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# **CAUSES OF INSTABILITY IN CEREAL PRODUCTION IN ETHIOPIA**

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# CAUSES OF INSTABILITY IN CEREAL PRODUCTION IN ETHIOPIA

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## **Abstract**

*In Ethiopia, average cereal production between the period 1990 and 2000 did not change significantly compared to the period between 1974 and 1990. However, cereal production between the period 1990 and 2000 was characterized by significant instability. This study reviews literature on factors with potential impact on instability in cereal production in Ethiopia and applies descriptive and variance decomposition procedures to determine the sources of increased instability in cereal production. It was found that production instability was caused more by increased yield instability than instability in an area. Yield instability could be the result of changes in technology, changes in policy and changes in weather conditions. It was concluded by this study that instability regarding yield was predominantly the result of weather variability. This is because, in Ethiopia, rainfall fluctuating from the long-term average is becoming more common, the use of high-powered inputs is limited to a small number of farmers, production is at subsistence level, and farmers' responsiveness to policy changes is constrained by infrastructural, institutional and the existing land policy.*

*Key words:* Cereals, detrending, differencing, production instability, variance decomposition, Ethiopia.

## **1. Introduction**

In Ethiopia, cereals, among which teff, barley, maize, sorghum, oats, millet and wheat, make up 85% and 90% of the total cultivated area and total production of field crops respectively and accounts for over 90% of modern input consumption (CSA, 2000; MEDaC, 1999). Cereal production has increased annually by 3% between 1960 and 2000. This phenomenon was, however, accompanied by increased variability in cereal production. The standard deviation of production of cereals as measured by the coefficient of variation (CV) around trend rose from 2% between 1960 and 1975 to 10% between 1974 and 1990 and to 13% between 1989 and 2000. These percentages are indicative of increased instability in cereal production. Instabilities in cereal production causes increased market and price instabilities and hence food insecurity.

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Studies of production instability hypothesize that variability increases with higher use of inputs, expansion of areas planted, weather variability and incentives. It was assumed in this study that the effect of short-term fluctuations in input use, weather and other factors which impact production variation in the short-term could be captured by yield (i.e. output per hectare). On the other hand, the effect of factors that could be considered long-term sources of production instability is assumed to be captured by fluctuation in areas cultivated (Hazell, 1984, 1985, and 1988a).

Hazell (1984, 1985 and 1988a), a pioneer in the study of production instabilities in cereals, computed fluctuations in cereal production directly by detrending the variables in question without studying the time series properties of the variables. What makes the present study different is that an attempt was made to apply time series econometric techniques in order to better understand the time series properties of the variables. Econometric theory recommends that least square detrending, to compute year-to-year fluctuations in cereal production, provides a better result only when a variable is confirmed to be a trend stationary process (Beveridge and Nelson, 1981; Chan, Hayya and Ord, 1977). If a variable is found to be a difference stationary process, differencing instead of detrending is the appropriate technique to compute year-to-year fluctuations in a time series variable.

The objective of this paper is to study the extent of instability in cereal production and to investigate causes of instability in cereal production in Ethiopia. The remaining sections of this study are organized as follows. Section 2 reviews literature on the potential sources of instability in cereal production in Ethiopia. In Section 3, descriptive statistics are applied to determine the extent of instability in cereal production and to identify possible causes of instability in cereal production by dividing available data into two periods. In Section 4, a variance decomposition method is employed to decompose changes in the average and variance of cereal production into four and ten component parts, to obtain insight into the possible causes of instability in cereal production in recent years. Finally, in Section 5 conclusions are provided.

## **2. Factors with potential effects on variability in cereal production**

Several factors could cause instabilities in cereal production in Ethiopia, among which fluctuations in areas sown, fluctuations in yield, fluctuations in weather conditions and changes in pricing and marketing policies. The potential effects of these factors on cereal production in general and cereal production instability in particular are discussed in this section.

### **2.1 Change in areas sown**

In Ethiopia, changes in areas sown constitute the major sources of production increase. This can be attributed to the domination of small-scale farmers, characterized by low input and low output rain-fed mixed farming with traditional technologies. Small-scale farmers constitute over 95% of total area sown and over 90% of agricultural output (MEDaC, 1999).

