Risk analysis of applying improved agricultural technologies in Gedaref rain-fed sector of eastern Sudan (1990-2004)

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ABSTRACT

It is argued that the adoption of recommended improved technology in the Gedaref area can increase farm income while diversification by introducing sheep and gum arabic enterprises to sorghum monoculture of the Gedaref may lead to farm income stability. Under these arguments in favor of diversification and the use of improved technology, this research work aims mainly at studying and analyzing the performance of the mechanized rain-fed sector of Gedaref under uncertainty. Specifically, the study has evaluated different production strategies in terms of risk efficiency under the proposed improved cultural practices. The study mainly applies a stochastic budgeting approach to evaluate the proposed production strategies under improved cultural practices. The stochastic budgeting simulation is done by using @ *Risk* software that allows the representation of uncertainty as probability distributions and then performs stochastic simulation using *Latin Hypercube* technique and the results are then given also as probability distributions. By applying the strategies of improved practices, farmer's chance to lose at the end of the planning period is very small. The Cumulative Distribution Functions (CDFs) graphs and the statistics generated from the stochastic simulation for the strategies under improved practices showed that, they are the dominant alternatives in terms of risk efficiency in a first degree sense i.e. they are preferable for a wide range of farmers' absolute risk aversion level ($+\infty > r_a <-\infty$). The results of comparing the distribution of each strategy within improved practices indicated that the application of the improved technological packages has a positive impact in maintaining income stability in all investigated strategies.

INTRODUCTION

In developing countries where farming is particularly weather-dependent, farmers face substantial risk and uncertainty of farm income fluctuations originated mainly from yield and price risk and uncertainties. Therefore, risk considerations in these areas are more important especially for poor farmers. Moreover, income risk is considered itself as a loss of welfare to risk-averse farmers. It might make modern crop technology less attractive to farmers and hence decelerate agricultural development.

In the study area of Gedaref in eastern Sudan, which is the main supplier of food crops and a large contributor to export earnings in the country, agriculture is typically characterized by a high degree of instability. The agricultural production in this area is associated with a high degree of uncertainty arising from a variety of factors among which, dependence of agriculture on unpredictable events like weather, unexpected prices changes and unexpected changes in governmental policies. The prevailing risk and uncertainty in the study area are clearly reflected on farmer's behavior. They often prefer farm plans that provide a satisfactory level of security even if this means sacrifying income on average. At the same time, farmers restrict themselves to the established technologies rather than venturing into new ones.

Although the soil and rainfall in Sudan are suited for a variety of crops such as sesame, cotton, sunflower and millet, the mechanized rain-fed sub-sector is essentially a sorghum monoculture system with occasional fallow periods. Since 1980, the area under sorghum averaged 87% of total crop area. Only 12% was allocated to sesame and 1% for other crops (Ahmed, 1994).

This extensive system uses mechanized plowing and planting, one or two hand weeding and hand harvesting with mechanical threshing. Traditional local cultivars without mineral fertilizers application or other improved agronomic practices characterize the system; even though technical advancement on improved varieties, use of chemicals and use of more efficient machinery have been achieved by research centers in Sudan since the early eighties. The immediate consequence of this extensive production technology predominant in the mechanized rain-fed sector is the low land productivity. Sorghum yields have been low and declining mainly due to the decline in soil fertility (Salih, 1993). With declining soil fertility and an erratic and variable rainfall, there has been an increasing variability in output over time. The coefficient of variation of output increased from 14% during the 1970s to 65% during the 1980s (Ahmed, 1994). Therefore, there is an urgent need of introducing and promoting intensive agriculture especially in Gedaref area which is a leading production area in this sub-sector.

This study will present an empirical approach to analyze mechanized rain-fed large scale farming of Gedaref area of eastern Sudan under uncertainty. The research work aims, first, to examine the potential of the farming system in generating sufficient farm income in the long run that guarantees the survival of the business through the risk-efficient strategy under improved cultural practices. Second, the analysis will examine the impact that new technology may have on farm income and on its variability. Moreover, the study of the large scale mechanized rain-fed sector and its implications for agricultural development is very helpful for planners and policy makers. And finally, the apparent limitations on comprehensive studies that consider risk analysis and risk management in this sub-sector; provide another incentive to conduct the current research.

