

# Market Reforms, Research Policies And SADCC Food Security



*Edited by*

*Mandivamba Rukuni & J.B. Wyckoff*

*University of Zimbabwe IIZIMSII Food Security Research in Southern Africa Project*

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# Regional Crop Production Instability In Zambia And Its Implications For Food Security

*Phiri Maleka, John Milimo and Catherine Siandwazi<sup>1</sup>*

## INTRODUCTION

The occurrence of instability in crop output increases risk and uncertainty in the agricultural sector. This may adversely affect the decision making process of both farmers and policy makers for stabilising output and food security in a country (Murshid, 1987; Singh, 1989). Furthermore, instability in crop production has an adverse effect on prices offered to farmers for their crops (Amhed, 1988). This is because producer prices of crops rise when output falls and *vice versa*. The rise and fall of producer prices due to crop production instability ultimately results in fluctuations in farmers' income and food consumption levels. This in turn affects food security. The definition of food security in this study follows that of Hay and Rukuni (1988) which encompasses all endeavours to stabilise growth of food output and food consumption.

The objective of stabilising crop production has been emphasised in all of Zambia's past and present National Development Plans.<sup>2</sup> However, this objective has not been realised and instability in crop production remains a problem at both the national and regional levels.<sup>3</sup>

Despite this crop production instability and its potential detrimental effects on prices, incomes and food security, no attempt to measure crop production instability in Zambia at the national and regional levels had been undertaken. This paper,

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<sup>1</sup>Phiri Maleka and John Milimo are with the Rural Development Studies Bureau of the University of Zambia while Catherine Siandwazi is Coordinator, National Food and Nutrition Council.

<sup>2</sup>Zambia has formulated four national development plans since it gained its independence in 1964.

<sup>3</sup>See Annual Plans 1982 to 1988 and Economic Reports 1982 to 1988.

reports an attempt to measure crop production instability in Zambia at the regional or provincial levels.<sup>4</sup> The objectives of this paper are:

- to measure crop production instability in Zambia's nine regions/provinces for maize, cotton, sorghum, sunflower, soyabeans and rice. These crops are chosen because of their national importance and data availability (Fourth National Development Plan, 1989);
- to identify the correlation between the production of maize and other crops. Maize is chosen as a yardstick because it accounts for more than 60 percent of the value of crop output in Zambia (Levi and Mwanza, 1986; Sano, 1988);
- to measure the relationship between instability in yield and hectareage and the instability of production of these crops; and,
- to identify the implications of crop production instability on food security.

#### SOURCES OF DATA AND METHODOLOGY

Relationships between instability in crop production, yields and hectareage planted were estimated using multiple regression and other analytical techniques. Seven years of time series data (1980-1986) on production, yield and hectareage of the above six crops were used for these estimates. These data were collected from secondary sources for all nine of Zambia's regions/provinces: Central, Eastern, Lusaka, Southern, Northern, Luapula, Copperbelt, North-Western and Western. It is recognised that seven years of data covers too short a time period to make a definitive analysis of crop production instability. However, data availability established the effective constraints. Data sources were official government publications including Annual Plans 1980-1986, Economic Reports 1980-86, Food Strategy Study 1981-1985 and Agricultural Statistics Bulletins 1984 and 1986.

Crop production instability can be measured by various methods. The method used by several researchers (Firch 1977, Sagar 1980, Green and KirkPatrick 1981, Hazell 1982, 1984, 1986, Alauddin and Tisdell 1986, Murshid 1986 and Singh 1989) is the coefficient of variation. This is defined by Murshid (1986) as the standard deviation divided by the mean and multiplied by 100. An equation can be written as:

#### EQUATION 1

$$CV = \frac{S}{\bar{x}} \times 100$$

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<sup>4</sup>The words regional and provincial are used interchangeably in this paper.

Where:

CV = Coefficient of Variation;

S = Standard Deviation; and

$\bar{x}$  = Mean.

