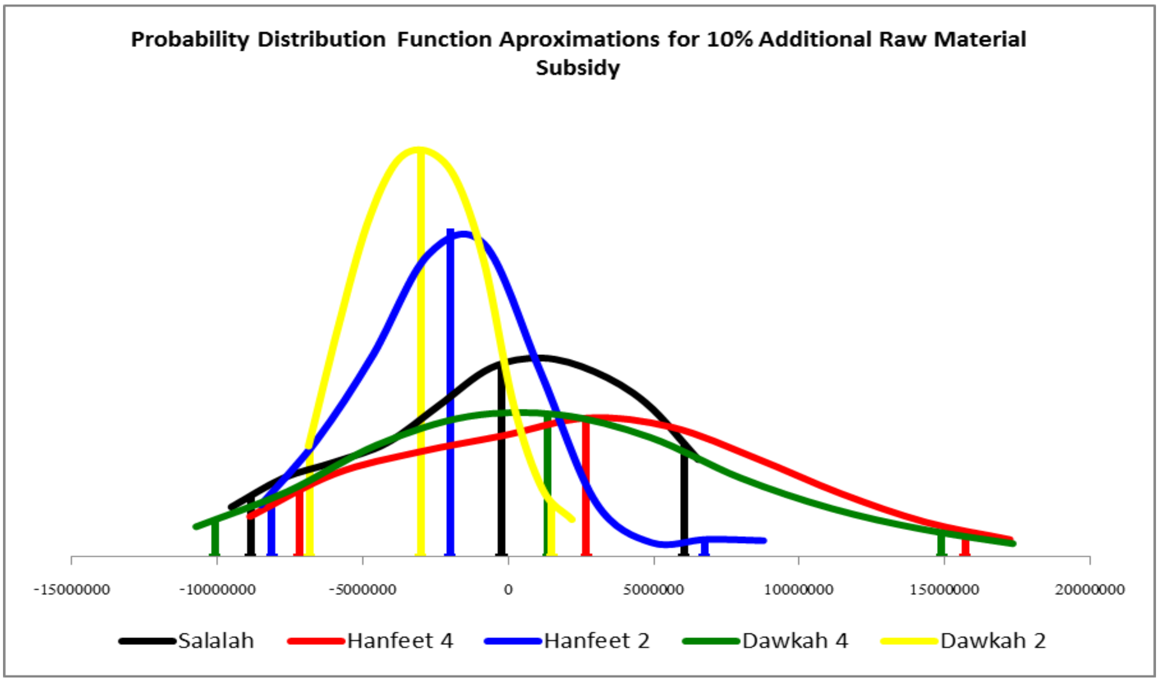


Figure 51 : Comparison of five Probability Distribution Function for Government capital and raw material subsidies.

The probability distribution function approximation with 10%additional raw material subsidy revealed that additional raw material subsidy increased NPV for Hanfeet and Dawkah location significantly. However, if society considers this a critical project and cannot afford to have it give low yields, no raw material subsidy will be preferred, since there is less chance that the NPV will fall below the mean. The comparison of RM subsidy with no RM subsidy is less clear-cut: RM subsidy option has a much higher mean than No RM subsidy, but its variance is also greater. Clearly, there is a trade-off between a higher expected NPV and the acceptance of greater risk. The decision-maker, not the analyst, will have to decide what weights to apply to higher mean NPV versus greater risk.

As explained in the methodology section, lower level target income and upper level target income was set to RO 0.00 NPV and RO 1,000,000 respectively. Using stoplight analysis with the aid of SIMETAR software, probabilities for obtaining less than RO 0.00 NPV for the project after raw material subsidy reduced from 80% to 32% for Hanfeet Farm and from 94% to 44 for Dawkah Farm. The analysis also shows chance of getting more than RO 1,000,000 increased from 12% to 62% for Hanfeet and from 4% to 50% for Dawkah Farm.