METHODOLOGY

Stochastic budgeting principles

The stochastic budgeting approach was used as an analytical tool to investigate the study objectives. The stochastic budget analysis is like an ordinary budget except that uncertainty in some variables in the budget are recognized and taken into account. Stochastic or risk budgeting is carried out by attaching probabilities of occurrence to the possible values of the key variables in a budget, thereby generating the probability distribution of possible budget outcomes (Dillon and Hardaker,1993; Hardaker *et al.,* 1997). The probabilities used should be those of the decision maker, i.e. his or her personal or subjective probabilities based on experience, intuition and/or other available information , for example historical data. Stochastic features are introduced to a budget by specifying probability distributions for selected variables, usually those judged to be more important in affecting the riskiness of the selected measures of performance. Then a sampling procedure is used to evaluate the budget for a sufficiently large number of scenarios, with a record made of the distribution of the performance measure made across these scenarios. Output can be in the form of the probability distribution of the selected performance measure or could be summarized in terms of moments of the distribution, such as mean, variance, or standard deviation or could be graphed in the form of cumulative distribution function (CDF).

As in ordinary budgeting, it is then possible in stochastic budgeting to vary the decision rule and to evaluate alternative options to find the best one amongst a finite number of alternatives (Hardaker *et al.,* 1997). Thus, in a farm management analysis, a stochastic budget can be constructed in various forms, e.g. as a partial budget, whole-farm budget, cash-flow budget, profit budget or a budget for investment appraisal. It also may represent a single or multi–period budget. Because the CDF is more convenient to work with rather than the PDF as argued by Hardaker *et al.* (1997; 2004), it was used to display stochastic budget results in this study. The cumulative distribution function $F(x)$ as defined by Hardaker *et al.* (1997; 2004), is a function that gives the probability P that the variable X will be less than or equal to x, i.e. :

$$F(x) = P(X \leq x) \quad (1)$$

where, $F(x)$ ranges from zero to one.

Ranking farmers' risk aversion

The business risk model within the context of this study gives a separate full distribution of the Net Present Value (NPV) for the stream of net cash flow for determined strategies at the end of the planning period represented by their cumulative distribution functions (CDFs).The different CDFs obtained are then ranked using stochastic efficiency analysis which is based on the subjective expected utility (SEU) approach expressed in terms of their certainty equivalents (CEs). Accordingly the risk-efficient strategy or strategies under the improved cultural production practices are then obtained for different levels of farmers risk aversion.

The method of stochastic efficiency with respect to a function (SERF) which was introduced by Hardaker *et al*. (2004) was used to rank farmer attitudes towards risk. The method works by identifying utility efficient alternatives for ranges of risk attitudes, not by finding (a subset) of dominated alternatives. Conversely, all the alternatives over the range of risk aversion are compared simultaneously; only those that are optimal for some values of the risk aversion coefficients are identified as efficient. The *SERF* orders alternatives in terms of certainty equivalents (*CEs*) as a selected measure of risk aversion is varied over a defined range. It is argued that it makes more sense to compare the alternatives in terms of certainty equivalents (*CEs*) over the range of risk aversion of interest, since *CEs* can be more readily interpreted. The *SERF* can be applied for any utility function for which the inverse function can be computed based on ranges in the absolute, relative, or partial risk aversion coefficient, as appropriate. One additional advantage of *SERF* is that it requires no special software. The method can be implemented in worksheet software such as Excel allowing for graphical presentation of results that can be understood by a wide range of potential users.

To illustrate the *SERF* method and according to the *SEU* hypothesis, the utility for each risky alternative can be calculated depending on the degree of risk aversion (*r)* and stochastic outcomes of *x* as:

$$U(x,r) = \int U(x,r)\, f(x)\, dx \qquad (2)$$

for the chosen form of the utility function. Then *U* is calculated for selected values of *r* in the range r_1 to r_2.

This method ends up with a vector of Certainty Equivalents *CEs* for each of the *n* alternatives calculated for several values of *r* within the bounds $r_1 \leq r \leq r_2$. At each r_i the efficient set contains only the alternative(s) that yield(s) the highest *CE*. The efficient set can be identified over a subset of the full range of, r_i as may be required for policy analyses. Only those alternatives which have the highest (or equal highest) *CE* for some values of *r* in the relevant range are included in the efficient set. All other alternatives are dominated in the *SERF* sense. The *CEs* of the alternatives can be presented in tabular or graphical form which allows for ready identification of the efficient set.

Overview of the investment strategies

In the study area, prices of agricultural outputs and inputs are highly volatile due to market instability. This is especially true when long-term planning is considered. On the other hand, factors such as weather (especially rainfall variability) and plant and animal diseases cause farm products yield uncertainty. All these factors cause higher activity gross margins volatility, especially for sorghum and sesame crops. The prices of forest products and animal products largely follow the world market prices and also vary between years. For simplicity, in the stochastic budgets, the fixed cost items and other possible changes are assumed to be at the same trend level throughout the planning period. The plan was prepared for the agricultural activities of the study according to the 2003/2004 information for the planning period 2003-2023.