The coefficient of variation is used in this study because it is both easy to compute and to understand (Murshid, 1986). It is an appropriate instrument to measure instability in situations where data are limited and do not show any trend pattern (Research Notes, 1989).

To measure instability in crop production, coefficients of variations were calculated for production, yield and hectarage for the above mentioned crops in all of Zambia's regions/provinces for the 1980-1986 period. The values for these calculated coefficients of variation are reported in Tables 1, 2 and 3. The correlation between maize production and production of other crops is shown in a correlation matrix table, Table 4.

Since instability in crop production is a function of instabilities in hectarage and yield of crops (Murshid, 1986), and as the coefficient of variation for each crop is computed for the nine regions, it is possible to apply a regression model to measure the contribution of the variations in yield and hectarage to the variation of production. A log transformation regression model was used to measure these relationships for all of the six crops analysed. In this model, the dependent variable is the coefficient of variation of the production for each of the crops, Table 1. The independent variables are the coefficients of variation of yields and hectarages for the respective crops presented in Tables 2 and 3. The specification of this model is as follows:

#### EQUATION 2

$$\log P_{icv} = \log A_0 + A_1 \log Y_{icv} + A_2 \log H_{icv} + U$$

Where:

$P_{icv}$  is the production coefficient of variation for crop i;

$A_0$  is a constant;

$Y_{icv}$  is the yield coefficient of variation for crop i;

$H_{icv}$  is the hectarage coefficient of variation for crop i;

U is the error term with constant variance and zero mean.



The estimated coefficients of the variables in equation 2 measure the contribution of yield and hectarge to total crop production instability.

## RESULTS AND DISCUSSIONS

The results of crop production instability are classified into three components:

- results pertaining to the measurement of crop production instability;
- results identifying the correlation between the production of maize and the production of other crops; and,
- results measuring the contribution of variation in yield and hectarge to variation in production of the six crops.

The presentation and discussion of results follows this classification.

### Measurement of Crop Production Instability

Results of crop production instability are reported in Table 1. This table can be analysed from two perspectives, namely, the perspective of analysing instability in crop production according to crops, and, that of analysing crop production instability on the basis of regions. The analysis of the results of this table takes into consideration both of these perspectives.

**Table 1**  
**Coefficient of variation for production of crops by region**  
(%)

Region/Province	Maize	Cotton	Sorghum	Sunflower	Soyabeans	Rice
Central	12,22	63,23	10,53	39,52	62,30	64,74
Copperbelt	50,82	104,14	37,92	50,70	54,00	73,49
Eastern	18,24	39,38	31,02	37,39	21,41	18,56
Luapula	41,05	103,57	59,97	42,49	106,90	46,62
Lusaka	24,21	39,39	71,09	58,21	88,13	87,21
Northern	40,03	103,93	68,91	54,95	154,35	46,42
North-Western	25,48	59,80	69,52	77,81	95,86	53,73
Southern	33,62	53,58	88,37	50,74	66,64	74,05
Western	32,63	78,19	62,57	34,13	54,67	33,02

The analysis of crop production instability according to crops is done by looking at the rows of Table 1. For example, in the row indicating the Central Region, rice shows the highest crop production instability. This is followed by cotton and soyabeans. Maize and sorghum show the lowest crop production instability. The high production instabilities for rice, cotton and soyabeans were due to government policies designed to increase production of these crops during the 1980s.

Since it is hypothesised that crop production is influenced by yield and hectareage, the computed coefficient of variations for yield and hectareage, Tables 2 and 3, are compared with the computed coefficients of variation for crop production presented in Table 1. This permits us to draw inferences on whether a relationship, in terms of the magnitude of the respective coefficients of variations, (*i.e.*, production *versus* hectareage and yields), exists. Such a comparison, though crude, gives a rough indication as to whether crop production instability can be explained by instabilities in yield and hectareage. On the basis of this comparison, one observes a general pattern that high crop production instabilities, Table 1, are roughly matched by high yield and hectareage instabilities, Tables 2 and 3. Hence, one might deduce that instability in yield and hectareage explains crop production instability. This holds true for most of the crops shown in Tables 1, 2 and 3.

