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Developing Rainfall-Based Index Insurance in Morocco

Jerry Skees
Stephanie Gober
Panos Varangis
Rodney Lester
Vijay Kalavakonda

Almost 90 percent of Moroccan agriculture is not irrigated, and since most of Morocco's crops depend on adequate rainfall, yields and production vary widely. A drought insurance program based on rainfall index contracts is feasible in parts of Morocco and could significantly benefit its farmers.

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Summary findings

Cereal production accounts for about 70 percent of all agricultural land in Morocco. Cereal producer prices, influenced by the government, are higher than world prices. Production is divided into six broad agroclimatic zones. About half of cereal production is concentrated in the favorable and intermediate zones; the rest occurs mostly in less favorable (arid and semi-arid) zones, with average annual rainfall below 450 millimeters.

Skees and colleagues assess the feasibility of rainfall-based index insurance to provide effective, low-cost drought insurance for Moroccan farmers and rural dwellers. Their analysis focuses on Morocco's three main cereal crops—hard wheat, soft wheat, and barley—using data on annual production and planting from 1978–99. Maize is included in some of the analysis.

The benefits of this program over the traditional insurance scheme are that it minimizes the risk of moral hazard and adverse selection and promotes a streamlined pay-out process. These features make the program more attractive to international re-insurers and investors in capital markets.

A rainfall-indexed insurance product is feasible in Morocco, where the statistical correlation between rainfall and cereal revenues is rather strong in 17 provinces in the more favorable agroclimatic zones. Proportional rainfall insurance contracts would pay the insured an amount based on the shortfall in actual rainfall during a set period compared with the trigger rainfall. The contracts could be purchased in any amount, allowing farmers to insure the full amount of their expected revenue if they wish.

This paper—a joint product of Private Sector Development and Finance Group, Middle East and North Africa Region; Rural Development, Development Research Group; and Financial Sector Department—is part of a larger effort in the Bank to analyze the feasibility of weather-based index insurance markets in developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Pauline Kokila, room MC3-510, telephone 202-473-3716, fax 202-522-1151, email address pkokila@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at sgober@worldbank.org, pvarangis@worldbank.org, rlester@worldbank.org, or vkalavakonda@worldbank.org. April 2001. (37 pages)

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INTRODUCTION[1]

1. Interest in developing catastrophic weather insurance products for rural dwellers in developing countries has grown dramatically in recent years. This interest has been fueled by the successful introduction of new products for the management of systemic risks to international financial markets in recent years. These products include catastrophe bonds and area yield crop insurance options, and their success suggests that it may be possible to package catastrophic weather and natural event risks facing developing countries and reallocate them to international markets in a cost efficient manner, bringing affordable risk management services to rural dwellers in agriculture-dependent countries.

2. The World Bank, in collaboration with the International Food Research Institute, the *Istituto di Studi Economici e Sociali*, and several universities and private consultants, is conducting a study to explore the feasibility of weather-based insurance in four developing countries: Ethiopia, Morocco, Nicaragua, and Tunisia. The study explores the feasibility of weather-based index insurance for providing cost-effective risk management services to rural people for coping with catastrophic events that can profoundly depress agricultural production and rural incomes.

3. This report on the feasibility study in Morocco has several main objectives: (a) to assess Morocco's exposure to weather-related risk and the need for weather risk management products; (b) to document the functions and experience of private and public institutions that currently provide agricultural insurance in this country; and (c) most importantly, to simulate the effect of rainfall-based index contracts in reducing the revenue volatility of grain producers in Morocco and examine the costs relative to the insurance coverage provided.

FEATURES OF MOROCCAN AGRICULTURE AND WEATHER-RELATED RISKS

4. In Morocco, 47 percent of the total population and most of the poor live in rural areas. Economic developments in agriculture play a crucial role in determining the living standards of rural households. On average, agriculture accounts for about 17 percent of gross domestic product (GDP), but this percentage fluctuates, mainly due to climatic—especially rainfall—variations. Almost 90 percent of Moroccan agriculture is non-irrigated, and since most of Morocco's crops rely on adequate rainfall, this has translated to wide variations in yields and production. For example, the production of cereals fell from 9.5 million tons in 1994 to 1.6 million tons in 1995 due to drought. Large-scale irrigation schemes are administered by the *Offices Regionaux de Mise en Valeur Agricole*

[1] Jerry Skees is H.B. professor in the department of agricultural economics at the University of Kentucky, Stephanie Gober is a Financial Sector Specialist at the Middle East and North Africa Region at the World Bank, Panos Varangis is a Senior Economist at the Research Department of the World Bank, Rodney Lester and Vijay Kalavakonda are Lead Specialist and Financial Analyst respectively with the Financial Sector Department at the World Bank, and Kuami Kumako is a graduate student at the University of Kentucky. The authors wish to thank the Government of Morocco, MAMDA and CNCA for their cooperation. The findings, interpretations and conclusions presented in this paper are entirely those of the authors.

(ORMVA), but localized on-farm irrigation is also important. The main crops grown in irrigated areas are higher value crops such as legumes, horticultural, fruits, and industrial crops, but cereals are also grown in some irrigated areas.

5. Agriculture in Morocco is characterized by a dichotomy between the traditional and commercial sectors. The traditional sector consists of small farms in rain-fed areas involved predominantly in cereal, legume, and livestock production. The commercial sector operates mainly in irrigated areas. Farm surveys indicate that about 70 percent of farms are small in size (under 5 hectares) and account for 23 percent of total land under cultivation. Farms under 20 hectares (ha) in size represent 96 percent of the number of farms in operation. The average size of a farm in Morocco is 5.7 ha.

Cereal Agriculture

6. Cereal production is the most significant agricultural resource, accounting for about 70 percent of all agricultural lands. Cereal producer prices are heavily influenced by the government and are set at relatively high levels compared to world prices. This is to encourage cereal production in the country. At present wheat prices are around 250 MAD per quintal[2] (US$250 per ton). The main cereal crops are hard wheat, soft wheat and barley. Recent studies have shown a high correlation between cereal production and agricultural GDP. This indicates that cereal production is the major determinant of agricultural GDP, and the high variability of production leads to high variations in agricultural GDP.

7. Cereal production is divided into six broad agro-climatic zones according to their cereal "production potential". The zones are *favorable, intermédiaire, défavorable sud, défavorable orientale, montagneuse*, and *saharienne.* In broad terms these agro-climatic zones relate to topography but most importantly to rainfall, which decreases from north to south and from west to east. About 50 percent of cereal production is concentrated in the first two zones (favorable and intermediate), with the rest of the production in the less favorable production zones: arid and semi-arid areas with average annual rainfall below 450 mm.

8. During the late 1980s and 1990s, the cereal-growing area has increased, resulting in increases in cereal production. At the same time, however, the volatility of cereal production has increased. Average cereal yields have fluctuated from 0.5 to 1.5 tons per ha in the last 20 years. The coefficient of variation in cereal yields over this period has been around 40 percent. Most of the yield variation, as expected, is in the less favorable growing areas. For example, the coefficient of variation of cereal yields is over 70 percent in the Saharan zone and around 40 to 50 percent in the mountainous and unfavorable southern regions. In contrast, yield variation is only about 24 percent in the favorable region. The high variability of yields among zones and in different years has very important implications for the design of crop insurance schemes to protect farmers.

9. The increase in yield and production variability in the late 1980s and 1990s has been attributed to greater variability in climate and rainfall during this period but also to

[2] One quintal = 100 kilograms = 0.1 metric tons

the expansion of cereal production to less favorable lands in areas with less rainfall and more variable rainfall. It appears that price incentives have pushed cereal production to less productive areas. In addition, the increased use of improved seeds and fertilizers, while increasing overall yields, also tends to increase variability because these seeds and fertilizers require water to achieve the desired gains and can result in lower yields if rain is lacking.

Rainfall, Drought, and the Cereal Growing Cycle

10. Morocco receives most of its precipitation during the northern hemisphere winter semester (October-March), and the most significant climatic feature is rainfall (Lamb and Peppler, 1988). Precipitation is inversely related to the concurrent state of the North Atlantic Oscillation (NOA)[3]. This inverse relationship between Moroccan precipitation and the NOA is stronger around the Atlantic coast. Approximately 95 to 98 percent of rainfall occurs in the country during the period from October to May and this coincides with cereal production cycle. There are three important phases for cereal production in Morocco:

- October-December: seeding phase
- January-February: vegetation growth
- March-May: flowering, reproduction, and spiking

11. While the variation in total annual rainfall is typically relatively low (coefficient of variation of 16.5 percent), monthly rainfall is very erratic. For example, the coefficient of variation in monthly rainfall between November and April exceeds 50 percent. Among regions, the higher coefficients of variation of rainfall are associated with regions that also have lower average rainfall. Those are the less favorable regions, mainly the Saharan, the mountainous, and the unfavorable southern regions.

12. Since 1980, many diverse studies have been conducted on drought in Morocco. In 1988 Lamb and Peppler studied large-scale atmospheric features associated with drought in Morocco. Rognon in 1996 analyzed different droughts that struck Morocco between 1944 and 1984 and noted that they were not persistent and not geographically widespread. Since 1980, however, droughts in Morocco have been very severe with a decrease in precipitation of about 25 percent, compared to historical averages.

13. Studies have shown that the country is stricken by drought once in 10 years on average, but with no chronological pattern. Other studies about drought forecasting also found that it is not possible to make any rainfall forecast at the beginning of the agricultural season. Drought in Morocco is in fact a phenomenon related to the NOA and is difficult to characterize nationwide or in any specific agricultural region. Studies are still underway to compare drought events with each other to find a sustainable forecasting relationship. El Mourid and Watts are working on spring rainfall forecasting using fall

[3] The term North Atlantic Oscillation (NOA; Rogers, 1984) refers to a large-scale alternation of atmospheric mass between the North Atlantic regions of subtropical high pressure (centered near the Azores) and subpolar low pressure (extending south and east of Greenland).

rainfall in Morocco. Currently, the *Direction de la Météorologie Nationale* is conducting research on the relationship between sea level temperature and precipitation in Morocco.

14. In 1998 Barakat and Handoufe worked on agricultural drought-related problems in Morocco. Drought may be defined and viewed from different angles; accordingly, they defined agricultural drought as a rainfall deficit sufficient to cause a significant reduction in agricultural production. In the past it has been difficult to set a minimum rainfall threshold below which a drought year may be declared nationwide. Many authors used to set a threshold arbitrarily (e.g., rainfall below 10 percent of normal), but these methods are not realistic. Barakat and Handoufe instead used agricultural production data for which they estimated the normal value through a regression across time. They then determined the production threshold below which production in a given year is considered drought-stricken. Details of this work are provided in Annex 1 to this report.