Four groups of strategies of improved practices for growing sorghum and sesame were recommended. These improved practices include growing improved varieties of sorghum and sesame, applying nitrogen fertilizer in the form of urea, and using herbicides for weed control instead of hand weeding. The additional costs involved here, entails the cost of the improved seeds, fertilizer and herbicides and their application. A summary of the four strategies under investigation and the share of sorghum, sesame and gum arabic in the farm land in each strategy are:

1. Sorghum (80%) + sesame (20%)
2. Sorghum (72%) + sesame (18%) + gum arabic (10%)
3. Sorghum (80%) + sesame (20%) + sheep (Sample size)
4. Sorghum (72%) + sesame (18%) +gum arabic (10%) + sheep (Sample size)

Estimation procedure of the empirical model

The traditional whole-farm budgeting based on fixed-point estimates of production, prices and financial variables assisted by sensitivity analysis is argued to be a little help to estimate financial results. This is especially true when many variables included in the budget are uncertain. As a result, the alternative techniques of stochastic budgeting are introduced. This approach accounts for some of the main uncertainties in the evaluation process and moreover gives an indication of the distribution of outcomes.

The stochastic budgets used in this study are built up from deterministic whole-farm budgets, formulated in an Excel spreadsheet. The models produce separate financial reports of the *NPV* at the end of the 20-years planning period for each of the four strategies under evaluation. The financial reports are derived from equations linking the farm production activities, capital, financial and tax obligations. Consumption activities were excluded from the analysis, since this farming system is market oriented and the research concentrates mainly on investigating the profitability and risk-efficiency of the new investments compared to the existing ones.

Stochastic features were introduced into the budget by specifying probability distributions for the variables assumed to be most important in affecting the riskiness of the selected measure of financial performance. To keep the model practicable and reasonably transparent, only those stochastic variables assumed to be most important for the decision making process were modeled using probability distributions. The probability distributions used in this study were partially based on historical data (objective frequencies) and partially based on subjective judgments.

Given that the available historical data is sufficient and relevant, historical inflation corrected gross margins of sorghum and sesame, prices of sorghum, sesame, gum arabic and sheep in addition to the variable costs of improved sorghum and sesame were entered separately to *BestFit* software. The historical data used for the distribution of prices and yield is for the period 1990-2004. The *BestFit* software assigned a set of probability distributions to the given set of historical data of each stochastic variable included in the budgets. Comparing the resulting set of the probability distributions according to the statistics generated by the program and by applying some selection criteria, the best probability distribution for each uncertain variable included in the budget was then chosen.

Probability distributions for improved sorghum and sesame yields were elicited from experts in the study area who are used to work in the Canadian project on the improved technologies in the Gedaref area. Experts gave judgments of the lowest, highest and most likely values for yields of sorghum and sesame in the study area. Accordingly, improved sorghum and sesame yields were assumed to be approximately triangularly distributed, with a maximum of 6 sacks/fed (One feddan equal 0.42 hectares and one sack = 90 kilogram), most likely value of 4.5 sacks/fed and a minimum of 3 sacks/fed for sorghum and a maximum value of 3.5 kantar/fed, most likely of 2.6 kantar/fed and a minimum of 1.7 kantar/fed for sesame.

One important aspect that is to consider in stochastic budgeting is the question of the stochastic dependency between variables (Hull,1980; Hardaker etal., 1997). The distribution of performance variables may be seriously compromised if important stochastic dependencies are ignored. Within this study, a rank correlation matrix was built for the uncertain variables included in the budgets.

A *Latin hypercube* sampling procedure with @risk add-in software from Palisade corporation (1997) was used to evaluate the budgets for a large number of iterations. In the simulation, values of parameters entering into the model were chosen from their respective probability distributions by *Latin hypercube* sampling and were combined according to functional relationships in the model to determine an outcome. The process was repeated a large number of times to give estimates of the output distributions of the performance measure which was expressed as cumulative distribution functions (CDFs) and summarized in terms of the moments of the distributions. The results presented here are based on 2200 sample simulation experiments. Because the simulated distributions of results changed very little as more sample experiments were used, it can be concluded that the number of samples was sufficient to provide stable outcomes. For the 2200 iterations used in the current simulation process, the mean and standard deviation of the outcome change by less than the specified convergence level of 1.5%. This indicates that the number of iterations used was sufficient to provide stable outcomes. The random generator used in the simulation process was seeded to ensure that the same set of random samples would be sampled for each strategy evaluated.

Based on the above justification, the net present value (NPV) of farm income was used in the current study as a measure of performance in the stochastic budgeting analysis at the end of the twenty years planning period to evaluate the proposed four strategies in terms of their risk efficiency. To calculate the NPV for the four strategies under consideration, farm income was obtained separately for each strategy in each year of the planning period. To get annual farm income, the cash costs were deducted from the cash benefits in each strategy.