Similarly, in the row indicating the Northern Region, Table 1, soyabeans show the highest production instability. This is followed by cotton and sorghum. The lowest production instability in the Northern Region is observed in the maize and rice crops. The high production instability of soyabeans, cotton and sorghum may have occurred because of 1980 government policies which encouraged farmers in the Northern Region to grow more of these crops as complementary cash crops to maize and rice.

Columns in Table 1 give information on crop production instability according to regions. For instance, in the column indicating maize, Copperbelt has the highest maize production instability. This is followed by Luapula, Northern and Southern Regions. The lowest maize production instability is registered in Central and Eastern Regions. The high maize production instability in the Copperbelt Region seems to be explained by the high hectareage instability for the same crop in the same region, Table 3. This, in turn, might be a result of increased harvested hectareage in the 1980s for maize by large scale commercial farming enterprises.

For cotton, the highest production instability was in the Copperbelt (104.14 percent). This was followed by Northern and Luapula Regions, (103.93 percent) and (103.57 percent), respectively. The lowest production instability for cotton was in Lusaka (39.39 percent). The high production instability for cotton in the Copperbelt appears to be explained by high variation in cotton yield, Table 2. This high cotton yield instability seems to reflect the increasing application of modern technology by commercial farmers in cotton production.

The highest production instability of sorghum was in the Southern Region (88.57 percent), followed by Lusaka (71.09 percent) and North-Western (69.52 percent). The Central Region had the lowest production instability for sorghum. The high sorghum production instability in Southern Region may have resulted from the increased hectareages planted due to the government encouraging farmers to grow sorghum for the stockfeeds and bottled beer industries in Lusaka.

**Table 2**  
**Yield coefficient of variation for crops by region**  
 (%)

Region/Province	Maize	Cotton	Sorghum	Sunflower	Soyabeans	Rice
Central	15,00	25,37	20,56	9,19	37,63	27,27
Copperbelt	23,60	114,74	27,96	43,86	17,44	26,81
Eastern	14,73	21,79	45,40	7,21	25,06	13,59
Luapula	8,90	6,47	14,51	16,42	52,67	17,40
Lusaka	48,14	42,56	31,47	38,17	33,57	35,59
Northern	14,86	35,49	33,90	47,00	26,82	27,67
North-Western	18,92	17,27	79,92	5,35	31,61	24,83
Southern	13,18	25,63	54,66	38,55	36,14	44,54
Western	23,31	29,29	34,65	36,65	19,62	14,53

North-Western Region had the highest production instability for sunflower (77.81 percent), followed by Lusaka (58.21 percent), Northern (54.95 percent), and Copperbelt (53.70 percent). The Western Region had the lowest production instability for sunflower, (34.13 percent). Sunflower production instability in the North-Western Region seems to be explained by instability in hectareage allocated to sunflower, Table 3.

Soyabeans registered the highest production variability in the Northern Region (154.35 percent), followed by Luapula (106.90 percent), North-Western (95.86 percent), and Lusaka (88.13 percent). The Eastern Region had the lowest variability (21.41 percent). The high production instability of soyabeans in the Northern Region appears to be explained by the variability of hectareage for this crop, Table 3.