Table 1. Different Rainfall Deficit Thresholds (in %) between October and May

Selected Station and Normal Rainfall (mm)	Security Threshold	Alarm Threshold	Tolerance Threshold	Critical Threshold	Maximum Deficit	Year
Taza (629.2)	31.2	32.2	38.9	39.7	69.0	1994/95
Meknes (555.2)	19.3	31.0	32.5	34.5	53.7	1994/95
Azilal (508.0)	22.7	25.2	37.1	41.3	70.0	1980/81
Fes (503.2)	26.5	26.9	33.4	34.3	68.9	1994/95
Khemisset (483.8)	17.8	20.1	27.5	34.3	50.7	1994/95
Ben Slimane (458.6)	10.5	20.1	30.2	38.9	70.2	1994/95
Safi (366.0)	13.3	25.2	26.2	36.6	60.0	1986/87
Settat (358.2)	17.2	25.5	41.8	45.2	60.2	1994/95
Average	**19.8**	**25.8**	**33.5**	**38.1**	**62.9**	
Coefficient of Variation CV (%)	34.3	17.0	16.5	10.3	12.5	

Source: Barakat and Handoufe, 1998.

Note: In the above table,

- The security threshold is the deficit reached without any fear of drought.
- The alarm threshold corresponds to the minimum rainfall deficit registered during a drought year.
- The tolerance threshold is the maximum deficit reached without the occurrence of a drought.
- The critical threshold is the deficit from which the occurrence of a drought is certain.
- The maximum deficit is the greatest deficit reached during the time series studied.

15. Yacoubi et al (1998) also found the following interesting results for the Settat region in Morocco:

- There is only 12 percent chance of having a drought year when none of the first three months of production (October, November, and December) is deficient in rainfall.
- There is 43 percent chance of having a drought year when the month of October is deficient in rainfall.
- When both the months of October and November are deficient in rainfall, the probability of having a drought year is 55 percent

16. In this case, drought is specifically defined in agronomic terms: a province is considered dry when the yield is too low. In reality, the concept of drought in arid regions across the world is beyond the scope of this report.[4] Yacoubi et al in their study found that many rainfall factors could be at the origin of yield shortfall in a specific region. They accordingly classified drought years in six categories as follow:

- Type 1 drought year: rainfall deficit at the end of the production cycle only
- Type 2 drought year: rainfall deficit in the middle of the cycle only
- Type 3 drought year: rainfall deficit in the middle and end of the cycle only
- Type 4 drought year: rainfall deficit at the beginning of the cycle only
- Type 5 drought year: rainfall deficit at the beginning and end of the cycle only
- Type 6 drought year: rainfall deficit at the beginning and middle of the cycle only
- Type 7 drought year: rainfall deficit during all three parts of the cycle

17. Yacoubi et al (1998) found a significant positive linear relationship between cereal production and annual rainfall in non-irrigated areas. As a result, farmers in these regions face high production risks and consequently high income variability. Other studies found that yields are linearly related to cumulative rainfall in January through March. However, aggregated rainfall during that period of time does not completely explain the relationship. Especially, high geographically concentrated rainfall may lead to low aggregated yields. Likewise, high cumulative rainfall may lead to low aggregated yields, if the rainfall is concentrated in a restraint period instead of being uniformly distributed over time (Mission Report; The World Bank, May 2000).

18. In response to the persistent problems of drought in Morocco, the government has established a National Drought Observatory. Its objectives are: a) to create an early warning system permitting the launching of an emergency program to ease the short-term effects of drought; and b) to improve decision-making tools in the medium to longer-term that integrate drought risks in economic planning.

Farmers' Risk Management for Drought

19. Farmers exposed to drought over time have adopted strategies to cope with this risk. Examples are water conservation, use of drought-resistant seeds, diversified farming systems, food storage, use of livestock, and the development of off-farm sources of income. In particular, several studies, in addition to field visits, have indicated that there is a high dependence on off-farm income to sustain small farm households. Livestock (mainly sheep) also play an important role in drought risk reduction, although farmers often complain that they have to sell their livestock in difficult times when prices are lower.

20. There are also differences among zones in the strategies used to deal with drought. In less favorable areas (rainfall of approximately 200-400 mm), a common

[4] See Wilhite D. A. and Glantz M. H. "Understanding the drought phenomenon: the role of definitions". Water Inter 1985; 10.

practice is to adopt low input application, increasing input application only when climatic (rain) conditions appear favorable. This strategy has the impact of lowering potential yields. Farmers in these areas also tend to use local varieties of seeds most resistant to drought, without regard to their other qualities. Farmers are thus using the seeds that have the lowest yields and which are least responsive to fertilizers. In the favorable areas in the northwest of the country, farmers use a higher input technology as they have a greater certainty of achieving an acceptable return.

21. The lack of access to financial services also seems to create problems for farmers dealing with drought. In good years, farmers tend to store their grain surplus by feeding it to livestock. Grain storage is highly risky due to the potential for vermin infestation, but feeding surplus grain to livestock is also a risky approach to savings. In drought years, livestock and thus savings, are threatened by the absence of drinking water. When farmers are in need of cash, they are often forced to sell livestock when prices are low. Alternative financial savings mechanisms appear to be unavailable or undesirable. In particular, banking services are not easily accessible to farmers who live in remote areas or who may be poorly educated or illiterate. These facts suggest that the introduction of micro-financial services in rural areas could complement insurance schemes to help rural inhabitants manage their drought-related risk.

22. These observations have significant implications for the design of a drought insurance scheme. The introduction of drought insurance in Morocco should not attract farmers away from traditional forms of risk management, which are important for the security of rural household incomes. However, there are limited alternatives available to assist farmers in mitigating drought risks. Insurance can provide financial security to farmers to survive until the next crop season, but should not encourage high risk cropping, adoption of inappropriate technologies or expansion of production into inappropriate lands.

Effects of Drought on Agricultural Lending in Morocco

23. The development of drought insurance in Morocco is closely linked to rural credit, in particular as a means of reducing the exposure of *Caisse Nationale de Crédit Agricole* (CNCA, the public agricultural bank) to climatic risks. Although there has not been a formal study of the link between drought and loan delinquency, an important issue in Moroccan agricultural policy has been the government's forgiveness of farm loans following drought. It could be argued that borrowers' expectations of debt relief may have contributed to their reluctance to repay loans. It has therefore been recognized that the development of formal drought insurance could help improve borrower repayment discipline by diminishing farmers' inability to repay following a drought.

24. CNCA finances about 11 percent of loans to the Moroccan economy and more than 80 percent of all loans to the agricultural sector. Although most of CNCA's lending is agricultural, almost one-third of its total portfolio is composed of non-agricultural loans. Over the past several years, CNCA's financial position has been weak, with a high level of non-performing loans, under-provisioning, and operating losses. In 1997, the bank was restructured and new management was brought in to work to correct these

problems, but—due in part to the negative effect of severe, successive droughts since the reorganization—significant progress has not yet been achieved.

25. In 1999, CNCA made the purchase of drought insurance a mandatory condition for obtaining an agricultural loan in the areas covered under the current drought insurance scheme. This requirement is widely credited with the increase in insurance subscriptions this year, but it is not known if the cost of this mandatory insurance contributed to the significant drop in the number of CNCA borrowers in the last year (from 287,941 in 1998 to 194,093 in 1999). Ideally, an insurance product would be a tool not only to protect CNCA's loan repayment but also to help ensure that financially viable farmers have access to credit.

26. The Moroccan government has incurred significant fiscal costs in its support of CNCA and agricultural lending, but also for general drought relief. However, in addition to these, the catastrophic drought of the 1999-2000 crop year led the government to announce a massive relief program. Over an 18 month period, the government will spend 6.5 billion MAD (about US$650 million) on drought relief, for programs to protect livestock and forests as well as to provide water for villages and herds in drought-stricken areas. Given the significant costs of providing drought relief to farmers and supporting CNCA's financial viability, the Moroccan government has expressed strong interest in finding cost-effective ways to aid farmers in managing their drought risk and improving their ability to repay agricultural loans consistently.

CURRENT MOROCCAN DROUGHT INSURANCE SCHEME

History and Description of Current Scheme

27. During the last ten years there have been several important studies on the subject of drought insurance in Morocco. Specifically worth mentioning are the "Report on Agricultural Risk Management and Insurance Fund", written in 1993 by Agricultural Risk Management Limited for KfW and the World Bank, and the World Bank's "MENA Rural Finance: Performance, Constraints And Options" 2000 report on Egypt, Morocco and Tunisia. This report provides a brief assessment of recent developments in Moroccan drought insurance and focuses on the implications for the development of alternative insurance based on a rainfall index.

28. The Morocco National Rural Finance Project (Loan 3662-MOR) included a specific provision for the development of an insurance scheme under institutional development that was not to be funded by the World Bank. This led to the 1993 study mentioned above. Following the recommendations of the study, a pilot project to provide drought insurance in cereal production was implemented starting with the 1995-96 crop season. The program was to be managed by *Mutuelle Agricole Marocaine d'Assurances* (MAMDA, the agricultural mutual insurance company).

29. This insurance scheme has been operating for five years. Until 1998-99 the program provided insurance if yields fell below certain thresholds. Three threshold

levels were set: 0.8, 1.6, and 2.4 tons per ha. The indemnification amounts were set at 850 MAD/ha, 1,700 MAD/ha, and 2,380 MAD/ha respectively, and the respective premiums were 102 MAD/ha, 204 MAD/ha and 306 MAD/ha.

30. In 1999-2000, the program started indemnifying threshold levels of revenue (but still insurance is triggered by yield shortfalls); that is, farmers are now insured for a specified revenue level of either 1,000 MAD/ha, 2,000 MAD/ha, or 3,000 MAD/ha rather than being insured for a specific yield levels. During the first year of this program, the Moroccan government subsidized 50 percent of the premium costs for this insurance scheme, and the premium cost to the farmers for the scheme was 60 MAD/ha for Level 1 (i.e., 1,000 MAD/ha), 120 MAD/ha for Level 2, and 180 MAD/ha for Level 3. In percentage terms, this means that in the first year of this program, the farmers paid a premium of six percent of the coverage amount and the government subsidized six percent, which translates to a total risk premium of 12 percent[5]. The government subsidy will be phased out over a period of five years, with the farmers' rates increasing by 15 percent per year to replace the subsidy.