To obtain annual net farm income of the improved sorghum and sesame enterprises, the 2003/2004 fixed costs trend levels were used in the stochastic budgets. Improved sorghum and sesame variable costs, yields and prices are represented in the stochastic budgets in the form of probability distributions obtained from historical data for variable costs and prices and elicited as subjective probabilities for the two crops yields.

Regarding gum arabic costs and returns in the stochastic budgets, the fixed and variable costs are varied over the first four years of the planning period. From the fifth to the 20^{th} year of the planning period, costs are assumed to be constant at the same trend level of the season 2003/2004. Yield of gum arabic is also assumed to be constant at 2003/2004 trend level over the whole planning period.

Concerning sheep enterprise, costs are also varied during the first four years of the planning period and assumed to be at the same trend level from the fifth year and thereafter, while yields from sheep are assumed to be constant at the trend level of 2003/2004 throughout the planning horizon. On the other hand, prices of gum arabic and sheep were represented in the stochastic budgets by their probability distributions obtained from historical data over the period 1990-2004.

Based on the above information, farm income and then NPV were calculated for each strategy based on the types of activities included in each strategy. In the stochastic budgets all values are corrected for inflation including the stochastic variables and other costs items (fixed and variable costs). The discount rate used for calculating the NPV at the end of the planning period, is 12%. This discount rate was chosen according to suggestions by Mustafa *et al*. (1995), who argued that the discount rates used in investment appraisal in developing countries ranges between 15-18 percent and usually a discount rate of 12% is used. Moreover, this discount rate is the real discount rate declared by the Bank of Sudan for the year 2003/2004.

The *NPV* in the current analysis was calculated according to the following formula:

$$\text{NPV} = \sum_{i=o}^{n} \frac{c_i}{\left(1+\frac{r}{100}\right)^i} \qquad (3)$$

where,

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

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

r = the discount rate.

RESULTS AND DISCUSSION

Stochastic budgets results for the strategies under the improved practices

In this section the results of the stochastic budgeting and stochastic efficiency analysis for the production strategies under the improved practices in growing sorghum and sesame crops are presented and interpreted. The main statistics obtained from running the stochastic budget with a risk for the strategies one to four are summarized in Table 1. It shows the simulation results for *NPV* of the farm income for the specified strategies at the end of the twenty years planning period (2003/04-2022/23). The statistics shown in the Table are the maximum, minimum, mean, mode, range, standard deviation and the coefficient of variation for the four strategies under consideration. The results show that the coefficient of variations for strategies one and two are higher than the coefficient of variations for strategies three and four. These are 32%, 34%, 44% and 46% for strategy four, three, two and one, respectively. The results reveal some degree of farm income variation for the four strategies at the end of the planning period. However, the variation in farm income is lower in the improved strategies compared to the traditional ones as depicted by the values of the coefficient of variation. In terms of risk efficiency, the results also show that strategy four has the most preferred characteristics followed by strategy three while strategy one involved the least favourable characteristics.

Figures 1, 2, 3 and 4 show the distributions for the NPV of the net farm income presented in the form of CDFs graphs generated at the end of the planning period for each of the production strategies when the improved cultural practices for growing sorghum and sesame are used by farmers.

Table 1. Risk simulation results for NPV of net farm income for the improved strategies, Gedaref area, Sudan.

Description	Net farm income SP/1000 feddan farm Output			
	Strategy 1	Strategy 2	Strategy 3	Strategy 4
Minimum	-70,251	-55,413	-55	14,783
Maximum	922,351	837,269	998,422	913,340
Mean	215,227	202,322	309,688	296,783
Std dev	98,712	88,918	104,204	94,999
Mode	182,909	177,385	266,619	376,111
Range	992,603	892,683	998,477	898,556
CV%	46	44	34	32

Figure 1 and Table 2 show that in strategy one, 90% of the NPV of farm income lies between the values SP 92,678 and SP 398,526 which have the cumulative probability of 0.05 for the lower bound and 0.95 for the upper bound. This indicates that 90% of net farm income in strategy five lies within the range SP 305,849. The expected value of the NPV of farm income for this strategy is SP 215,227 with SP 98,712 standard deviation. The probability of getting this expected value and less is 0.58 and hence the probability of getting the expected value and more is 0.42.

Table 2. Cumulative probabilities for some key values in strategy one, Gedaref area, Sudan.