In Ethiopia, expansion in areas sown as a potential source of production increase in recent years is being challenged by a decrease in holding sizes, which are presently estimated to be less than one hectare. Decrease in holding size is considered to be a direct consequence of the existing land policy, which disallows transfer of land and declares land the property of the state. Until 1989, new claims for land were entertained through land redistribution schemes. However, in 1989, land redistribution was officially banned because of decline of holding size. Consequently farmers who wish to plough, but who have no land, rely on family plots or enter into various forms of sharecropping arrangements. According to the 1996/1997 survey, 63% of households held less than 1 hectare each, while 24% and 13% respectively held between the range of 1.01 and 2.00 hectares and more than 2 hectares each (CSA, 1997). Comparisons with earlier survey reports indicate that the number of households with relatively larger plots is decreasing, while smaller plots are increasing. This can be attributed to the effect of land redistribution schemes.

The facts about land use at the national level have potentially imposed limits on an increase in areas sown as a major source of increase in production. This is because firstly, the amount of land being withdrawn from agriculture due to land degradation has increased over the years, resulting in an increase in land classified as non-suitable for farming. Secondly, cultivated land as a percentage of agricultural area has increased. It has risen from 21% between 1961 and 1975, to 32% between 1992 and 2000. The increase in the area cultivated is made possible by the expansion of cultivation to areas that were previously designated as permanent pasture or forests, or land previously categorized as unsuitable for farming. Forests covered 40% of the land area at the turn of the century, but less than 4% today (Alemu, 2002).

## **2.2 Change in yield levels: a measure of technical advancement in agriculture**

In this section, the possible impact of yield, which represents production per hectare, on instability in cereal production is discussed. Theoretically, yield is affected by agricultural research and extension, weather, incentives, and the like. In this section, the focus is only on the effect on yield of agricultural research and extension. Discussions on the potential effects of other factors on the instability in cereal production will be discussed in the subsections that follow.

Increase in yield entails increased use of high-powered inputs. The availability and diffusion of the latter rest on the growth of agricultural research and extension in a country. In this case, the term high-powered input refers to chemical fertilizers, pesticides, seeds of improved varieties, herbicides and the like. Agricultural research and extension are, in turn, affected by choices regarding development policies. A policy that prioritizes agriculture in resource allocation is vital for the expansion of agricultural research and extension activities. This is because agricultural research generates improved technologies, while agricultural extension popularizes the use of these technologies among farmers.

The beginning of agricultural research in Ethiopia dates to 1947, when it was initiated by the Ambo Agricultural High School. Later, the Jimma Agricultural and Technical School, in 1952, and the Alemaya College of Agriculture, in 1956, joined the Ambo Agricultural High School (Goshu, 1995). In 1966, the Institute of Agricultural Research (IAR) was established (Goshu, 1995), and renamed The Ethiopian Agricultural Research Organization (EARO) in the 1990s. Since then, the Regional Research Centers and the Biodiversity Institute have also entered the agricultural research arena (EEA, 2000).

Despite the long history of agricultural research in Ethiopia, farmers in the country have benefited little from modern agricultural technologies. Currently, improved seed is used on only 2% of the country's cultivated area (Wolday, 2001). According to this author, this is attributed to the high price of the seed and farmers' preference for using their own seed. Lack of resources, inappropriate policies and institutional deficiencies are also causes of the low level of technology generation in the country (EEA, 2000).

Agricultural extension dates back to the introduction of Integrated Rural Development (IRD) projects in the country in the late 1960s (IEG, 1967). IRD had many objectives. It attempted to introduce peasants in a few promising regions to a commercial market system, improved distribution of seeds and fertilizer, provide credit, disseminate better implements, promote rural health, expand storage facilities, and the like (IEG, 1967). The project was renamed Minimum Package Project I (MPPI) in 1971 and its services were scaled down to the provision of fertilizer and credit services with the intention of expanding its coverage to include the entire country. However, its operation was halted in the mid-1970s as a result of donors' withdrawal of funding once socialism was introduced as the political system of the country. The MPPI was renamed MPPII in 1981 after the renewal of the World Bank's commitment to finance the project. In June 1984, the MPP was replaced by the Peasant Agricultural Development Extension Programme (PADEP). It differed from the IRD and MPP projects in that it aimed to develop and disseminate appropriate technologies at the zonal level, using a training-and-visit approach (Dejene, 1990). PADEP gave way to a new agricultural extension programme known as the Participatory, Demonstration and Training Extension System (PADETES)

in 1994/95. The main difference between PADEP and PADETES is that PADETES merges the training-and-visit approaches of PADEP with the technology diffusion system of the Sasakawa Global 2000. Overall, agricultural extension systems in Ethiopia have, since 1960, concentrated on the promotion of the use of "input packages" in high yielding areas of the country. The system neglects low yielding areas, which are the most food insecure areas of the country. These regions are characterized by erratic rainfall and small land holding sizes.