**Table 3**  
**Hectareage coefficient of variation for crops by region**  
 (%)

Region/Province	Maize	Cotton	Sorghum	Sunflower	Soyabeans	Rice
Central	16,98	41,60	3,31	12,09	71,08	48,20
Copperbelt	48,72	41,32	30,02	32,27	34,18	67,97
Eastern	14,43	31,89	17,94	18,77	27,43	16,47
Luapula	31,05	85,42	67,79	14,41	97,16	36,20
Lusaka	115,23	37,07	44,48	21,20	69,73	87,65
Northern	35,61	71,48	46,00	45,00	111,00	35,91
North-Western	15,69	101,43	14,92	75,66	101,00	53,05
Southern	20,31	27,51	54,88	40,79	77,64	20,25
Western	39,10	47,75	56,21	40,09	56,00	36,86

Rice showed the greatest production instability in Lusaka (87,21 percent), followed by the Southern (74 percent), and Copperbelt Regions (73,49 percent). The lowest variability occurred in the Eastern Region (18,56 percent). The high production instability for rice in the Lusaka Region seems to be explained by the variability of both yield and hectareage, Tables 2 and 3.

#### Variation of the Production of Maize in Relation to the Variation of Other Crops

Results showing the variation of maize production in relation to other crops are presented in Table 4. Columns of Table 4 relate to the relationship between maize and other crops by regions. Rows of the same table relate to the relationship between maize and other crops within regions. This relationship (correlation) might be highly/lowly positive or highly/lowly negative, respectively. If the relationship is positive, it indicates that the two crops are complementary. This means that an increase in the production of one crop results in a corresponding increase in the production of the other crop. A negative (correlation) relationship implies substitution between the two crops in question. Thus, an increase in the production of one crop results in the decrease in the production of the other (Murshid, 1986 and Hazell, 1986).

**Table 4**  
**Correlation matrix of production of maize in relation to the production of other crops**

Region/Province	Maize	Cotton	Sorghum	Sunflower	Soyabeans	Rice
Central	1,00	0,855	0,682	0,846	0,607	0,785
Copperbelt	1,00	0,629	0,046	0,953	-0,049	-0,461
Eastern	1,00	0,276	0,826	-0,209	-0,408	0,356
Luapula	1,00	0,637	0,746	0,102	0,735	0,707
Lusaka	1,00	0,225	0,719	0,657	0,223	-0,708
Northern	1,00	-0,092	-0,806	-0,016	0,022	0,711
North-Western	1,00	0,262	0,481	0,619	0,611	0,099
Southern	1,00	-0,063	-0,103	-0,629	0,847	-0,606
Western	1,00	0,277	0,669	0,508	0,833	0,315

Looking at the column which indicates cotton, one observes that a very high and positive production relationship exists between cotton and maize in the Central, Luapula and Copperbelt Regions. Thus, cotton and maize are highly complementary crops in these three Regions.

Similarly, the production relationship between maize and sorghum is highly significant and positive in the Eastern (0,826), Luapula (0,7457), Lusaka (0,719), Central (0,682) and Western Regions (0,669). The high and positive production relationship between sorghum and maize in these regions is not strange because,

whilst maize is grown as both a food and cash crop, sorghum is mainly grown for beer brewing. Moreover, both crops are grown during the same season.

There is a high and positive production relationship between maize and sunflower in the Copperbelt (0,953), Lusaka (0,657) and North-Western Regions (0,619). However, the production relationship between sunflower and maize, though highly significant, is negative in the Southern Region. The negative relationship between maize and sunflower in the Southern Region indicates that these two crops might be substitutes.

The production relationship between maize and soyabeans is highly significant and positive in Southern (0,735), Western (0,833) and Luapula Regions (0,735). Rice and maize showed a very high and positive production relationship in Central (0,785), Northern (0,711) and Luapula Regions (0,707).

The production relationship between maize and other crops within regions is observed across rows. For example, the relationship between maize and other crops in Central Region can be observed in the first row. Very high and positive production relationships exist between maize, on the one hand, and cotton, sorghum, sunflower, soyabeans and rice on the other, Table 4. The positive relationship between maize and other crops in the Central Region is expected because these crops are grown during the same season and by the same farmers using similar agricultural inputs (Annual Plans, 1984-1986).

