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Full Length Research Paper

African cereal demand and supply analysis: Past trends and future prospect

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For the past four decades there has been an overwhelming dependence on cereals for daily direct human food energy in Africa. Most of these demands were largely met through domestic production, although the contribution of import started to grow in recent years. In this paper, cereal production and import trend were analyzed in 51 countries in Africa from 1961 to 2003. A system model was used to analyze the future prospect of demand and supply scenarios in each country up to 2030. The UN population projection, WRI water and the FAO agricultural data was used. The result showed that 60% of the countries in Africa requires cereal yield less than 2 t/ha in 2030 with no expansion of agricultural land. Among the most populated countries, Egypt and Nigeria will have to rely on cereal import through trade, whereas Ethiopia could improve its stagnating low cereal yield. Expanding cropping land will be limited by availability of water in Ethiopia. Cereal aid will play significant role in its domestic cereal supply. Generally, most except smaller countries in Africa will have enough agricultural land for further expansion of cereal harvesting land or could easily improve cereal yield from historically low value. Moreover, cereal import will continue to occupy major part of domestic supply in Africa, though part of the import accounting for cereal aid will gradually be insignificant in most countries except in East Africa.

Key words: Africa, per capita cereal, harvesting land, cereal yield, import, aid.

INTRODUCTION

The world food security has made significant stride since the Green Revolution in 1960s (Grigg, 2001). This was partly achieved as a result of an unprecedented cereal yield improvement initiated and fueled by the use of high yielding variety seeds and large amount of chemical fertilizers (Gilland, 1993; Borlaug, 1970). Nevertheless, most countries in Africa could not participate in this revolution and remained with one of the least per capita cereal production in the world (Alexandratos, 1995).

Cereal crops are essential part of nutrition in Africa as well as in other continents, constituting large portion of daily food energy. In 2003, for example, 50% of food calorie and 53% of protein came from cereals (FAO, 2005), rates which were much higher than cereal's contribution in developed countries (Alexandratos, 1994). Although, economic growth in some parts of Africa is poised to affect dietary transition to a more livestock dominated nutrition in the foreseeable future, the vast majority of countries will continue to highly depend on cereals for direct food energy.

As population growth progresses, many countries in Africa turned to cereal import either through trade or/and aid. Even the South African countries like Botswana, Zimbabwe, Malawi and South Africa which were net exporters of cereals until 1990s have eventually become net importers (FAO, 2005).

The major challenge for most African countries will be keeping the level of cereal supply and transition to better nutrition in pace with population growth and safeguarding the sustainability of the resource use. In the past, cereal demands were largely met through continuous expansion of harvesting lands with little augmentation in cereal yields. Expansion of harvesting lands or increasing cropping intensity has also been constrained by lack of sufficient renewable water essential for irrigation and/or double-cropping. There is a lot of uncertainty on t he extent

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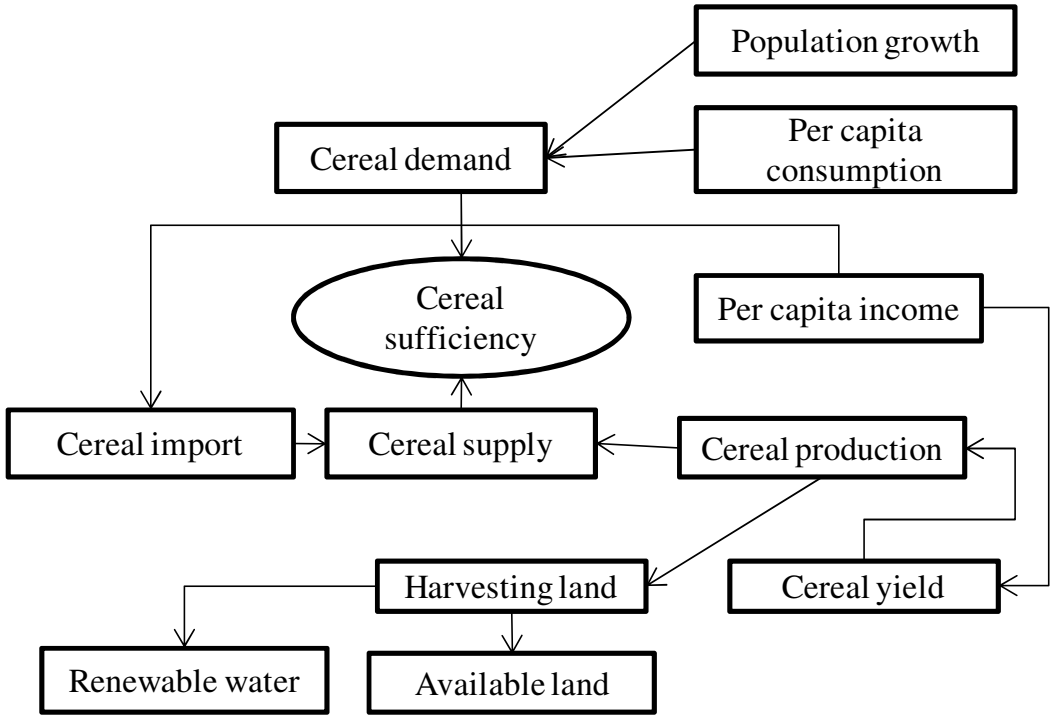