31. In order for the insurance scheme to begin making indemnity payments, an official drought declaration must be made, based on a joint decision of the MoA and the MoF, using reports from the MoA's provincial services to verify that the realized average yield achieved in a given rural commune is less than 60 percent of the average historical area yield for that commune. At Level 1, the insurance pay-out is based on the realized average area yield for the rural commune. For the other two levels, the pay-out is based on assessments of the individual farm's realized yield. Under the terms of the agreement for this insurance scheme, the drought declaration must be made no later than May 10; the individual farm assessments must be completed by July 15; and all indemnity payments are to be completed by July 31.

32. For all three insurance levels, the appropriate yield (either average area yield or individual farm yield) is multiplied by the price (set at 130 MAD/quintal for barley, 200 MAD/quintal for soft wheat, and 220 MAD/quintal for hard wheat) to determine the farmers' "actual" income, and this "actual" income is subtracted from the insured income level to determine the amount of the indemnity payment. The formula for indemnification is thus:

Insured Level - (Unit Price x Yield) = Indemnification

Example: (2,000 MAD/ha insured) – (200 MAD/quintal x 6 quintals/ha [farmer's actual yield used for Level 2 insurance]) = 800 MAD/ha indemnification.

33. Once a drought is declared, the current insurance scheme obtains funds for indemnification from the following sources, in order of use:

(i) premiums paid in by farmers, net of the cost of reinsurance, cover losses up to a maximum of 59 million MAD,

[5] Distributions costs for this scheme are absorbed by the two institutions which sell policies, MAMDA and CNCA, and the premiums received do not cover these or other administrative costs of the scheme.

(ii) excess-of-loss reinsurance covers losses in excess of 59 million MAD, up to 80.78 million MAD at a cost of 4.25%, then the cost increases to 5.15% for losses from 80.78 million MAD up to maximum losses of 172 million MAD[6],

(iii) the government's contributions cover losses exceeding 172 million MAD, until these contributions are exhausted[7]. The contributions are:

- 120,000,000 MAD per year and
- subsidies for the farmers' insurance premiums, calculated based on the area insured, but limited to no more than 40 million MAD in the first year, phasing out to zero by the sixth year,

(iv) interest or dividend income on any of the above resources is used after the government's contributions are exhausted, and

(v) a contribution from MAMDA of up to 80 million MAD is used when all other resources have been exhausted.

Results of Current Scheme

34. A total of 111,697 ha were subscribed in the insurance scheme in 1999-2000, with 47,114 ha (42 percent) at Level 1 (1,000 MAD/ha), 36,672 ha (33 percent) at Level 2 (2,000 MAD/ha) and 27,911 ha (25 percent) at Level 3 (3,000 MAD/ha). CNCA sold insurance to a total of 18,135 farmers for coverage of 102,860 ha (92 percent of total land insured). Almost all the land insured at Level 1 or Level 2 was covered by policies sold by CNCA, but policies sold by MAMDA covered 26 percent of the land covered by insurance at Level 3. In total, MAMDA sold insurance for 8,837 ha (8 percent of total land insured). Of the insurance sold directly by MAMDA, 7,362 ha (83 percent) were at the highest level of indemnification (3,000 MAD/ha). This level is generally sold to larger farms: a total of 770 farmers bought insurance from either MAMDA or CNCA at Level 3, which corresponds to an average of 36.2 ha insured per farmer. The average number of hectares covered by individual insurance policies at Level 1 was 3.6 ha, compared to 6.8 ha Level 2.

35. The total amount of premiums collected for 1999-2000 was about 12.25 million MAD (or US$1.2 million), and the total indemnification paid in the same year was around 200 million MAD (US$20 million). The indemnification paid this year consumed all reinsurance funds, all contributions from the government, and part of MAMDA's 80 million MAD contribution, as described above.

Observations on Current Scheme

36. The current insurance scheme is available in 18 Moroccan provinces or *wilayate* (excluding certain parts of 3 provinces), with a total possible subscription area of 300,000

[6] This reinsurance scheme was begun with international reinsurers in 1998 on a five-year basis. The losses from the 1999 drought exceeded the total premiums which will be paid to the reinsurers over the five year period.

[7] The government's contributions to the scheme will end once MAMDA's stability reserve reaches 450 million MAD.

ha. In 1999-2000, only 111,697 ha were subscribed, a participation rate of 37 percent. Although this is a low participation rate, it is higher than previous years. According to a review of the scheme conducted in September 1998, the main reasons for the relatively low participation in the insurance scheme are:

- *Farmers' lack of familiarity with and understanding of insurance.* Education and technical assistance are very important, and the results are better where there are active extension agents and energetic farmer leaders.
- *Low level of indemnification (income coverage),* which is a particular problem for larger farmers.
- *Narrow coverage.* Farmers want a more generalized insurance scheme in terms of both the perils and the crops which are covered.
- *Linkage to average yield for commune* (for the 1,000 MAD/ha insurance level). Farmers prefer individualized coverage.
- *Long delays in receiving indemnification.* Last year it took more than four or five months for indemnity payments to be made to farmers. This year, the team was told that the official drought declaration would be made in May, in order for payments to be made by August at the latest (missing the contractual deadline of July 31). For the 1999-2000 crop year, if there had been a total declaration of drought, well over 6,000 farms with coverage at 2,000 MAD/ha and 3,000 MAD/ha would need to have been assessed individually.
- *Up-front cost of insurance.* The team was told that there is a problem with the requirement to pay the premium at the beginning of the crop year, before planting, when farmers do not necessarily have cash available.

37. The survey of farmers and agricultural organizations and three representative regions (one with high penetration of insurance coverage, one with low penetration, and one with variable penetration) revealed the following:

- Only 5% of farmers surveyed were consistently loyal to the program.
- Most of knowledge of the insurance system was attained through work centers.
- 5% of the farmers had a good understanding of the scheme, however 31% had poor or no understanding.
- For farmers who never subscribed, the main reasons were complexity and lack of funds. The latter issue was as expected most important with farmers with less than 20 ha (68% of those surveyed) and least important for those with more than 50 ha (11%).

38. Most farmers are purchasing drought insurance mainly because it is now a condition for receiving a loan from CNCA. Farmers can finance the insurance premium through the loan. Staff from MoA told the team that they believe that 90 percent of the subscription to insurance is due to the credit requirement. This is reflected in the fact that in 1999-2000, 92 percent of the insurance was sold through CNCA and only eight percent was sold directly by MAMDA.

39. The subscription rate for the insurance scheme is much higher in regions where farmers are better organized and the regional MoA offices have managed to disseminate information effectively to farmers in their region. For example, the province of Settat has

a participation rate of 61 percent for 1999-2000. Other provinces with high participation rates are Safi (63 percent), Wilaya de Marrakech (54 percent), Wilaya de Rabat (52 percent) and Kenitra (48 percent). Rabat and Kenitra are in the favorable zone, Settat is located in the intermediate zone, and Marrakech and Safi in the unfavorable zone of the south.

40. The experience of the current drought insurance scheme in Settat shows that participation rates increase significantly following a year in which indemnification was paid.

Crop Year	Area Insured in Settat	Indemnification Paid
1995-1996	2,165 ha	No
1996-1997	210 ha	Yes
1997-1998	1,036 ha	No
1998-1999	1,136 ha	Yes
1999-2000	14,511 ha	Yes

Weaknesses of Current Scheme

41. The current drought insurance scheme has two underlying weaknesses. First, for the two higher levels of indemnification it relies on the traditional approach of assessing individual yields. Although farmers in Morocco seem to prefer individual farm assessment, this exposes the insurance scheme to moral hazard and adverse selection problems, adds significantly to the administrative costs of the insurance scheme, and leads to delays in indemnity payments to the farmers.

42. The second major drawback of the current scheme is that the cost to the government is quite high for relatively limited coverage. For 1999-2000, the government paid around 12 million MAD for premium subsidies, plus its 120 million MAD contribution to the scheme's indemnity fund, which was used in full to cover indemnity payments for this year's drought. This investment of more than 130 million MAD supported insurance coverage for only 111,697 ha, out of a total of more than 5 million ha used for cereal production in Morocco. The current program is limited to participation on a total of 300,000 ha, in part because the government is unable to support the cost of providing coverage for a larger area. Furthermore, the maximum indemnification available under the current scheme is 3,000 MAD/ha, which is less than farmers' potential income in a good crop year. The current drought insurance scheme's limits essentially provide coverage for farmers' input costs rather than protecting against loss of income. In the next section, the feasibility of insurance based on rainfall is examined to determine if such a product could offer an acceptable risk hedge against drought to a larger number of farmers in Morocco at a lower cost to the government.

ANALYSIS OF THE FEASIBILITY OF RAINFALL CONTRACTS

43. The following analysis focuses on Morocco's three primary cereal crops: hard wheat, soft wheat, and barley. These crops are planted in the fall and subject to basically the same weather events. The primary source of information used in this analysis is data

supplied by the MoA. These data include the annual production and plantings from the 1978-79 campaign to the 1998-99 campaign. Since maize data were also supplied, maize is added to some of the analysis.

Adjusting Yield Data

44. Data for the four commodities, barley, hard and soft wheat, and maize, were adjusted using procedures described in detail in Annex 2. Figures 1 and 2 in Annex 2 show the trends in harvested hectares for wheat and barley respectively. Since 1979, total hectares of harvested wheat have nearly doubled, with most of the increase in soft wheat. In the past 20 years, hectares of harvested wheat have increased from just over 1.5 million ha to between 2.8 and 3.0 million ha, while harvested barley has gone from about 1.6 million to 2.2 million ha. The data used in Figures 1-4 (Annex 2) are from the USDA world crop data base and match the data supplied by the Ministry of Agriculture in Morocco quite well.

45. Figures 3 and 4 in Annex 2 show the trends in yield per ha for the national data, demonstrating that the trends have slowed or reversed for the nation. Wheat yield increases have turned flat nationally, and barley yield increases are now negative. These trends have two probable explanations: 1) rainfall has been lower on average with more serious droughts in the 1990s; and 2) the increased plantings may be occurring on less productive land with lower yields, bringing the average yield down. In either case, these trends raise serious concerns for developing policies to address productivity of cereal crops in Morocco.

46. When trying to model risk from natural hazards, it is very common to first attempt to estimate the value at risk in today's terms. For example, when modelers examine earthquake or hurricane risk, they use current property values and the amount of property that is in a specific location and then go back through time to estimate how much damage previous events would do to the current property. These models are built in the same fashion. To estimate the current crop value by location, an average of the previous three years of plantings are used. Current prices for each commodity are also used. The series of adjusted yields (21 years by 36 provinces by four crops) is then used to develop a matrix of revenues for the specific events in today's terms:

$$\text{Revenue}_{tpc} = \text{Adjusted yield}_{tpc} \times \text{Hectares}_{tpc} \times \text{Price}_{c}$$

where t= year, 1979-1999 : p = province; 1-36: and c = crop; 1-4.