Fertilizer, pesticide, herbicide and improved seed use has increased since the 1970s (FAO, 2000). This coincided with the expansion of agricultural research and extension. Despite such encouraging jumps in modern input consumptions, however, only 25% and 2% of Ethiopian farmers currently apply fertilizer and improved seeds respectively on their fields (MEDaC, 1999; Wolday, 1998). This is reflected in the low level of output per hectare, which has not shown a significant increase for the past 25 years. Despite its long history of agricultural research and extension, Ethiopian farmers have benefited little from these activities. Therefore, its contribution to changes in cereal production over the years is expected to be very small. With regard to its possible impact on variability in cereal production over years, it is expected to result in stability rather than instability. This because in accordance with empirical results found elsewhere, it is believed that cereals grown with technologies result in greater output stabilization than cereals grown with traditional technologies.

### **2.3 Pricing and marketing policies**

Agricultural policy is a broad concept. It includes output policy, input policy, land policy, research policy, irrigation policy, and many others. The land policy and the research policies of the country, which are part of agricultural policies, were discussed in the previous section, therefore these perspectives are not repeated here, neither is the irrigation policy considered. This is because, in Ethiopia, cereal production is predominantly rain-fed. In the remainder of this section, attempts are made to summarize the output and input price policies of Ethiopia since the 1960s and their possible impact



on the instability of cereal production. Output policy refers to output price and output marketing policies, whereas input policy focuses on variable input price and variable input delivery systems (Ellis, 1992).

The types and diversity of output and input policies vary from one economic system to the next. Contrary to command-based economic systems, prices in the market-based economic systems are determined by markets. In such systems, the role of the government is limited to ensuring the proper functioning of markets. In the command-based economic systems, government fixes farm output and input prices, manages output marketing and input delivery systems, and imposes physical marketing restrictions on free-market operations. Theoretically, such control over output-input pricing and output-input marketing and delivery systems targets resource transfer from agriculture to develop the manufacturing sector. In practice, however, according to Ahmed (1988), it attempted to ensure food availability, at cheap prices, to the politically active section of a society, mostly urban dwellers and the military. The difference between the selling price and producer price was mostly used to administer parastatals (Ahmed, 1988).

Be it in a command-based or a market-based economic system, market and non-market mechanisms of resource transfer from agriculture to develop non-agriculture were influenced by the perception that structural transformation of the economy solves economic backwardness. In command-based economic systems, non-marketing mechanisms were instituted to strengthen government monopsony over farmers' produce. Some of the non-marketing mechanisms included fixed quota delivery to government marketing parastatals at government-set rates, and the introduction of grain checkpoints to restrict free grain movement.

Ethiopia has seen two economic systems since 1970s. These include a command-based economic system (1975-1989), henceforth called the 1<sup>st</sup> period, and a market-based economic system (since 1992), henceforth called the 2<sup>nd</sup> period. In the paragraphs that follow, the possible impacts of agricultural policies on instabilities in cereal production are discussed. Firstly, background information about policies prior to 1975 is provided.

Before 1974, output prices were determined by markets. In addition, output-marketing systems were free from government control. With regard to input pricing and delivery systems, modern input use was unknown to the majority of small-scale farmers until IRD projects were introduced, with the assistance of donors, in a number of promising regions of the country in the late 1960s. The first government-controlled grain marketing parastatal in Ethiopia was the Ethiopian Grain Board (EGB). It was established in 1950 by Proclamation No. 113 of 1950. Its primary objective was to combat unlawful tendencies fostering monopoly in the grain markets. Ten years later, in 1960, EGB was renamed the Ethiopian Grain Corporation (EGC) and its role was strengthened by Proclamation No. 267 of 1960, which allowed EGC to incorporate a grain-price stabilization scheme as one of its additional objectives.