Figure 1. Scheme of cereal demand and supply system analysis model.

of expansion of these limited agricultural lands in different countries in Africa in the backdrop of increasing cereal demand.

The other factor that has limited expansion of cereal production is the absence or meager use of chemical fertilizer (Larson and Frisvold, 1996; Ladha et al, 2005). Use of chemical fertilizers that fueled much of crop production growth in other parts of the world is in limited production and use in Africa. Only few North African countries and South Africa produce chemical fertilizers, whereas most of the other countries rely on import. The average chemical fertilizer use was only 8 kg/ha in 2002 compared to the world average of 91 kg/ha the same year (FAO, 2005). Increasing cereal yield in Africa requires significant improvement in the use of chemical fertilizers from the present level (Larson and Frisvold, 1996; FAO, 2004; Kelly and Crowford, 2007). In turn, the level of economic growth of each country determines their potential to import and use these chemical fertilizers.

Understanding the state of cereal demand and supply in Africa requires analyzing specific conditions in each country differentially and systematically rather than treating the whole continent as a homogeneous unit. All countries in Africa did not have similar experience in cereal supply in the past and will not obviously have in the future. This study analyzed past trends and future prospect of cereal demand and supply in 51 African countries with special emphasis on countries with large population. The countries were grouped based on their possible supply scenarios: expansion of harvesting land, cereal yield improvement or import from international market. The result of the study will help identify countries which will face major challenge in cereal food supply system and broaden our understanding on nutrition in Africa. The result can also be used as input in formulating strategic cereal aid policies for countries of critical importance.

MATERIALS AND METHODS

A country-wide system model shown in Figure 1 was used to analyze and classify countries based on their past trends and future scenarios of cereal demand and supply. Firstly, the past cereal production and net import trend was described and analyzed.

Secondly, future cereal demand of each country was projected using rate of population growth and per capita cereal consumption. Input for future population was taken from the middle variant of the UN population prospect (UN, 2005). The per capita cereal demand in 2003 was assumed to remain unchanged. The future supply of cereals was estimated from local production and import on international market. The potential of local production was assessed using available arable land, (FAO, 2005), renewable water (WRI, 2008) and cereal yield. The potential of each country for cereal yield increament was inferred from their per capita GDP; (WDI, 2008); potential cereal import was also evaluted using the same indicator. The choice between improving cereal yield and increasing cereal import was assessed using the level of cropping intensity and available unused land which is suitable for agriculture.

Countries were divided into three groups based on their level of cropping intensity (CI) which is calculated by dividing harvesting

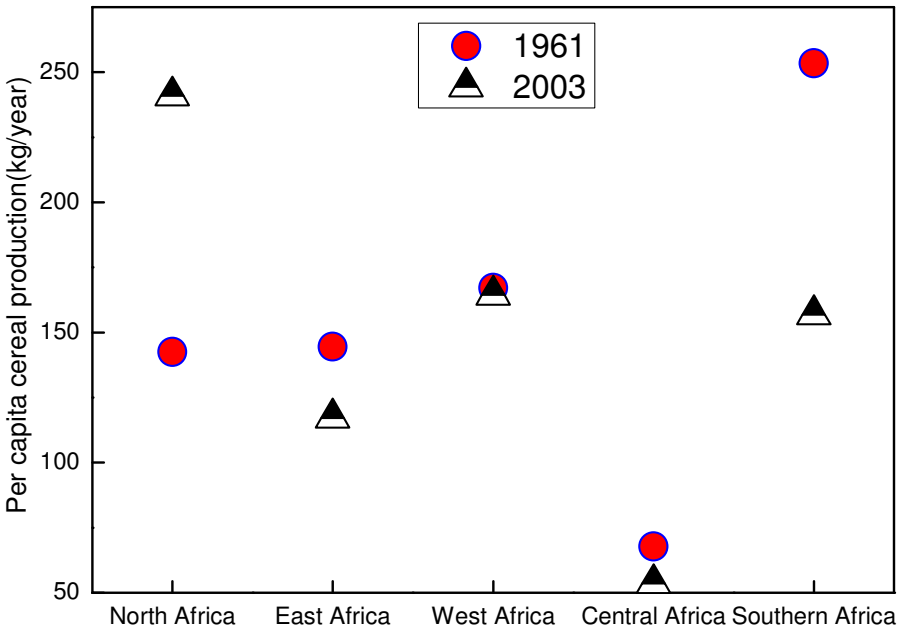

Figure 2. Change in per capita cereal production among African regions in 1961 and 2003.