Description	Values (SP)	Cumulative probability
Zero	0	0.002
5th percentile	92,678	0.05
Mean	215,227	0.58
95th percentile	398,526	0.95

For strategy two, the information provided by Figure 2 and Table 3 illustrate that 90% percent of the NPV lies between the values SP 90,959 and SP 366,697 with the cumulative probability of 0.05 for the lower bound and 0.95 for the upper bound and hence 90% of farm income for this strategy lies within the range SP 275,738. The mean value of NPV for strategy two is SP 202,322 with SP 88,918 standard deviation. The probability of getting this expected value and less is 0.58 and, hence, the probability of getting the expected value and more is 0.42.

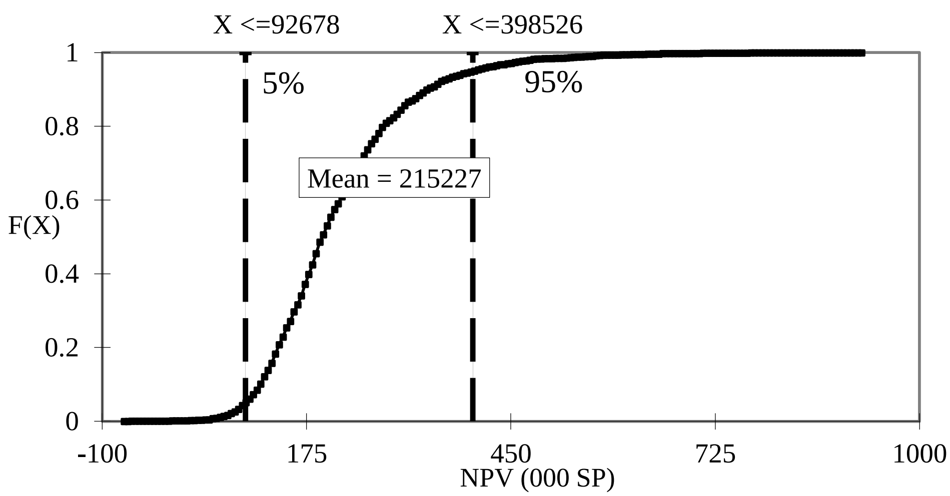

Figure 1. CDF of NPV for strategy one: improved sorghum and sesame, Gedaref area, Sudan.

Table 3. Cumulative probabilities for some key values in strategy two, Gedaref area, Sudan**.**

Description	Values (SP)	Cumulative probability
Zero	0	0.002
5th percentile	90,959	0.05
Mean	202,322	0.58
95th percentile	366,697	0.95

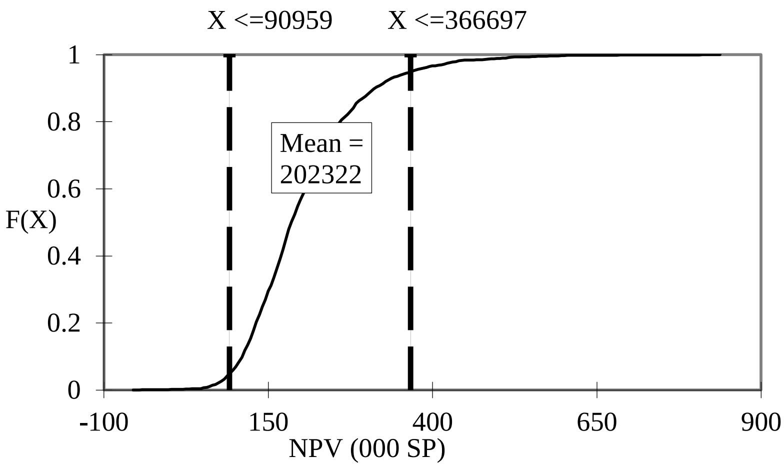

Figure 2. CDF of NPV of strategy two: improved sorghum and sesame and gum arabic trees, Gedaref Area, Sudan.

Figure 3 and Table 4 demonstrate that 90% of the NPV in strategy three lies within the range of SP 322,826. This range has a lower limit of SP 176,488 with a cumulative probability of 0.05 and an upper limit of SP 499,314 with a cumulative probability of 0.95. A mean value of SP 309,688 and standard deviation of SP 104,204 of NPV are obtainable in strategy three. There is a probability of 0.57 to get this mean value and less and, hence, the probability of getting the mean value and more is 0.43.

Table 4. The cumulative probabilities for some key values in strategy three, Gedaref area, Sudan.