47. The four crops are maize, barley, and soft and hard wheat. National prices are used in all provinces: 190 MAD/quintal for maize; 190 MAD/quintal for barley; 250 MAD/quintal for soft wheat; and 280 MAD/quintal for hard wheat. For this study, prices are not allowed to vary. Nonetheless, there is a negative correlation between prices and yields in Morocco. Thus, the estimates of relative risk in revenue are larger than would be the case if more information about price and yield relationships were built into the modeling exercise. The procedure used estimates of what the current year's revenue would be if some of the past yields were repeated. These Monte Carlo procedures are empirically based with appropriate adjustments for trend and current distribution of the crop. By using the historic yields that are trend adjusted, one preserves the correlation

among crops and across space just as it was realized over the 21 year period. These correlations become very important as they play a major role in the examination of the risk profile for alternatives that may be tried across any number of provinces and crops in Morocco.

48. Table 2 below presents the complete matrix of the estimated value of the four crops in today's terms. The share of total value of the four crops for each province is also provided. The total annual value for all four crops is estimated to be 11.4 billion MAD or about US$1.1 billion. The three dominant zones are along the coast: the favorable rain-fed zone (*bour favorable*) is north of Casablanca and has a 26 percent share of total production value for these crops; the intermediate zone includes Casablanca with a 21.1 percent share; and the unfavorable southern rain-fed zone (*défavorable sud*) is south of Casablanca with a 24.3 percent share. Table 3 demonstrates that there are important and significant differences in the expected yield per hectare, even within zones. For example, even within the more favorable northern zone, soft wheat yields range from 0.5 tons per hectare to 1.5 tons per hectare.

Table 2. Estimates of Expected Crop Value by Province and Zone
(all values in 1,000 MAD)

Province	Zone	Maize	Barley	Soft Wheat	Hard Wheat	Share
BEN_SLIMANE	B.FAVORABLE	5,609	46,940	182,878	147,117	3.4%
FES	B.FAVORABLE	1,079	55,556	153,683	96,690	2.7%
KENITRA	B.FAVORABLE	6,120	25,738	521,110	79,211	5.5%
KHEMISSET	B.FAVORABLE	11,373	84,339	402,085	94,525	5.2%
MEKNES	B.FAVORABLE	905	11,555	186,866	28,055	2.0%
RABAT	B.FAVORABLE	1,983	6,185	38,882	3,220	0.4%
TAOUNATE	B.FAVORABLE	270	56,597	184,239	154,210	3.5%
TAZA	B.FAVORABLE	1,359	147,179	52,853	171,817	3.3%
BOULMANE	D.ORIENTAL	2,396	23,996	10,539	16,215	0.5%
EL_HOCEIMA	D.ORIENTAL	352	111,593	27,360	5,940	1.3%
FIGUIG	D.ORIENTAL	838	11,081	5,535	3,685	0.2%
GUELMIM	D.ORIENTAL	97	1,436	2,292	277	0.0%
NADOR	D.ORIENTAL	148	285,265	76,246	14,009	3.3%
OUJDA	D.ORIENTAL	0	88,552	67,702	41,642	1.7%
AGADIR	D.SUD	12,057	90,204	100,655	24,683	2.0%
EL_KELAA	D.SUD	2,624	256,759	377,423	248,262	7.8%
ESSAOUIRA	D.SUD	33,391	193,071	12,480	11,191	2.2%
KHOURIBGA	D.SUD	0	210,273	82,110	44,150	3.0%
MARRAKECH	D.SUD	154	259,913	90,708	98,213	3.9%
SAFI	D.SUD	58,140	231,217	159,348	176,976	5.5%
CASABLANCA	INTERMED	8,881	26,292	84,010	25,298	1.3%
EL_JADIDA	INTERMED	123,478	221,160	273,223	353,191	8.5%
SETTAT	INTERMED	45,925	292,185	370,760	577,770	11.3%
AZILAL	MONTAGNE	96	134,862	36,890	50,955	2.0%
B_MELLAL	MONTAGNE	25,935	74,010	723,600	199,660	9.0%
EL_HAJEB	MONTAGNE	600	23,256	145,800	40,698	1.8%
IFRANE	MONTAGNE	359	41,880	33,330	56,000	1.2%
KHENIFRA	MONTAGNE	382	28,118	87,655	91,336	1.8%
ERRACHIDIA	SAHARIEN	5,456	9,440	26,072	59,122	0.9%
OUARZAZATE	SAHARIEN	6,620	67,037	60,186	2,262	1.2%
TATA	SAHARIEN	429	2,315	860	113	0.0%
TIZNIT	SAHARIEN	332	51,437	5,940	228	0.5%
CHEFCHAOUEN	TANGEROIS	749	25,223	73,085	12,748	1.0%
LARACHE	TANGEROIS	217	2,592	34,959	59,025	0.8%
TANGER	TANGEROIS	104	9,841	3,331	49,029	0.5%
TETOUAN	TANGEROIS	152	16,797	11,988	76,832	0.9%
	TOTALS BY ZONE TYPE					
	B.FAVORABLE	28,698	434,089	1,722,596	774,845	26.0%
	D.ORIENTAL	3,830	521,923	189,674	81,767	7.0%
	D.SUD	106,366	1,241,438	822,723	603,476	24.3%
	INTERMED	178,283	539,637	727,993	956,259	21.1%
	MONTAGNE	27,371	302,126	1,027,275	438,649	15.7%
	SAHARIEN	12,837	130,228	93,058	61,725	2.6%
	TANGEROIS	1,222	54,453	123,363	197,633	3.3%
NATIONAL TOTALS		**358,610**	**3,223,894**	**4,706,683**	**3,114,355**	**100%**

Table 3. Estimates of Current Yield per Hectare (Quintals)

Province	Zone	Maize	Barley	Soft Wheat	Hard Wheat
BEN_SLIMANE	B.FAVORABLE	8.2	16.6	15.2	13.7
FES	B.FAVORABLE	5.5	9.3	8.9	8.5
KENITRA	B.FAVORABLE	15.1	10.9	9.0	7.8
KHEMISSET	B.FAVORABLE	7.3	11.8	9.3	8.2
MEKNES	B.FAVORABLE	6.5	11.4	11.3	8.9
RABAT	B.FAVORABLE	5.4	8.2	5.0	3.8
TAOUNATE	B.FAVORABLE	6.1	8.4	7.6	6.6
TAZA	B.FAVORABLE	6.5	8.1	8.2	8.1
BOULMANE	D.ORIENTAL	8.8	9.3	7.3	9.0
EL_HOCEIMA	D.ORIENTAL	11.1	9.6	7.4	10.0
FIGUIG	D.ORIENTAL	14.7	9.1	9.4	7.2
GUELMIM	D.ORIENTAL	7.6	2.2	3.7	1.8
NADOR	D.ORIENTAL	11.6	11.7	7.9	11.3
OUJDA	D.ORIENTAL	5.5	4.9	5.2	4.2
AGADIR	D.SUD	16.7	8.5	12.3	3.9
EL_KELAA	D.SUD	14.8	9.1	11.5	7.1
ESSAOUIRA	D.SUD	2.9	4.8	5.5	6.5
KHOURIBGA	D.SUD	NA	8.4	7.2	10.5
MARRAKECH	D.SUD	12.1	7.0	7.4	6.6
SAFI	D.SUD	3.4	6.7	7.8	6.9
CASABLANCA	INTERMED	12.3	17.0	11.2	11.5
EL_JADIDA	INTERMED	6.6	15.4	15.9	9.7
SETTAT	INTERMED	6.4	12.4	12.6	10.4
AZILAL	MONTAGNE	15.3	11.9	8.1	8.4
B_MELLAL	MONTAGNE	35.0	18.0	17.1	8.9
EL_HAJEB	MONTAGNE	8.6	16.2	15.3	14.4
IFRANE	MONTAGNE	8.1	10.1	10.0	10.3
KHENIFRA	MONTAGNE	6.7	9.4	7.0	7.9
ERRACHIDIA	SAHARIEN	14.6	19.8	20.5	16.2
OUARZAZATE	SAHARIEN	13.4	13.5	17.3	13.8
TATA	SAHARIEN	11.3	8.6	12.2	4.3
TIZNIT	SAHARIEN	7.5	2.7	3.5	3.6
CHEFCHAOUEN	TANGEROIS	7.4	9.4	8.7	7.5
LARACHE	TANGEROIS	11.4	13.8	10.2	9.3
TANGER	TANGEROIS	4.1	12.9	10.2	10.5
TETOUAN	TANGEROIS	8.0	12.4	11.2	8.9

49. By themselves, the levels of expected yields and revenue reveal little about the relative risk. Given the matrix of 21 years of adjusted yields, a profile of these risks can be developed as well. Since expected yields vary greatly among crops and provinces, risks measures are normalized by using the coefficient of variation (CV).

$$CV = \text{Standard Deviation} / \text{Mean}$$

50. CV is a good measure of relative risk as long as the risks are normally distributed, as most of these are. The assumption of normality was tested and could not be rejected for the Moroccan revenue data.[8] Table 4 shows that there are great differences in the risk profile across Morocco. As one would expect, the relative risk for the revenue generated from the four crops is generally lower than the relative risk for the individual crops. CVs are only reported for complete data sets of 15 years or greater. One must be careful in interpreting these values. For example, a very low number may simply mean that incomes are consistently low. In general however, they are a reasonable measure for sorting relative risk.