land by arable land. CI shows the percentage of arable land that is used for cropping. The value of CI could also incorporate lands under double cropping and should be interpreted causitously especially when the value is more than 100%.

The supply side of each group of countries was assessed according to their available and potential arable land, ability to improve cereal yeild and possibility of expanding cereal import from international market. The potential for cereal yield imporvement and import was evaluated using their per capita GDP.

RESULTS AND DISCUSSION

Past cereal demand and supply

Analysis of past trend showed that in most countries in Africa there has been a decline or stagnation of per capita cereal production. Per capita cereal supply, however, has increased by more than 10% between 1961 and 2003 as a result of 1100% increase in mostly traded cereal import. Cereal production grew by an annual rate of 2.02% from 46.3 Mt in 1961 to 130.5 Mt in 2003. On the other hand, the population has grown from 289 to 906 million people between 1961 and 2007, that is, an average of 2.6% annual growth. This disparity in growth rate led to a 43.5% decline in per capita cereal production between 1961 and 2003. The decline was compensated by a considerable rise in traded cereal import in most countries, except for those that were food aid dependent like Ethiopia and Sudan which accounted for about half of food aid in Africa in 2003. The total annual cereal import has increased from 5 to 47 Mt between 1961 and 2003, of which food aid accounted for only between 1.7 - 3.3 Mt.

Expansion of harvesting land was responsible for 56% of growth in cereal production between 1961 and 2003, while cereal yield improvement accounted for 44% of the growth. Cereal harvesting land grew from 57 Mha in 1961 to 106 Mha in 2007, whereas, cereal yield rose from 0.8 to 1.3 t/ha during the same period. Much improvement can be made in cereal yield as a result of very low level in most of the countries. Only Egypt and South Africa achieved an average cereal yield more than 3 t/ha that affected production and supply of cereal for domestic as well as export market.

The change in per capita cereal production has not been uniform in all regions of Africa. Figure 2 shows the regional differences in per capita cereal. North Africa was the only region where growth of cereal production exeeded population growth between 1961 and 2003. In West and Central Africa, cereal production grew at a similar rate with population growth keeping the per capita production unchanged. In the remaining two regions, rate of population growth superseded the rate of cereal production resulting in declining per capita cereal production.

African countries have been heavily relying on domestic cereal production like maize, wheat and sorghum for food in the early 1960s when import was accounting only for about 10% of the total domestic supply. The import itself was in turn dominated by cereal