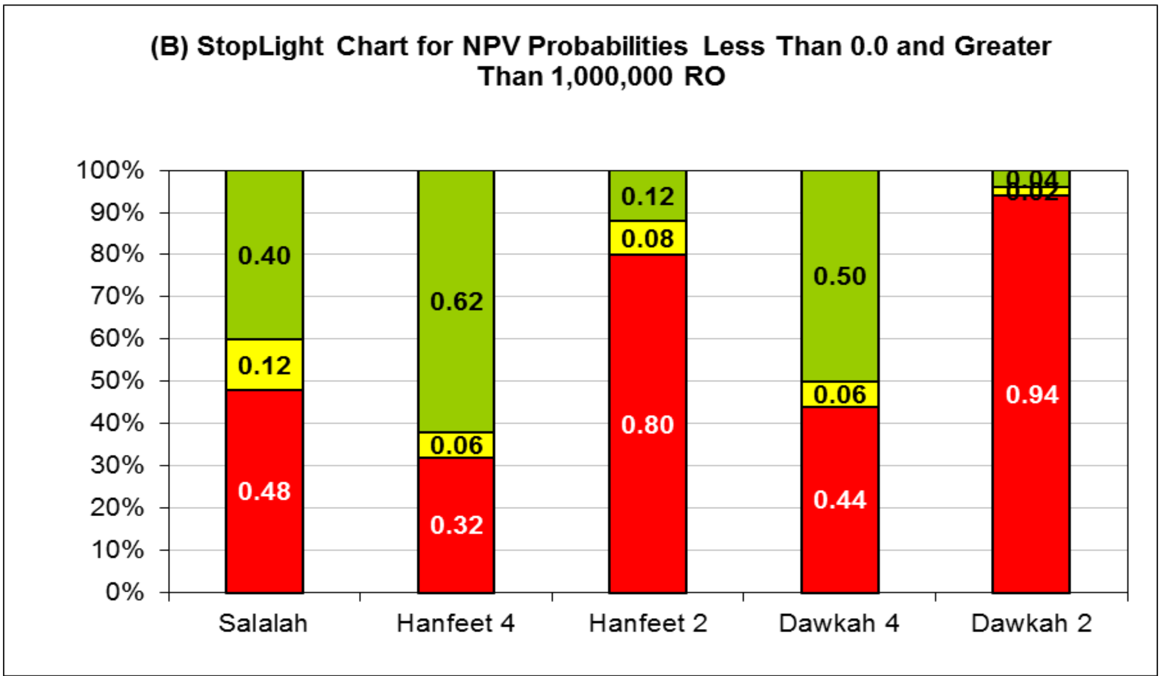


Figure 52 : StopLight chart for NPVs of 10% additional raw material subsidy to Hanfeet and Dawkah Farms.

Results from the stoplight analysis indicate that there is 62 percent chance for Rhodes grass cultivation at Hanfeet with raw material subsidy RO 19.67

per ton to generate NV greater than RO 1,000,000, and 6 percent the NPV is in-between RO 0.0 and RO 1,000,000. For Dawkah Farm the analysis indicate that there is 50 percent chance for getting RO 1,000,000 NPV with raw material subsidy RO 35.47 per ton and 6 percent the NPV is in-between RO 0.0 and RO 1,000,000. This implies that increasing raw material subsidy at Hanfeet Farm from RO 10.12 to RO 19.67 will generate 68 percent positive NPV and increasing raw material subsidy at Dawkah Farm from RO 27.28 to RO 35.47 will generate 56 percent positive NPV.

Chapter Eight

Summery, Conclusion and Recommendation

CHAPTER 8
SUMMERY, CONCLUSION AND RECOMMENDATION

8.1 Summary :

This study has developed a model for analyzing the profitability and risk in a Rhodes Grass investment and used this model to analyze the economic feasibility with risk and uncertainty environment. The Monte Carlo simulation has proven to be a simple way of applying the effect of several risky factors in the same calculations. Though the variables themselves were hard to define and finding the most suitable empirical data wasn't straightforward. The statistical methods such as the Monte Carlo simulation would be appropriate for the analysis of an investment of this kind. Making it possible to insert lots of information in the model but still producing understandable results seems to be the strength of the Monte Carlo simulation. The method gives comprehensive results that increase the decision makers understanding of the possible outcomes in a project. The development done in this thesis to complement this method with the SERF model further clarified the overview of the investment alternatives.
The main task of project evaluation is to estimate the future values of the projected variables such as crop yield and other main and key variables which effect NPV and IRR of the project. The project analyst utilizes information available regarding a specific event of the past to predict a possible future outcome of the same or a similar event. Under such circumstance conventional project evaluation approach is not recommended and dynamic simulation analysis is the appropriate methodology to incorporate risk and uncertainty.

In traditional methods, we can select the project with only the greater expected NPV and IRR, but it will often lead us to suboptimal decisions as the expected return on investment (NPV) of a decision quite often carries a high degree of uncertainty with interrelated dynamics.

The use of dynamic simulation analysis and underground water risk analysis in this study did not gave a single value of NPV but gives a range of values and allocate probability of all possible expected NPV and IRR. The prospective investor and Government are therefore provided with a complete risk/return profile of the project and this will enhance investment decision.