Description	Values (SP)	Cumulative probability
Zero	0	0.001
5th percentile	176,488	0.05
Mean	309,688	0.57
95th percentile	499,314	0.95

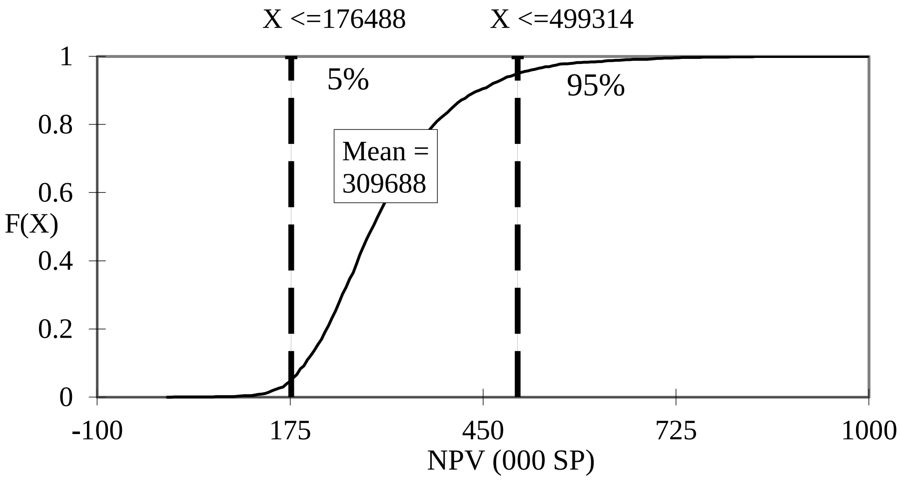

Figure 3. CDF of NPV for strategy three: improved sorghum and sesame and sheep production, Gedaref area, Sudan.

For strategy four, Figure 4 and Table 5 depict that 90% of NPV of farm income lies between the values SP 174,774 and SP 468,329, which have the cumulative probability of 0.05 for the lower bound and 0.95 for the upper bound. Accordingly, 90% of farm income lies within the range SP 293,555 for this strategy. The mean value of NPV of farm income for strategy four is SP 296,783 with SP 94,999 standard deviation. The probability of getting this expected value and more is 0.44, while the probability of getting the mean value and less is 0.56.

Table 5. The cumulative probabilities for some key values in strategy four, Gedaref area, Sudan.

Description	Values (SP)	Cumulative probabilit
Zero	0	0
5th percentile	174,774	0.05
Mean	296,783	0.56
95th percentile	468,329	0.95

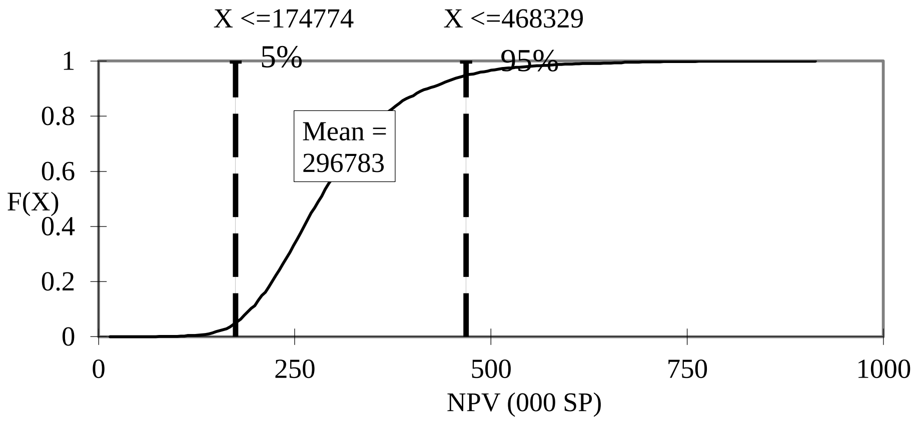

Figure 4. CDF of NPV for strategy four: improved sorghum and sesame, gum arabic trees and sheep production, Gedaref area, Sudan.

Also from Figures 1, 2, 3 and 4 it can be observed that the probabilities of getting income enough to cover the cash expenses required for the agricultural production for the next growing season were as follows: Taking 2003/2004 costs levels and trend assuming that inputs levels and prices are not changing during the twenty years period, there is a chance of 0.5% to attain farm income of SP 41,628 and less in strategy one, compared to 0.4% chance to achieve SP 38,290 and less farm income in strategy two, a 0.1% chance to get SP 43,409 and less farm income in strategy three and a 0.05% chance to maintain farm income of SP 40,071 and less in strategy four. Conversely, there is a chance of more than 99.5% to obtain farm income equivalent to cash expenses and more in the strategies from one to four. Similar to the traditional strategies, there are no considerable differences in the chances of obtaining income enough to cover variable costs and total costs, from those for obtaining income enough to cover cash expenses, since the majority of the costs are concentrated on the variable costs items and only slight additional costs are involved as fixed costs.