Between 1974 and 1990, the free-market based output and input policies were replaced by a command-economy based output and input policies. In 1976 the output pricing policy was replaced by a fixed pricing system and the output marketing policy was changed with the establishment of the Agricultural Marketing Corporation (AMC) as a sole collector of grain from farmers in the same year. AMC's power in grain marketing was increased by subsequent government policies. Various physical measures were also instituted to enhance the grain procurement capacity of the AMC. These include restrictions on the free flow of surplus grain to deficient regions and the imposition of severe penalties for farmers failing to comply with fixed grain quota deliveries. The penalties ranged from the denial of access to service cooperative shops to buy non-agricultural goods, to depriving them of their right to access to land (Befekadu and Tesfaye, 1990). These measures positioned AMC as the sole collector of grain from farmers at fixed rates.

The input pricing and marketing policy of the country was also in line with socialist principles. Chemical fertilizers and improved seed varieties are the most important types of modern inputs. Prices of these inputs were fixed by the government. In addition, input delivery systems were controlled by two state-owned parastatals, namely the Agricultural

Input Supply Corporation (AISC) and The Ethiopian Seed Corporation (ESC). Much of the fertilizer and seed supplied by AISCO and ESC were sold at favourable prices to the newly created socialist-based structures of production organizations, namely Producer Cooperatives (PC) and State Farms (SF). The system marginalized private farms, which accounted for over 90% of area sown and cereal production between 1975 and 1989 (Alemu, 1995)

Therefore, one may argue that the output and input policies of Ethiopia in the 1980s had repercussions for farmers' incentives. This resulted in production stagnation. According to Gutu (1990), cereal production per person declined by 3% a year in the 1980s. The change in the mix of production, due to switches in production from cereals to other crops, could also have played its part in production stagnation. According to Befekadu and Tesfaye (1990), switches from cereal production to oilseeds were some of the strategies adopted by many farmers to evade grain delivery quotas by the AMC.

The socialist-based output and input policies were changed by the March 1990 policy reform. The reforms introduced a mixed economic system. It promised the gradual dismantling of socialist-based production structures and proposed the introduction of new output and input policies within a framework of a market economy. To this end, fixed pricing was abolished and the monopsonistic power of AMC in the grain market was revoked. In 1992, the political setup of the country changed, reinforcing the major changes that were introduced by the March 1990 reform. AMC was renamed the Ethiopian Grain Trade Enterprise (EGTE) and, like the EGC of the 1960s, its purpose was reduced to playing the same role as private traders. It was restricted to wholesale trade for regulatory purposes only. However, the problem of infrastructure and lack of clear vision in the agricultural output marketing system of the country prevented EGTE from accomplishing its objective of price stabilization. A case in point is the trend decline in the producer prices of cereals over the past eight years, which was attributed to higher production as a result of good weather conditions and expansion in agricultural extension activities. It was reported that many farmers who acquired modern inputs through loans from government institutions in the year preceding the harvest were unable to repay due

to lower grain prices. This is reported to have caused decline in farm input utilization in recent years, impacting hugely on the realization of the agriculture-led development strategy, which aims to achieve self-sufficiency in food production through the promotion of the use of input packages.

In the area of input pricing and marketing, fertilizer retail prices were liberalized while wholesale prices remained under the control of the government. Control over wholesale prices of fertilizers was phased out in 1996/97. Currently, there are six fertilizer marketing agencies, namely the Agricultural Input Supply Enterprise (AISE), Ethiopian Amalgamated Limited (EAL), Fertiline Private Limited, "Ambassel" Trading House Private Limited, "Guna" Trading Share Company and "Dinsho". Wholesalers, retailers, cooperatives and regional and zonal agricultural offices also serve as marketing outlets for fertilizer by selling fertilizers directly to farmers.

With regard to the pricing and marketing of improved seeds, the Ethiopian Seed Corporation's (ESC) monopoly over seed production and distribution, which lasted for 14 years since 1978, was ended in 1992. At present, seed marketing is partially liberalized. In addition to the Ethiopian Seed Enterprise (ESE), which controls close to 95% of the improved seed supply (Mulat, Kelly, Jayne, Said, Levallee and Chen, 1998), Pioneer Hybrid International (PHI) is engaged in the popularization of improved input use in the country. Various research results have shown that recent changes in the output and input policies have improved the performance of grain and input markets. In the grain market, the policies have caused an increase in the number of grain traders and resulted in the spatial integration of grain markets (Wolday, 1999; Asfaw and Jayne, 1998). This does not, however, imply that efficiency has been attained. Grain markets are presently constrained by lack of effective competition. Very few traders control over 43% of the grain traded at the wholesale level, and 79% of annual grain sales occur immediately after harvest (Gebremeskel, Jayne and Shaffer, 1998). This means that efficiency in the grain market is constrained by factors such as limited access to working capital, limited storage facilities, poor road conditions, presence of too many unlicensed grain traders and

high and unsystematic tax assessment (Wolday, 2001; Gebremeskel *et al.*, 1998; Alemayehu, 1995).