Dynamic Simulation Model :
Creating a model to forecast the potential environmental impacts of current and future Rhodes grass production is plagued with uncertainty, particularly

due to underground water level rapid changes. Ignoring this risk and uncertainty leads to a unique point estimate that is unlikely to be accurate. Dynamic simulation model and scenario analysis are methods that will incorporate these unknowns. Richardson and Mapp (1976) gave the first formal presentation that introduced risk into business investment decisions using stochastic simulation to generate probabilistic cash flows. One of the primary benefits to using a stochastic simulation approach is that the analyst can provide the decision maker with more information than deterministic results allow. The resulting models offer the ability to make recommendations, to analyze policy, to provide planning tools for water managers, and to determine efficient allocations of resources. The resulting models offer the ability to make recommendations, to analyze water policy, to provide planning tools for water managers, and to determine efficient allocations of resources.

The aim of this study was to develop a method of analyzing the economic feasibility of a Rhodes grass cultivation investment at Najed Area in regards to profitability and risk. The developed model included a net present value calculation run in a Monte Carlo simulation with specifically defined of risk and stochastic variables. This simulation resulted in an illustration of the investment profitability with associated probability. It also highlights the most important risk and uncertainty factors in a sensitivity analysis and incorporated in the Dynamic models.

The study reveals that NPV conventional approach is unable to address and properly evaluate the impact of the risk and revenue sharing mechanisms between the private and public sectors as an integrated part of the financial valuation of Najed Project. In other words, the conventional NPV approach is unable to determine the correct market value of the government support option such as capital cost subsidy. Therefore, there are many concerns about the validity of the results and reliability of using the conventional NPV analysis approach for economic evaluation of such a big and risky project. However, the conventional NPV approach applied as a basis of decision making in Najed Project did not gave a complete picture and enough information to private investors and Government as the financial solvency of the project and creditworthiness of the investor would be in trouble in future and will result in the possible project failure.

The described limitations of the conventional NPV approach can be overcome by using a different approach for evaluating investments under uncertainty. The Monte Carlo Simulation Models Analysis is used for Hanfeet and Dawkah Locations with Government capital subsidy and the model result showed unviable results. There were low probability to get (NPV≥0) i.e. 4% for Hanfeet Location and negative NPV for Dawkah location.

While some traditional approaches struggle to remain compatible with multiple sources of uncertainty, stochastic simulation remains as the preferred method for modeling multiple sources of uncertainty. Stochastic simulation allows for the evaluation of risk from stochastic environmental variables, input variables, technological variables, and alternative scenario options. Incorporation of probability distributions on each uncertain variable allows the researcher to obtain confidence and/or prediction intervals for the key output variables and, thus, a robust set of results can be obtained (Rossi, Borth, and Tollefson 1993).

New water policy impacts :

The study also test new water policy imposed at Najed area and its effect on project profitability and NPV and IRR. Different underground water level and its effect on crop yield and NPV was also tested and incorporated in Monte Carlo simulation model.

New water policy implemented at new developed Najed area developed to sustain underground water and keep resources for new generation. The new policy increase capital and operation cost of the project and reduced project viability. Monte Carlo Simulation model used to incorporate water shortage in simulation models. Simulation of the stochastic variables under alternative scenarios (including alternative ground water level) used to allow for robust evaluation of the impacts of water availability at each farm location on Rhodes grass cultivation and its economic performance. The new water policy impact in the project appraisal and enhance decision making also performed by comparing new farm location (Hanfeet and Dawkah) Salalah location model.

The dynamic MCS model used in this study highlights project areas that need further investigation. It aids the reformulation of projects and water policy to suit the attitudes and requirements of the investor. A project may be redesigned to take account for the particular risk predispositions of the investor and risk could be allocated to parties who are best able to manage and mitigate the risk.

The Government capital cost subsidy given to Najed Project of R.O. 11.26 Million reduced project loss for Hanfeet and Dawkah location, but could not make project attractive to investors and desert farming. Salalah location model with a probability of 10% of underground water reduction got a positive NPV of RO 62 181 and 13% IRR without Government subsidy where as other location got a negative NPV and IRR. The government subsidy and support increased NPV and IRR of Salalah location to RO 915 448 and 17% respectively. However, the existing Government subsidy could not made farming at Hanfeet and Dawkah location attractive due to low yield and higher investment and operation cost compared to Salalah location.

Some important conclusions can be gleaned from the firm location literature review. First, many of the studies in location science emphasize the importance of minimizing cost or maximizing coverage of a given location. Very few focus on analyzing long-term profitability of a business. Second, most studies (until recently) did not consider the effects of stochastic inputs such as ground water level, outputs, and alternative scenarios when considering location choices. Deterministic models did not incorporate risk and uncertainty into the modeling of location choices. This limited the determination of optimum location choices, as unknown future states were not accounted for.