[8] This is also likely due to the fact that the revenue data is a portfolio of four crops

Table 4. Estimate of Relative Risk (CV) for Revenue

Province	Zone	Maize	Barley	Soft Wheat	Hard Wheat	Four Crop
BEN_SLIMANE	B.FAVORABLE	51%	47%	46%	52%	46%
FES	B.FAVORABLE	44%	42%	49%	49%	46%
KENITRA	B.FAVORABLE	29%	35%	35%	52%	35%
KHEMISSET	B.FAVORABLE	35%	41%	41%	47%	41%
MEKNES	B.FAVORABLE	40%	34%	37%	38%	37%
RABAT	B.FAVORABLE	40%	48%	39%	48%	39%
TAOUNATE	B.FAVORABLE	.	44%	46%	44%	44%
TAZA	B.FAVORABLE	40%	42%	54%	44%	42%
BOULMANE	D.ORIENTAL	32%	32%	48%	28%	28%
EL_HOCEIMA	D.ORIENTAL	30%	33%	39%	42%	32%
FIGUIG	D.ORIENTAL	.	44%	65%	40%	41%
GUELMIM	D.ORIENTAL	.	105%	200%.		164%
NADOR	D.ORIENTAL	.	35%	35%	43%	32%
OUJDA	D.ORIENTAL	.	51%	40%	54%	45%
AGADIR	D.SUD	43%	65%	51%	45%	48%
EL_KELAA	D.SUD	87%	58%	55%	52%	54%
ESSAOUIRA	D.SUD	55%	58%	64%	62%	54%
KHOURIBGA	D.SUD	.	63%	65%	62%	62%
MARRAKECH	D.SUD	58%	56%	56%	52%	54%
SAFI	D.SUD	54%	49%	64%	58%	52%
CASABLANCA	INTERMED	46%	44%	51%	54%	47%
EL_JADIDA	INTERMED	48%	49%	44%	69%	50%
SETTAT	INTERMED	61%	61%	68%	79%	70%
AZILAL	MONTAGNE	.	40%	27%	38%	36%
B_MELLAL	MONTAGNE	31%	57%	35%	41%	36%
EL_HAJEB	MONTAGNE	.	.	.	.	.
IFRANE	MONTAGNE	27%	28%	23%	27%	24%
KHENIFRA	MONTAGNE	40%	49%	39%	35%	37%
ERRACHIDIA	SAHARIEN	55%	30%	33%	28%	25%
OUARZAZATE	SAHARIEN	30%	23%	19%	45%	19%
TATA	SAHARIEN	.	71%	51%.		61%
TIZNIT	SAHARIEN	57%	121%	119%.		120%
CHEFCHAOUEN	TANGEROIS	20%	25%	23%	26%	21%
LARACHE	TANGEROIS	35%	23%	26%	25%	20%
TANGER	TANGEROIS	.	32%	29%	29%	30%
TETOUAN	TANGEROIS	27%	25%	19%	21%	20%

Designing Rainfall Contracts to Reduce Relative Risk

51. The benchmark for reducing risk now becomes the CV measures. Special care is needed to design rainfall contacts that will reduce relative risk. Limited data were supplied for monthly rainfall totals; monthly rainfall data that matches the 36 province names were supplied for only about 30 of the provinces. These data date from the 1984-85 crop year forward. In addition, an international data set was purchased and matched with the data supplied by the Moroccans for 15 provinces. In these provinces, the

international data set matched the Moroccan data sets very well. The international data begin in 1931, allowing further examination of some important trends in rainfall.

52. Special care was taken to fill in missing data first with data from surrounding provinces for a few limited cases between 1984-85 and 1998-99 and then for the 1978-79 to 1984-85 crop years. In some cases (about six provinces), no data were available. In these cases, the average rainfall for that zone type was calculated and used. In the end, an actual or a proxy rainfall measure was obtained for every province. These data were for September to April for all provinces and from September to May in the 15 key provinces studied. Clearly, this work would have been more robust if more data had been obtained. However, this makes the results even more encouraging, because they would probably be improved by more detailed rainfall data.

53. In a previous study (Kumako, 2000), many different combinations of monthly rainfall were examined to identify the combinations that were most highly correlated to crop yields. However, Kumako (2000) used only data for the 15 provinces on which this study is focusing. The Kumako (2000) study was used to narrow the set of combinations to be examined. Clearly, using only 21 years of data to examine these relationship can result in spurious correlations. Thus, four factors influenced the selection of key months for rainfall contracts:

- (i) previous results from the Kumako (2000) study,
- (ii) knowledge of the crop cycles and critical periods for rain,
- (iii) a cautious approach using judgment and heuristics rather than simply relying on the correlations, and
- (iv) a constraint that similar periods be used in contiguous geographic areas.

54. After learning that September rainfall did not have much influence on yields, the cumulative rainfall for four periods were examined:

- (i) October to March
- (ii) October to April
- (iii) November to March
- (iv) November to April

55. Rainfall in May can be important in a number of areas; however, May rainfall data was available for only 15 provinces. May is more important when maize is added to the total revenue. Since wheat and barley are fall-planted crops and are more dominant, it made sense to combine these crops into one measure of revenue as described above. The correlations are developed for the four rainfall periods versus the revenue for the three fall planted crops. Based on these results (shown below in Table 5), it was decided to focus on three zones: favorable rain-fed (*bour favorable*), unfavorable south (*défavorable sud*), and intermediate. Correlations for these three zones average 69 percent over the full 21-year period. They increase to an average of 77 percent over the last decade. This indicates a higher exposure to rainfall risk, which could be attributed to increased cultivation of marginal areas that are more susceptible to weather risks and/or because of the downward trend in average rainfall. Some isolated provinces in other

zones may also lend themselves to pilot testing. However, the three key zones comprise about 71 percent of the total value of the four crops. This fact along with the higher correlations are the reasons for focusing on these three zones. Based on the correlations, rainfall from November to March is more highly correlated with revenues in the North, including the *bour favorable*, *Tangerois*, and *Orientale* zones. Rainfall for October to March is used for the rest of the country.

Table 5. Correlation Between Revenue and Rainfall

Zone	Province	Rainfall Period	Pearson Correlation	Rainfall Period	Pearson Correlation
		----------1979-1999 --------	-----	----------1990-1999 -------------	
RECOMMENDED					
	B.FAVORABLE	***Oct-Mar***	***76%***	***Nov-Mar***	***82%***
	D.SUD	***Oct-Mar***	***77%***	***Oct-Mar***	***82%***
	INTERMED	***Oct-Mar***	***71%***	***Oct-Mar***	***73%***
B.FAVORABLE	BEN_SLIMANE	Oct-Mar	77%	Oct-Mar	73%
B.FAVORABLE	FES	Nov-Mar	76%	Nov-Mar	85%
B.FAVORABLE	KENITRA	Oct-Mar	59%	Oct-Mar	65%
B.FAVORABLE	KHEMISSET	Oct-Mar	77%	Oct-Mar	84%
B.FAVORABLE	MEKNES	Nov-Mar	81%	Nov-Mar	85%
B.FAVORABLE	RABAT	Nov-Mar	48%	Nov-Mar	59%
B.FAVORABLE	TAOUNATE	Nov-Mar	69%	Oct-Mar	84%
B.FAVORABLE	TAZA	Nov-Mar	62%	Nov-Mar	91%
D.SUD	AGADIR	Nov-Mar	77%	Nov-Mar	89%
D.SUD	EL_KELAA	Oct-Mar	66%	Oct-Mar	72%
D.SUD	ESSAOUIRA	Nov-Mar	69%	Oct-Mar	82%
D.SUD	KHOURIBGA	Oct-Mar	57%	Oct-Mar	90%
D.SUD	MARRAKECH	Oct-Mar	75%	Oct-Mar	78%
D.SUD	SAFI	Oct-Mar	73%	Oct-Mar	71%
INTERMED	CASABLANCA	Oct-Mar	60%	Oct-Mar	60%
INTERMED	EL_JADIDA	Oct-Mar	63%	Nov-Mar	64%
INTERMED	SETTAT	Oct-Mar	70%	Oct-Mar	69%
		Average	**69%**		**77%**
		REST OF THE COUNTRY			
D.ORIENTAL	BOULMANE	Oct-Apr	9%	Oct-Apr	50%
D.ORIENTAL	EL_HOCEIMA	Oct-Apr	35%	Oct-Apr	65%
D.ORIENTAL	FIGUIG	Nov-Mar	36%	Oct-Apr	40%
D.ORIENTAL	GUELMIM	Oct-Apr	23%	Oct-Apr	17%
D.ORIENTAL	NADOR	Nov-Mar	50%	Nov-Mar	60%
D.ORIENTAL	OUJDA	Nov-Mar	58%	Oct-Apr	65%
MONTAGNE	AZILAL	Nov-Mar	71%	Nov-Mar	81%
MONTAGNE	B_MELLAL	Nov-Mar	61%	Oct-Mar	58%
MONTAGNE	EL_HAJEB	Oct-Mar	47%	Nov-Mar	54%
MONTAGNE	IFRANE	Oct-Apr	46%	Oct-Mar	59%
MONTAGNE	KHENIFRA	Oct-Apr	86%	Oct-Mar	94%
SAHARIEN	ERRACHIDIA	Oct-Mar	46%	Oct-Apr	62%
SAHARIEN	OUARZAZATE	Oct-Apr	55%	Oct-Apr	44%
SAHARIEN	TATA	Nov-Mar	68%	Oct-Mar	81%
SAHARIEN	TIZNIT	Oct-Mar	69%	Oct-Mar	79%
TANGEROIS	CHEFCHAOUEN	Nov-Mar	30%	Nov-Mar	37%
TANGEROIS	LARACHE	Nov-Mar	-7%	Oct-Mar	-18%
TANGEROIS	TANGER	Nov-Mar	45%	Oct-Mar	57%
TANGEROIS	TETOUAN	Nov-Mar	24%	Nov-Mar	34%

56. A number of alternative rainfall contracts can be considered (see Skees, 2000). For this study, the focus is on proportional contracts. The proportional contract simply pays in percentage terms for levels of rainfall below a well-specified strike or threshold. For example, if the median rainfall in a given province is 300 mm from November to March, one might begin payments anytime rainfall is below 250 mm. These payments would be based on the level below the strike of 250 mm. The percentage calculation would be performed as follows:

If rainfall from November to March < 250 mm, then
payment percentage = (250 – actual rain) / 250

For example, if the rainfall is 200 mm, the payment percentage would be 50/250 or 20 percent. Those at risk (farmers, agribusinesses, farmer organizations, banks, etc.) would purchase contracts at some specific value, say 1,000 MAD. If the payment rate is 20 percent and the insured purchased 10 units of the 1,000 MAD, the actual payment would equal .20 x 10 x 1000 = 2000 MAD. The contract could also simply be sold in any MAD unit value. The principles are the same:

Indemnity = payment percentage x total MAD value or liability.

57. With rainfall contracts, the payment is based solely on the rainfall shortage event. If crops suffer a serious problem due to freeze, hail, or even excess rain, there may be no payment. These contracts offer the advantages outlined earlier and in Skees (2000). To make an assessment of how well the rainfall contracts will work, it was simply assumed that an insured would purchase a value that would equal the median revenue value. In this case, the unit is a province. Therefore, it was assumed that the value of the rainfall contract is equal to the median revenue. Now a very direct comparison can be made between the percentage below the rainfall strike and the percentage below the median revenue. In addition, the rainfall strikes were developed so that every province would pay the same premium rate for rainfall insurance—either 10 percent or five percent. Premium rates are the average of the percentage payments over the 21-year period. Table 6 shows the median rainfall and the trigger or strike rainfall levels for both the 10 percent and five percent premium contracts in each of the seventeen provinces in the three recommended zones.