In the input market, improvement in fertilizer consumption was registered recently. This is attributed largely to the introduction of the new extension programme in 1994. However, fertilizer marketing is affected by supply and demand problems. On the supply side, fertilizer marketing is constrained by the limited involvement of the private sector in the running of wholesale and retail outlets, delays in the availability of hard currency for fertilizer imports, and the like. On the demand side, fertilizer marketing is affected by high fertilizer prices, household assets, and availability of extension services, to name a few (Mulat *et al.*, 1998; Wolday, 2001).

In summary, the change in economic system from a market based to command based in the 1970s brought with it unfavorable agricultural policies for cereal producers. These policies, as discussed above, were devoid of incentives and were major causes of output stagnation. It resulted in, *citrus paribus*, greater instability in cereal production due to its discrimination against agriculture and the incentive structures that were destroyed, which are believed to have culminated in production and marketing uncertainties. During the third period, however, a move to more favourable agricultural policies, which introduced new incentive structures, was made. This should, *citrus paribus*, lead to higher cereal production and should result in less instability in cereal production compared to the period prior to it. The new agricultural policy gave rise to new incentive structures for farmers. It helped minimize most of the production and marketing problems experienced during the second period.

## **2.4 Weather variability**

As stated in the earlier sections, expansion of area sown, fluctuations in fertilizer availability and policy related factors have the potential to cause variations in cereal production. The importance of weather variability in the variation of cereal production is discussed next.

Given that only 25% and 2% of Ethiopian farmers utilize fertilizer and improved seeds respectively (MEDaC, 1999), that cereal production is predominantly rain-fed, and that fluctuations in rainfall from the long-term average are increasing (Webb, Brown and Yohannes, 1992) modern inputs are unlikely to dominate the effect of weather on cereal production. According to Jaeger (1991), *“cereals are the most susceptible crop to moisture stress, and for most countries, variations in average yields of cereals result primarily from variations in weather.”*

A number of studies attribute the continued dependency of cereal production on weather change to inappropriate economic policies. According to these studies, events such as droughts do not happen suddenly. Drought results from an accumulation of a host of economic problems, which, over time, erode the capacity of farmers to cope (Webb *et al.*, 1992; Pickett, 1991). An attempt is made to prove this premise by comparing standard deviations of cereal production (measured by CV) for the three economic systems that the country has experienced since the early 1960s. Results show that CVs were the highest when the country had non-conducive agricultural policies (Table 1). Between 1975 and 1990 alone, the period when socialism was the economic system of the country, fluctuations in cereal production, solely attributable to weather variability, occurred in nine out of a total of 17 years (Alemu, Oosthuizen and Van Schalkwyk, 2004).

## **3. Changes in cereal production: a descriptive method**

In this section, descriptive statistics are used to identify factors causing instability in cereal production. Since Ethiopia has experienced one change in its economic systems

since 1974, an effort is made to divide the time series data on cereal production, areas sown, yield and producer prices into two periods, namely, 1975 - 1989, hereafter 1<sup>st</sup> period, and 1990 - 2000, hereafter 2<sup>nd</sup> period. It is believed that this division assists in identifying factors responsible for instability in cereal production under the different economic systems.

### **3.1. Method of analysis**

To measure the extent of change in cereal production between periods, data on cereal production, area and yield were collected from the FAO statistical database and the data obtained were divided into two time periods, i.e. the 1<sup>st</sup> and the 2<sup>nd</sup> period.

The extent of instability in cereal production was analyzed by computing the following statistics, namely average production, coefficient of variation (CV), the F-statistics, and the probability of a 5% shortfall below the trend line. The CVs were computed based on results on the fitted trend lines of polynomials of different order. Two deterministic trend lines were fitted for each crop, making the total number of equations estimated equal to 14. The probabilities were computed by denoting that detrended production in year  $t$  is  $\hat{a}_t = \bar{a} + e_t$  (where  $\bar{a}$  is the period mean and  $e_t$  is the deviation from the mean). The probability of a shortfall of 5 per cent or more below trend is derived from  $\Pr \{0.95 \bar{a} \geq \bar{a} + e_t\} = \Pr \{-0.05 \bar{a}/\sigma_e \geq e_t/\sigma_e\}$   $\sigma_e$  is the standard deviation of  $e_t$ . Assuming that  $e_t$  is approximately normally distributed, the desired probability can be obtained from tables for the cumulative normal distribution (Hazell, 1985).