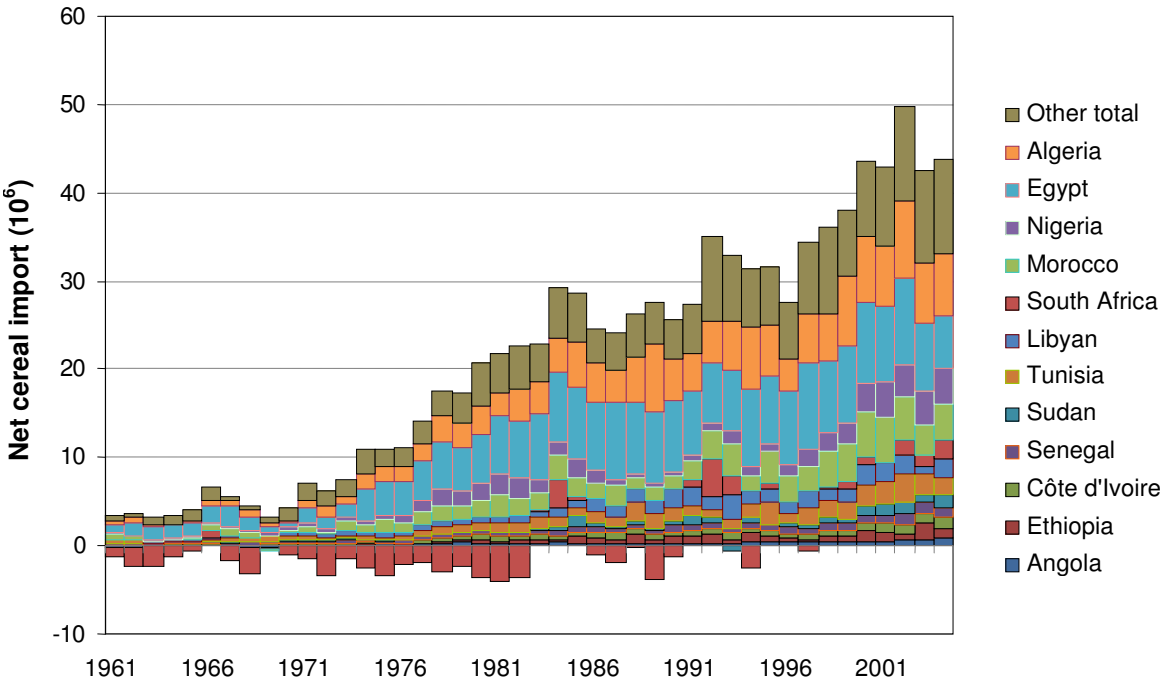

Figure 3. Net cereal import in major importing countries from 1961 - 2005.

aid that accounted for 34% of the 5 Mt imported cereal in 1961. On the contrary, while the proportion of cereal import grew to 28% of the total domestic supply in 2003, the contribution of external cereal aid declined to only 6%. In 1961, the North African countries of Egypt, Morocco, Tunisia and Algeria were the major recipients of food aid. Gradually, these countries were overtaken by East African countries like Ethiopia and Sudan which accounted for half of the total cereal aid in Africa in later years.

Only twelve countries acounted for 75% of the cereal import in Africa in 2003 (Figure 3). Among these countries, Egypt, Morocco, Algeria and Nigeria have experienced major growth in cereal import significantly affecting their per capita supply and offsetting the effect of high population growth. These countries accounted for more than half of the total cereal import. It can be argued that in most of the remaining highly populated countries, traded cereal import did not have major impact on domestic cereal supply that most of them have had to rely on domestic production or cereal aid.

Cereal cropping land potential

In classifying countries based on their potential for expansion of harvesting land or increased cropping intensity, that is, the percentage of harvesting land to arable land, countries were categorized into three groups. The first group comprised countries with cropping intensity less than 50% and was called low CI countries. The second group had CI between 50 and 100% and was called intermediate CI countries. The third and final group had CI above 1 and was categorized as high CI countries. Although there is a pattern that countries from the same region dominated one of the categories, countries were widely spread throughout the groups. Each category is discussed below in detail.

Low CI countries

This group is dominated by southern and central African countries which were characterized by maize production and availability of abundant potential agricultural land respectively. The South African countries were the major net exporters of cereals in Africa before 1990s. However, as can be seen from Figure 2, all of these countries became net importers of cereals thereafter. The shift in trend resulted from population growth exceeding rate of cereal production and increase in per capita consumption in countries that experienced economic growth. The central African countries in this group, on the other hand, have abundant potential arable land for future expansion in spite of their limited reliance on cereals.

It can be seen from Figure 4a that in five of the nine countries in the group, CI has declined between 1961 and 2003. Although CI is expected to increase in

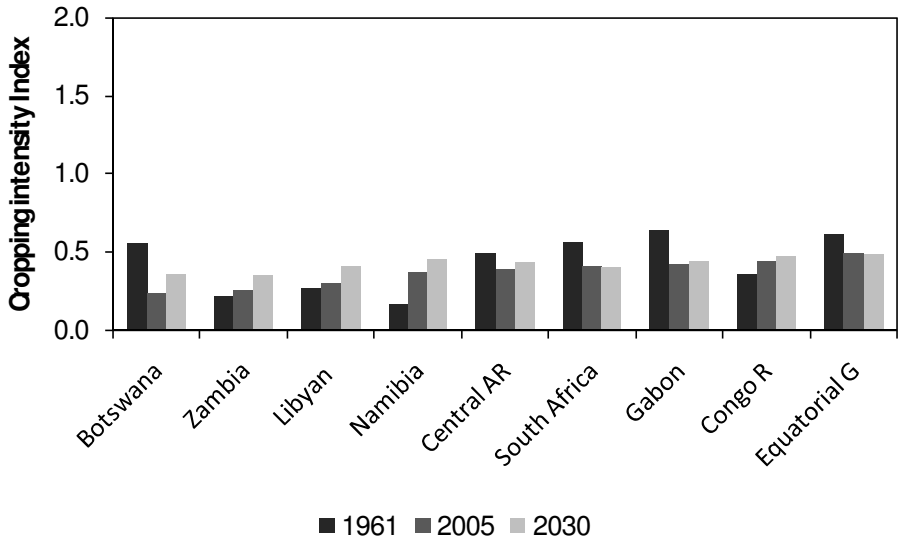

Figure 4a. Change in cropping intensity in countries with low CI (CI is a multiple of 100 when in percentage).