Another unique contribution is a demonstration of stochastic simulation to solve location problems. Most published works take input variables as given. Very few published works incorporate stochastic variables into the evaluation of location choices. This study incorporated stochastic variables and alternative scenario choices (water policy) and locations using simulation. This allows for sensitivity analysis and comparison of key control variables which directly affect the probability of economic success.

Risk and uncertainty is usually investigated by incorporating uncertain planning horizons and finding robust solutions. Some dynamic programs incorporated unknown future states in an infinite planning horizon. These studies were difficult to solve and solutions are dependent upon which robust criteria is chosen. There are very few location studies with stochastic inputs and outputs that incorporate scenario planning.

The required level of confidence for each model is the acceptable level of risk that the investor would take in each project location. The probability of Salalah Farm model to be profitable increased from 40% without subsidy to 60% with Government capital subsidy at a confidence level of 90%. The spread among minimum and maximum NPV for Salalah farm is higher than other farm locations and also higher with government subsidies in all other location. However, this indicates that under government subsidy more farmers are making profit. With government subsidy model distribution skewed to the right and more chance of getting NPV below the mean NPV than expected in a normal distribution and NPV near minimum being observed more than NPV near maximum.

The risk analysis shows that NPV distribution is right skewed and most of the NPV below the mean. Although the Government subsidy makes NPV distribution more symmetric for all level of water reduction, but government should introduce more subsidy programs to make desert farming more attractive investment.

Risk management strategies

This section presents the model variables in coastal (Salalah reference model) and desert areas (Hanfeet and Dawkah location). Desert farming area received government incentive to encourage farmers to develop Najed area. Salalah location model represent area with no water shortage, 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 scenario 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.

The result shows that the probability of having positive NPV of Hanfeet Farm Location increased with raw material subsidy from 21% to 43% and for Dawkah Farm Location from 4% to 47%. However, with the aim of evaluating both the economic and financial results of the model analysis, it is necessary to take into consideration the compromise that should be made between project policy with a high financial risk but also high social benefits and on the contrary, project with a low financial risk but reduced social and environmental benefits.

SERF analysis is done assuming a negative exponential utility function for which Absolute Risk Aversion Coefficient (ARAC) range is set to be 0.0 and +0.0000013. SERF uses Certainty Equivalents (CE) to rank risky alternatives. Certainty equivalent value shows the amount of money that the decision maker would have to be paid to be indifferent between the particular scenario and a no risk investment. We also estimated confidence premiums for each alternative. Confidence premium indicates how much a decision maker has to be paid to switch from the preferred strategy (Salalah) location. Hanfeet and Dawkah locations with and without ground water recharge compared with Salalah location (Base Model). Certainty Equivalents (CE) for Hanfeet1 (No water re-charge) reached 4.2 million and Dawkah1 (No water re-charge) reached 5.9 million and Hanfeet2 (with water re-charge) reached 2 million Omani Rials. With minimum raw material subsidy Hanfeet3 (with water re-charge) reduces to RO 97,000 and Dawkah3 RO 557,000.

Farmers in developed countries treat risk just as they treat any other production input, such as fertilizer, seed, and machinery, by balancing the returns from its use with the associated increased cost. For example, in years in which the returns to corn are expected to be higher than the returns to soybeans, farmers can increase expected profits by planting more corn crop and less soybeans. But the increase in expected profits only comes about by taking on more risk, because growing more corn typically reduces diversification. Farmers that have a high tolerance for risk (which means that risk imposes a low cost on them) will tend to plant more corn than will farmers with a lower tolerance of risk. But in Najed Project diversification are limited as Government force investors to grow Rhodes Grass crop only. Moreover, if investors and farmers are fully understand the risks they face they could not obtain and pay appropriate risk reduction tool from private markets in Oman as risk management tools do not exist in private market. As a result, agricultural activities cannot be increased through subsidized risk management only.

Ranking alternatives and scenarios

The main task of this paper is to investigate 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 large effect of new water policy and underground water restriction and control on fodder crop yield and net present value. The Government grant of 11.26 Million Rials are given to Najed Project to be used in project infrastructure. This grant increased project viability in case of low risk of water availability areas, but with high risk of underground water 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 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.

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 lake 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 private sectors at Najed area.

A DM's willingness to pay represents the personal value, or utility, of a good to the DM. The value of purchasing insurance options is determined by calculating the difference in the CEs at each irrigation level for the alternatives with and without raw material subsidy options. The study reveals the risk premium decreases with the number of irrigations, showing that raw material subsidy options are worth less to the DM when less irrigation are used.