### **3.2. Results of descriptive statistics**

According to Table 1, average total cereal production increased by 13% in the 2<sup>nd</sup> period from its level in the 1<sup>st</sup> period. This increase was however statistically insignificant, indicating that no significant change in average total cereal production occurred in the 2<sup>nd</sup> period. Table 1 further shows that three crops, namely teff, maize, and wheat, which accounted for over 61% of total cereal production in 2<sup>nd</sup> period, registered statistically

significant changes in their means. To measure the degree of variability in cereal production, in general, and individual cereal crops, in particular, coefficients of variation (CV)<sup>2</sup> and F-statistics<sup>3</sup> were computed (Table 1). According to the F-statistic, variance of total cereal production in the 2<sup>nd</sup> period was statistically greater than the 1<sup>st</sup> period. On the other hand, the CV of total cereal production rose from 10% to 13%, an increase of 30% (Table 1). This suggests that total cereal production was highly variable or unstable in the 2<sup>nd</sup> period. Much of this instability may be attributed to higher variability in the production of individual cereal crops, namely wheat, maize, millet, and sorghum, for which F-statistics were statistically significant (Table 1). On the other hand, much of the increase in the CV of total cereal production in the 2<sup>nd</sup> period may be attributed to a higher increase in the CV of teff, from 7% to 13%<sup>4</sup>.

**Table 1: Changes in the mean and variability of cereal production between 1974-1990 and 1990-2000**

Crop type	AVG production			Coefficient of Variation (%)			F-ratio			Probability of 5% shortfall below trend	
	2 <sup>nd</sup> P	3 <sup>rd</sup> P	% Δ	2 <sup>nd</sup> P	3 <sup>rd</sup> P	% Δ	Production	Area	Yield	2 <sup>nd</sup> P	3 <sup>rd</sup> P
Wheat	675	982	45**	12	8	-33	0.53**	0.25	0.66**	70	80
Barley	843	823	-2	8	10	25	1.98	0.423	2.49	77	79
Maize	1164	921	-21**	31	19	-39	5.06***	0.15	9.6***	69	86
Oats	31	51	65	37	30	-19	1.94	2.83*	1.21	74	75
Millet	194	222	14	17	33	94	0.55**	0.39**	0.22	69	78
Sorghum	1000	1111	11	21	17	-19	0.38*	0.08	3.03**	76	79
Teff	1093	1531	40**	7	13	86	0.27	0.04	0.19	74	77
Cereal Total	4996	5644	13	10	13	30	0.53**	0.03	1.44	72	80

<sup>2</sup> Based on the fitted trend lines of polynomials of different order. Two deterministic trend lines were fitted for each cereal crop.

<sup>3</sup> To check that variance of cereal production in the first period is significantly different from variance of cereal production in the second period.

<sup>4</sup> In relative terms, the coefficient of variation of oats is the highest, but in absolute terms, its impact on the variability of total cereals is the lowest since its contribution to change in total cereal production stands between 3% and 7%.



\* Significant at 10%, \*\* significant at 5% and \*\*\* significant at 1%

Next, investigation was conducted into whether the registered instability in total cereal production in the 2<sup>nd</sup> period was caused by instability in yield (a measure of short-term source of variability) or instability in area (a measure of long-term source of variability). Results show that area and yield variances had little to do with this because their F-ratios were statistically insignificant (Table 1). To probe further the matter, the CVs of the producer prices of cereals, used as a proxy for incentive changes, were analyzed. However, they were found to be lower in the 2<sup>nd</sup> period, both individually and as a group (Appendix 1). This is expected because, theoretically, a move to a better marketing and pricing policy is likely to cause greater stability instead of instability of supply over years. Therefore, considering that the 30% increase in CV of total cereal production is caused predominantly by good weather, which was relatively common in the 2<sup>nd</sup> period (Alemu, Oosthuizen and Van Schalkwyk, 2004), and based on findings elsewhere that variability in total cereal production results primarily from variation in weather (Jaeger, 1991), much of the instability in total cereal production during the 2<sup>nd</sup> period may be attributed to favourable climatic change.