However, the production relationship between maize and other crops in the Eastern Region is highly positive only for sorghum. The rest of the crops, apart from sunflower and soyabeans, have a low but positive production relationship with maize. Sunflower and soyabeans register low and negative relationships with maize. The negative relationship between sunflower and soyabeans on the one hand and maize on the other seems to confirm Sano's (1988) assertion that sunflower and soyabeans act as substitute crops for maize in the Eastern Region.

#### **Variation of Area and Yield to Variation in Total Crop Output**

Results showing the contribution of variation of hectareage and yield to total crop production variation are tabulated in Table 5. The results of this table can be interpreted by reading down the columns. For example, column 2, which represents maize, shows that variation in maize production is significantly influenced by the variation in hectareage at the five percent level of significance. The impact of variation in yield on variation in maize production, though significant, is less than that for hectareage, Table 5. Moreover the negative sign of the estimated yield coefficient is worrying because it is contrary to what one might expect. A positive relationship is normally expected to exist between variation in maize yield and variation in maize production.

**Table 5**  
**Contribution of yield and hectareage instabilities to total crop production instability**  
**(Dependent Variable (Total Crop Production))**

Independent/ Variable	Maize	Cotton	Sorghum	Sunflower	Soyabeans	Rice
Log (Yield)	-0,666	0,089	0,626	-0,039	-0,425	0,876
T - Values	(-1,62) <sup>b</sup>	(0,459)	(3,636) <sup>a</sup>	(-0,399)	(1,340)	(5,914) <sup>a</sup>
Log (Hectareage)	0,611	0,390	0,630	0,268	1,235	0,392
T - Values	(2,091) <sup>a</sup>	(1,300)	(6,908) <sup>a</sup>	(1,911) <sup>a</sup>	(5,486) <sup>a</sup>	(3,550) <sup>a</sup>
F - Ratio	2,205	0,850	30,069	1,829	18,478	34,041
R <sup>2</sup>	0,424	0,22	0,909	0,379	0,8603	0,919
Durbin-Watson	2,0	3,513	1,79	1,42	2,52	2,52

Note:  
<sup>a</sup> Significant at 0,05 percent level.  
<sup>b</sup> Significant at 0,10 percent level.

The R<sup>2</sup> indicates that variations in maize yield and hectareage explain about 42 percent of the total variation in maize production. The remaining 58 percent of the variation in maize production is explained by other factors such as rainfall. The Durbin Watson of 2,00 indicates the absence of autocorrelation in the maize equation.

Similarly, if we look at the last column, rice, it is observed that both the variation in rice yield and hectareage significantly influence variation in rice production at the five percent level of significance. The results of the rice column also indicate that the variability in rice yield and hectareage explains about 92 percent of total rice production variation. Again, a Durbin Watson coefficient of 2,52 is sufficiently high to indicate the absence of autocorrelation in the rice equation. Interpretation for the remaining variables in Table 5 follows a similar pattern.

#### IMPLICATIONS FOR FOOD SECURITY

Food security is usually defined as ensuring the availability of a sustainable supply of food at affordable prices to all members of society (Hay and Rukuni, 1988; Mellor, 1988; Hlophe, 1989 and Banda, 1989). The causes of food insecurity have been identified as: inadequate storage and poor transport facilities, a general low level of investment in agriculture and high consumer prices relative to peoples' income. (Dhliwayo, 1989; Takavarasha and Rukovo, 1989; and, Amani and Kapunda, 1989) If high crop production instability, Table 1, implies high crop output, then high crop production instability may have adverse implications on food security. This is because high crop output may result in low prices for farmers and

excessive government owned food stocks which create storage problems. For example, during the bumper maize harvest years of 1987-88 and 1988-89, much of the maize was not collected and moved to safe maize storage facilities resulting in significant losses in the maize crop. Factors contributing to this problem were poor road networks and inadequate transport facilities (Banda, 1989).