Figure 5 compares the four production risky prospects under improved practices according to their CDFs. The figure indicates that the CDFs graphs of strategies three and four lie to the right of the CDFs graphs of strategies one and two. According to the stochastic dominance criteria, strategies three and four dominate strategies one and two in a first degree stochastic sense, i.e. they are preferable for a wide range of absolute risk aversion level ($+\infty > r_a < -\infty$). Based on the above results, it can be concluded that ranking the different strategies according to their CDFs graphs shown in Figure 5 or according to their statistics performed in Table 2, strategies three and four dominate strategies one and two. As in strategies three and four, the risk efficiency achieved in strategies three and four is attributed mainly to the introduction of sheep to the farming system.

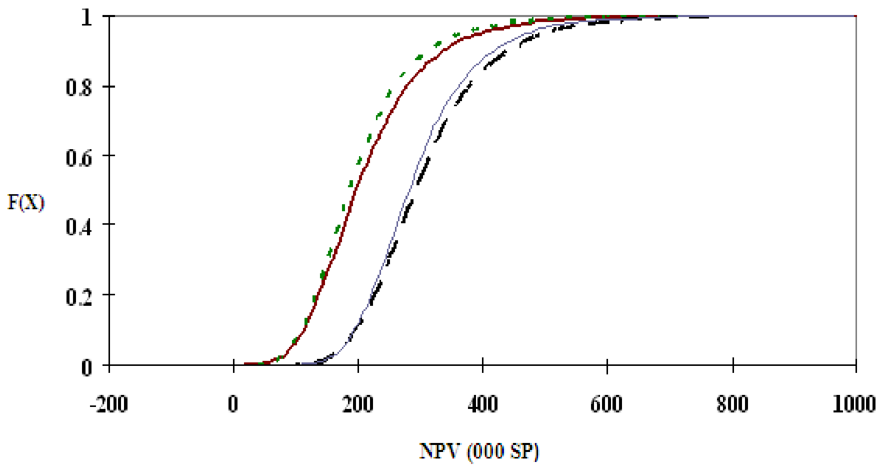

Figure 5. CDF graphs comparison for the different strategies under improved practices, Gedaref area, Sudan.

Results of stochastic efficiency analysis (SERF)

As stated earlier, it is also important to consider the farmer's attitude to risk alongside their beliefs about the uncertain events when planning farm business under uncertainty. Therefore, the stochastic efficiency analysis, which incorporates these two factors, was conducted for strategies one to four and the results are presented in this section.

Figure 6 shows SERF results for strategies one to four under the improved practices for sorghum and sesame over the absolute risk
aversion $r_a(z)$ range of 0.0017 to 0.0133, which corresponds to relative risk aversion coefficient $r_r(z)$ in the range 0.45 to 3.6 assuming a negative exponential utility function. This range is equivalent to a range of relative risk aversion with respect to wealth, $r_r(w)$, between 0.5 and 4. The range for $r_r(z)$ and $r_a(z)$ are approximated with wealth *w* equal to SP 300,000 and income *z* equal to SP 270,000.

As can be seen from Figure 6, the points of highest CE values are comprised of values for strategies three and four only, implying that these two strategies form the risk-efficient set. The SERF results show that the value of $r_a(z)$ where CE curves for strategies three and four cross is $r_a(z)$ = 0.0086 i.e. where $r_r(z)$ = 2.3. This indicates that subsets of the SERF efficient-set can be formed for the above specified risk aversion levels. Thus, the *SERF* efficient-set contains only strategy three for farmers with risk aversion levels less than 0.0086 and strategy four for farmers with risk aversion levels greater than 0.0086. Taking the concept of risk premiums into consideration, for farmers in the study area to switch from the less preferred strategy one to the dominant strategy three, for the specified range of relative risk aversion with respect to wealth $r_r(w)$ of 1.5 to 2.0, which is equivalent to absolute risk aversion $r_a(z)$ of 0.005 to 0.0067, the following results can be deduced from the figure: The risk premium (*RP*) between the specified strategies measured by the vertical distance between the *CE* curves for strategy one and three, ranges between SP 85,000 at $r_a(z)$ = 0.005 to SP 87,000 at $r_a(z)$ = 0.0067. This implies that the minimum sure amount that would have to be paid to farmers to switch from strategy one to three or the benefits that farmers could gain if allowed to move from strategy one to strategy four are in the range SP 85,000 to SP 87,000 for $r_a(z)$ range of 0.005 to 0.0067. On the other hand, the minimum sure amount that have to be paid to farmers or the gains that farmers would earn if they shift from strategy one to strategy four are in the range SP 82,000 to SP 85,000 at the absolute risk aversion level $r_a(z)$ range of 0.005 to 0.0067.