The minimum raw material subsidy at Hanfeet area (Hanfeet3) options are worth RO 97,000 for normally risk averse DMs, RO 1,321,000 for rather risk averse DMs, and RO 2,956,000 for extremely risk averse DMs. For Dawkah area (Dawkah3) the raw material subsidy worth RO 557,000 for normally risk averse DMs, RO 755,000 for rather risk averse DMs, and RO 1,349,000 for extremely risk averse DMs. As a result the proposed raw material subsidy will mitigate risk of new water policy imposed at Najed area and uncertainty surrounding the impact of adoption of new irrigation technologies.

The model was further developed with the stochastic efficiency in respect to a function (SERF) which enabled a ranking between the alternative policies in respect to both profitability and risk efficiency. The specific characteristic of a desert farming investment of being capital intensive gave further incentives to also include a payback time calculation in the model. Further, the aim was to use the developed model to investigate the profitability and economic risks involved in Rhodes grass project investment.

8.2 Conclusion :

With a required internal rate of return of 8 or 10 % the investment in desert farming is not profitable for all new location without government subsidy. The dynamic simulation scenario analysis reveals that not only has a very low expected NVP but also has high probabilities for the result to be negative.

With a minimum raw material subsidy as high as 14.19% at Hanfeet and 34.18% at Dawkah the investment seem feasible. The probability for getting positive NPV with capital and raw material subsidy increased to more than 45%. This is probably an acceptable risk for most investors, but it indicates that the alternative does not give room for a much higher required NPV.

The study also reveals even though the investment in Najed Project shows signs of profitability, it would not be feasible without government support. With the additional raw material subsidy increase from RO 10.12 to RO 19.67 per ton for Hanfeet location, the net present value increased to RO 1,796,959.If raw material subsidy increases from RO 27.28 to RO 35.47 per ton for Dawkah Farm, the NPV will increase to RO 1,268,085.

Conventional net present value approach which applied as a basis of decision making in Najed Project did not gave a complete picture and enough information to investors and Government as the financial solvency of the project and investor would be in trouble in future and will result in the possible project failure.

The minimum raw material subsidy option at Hanfeet location dropped rapidly in the rankings as the ARAC increased, suggesting that the rough knowledge of the risk attitude has significant importance in identifying preference ranking. Preference rankings indicated that the raw material subsidy of Rhodes grass production is a highly viable choice for risk averse farmers.

The Stochastic efficiency with respect to a function (SERF) analysis was performed to rank risky alternatives in terms of CE across a range of RACs. The result of rankings five alternative risk management strategies indicates that Hanfeet location with additional Raw material subsidy is the most preferred scenario over the range of risk preference from (0.0-0.00000013).

8.3 Recommendations:

1. The effect of Government capital grant given to project is evaluated for different new Farm Location at Najed area. The risk allocation and risk sharing for all parties needs to be formed according to risk optimization and best party who can mitigate and efficiently manage the risk.
2. The analysis shows the cost of uncertainty of the project is high. As a result, more information has to be obtained regarding hydraulics and underground water availability at Najed area before distributing more lands to farmers and private sectors at Najed area.
3. The project risk analysis using Monte Carlo Simulation technics shows that the project probability distribution of NPV is completely below the zero in case of sever water shortage. The expected loss ratio of Dawkah location (without Government subsidy) is high and record 0.73 which indicates that the project is totally exposed to risk, as a result, Government authorities needs to perform comprehensive study before planning to develop new farming areas at Najed.
4. The Government grant of 11.26 Million Rials are given to Najed Project to be used in project infrastructure. This grant increased project viability in case of low risk of water availability areas, but with high risk of underground water at the new developed area at Najed more Government subsidy are required to mitigate risk.
5. New water policy needs to be reformed and adjusted to cope with risk inherit the project. Moreover, Najed Project needs to be reformed and redesigned to suit the investor requirement and achieve economic sustainability.
6. There is no simple solution to guarantee decision taken by Government, but good decisions are more likely if three conditions are met:
   - The government’s decision makers should have a framework for judging when a guarantee is likely to be justified.
   - The government’s advisers should know how to evaluate and rank risky alternatives of a Government guarantee.
   - The government’s decision makers should follow rules that encourage careful consideration of a guarantee’s costs and benefits.
7. The study use SERF analysis to calculate Certainty Equivalents (CE) to rank risky alternatives. Certainty equivalent value shows the amount of money that the decision maker would have to be paid to be indifferent between the Salalah location and new location at Najed to compensate risk in investment.

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