The impact of rural infrastructure on crop production (implicitly on food security) is clearly illustrated in the Bangladesh study by Ahmed and Hossain (1987) when they show that good infrastructure is associated with 92 percent more fertilizer use per hectare, 4 percent more labour per hectare in farming, 30 percent more non-farm employment and a 12 percent higher wage rate.

On the other hand, if low crop production instability reflects a low crop output, then food shortages might occur. This, in turn, will result in high food prices and hunger and malnutrition among the disadvantaged members of society.

Both upward and downward instability in crop production is of major concern to food security policy analysts because both situations involve some degree of risk (Hazell, 1986). However, the degree and seriousness of the risks involved will depend to a great extent on how far crop output is above or below national food requirements.

#### **Implications of Relationships Between Production of Maize and Other Crops**

Results of the relationship between production of maize and other crops are presented in Table 4. Other crops are compared to maize because it is assumed that most households in Zambia are concerned not only with maximising food consumption (security) but also with maximising income from growing non food crops (Maleka, 1990). This is the situation in some parts of Zambia. For example, farmers in Gwembe Valley grow cotton to raise money to purchase maize flour and other basic non food items. A similar situation was observed by Mellor (1988) who wrote that, besides spending their acquired income on food, smallholders in Bangladesh and Malaysia spend 35 and 40 percent, respectively, of their increments to income on locally produced non-agricultural goods and services. A similar study in Nigeria noted that small farmers spend as much as 20 percent of their increments to income on locally-produced agricultural goods, such as vegetables and livestock, thus contributing to employment creation in the rural sector.

#### **Implications the Variation of Yield and Area to that of Total Crop Production**

The estimated contributions of yield and hectarage to total crop production instability are presented in Table 5. The results show that, with the exception of cotton, there are significant relationships between the instability in hectarage and the instability of crop production. However, there are significant relationships between instabilities in yield and production for only three of the six crops.

Thus, it would appear that policies aimed at stabilising crop hectarages would have a greater impact on production instability than those aimed at stabilising yields. Promoting the expansion of hectarage, for example, when it is estimated that it has a more significant influence than yield on crop production instability, may be a less appropriate strategy than one which stabilizes hectarage. In general, the implications of Table 5 lie in formulating policies which promote food security through manipulating yield and hectarage variables for the crop being analysed.

## SUMMARY AND CONCLUSIONS

Crop production instability in Zambia has assumed a greater importance because of its implications for food security. No serious study has been undertaken to analyse crop production instabilities in Zambia in spite of this concern. This study used seven years of data (1980-1986) to generate coefficients of variation and a correlation matrix for total crop production, yield and hectarage by region/province. A log transformation equation was used to test whether yield and hectarage variability significantly influence total crop production instability.

The results reveal that instability in crop production varies by crop and region possibly because of climatic and ecological differences in the nine regions. The overall results indicate that regions with very high rainfall, (that is, regions with rainfall values above the national average), tend to have higher crop production instability than those with average and below average rainfall. Of the six crops covered in this analysis, cotton and soyabeans have higher production instability within these higher rainfall regions than other crops. The regions with high rainfall are: Northern, North-Western, Luapula and Copperbelt (Muchindu, 1986). The relationship between variability in maize production and variability in the production of other crops differs by crop and region.

The relationship between variations of hectarage and yield and variations in crop production, reveals that hectarage has a more significant influence on production instability than yield. This is contrary to the findings of Hazell (1984), Murshid (1986) and Singh (1988) who reported that yield rather than hectarage instability contributed more strongly to crop production instability.

The results of this paper have important implications for some aspects of food security in Zambia. For example, high and/or low instabilities on crop production have implications on farmers' and consumers' prices received/paid, transport, storage facilities required, *etc.* These in turn affect the year to year availability of food to consumers.

Given the limited nature of the time series data available for this study, the findings should be treated as tentative and interpreted with caution. More research in crop production instability and on food security should be undertaken to guide policy makers in Zambia.



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