Considering Table 1, one can attribute the causes of significant instability in some of the individual crops, namely wheat, maize, millet, and sorghum<sup>5</sup>, to instability in yield (Table 1). Millet's instability is attributed largely to change in sown areas. Given the existing limit on the availability of chemical fertilizers and improved seed varieties, the increase in yield variances may be attributed largely to relatively good weather. This is supported by two findings. Yield variability is caused largely by climatic factors, since the adoption of new technology is likely to cause greater stability rather than instability in yields over years (CIMMYT, 1989). Furthermore, *“yields of crops grown with new technologies appear to have larger variances, but typically their coefficients of variation are lower than those of traditional technologies”* (Hazell, 1988b). Furthermore, findings on the implications of an increase in total cereal production variability on food security in the 1<sup>st</sup> and 2<sup>nd</sup> periods (last two columns of Table 1) are that the probabilities that cereal

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<sup>5</sup> The four crops together account for more than 61% of total cereal production.

production may fall by 5 percent or more below the trend each year, increased from 75 per cent in the 1<sup>st</sup> period to 81 percent in the 2<sup>nd</sup> period. These figures are indicative of the fact that food insecurity is at a higher level and is increasing.

To further analyze the factors responsible for the significant change in the variance of total cereal production in the 2<sup>nd</sup> period, a variance decomposition procedure was applied. This method attempts to analyze the components of change in the mean and variance of total cereal production. This is discussed at some length in Section 4.

#### **4. Components of change in cereal production**

In this section, changes in the average and variance of cereal production between the second and the third periods are analyzed. Changes in the average cereal production is believed to originate from four sources, namely changes in the mean yield, changes in the mean area, changes in the covariability between areas and yields and changes in interaction terms (see Hazel 1984 for method used). Likewise, the variance of total cereal production may be decomposed into eleven parts, namely, change in the mean yields, change in mean areas, change in yield variances and covariances, change in area variances and covariances, change in area-yield covariances, change in interaction between changes in mean yields and mean areas, interaction between changes in mean areas and yield variances, interaction between changes in mean yields and area variances, interaction between changes in mean areas and yields and changes in area-yield covariances and change in residuals (see Hazel 1984 for method used).

##### **4.1 Method of analysis**

Year-to-year fluctuations in areas sown and yields were computed as follows. First, to decide whether year-to year fluctuations should be computed by detrending or differencing the time series data, the classes of non-stationary process to which the variables under consideration belong were determined *a priori* (See Chan *et al.*, 1977 for the consequences of inappropriately differencing or detrending a time series variable).

The class of non-stationary process to which a variable belongs was conventionally tested by applying the Augmented Dickey-Fuller (ADF) procedure. However, this procedure assumes that the data under consideration is free of significant influence of structural breaks (see Perron 1989 for the consequences of applying conventional ADF on a data characterized by structural breaks). This was tested by applying a recursive analysis using the Dickey-Fuller regression to the full time series and none of the breaks was found to be significant. Next, ADF was applied to test for unit root in the series, which found that the data on area sown and yield for each crop are difference stationary processes. Estimates of the differenced production functions for each crop were computed from the products of the differenced area and yield series. Finally, changes in the average and variance of total cereal production were decomposed into four and ten parts respectively (see Hazell, 1984, 1985 and 1988a) with the assistance of a computer program that was written using a Matlab program.

## **4.2 Results for variance decomposition**

Trend lines were fitted to the full time series data of each crop to detrend their respective areas and yield. The type of equations chosen (linear or polynomial) to detrend the data was determined, based on goodness of fit and within sample period prediction error. Quadratic equations provided better fits for almost all the crops. To avoid the possibility of violating the homoscedastic assumption of a least squares procedure from the use of longer series, arising from changes in economic systems, a generalized least squares estimation procedure was used. Finally, estimates of detrended production functions for each crop were computed from the products of the detrended area and yield series.

Regarding individual crops' contributions to change in the average production of total cereals, teff accounts for 43%, wheat for 23% and sorghum for 21% of the total change in cereal production (column 6 Table 2).

**Table 2: Component of change in the average production of cereals; 1975-1989 and 1990-2000**

Crops	Change in mean yields	Change in mean area	Change in area-yield covariance	Interaction between changes in mean yields and mean areas	Contribution to change in average production of total cereals
	%				
Barley	-8.1	-13.1	4.6	22.7	6.1
Maize	19.7	-1.2	11.4	2.4	32.2
Teff	-19.6	-1.4	14.0	11.9	4.9
Millet	-3.3	26.2	20.3	12.3	55.5
Wheat	-0.6	-8.1	-5.7	1.1	-13.4
Oats	4.0	2.8	-12.0	3.8	-1.5
Sorghum	5.1	-0.2	23.5	-12.2	16.1
<b>Total</b>	-2.8	4.9	56.0	41.9	100.0

Of the four parts which constitute change in average production, increase in area-yield covariance accounts for 56% of the increase in the total cereal production.