Table 6. Median Rainfall and Strike Rainfall for 10% and 5% Contract

Province	Zone	Median Rainfall mm	10% Prem Trigger mm	5% Prem Trigger mm	Median Revenue 1,000 MAD
BEN_SLIMANE	B.FAVORABLE	337	291	229	371,414
FES	B.FAVORABLE	253	225	190	307,836
KENITRA	B.FAVORABLE	400	304	208	657,184
KHEMISSET	B.FAVORABLE	337	291	229	602,410
MEKNES	B.FAVORABLE	328	300	251	220,858
RABAT	B.FAVORABLE	325	302	232	51,961
TAOUNATE	B.FAVORABLE	337	291	229	411,429
TAZA	B.FAVORABLE	355	291	227	365,672
AGADIR	D.SUD	200	169	126	199,784
EL_KELAA	D.SUD	264	207	169	763,529
ESSAOUIRA	D.SUD	243	196	157	263,937
KHOURIBGA	D.SUD	272	254	205	305,499
MARRAKECH	D.SUD	177	138	108	504,918
SAFI	D.SUD	280	239	191	655,781
CASABLANCA	INTERMED	294	243	185	170,130
EL_JADIDA	INTERMED	322	291	211	1,104,407
SETTAT	INTERMED	305	272	210	1,694,888

58. Premium payments are simple to calculate:

Premium payment = Premium rate x total MAD value or liability

For example, a farmer purchasing rainfall insurance with a value or liability equal to 10,000 MAD would pay 10,000 x .1 = 1,000 MAD.

59. At this point, estimates comparing gross revenue for the province with no insurance and with rainfall insurance can be developed. With insurance, one adds any indemnity payments and subtracts the premium values from the revenue values with no insurance:

With Insurance $Revenue_{tpc}$ = $Revenue_{tpc}$ + Indemnity – $Premium_{tpc}$
where t= year, 1979-1999 : p=province; 1-17: and c=crop; 1-4
Premium = either the 0.10 or the 0.05 rate x median income
Indemnity = payment percentage x median income

60. It is now possible to make a direct comparison of relative risk with and without the rainfall contracts. Table 7 presents these results for both the 10 percent and five percent contracts. As one would expect, the reductions in relative risk are significantly greater with the 10 percent contract than the five percent contact. The weighted average relative risk is 42 percent without insurance. This declines to 36 percent with a five percent insurance contract and to 30 percent with a 10 percent insurance contract. In percentage terms, the relative risk goes down by 14 percent with the five percent contract

and by 29 percent with the 10 percent contract across these 17 provinces. In either case, the results are encouraging as the rainfall contracts demonstrate value in reducing risk.

Table 7. Reduction in Relative Risk With Rainfall Contracts

		CV with No Insurance	CV with 10% Contract	Reduction with 10% Contract	CV with 5% Contract	Reduction with 5% Contract
BEN_SLIMANE	B.FAVORABLE	46%	35%	-24%	40%	-13%
FES	B.FAVORABLE	46%	37%	-20%	41%	-11%
KENITRA	B.FAVORABLE	35%	23%	-34%	28%	-20%
KHEMISSET	B.FAVORABLE	41%	29%	-29%	34%	-17%
MEKNES	B.FAVORABLE	37%	27%	-27%	31%	-16%
RABAT	B.FAVORABLE	39%	33%	-15%	35%	-10%
TAOUNATE	B.FAVORABLE	44%	33%	-25%	37%	-16%
TAZA	B.FAVORABLE	42%	32%	-24%	35%	-17%
AGADIR	D.SUD	48%	44%	-8%	46%	-4%
EL_KELAA	D.SUD	54%	46%	-15%	50%	-7%
ESSAOUIRA	D.SUD	54%	42%	-22%	48%	-11%
KHOURIBGA	D.SUD	62%	56%	-10%	58%	-6%
MARRAKECH	D.SUD	54%	45%	-17%	49%	-9%
SAFI	D.SUD	52%	41%	-21%	45%	-13%
CASABLANCA	INTERMED	48%	37%	-23%	41%	-15%
EL_JADIDA	INTERMED	40%	30%	-25%	35%	-13%
SETTAT	INTERMED	63%	50%	-21%	56%	-11%
Total Market	**Total Market**	**42%**	**30%**	**-29%**	**36%**	**-14%**

61. Analysis for Kenitra gives a clear view of how these contracts stop the downside risk in revenue for the province. Significant income losses are replaced in 1981, 1992, 1993, and 1995 for this case. One can also see that the revenue without insurance is consistently higher in years when there are no losses. At this point it becomes useful to index everything so that any different unit values can be expressed as percentages. Indexing gives a direct comparison of the revenue changes with and without insurance. All values can be easily indexed now by using the ratio of actual revenue in a given year over the median revenue:

$$\text{REVINDEX} = \text{Actual revenue}_{tp} / \text{Median Revenue}_{p}$$

where t = year and p = province (note there is no c as revenue is for all 4 crops)

Since premium rate and rainfall contract payments are also percentages, it is now easy to adjust the REVINDEX value to reflect the effect after a purchase of insurance:

$$\text{REVINS} = \text{REVINDEX} + \text{Payment percentage} - \text{Premium rate (either 0.10 or 0.05)}$$

62. The details of these indexes appear in Table 8. For example, 1995 is the worse year in the 21 year period. In this year, revenue from the four crops was 28 percent of normal. Under a 10 percent contract, the rainfall payment percentage is 50 percent. The premium rate is 10 percent. Thus the REVINS = 28 percent + 50 percent -10 percent =

68 percent. Obviously, 68 percent of revenue is much better than 28 percent. Had the five percent premium rate contract been used the results would have been less favorable but still good: REVINS =28 percent +27 percent -5 percent = 50 percent rather than 28 percent of the normal revenue.

Table 8. Kenitra Revenue with and without Rainfall Insurance

	Revenue Without Ins./ Median Rev	Revenue With 10% Ins/ Median Rev	10% Ins Payment Percentage	Revenue With 5% Ins/ Median Rev	5% Ins Payment Percentage
1979	87%	77%	0%	82%	0%
1980	105%	95%	0%	100%	0%
1981	47%	66%	29%	42%	0%
1982	115%	105%	0%	110%	0%
1983	118%	108%	0%	113%	0%
1984	101%	106%	15%	96%	0%
1985	84%	74%	0%	79%	0%
1986	112%	102%	0%	107%	0%
1987	80%	70%	0%	75%	0%
1988	109%	99%	0%	104%	0%
1989	94%	84%	0%	89%	0%
1990	100%	90%	0%	95%	0%
1991	99%	89%	0%	94%	0%
1992	49%	101%	61%	88%	44%
1993	37%	83%	55%	67%	35%
1994	149%	139%	0%	144%	0%
1995	28%	68%	50%	50%	27%
1996	114%	104%	0%	109%	0%
1997	81%	71%	0%	76%	0%
1998	155%	145%	0%	150%	0%
1999	121%	111%	0%	116%	0%

63. These indexes also afford an opportunity to examine the performance of the rainfall insurance contract in more detail. Clearly one would like to receive payments from rainfall contracts in the crop years with the worst revenue shortfalls. The 21 years of revenue data were sorted from the worst year to the best year. The poorest three years were then identified for each province. The question then becomes, does the REVINS index exceed these three years? If so, this suggests that buying rainfall insurance will make the province better off in the lowest 15 percent of the events, or in the years that represent one in seven year events. This is a reasonable expectation for this type of insurance, yet it is a difficult test because payments are based solely on rainfall events for an extended time. In addition, some of the rainfall data is not even from stations within the provinces but is the average for the zone.

64. Table 9 provides detail for the underpayments in the lowest three years. The lowest year represents a one in 21 year event; the second lowest year is approximately a one in 10 year event and the third lowest year is a one in seven year event. The values in the table under each of these categories are the difference between the lowest revenue value and the REVINS value. For example, there would be no rainfall payment in Marrakech in 1987 because the REVINS value is 21 percent. The value in the one in 21 year column is four percent, which means that REVINS is four percent below the lowest REVINDEX value. The value in the one in seven year column is 10 percent below the

third lowest REVINDEX value. It is interesting to note that only two events have lower REVINS values than the lowest values of revenue. With 17 provinces and 21 years, there is a total of 357 events, so having only two events that are lower than the lowest REVINEX suggests that this would happen less than one percent of the time. Even the one in seven year event only occurs 10 times or about three percent of the time. Under the five percent premium rate contract, this value increases to about seven percent.

Table 9. Underpayments Based on Lowest 3 Years of Revenue

				REVINS as percent points below REVINDEX in an event with Frequency:			
Year	Region	REVINDEX	REVINS	>1 in 21	>1 in 10	> 1 in 7	Payment Percentage
10% Premium Contract							
1983	KHOURIBGA	5%	-5%	10%	32%	34%	0%
1987	MARRAKECH	31%	21%	4%	6%	10%	0%
1993	AGADIR	39%	59%		5%	11%	30%
1983	EL_KELAA	6%	27%		19%	27%	32%
1990	EL_KELAA	54%	44%		2%	10%	0%
1984	KHOURIBGA	30%	20%		7%	10%	0%
1993	SAFI	35%	27%		5%	8%	2%
1983	SETTAT	6%	7%		2%	3%	11%
1992	FES	25%	33%			2%	18%
1995	RABAT	10%	34%			18%	34%
5% Premium Contract							
1983	KHOURIBGA	5%	0%	5%	27%	30%	0%
1983	SETTAT	6%	1%	5%	8%	9%	0%
1995	ESSAOUIRA	18%	18%		3%	6%	5%
1993	AGADIR	39%	41%		24%	30%	7%
1981	EL_JADIDA	24%	39%		7%	12%	20%
1983	EL_KELAA	6%	16%		30%	38%	16%
1992	FES	25%	23%		2%	13%	3%
1981	KHEMISSET	38%	35%		3%	12%	2%
1984	KHOURIBGA	30%	25%		2%	5%	0%
1987	MARRAKECH	31%	26%		1%	5%	0%
1995	RABAT	10%	19%		15%	33%	14%
1993	SAFI	35%	30%		3%	5%	0%
1995	SAFI	9%	29%		4%	6%	25%
1987	AGADIR	70%	65%			5%	0%
1981	BEN_SLIMANE	49%	46%			3%	2%
1995	BEN_SLIMANE	8%	48%			1%	44%
1981	CASABLANCA	50%	45%			5%	0%
1995	CASABLANCA	12%	40%			10%	34%
1990	EL_KELAA	54%	49%			5%	0%
1981	KENITRA	47%	42%			5%	0%
1981	MEKNES	55%	50%			5%	0%
1992	MEKNES	46%	55%			0%	13%
1993	RABAT	34%	44%			8%	16%
1993	TAZA	43%	39%			4%	1%

Rainfall Plus Area Revenue Contracts

65. These results raise some questions about how much value might be obtained if one combined the rainfall contracts with area revenue insurance (with area yields varying, but prices and area remaining constant). Therefore, an area revenue policy was developed that would pay when the rainfall payment was less than a calculated area revenue contract.