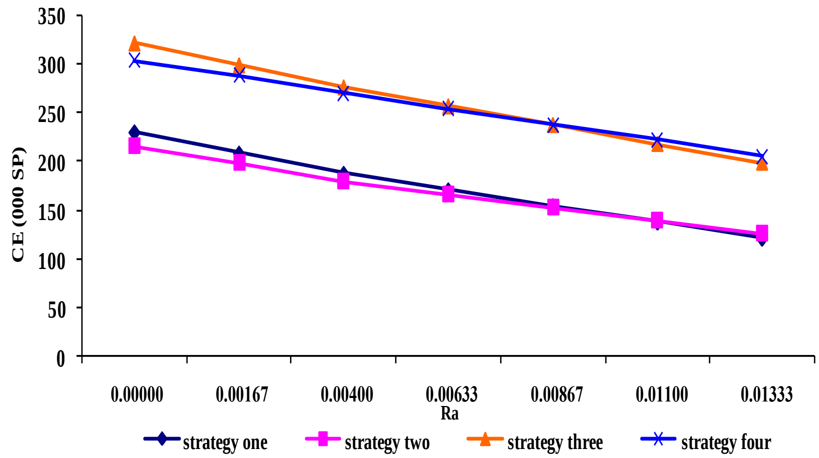

Figure 6. CE graphs for the different strategies under improved practices, Gedaref area, Sudan.

CONCLUSION

The results of stochastic simulation showed that the strategies from one to four under improved practices, farmer's chance to lose at the end of the planning period is very small in strategies one, two and three while their chance of gain is 100% in strategy four at the end of the same planning period. The CDFs graphs and the statistics generated from the stochastic simulation for the strategies under improved practices showed that strategy three which incorporates animal production to the system of growing improved sorghum and sesame and strategy four which involves additionally gum arabic enterprise, are the dominant alternatives in terms of risk efficiency in a first degree sense. They are preferable for a wide range of farmers' risk aversion. The results of comparing the distribution of each strategy under traditional practices to its counterpart under improved practices indicated that the application of the improved technological packages has a positive impact in maintaining income stability in all strategies compared to the traditional practices in growing sorghum and sesame crops.

Considering both farmers' attitude to risk besides their beliefs regarding uncertain events, the stochastic efficiency analysis derived strategies three and four as the risk-efficient among the strategies under the improved practices for farmers' relative risk aversion range with respect to wealth $r_r(w)$ of 0.5 - 4. In the improved strategies, farmers' attitude to risk in the study area did not affect the choice of the risk-efficient plans which remain the same for a wide range of farmers' risk aversion.

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تحليل المخاطر الناجمة عن تطبيق التقنيات الزراعية في منطقة الزراعة الآلية بالقضارف شرق السودان (1990-2004)

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الخلاصة

تنطوي ممارسة الأعمال الزراعية دائماً علي المخاطر، مما دعى إلى ضرورة الأخذ بالاعتبار المخاطر التي تواجه الأعمال الزراعية عند التخطيط لها. تشير الدراسات إلى أن تبني التقنيات الزراعية تؤدى إلى زيادة الدخل ، كما أن تنويع التركيبة المحصولية بإدخال الإنتاج الحيواني ومحصول الصمغ العربي يؤدى إلى استقرار الدخل الزراعي في حالة الزراعة الآلية بمنطقة القضارف. في ظل هذه المعطيات تهدف هذه الدراسة إلى تحليل ودراسة أداء العمل الزراعي في منطقة الزراعة الآلية بالقضارف تحت الظروف الحالية. ولقد قامت هذه الدراسة بتقييم استراتيجيات زراعية مختلفة في ظل التقنيات الحديثة المقترحة تحت ظروف المخاطر. وذلك باستخدام طريقة الميزانية الاحتمالية لتقييم الإستراتيجيات الزراعية المختلفة. استخدمت الميزانية الاحتمالية كأداة رئيسية في هذا التحليل كما استخدم أسلوب المحاكاة لهذه الإستراتيجيات بواسطة توزيع لاتين هايبركيوب للتوزيعات الاحتمالية والتي تعرض النتائج في صورة منحنيات الدوال التوزيعية التراكمية. أوضحت النتائج انه عند تطبيق التقنيات الحديثة فإن فرص خسارة المزارعين عند نهاية الفترة التخطيطية ستكون قليلة، كما أوضحت منحنيات الدوال التوزيعية التراكمية أن استراتيجيات التقنيات الحديثة تسود على التقنيات التقليدية الأخرى من ناحية كفاءتها في تقليل الأخطار كما أوضحت تفضيلها في مدى واسع من مقياس المزارعين المتجنبين للمخاطر. كما أوضحت نتائج مقايسات التوزيعات الاحتمالية لكل استراتيجيه على حده أن التقنيات الحديثة لها المقدرة على العمل على استقرار دخول المزارعين في جميع الاستراتيجيات المدروسة.