Table 3 shows the results of the decomposition of the change in the variance of cereal production. Wheat (68%), sorghum (62%), and barley (30%) account for almost the total increase in the variance in total cereal production.

**Table 3: Components of Change in the Variance of Total Cereal Production; 1975-1989 to 1990-2000**

Crops	Change in yield variance & covariance	Change in area variance covariance	Change in area-yield co-variance	Change in mean yield	Change in mean area	Change in interaction terms	Change in residuals	Row sum
	%							
Barley	-0.6	-23	36	22	1	-17	12	30
Maize	0.3	65	192	25	4	-176	-162	-51

Teff	1.7	-6	-474	57	0	-38	471	11
Millet	-0.2	-41	91	75	-1	-73	-30	20
Wheat	0.5	1	552	66	0	-82	-469	68
Oats	1.7	-12	-49	146	0	-133	5	-40
Sorghum	-0.1	95	-265	-31	4	-50	309	62
<b>Total</b>	3.2	80	83	360	7	-569	136	100

Of the ten component parts which constitute the total increase in the variance of cereal production, change in mean yield (360%) accounts for the majority of the instability in cereal production. This could be attributed to a large extent to instability in weather conditions. This is because modern input use is limited to few farmers. Proof of this is the limited contribution that agricultural research and extension has made in respect of the availability of improved seed varieties and extended use of chemical fertilizers, which are limited to 2% and 25% of farmers respectively. This may be supported by the findings of CIMMYT already mentioned in the previous section, namely that yield variability is mainly caused by climatic factors, since the adoption of new technology is likely to cause greater stability rather instead of instability in yields over years (CIMMYT, 1989).

## 5. Conclusion

Total cereal production, on average, has not registered significant changes in the 2<sup>nd</sup> period in comparison to the level registered for the same in the 1<sup>st</sup> period. This may be attributed to the following.

Firstly, the effect that the change to a favorable policy had on cereal production is limited because production is at a subsistence level and the links necessary for favourable policy changes to be translated into a sizable changes in production are at early stages of development. Studies show that farmers' responsiveness to policy changes in Ethiopia is affected by several factors, such as lack of infrastructure, underdeveloped institutions and the presence of a non-conducive land policy (Alemu, *et al.*, 2003b).

Secondly, technical progress had a limited effect on cereal production. This can be attributed to the low level of advance in technology generation and its dissemination in agriculture, which is reflected in limited change in production per hectare over many years.

Though average cereal production did not register significant change, it was found that it was characterized by increased instability. This was attributed by this study to instability in yield. Furthermore, results suggest that increased instability in yield, in turn, was caused predominantly by weather variability. The effects of a change to a favourable policy environment and improvements in the techniques of production were limited. Technical progress and good policies are expected to bring forth stability rather than instability in cereal production.

Increased instability in cereal production is directly reflected in increased market and price instabilities and therefore directly influences the welfare of farmers. Increasing the agricultural research and extension capabilities of the country in order to improve the supply of new drought-resistant crop varieties could mitigate these results, because it was proved elsewhere that cereals grown by using new technologies have lower coefficients of variation than cereals grown by means of traditional technologies.

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### Appendix 1: Producer Prices of cereals: 1961-1974, 1975-1989 and 1990-1994

Crop Type	Coefficient of Variation %			Changes %	
	1st Period	2nd Period	3 <sup>rd</sup> Period	1st and 2nd	2nd and 3 <sup>rd</sup>
Wheat	7.75	18.01	10.4	132.3871	-42.2543
Barley	13.15	17.24	10.76	31.10266	-37.587
Maize	13.78	20.96	9.7	52.1045	-53.7214
Oats	16.16	24.5	6.52	51.60891	-73.3878
Millet	16.95	26.62	9.47	57.05015	-64.4252
Sorghum	17.49	20.95	9.1	19.78273	-56.5632
Teff	9.76	15.73	11.15	61.16803	-29.1163
Cereal Total	9.25	15.9	10.03	71.89189	-36.9182