Area revenue payment = (Trigger on revenue – actual revenue) / Trigger on revenue
If percentage payment for rainfall < area revenue payment
then the new payment equal the area revenue payment.

To keep it affordable, the area revenue policy was set so that the pure premium rate would equal two percent. Thus, the combined pure premium would equal 12 percent (10 percent for the rainfall contract and two percent for the added value of the area revenue contract).

66. The combination of rainfall and area yield gives added reduction in relative risk. For only a two percent premium rate, the three-zone area relative risk can be decreased by about four percentage points, down to 28 percent relative risk. This is 33 percent below the relative risk without insurance (42 percent). Furthermore, there are only three cases where the REVINS index would not be greater than the third lowest revenue. Thus the added value can be significant. Beyond this advantage of the combined policy, the combination may also make reinsurance in the international capital markets more affordable for Morocco. The capital markets may be more willing to insure or hedge against rainfall risk than against area yields that are developed by the Moroccan government.

Understanding the Profile of Risk for Morocco

67. The model now allows an examination of the implications of various contracts on the aggregate losses for a potential test market of the three zones. Table 10 presents the loss ratio for the sum of all indemnities over the sum of all premiums for the market area. Premiums and losses are set based on the median revenue. The implicit assumption is that participation levels would be the same throughout the region. Table 10 gives some reason for concern: loss ratios exceed 100 percent in seven of the years. Thus a loss ratio in excess of 100 percent occurs in about one out of every three years. To be explicit, if 10 million MAD is insured at a premium rate of 10 percent, premiums of 1 million MAD will be collected. If the 1995 event is repeated, and the loss ratio is 500 percent, total losses will be 5 million MAD. With only 1 million MAD in premiums, the net losses would be 4 million MAD. Of issue here is how to finance indemnity payments in excess of premiums collected.

Table 10. Various Aggregate Loss Ratios			
Year	Loss Ratio for a 10% Rainfall Contracts	Loss Ratio for Combined Policy	Loss Ratio for Residual 2% Area Yield Contract
79	2%	0%	10%
80	7%	8%	0%
81	289%	281%	327%
82	40%	35%	70%
83	233%	140%	701%
84	142%	170%	0%
85	4%	5%	1%
86	5%	6%	0%
87	106%	101%	127%
88	0%	0%	0%
89	9%	10%	0%
90	6%	6%	4%
91	0%	0%	0%
92	359%	398%	166%
93	351%	383%	191%
94	0%	0%	0%
95	494%	496%	480%
96	0%	0%	0%
97	3%	0%	18%
98	0%	0%	0%
99	51%	61%	3%

Conclusions and Recommendations

68. Nearly half of the people in Morocco live in rural areas, and agriculture accounts for almost one-fifth of the country's GDP on average. Moroccan agriculture is highly dependent on rainfall and other climatic variations, and production fluctuates widely due to these variations. This is especially true for cereal production, which constitutes the most significant agricultural resource. Drought is a recurring problem in Morocco, and in addition to the risk management techniques currently employed by farmers, they should also be encouraged to explore other methods such as dry-land farming techniques in order to decrease their exposure to drought risk.

69. The government has incurred increasingly significant drought-related costs, both for direct subsidies and relief programs for farmers (6.5 billion drought catastrophe program in 1999-2000) and for expenses indirectly related to the drought problem, such as capital injections for CNCA due to the high level of non-performing agricultural (and other) loans. The government is seeking ways to help farmers' manage their drought risk while controlling its fiscal costs.

70. MAMDA has implemented a government-subsidized drought insurance scheme, which, starting in 1999-2000, is partially based on area yield. The government

contributes 120 million MAD per year to this scheme, plus partial subsidies of the farmers' premium payments. The program is limited to an area of 300,000 ha, of which only 111,697 ha were subscribed last year. Although the participation rate is rather low, it has increased due to CNCA's requirement that insurance be purchased in order to obtain a crop loan. In 1999-2000, CNCA sold about 92 percent of all drought insurance policies, while MAMDA sold about eight percent. Indemnities under this program are limited to 1,000 MAD/ha; 2,000 MAD/ha; or 3,000 MAD/ha, which is a constraint. The current scheme is limited not only in indemnification levels, but also in the area covered, and it is heavily dependent on government subsidies. In addition, because Level 2 and Level 3 insurance is based on assessments of individual farm yields, there are moral hazard and adverse selection risks, and the indemnification process is slow and costly to administer.

71. A drought insurance program based on rainfall contracts could have potentially significant benefits over the current scheme. For example using an objective trigger event should minimize moral hazard and adverse selection risk and promote a more rapid, streamlined pay-out process, in addition to increasing the potential interest of international re-insurers and capital markets in investing in the program. Based on analysis of rainfall and cereal yield data across the country, this study has determined that a rainfall index-based insurance product could be feasible in Morocco. The statistical correlation between rainfall and cereal revenue appears to be sufficiently strong in the 17 provinces in the *bour favorable*, *défavorable sud*, and *intermédiaire* climatic zones to support such a product (Table 5, above). Using data from a 21 year period, the trigger or strike rainfall level was determined for each of the 17 provinces for both a 10 percent premium contract and a five percent premium contract (Tables 6 and 7, above). These proportional contracts would pay the insured an amount based on the shortfall of actual rainfall during a determined period compared to the trigger rainfall, and the contracts could be purchased in any amount, allowing farmers to insure the full amount of their expected revenue.

72. Given the encouraging results of this feasibility analysis, we recommend to consider introducing proportional rainfall insurance contracts on a pilot basis in a few select provinces in Morocco. In selecting the provinces for the pilot scheme, it will be important to test the product in all three recommended agro-climatic zones. Using a variety of agro-climatic zones will help diversify the rainfall risk within Morocco and make the rainfall insurance contracts more attractive to MAMDA and foreign reinsurance companies. Future research will focus on further exploring the benefits of the proposed rainfall insurance scheme using historical simulations, where possible, and also making some assessment of the demand for rainfall index contracts.

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ANNEX 1: CALCULATING A DROUGHT THRESHOLD

In 1998 Barakat and Handoufe worked on agricultural drought-related problems in Morocco. In fact, drought may be defined and viewed from different angles. Accordingly, they defined agricultural drought as a rainfall deficit sufficient to cause a significant reduction in agricultural production. In the past it has been difficult to set a minimum rainfall threshold below which a drought year may be declared nationwide. Many authors used to set a threshold arbitrarily (e.g., rainfall below 10% of normal), but these methods are not realistic. Barakat and Handoufe instead used agricultural production data for which they estimated the normal value through a regression across time. They then determined the production threshold below which production in a given year is considered drought-stricken. The estimation was based on a 95 percent confidence interval on the regression line. The formula used for the confidence interval was:

$$S = y(x_0) - t_{1-\frac{\alpha}{2}} \left[\sqrt{\sigma^2 x.y [n + \frac{1}{n} + \frac{(x_0 - x)^2}{SSEx}]} \right]$$

where n, x_o, x, $y(x_o)$, $\sigma^2 x.y$ and SSEx are respectively the number of observations, the corresponding year, the mean value of observed years, the calculated value of production from the regression, the residual variance and the sum of squared errors of x.. The Student t value with n-2 degrees of freedom is denoted by $t_{1-\alpha/2}$. Any production level below the lower bound of the confidence interval is considered to be a drought year. The study was based on eight selected rainfall stations that were found to be representative of the country based on specified criteria. They also measured drought intensity across time as stated above. Different methods such as the Palmer Drought Severity Index are also currently used to measure drought intensity. The method used by Barakat and Handoufe is based on the following formula:

$$DI_x = 100(S-P_x)/S$$

where DIx is the drought intensity during a given year x, S being the lower bound of the confidence interval stated previously and Px the cereal production during year x. In their work, they also set different rainfall deficit thresholds between October and May (the production period) for the eight selected rainfall stations in cereal production regions (see Table A.1).

Table A.1. Different Rainfall Deficit Thresholds (in %) between October and May

Selected Station and Normal Rainfall (mm)	Security Threshold	Alarm Threshold	Tolerance Threshold	Critical Threshold	Maximum Deficit	Year
Taza (629.2)	31.2	32.2	38.9	39.7	69.0	1994/95
Meknes (555.2)	19.3	31.0	32.5	34.5	53.7	1994/95
Azilal (508.0)	22.7	25.2	37.1	41.3	70.0	1980/81
Fes (503.2)	26.5	26.9	33.4	34.3	68.9	1994/95
Khemisset (483.8)	17.8	20.1	27.5	34.3	50.7	1994/95
Ben Slimane (458.6)	10.5	20.1	30.2	38.9	70.2	1994/95
Safi (366.0)	13.3	25.2	26.2	36.6	60.0	1986/87
Settat (358.2)	17.2	25.5	41.8	45.2	60.2	1994/95
Average	**19.8**	**25.8**	**33.5**	**38.1**	**62.9**	
Coefficient of Variation CV (%)	34.3	17.0	16.5	10.3	12.5	

Source: Barakat and Handoufe, 1998.

Note: In the above table,

- The security threshold is the deficit reached without any fear of drought.
- The alarm threshold corresponds to the minimum rainfall deficit registered during a drought year.
- The tolerance threshold is the maximum deficit reached without the occurrence of a drought.
- The critical threshold is the deficit from which the occurrence of a drought is certain.
- The maximum deficit is the greatest deficit reached during the time series studied.

They found a linear relationship between the drought index estimated (DI) and the production deviation to the normal (Y). The relationship was: Y = 2.253(DI)+ 17,790 with a coefficient of determination, $R^2 = 0.925$.

ANNEX 2: DE-TRENDING YIELD DATA

Data for the four commodities, barley, hard and soft wheat, and maize, were de-trended using robust procedures that have been used to de-trend county yield data for the U.S. area-based crop insurance program, The Group Risk Plan. These procedures involve a customized windsoring technique and use of linear splines. Linear splines are used when there is a major change in the system during a time-series. In this case, Morocco significantly expanded plantings in the late 1980s. A linear spline basically allows for fitting of two linear regressions over the 21 year period with a knot in and around the year 1988. An SAS software package was used to fit these data. A nonlinear procedure smoothes the data around the knot. The windsoring technique involves fitting the spline two times. In the first fit, outliers are identified. The second fit dampens the influence of outliers by either capping or cupping them.

Figures 1 and 2 show the trends in harvested hectares for wheat and barley respectively. Since 1979, the harvested wheat hectares has nearly doubled, with most of this increase in soft wheat. Wheat production has increased from just over 1.5 million hectares to between 2.8 and 3.0 million in the past 20 years, while barley production has gone from around 1.6 million to 2.2 million hectares. The data used in Figures 1-4 are from the USDA world crop data base and match the data supplied by the Ministry of Agriculture in Morocco quite well. Figures 3 and 4 show the trends in yield per hectare for the national data. They demonstrate that the trends have slowed or reversed for the nation. Wheat yield increases have turned flat national and barley yield increases are now negative. Two probable factors may help explain these trends: 1) rainfall has been lower on average with more serious droughts in the 1990s; and 2) the increased plantings are probably occurring on less productive land with lower yields, bringing the average yield down. In either case, there are serious concerns about how to develop policies to address productivity of cereal crops in Morocco.

Trends were developed for every province and crop. These trends were then used to adjust the historic yields for today's conditions. A rather straightforward and commonly used adjustment process was implemented whereby the ratio of the actual yield to the trend yield was multiplied by the 1999 forecast yield. These procedures also provide a simple means to adjust for heteroscedasticity (i.e., the variance in the yields around trend are increasing through time).

$$\text{Adjusted Yield}_t = (\text{Actual yield}_t / \text{Trend yield}_t) \times \text{Forecasted 1999 Yield}$$

where t = 1960 to 1999 for the figures and 1979 to 1999 for the province data.

Once data are normalized for any trends, it becomes possible to examine the risk profile for various provinces and then to aggregate that risk into any level desired (e.g., country or zone).

Figure 1: Trend in Wheat Harvested Hectares

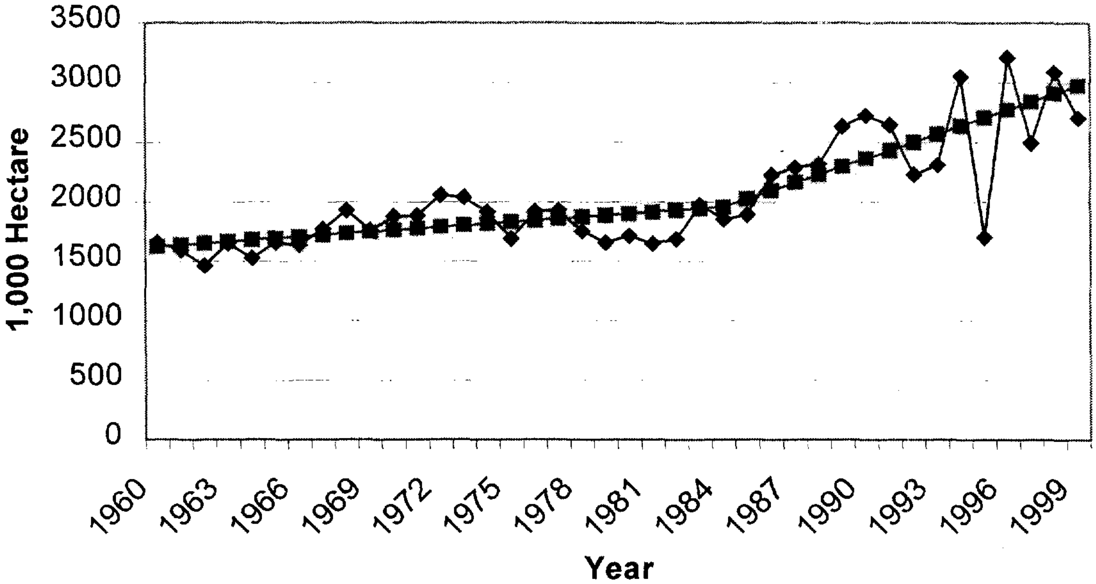


Figure 2: Trend in Barley Harvested Hectares

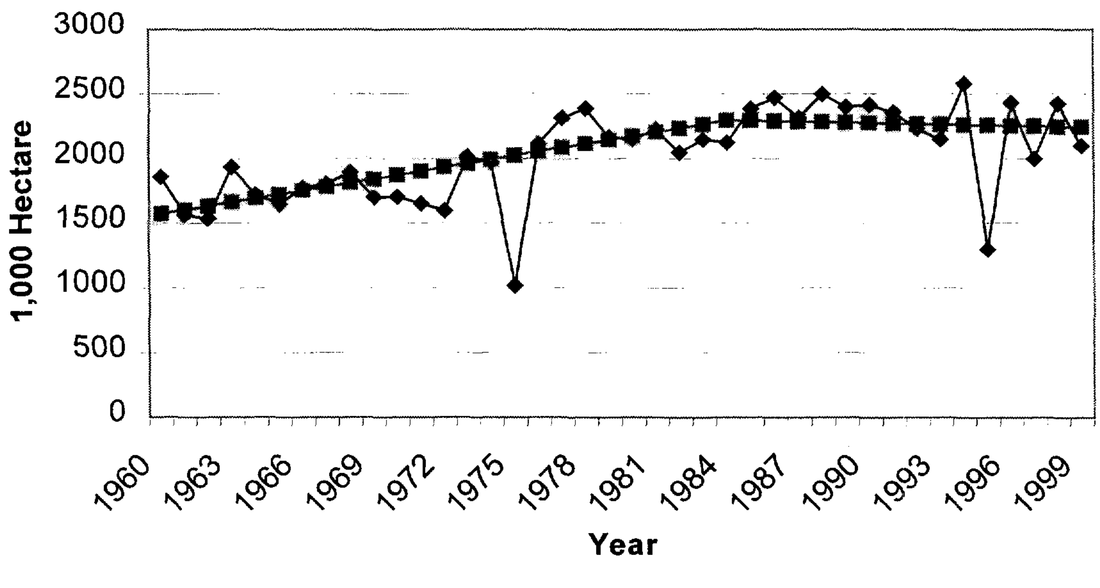


Figure 3: Actual and Adjusted Wheat Yields

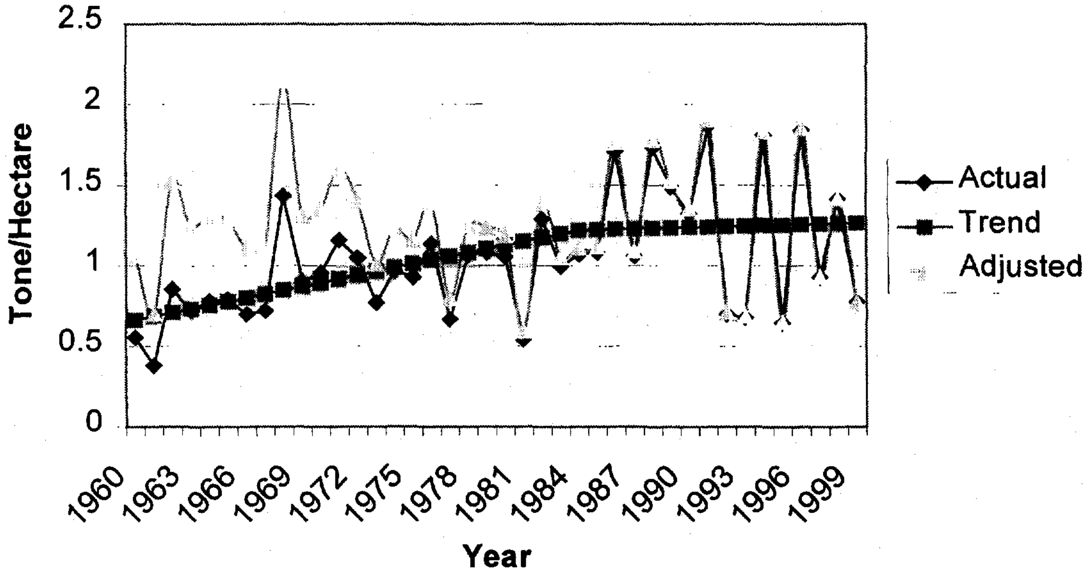
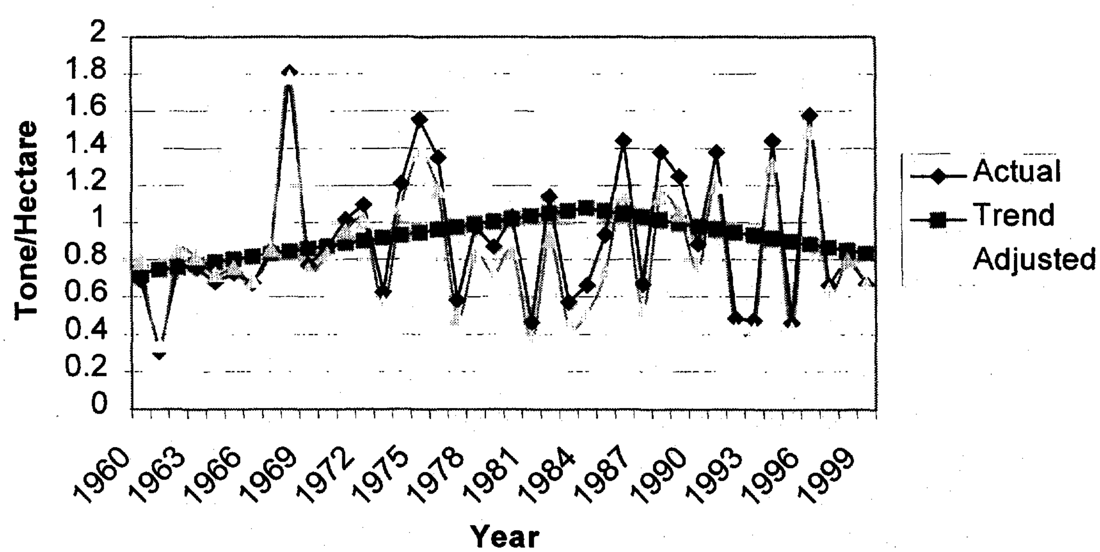


Figure 4: Actual and Adjusted Barley Yield



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