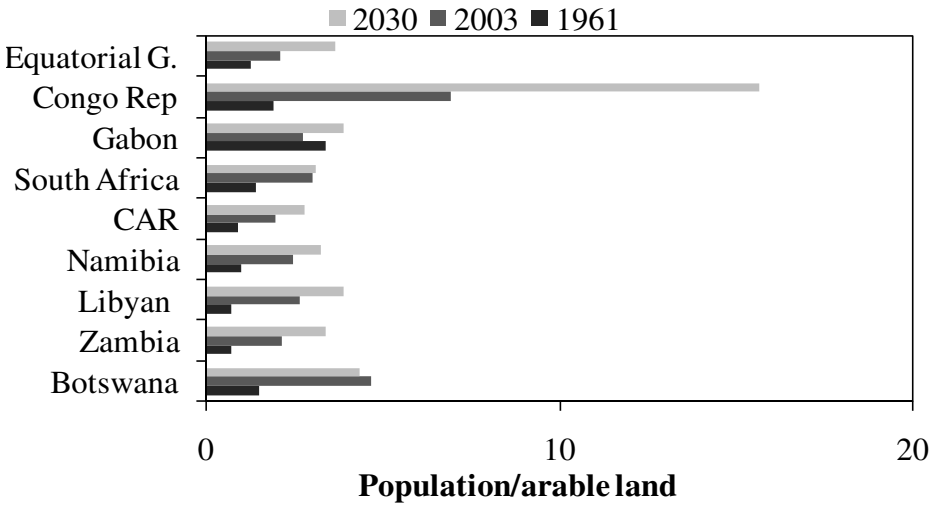

Figure 4b. Change in population per arable land density in low cropping intensity countries between 1961 and 2030.

countries like Libya, Namibia and Congo Republic, their CI will remain below 50% by 2030. At the end of the projection period, these group of countries will most likely remain under low CI in the projected period and face insignificant challenge in expanding cropping area and, therefore, increasing cereal production.

Figures 4b and 4c shows the change in available per capita arable land and cereal yield respectively. Population growth in the four decades after 1960s has resulted in population-harvesting land density below 10 people/ha for majority of the countries. Except for Congo Republic, this density will remain relatively unchanged within the projected period as a result of decline in population growth.

Cereal yield in these countries has been low as was common in most SSA. South Africa and Gabon have had relatively better cereal yield in the group. The two countries have correspondingly maintained good economic growth for many years to affect the necessary agricultural inputs for yield improvement. Cereal yield requirement will not surpass more than 4 t/ha in 2030 under a scenario with no expansion harvesting land.

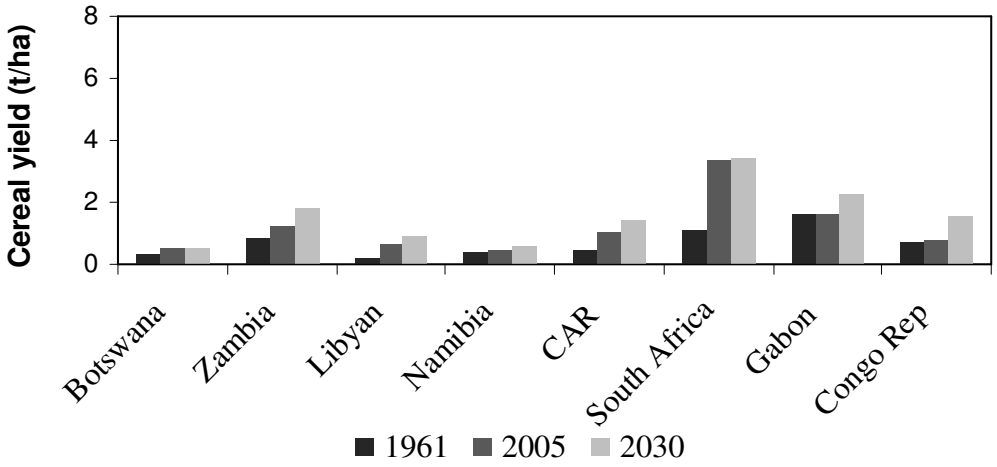

Figure 4c. Cereal yield change in low CI countries between 1961 and 2030.

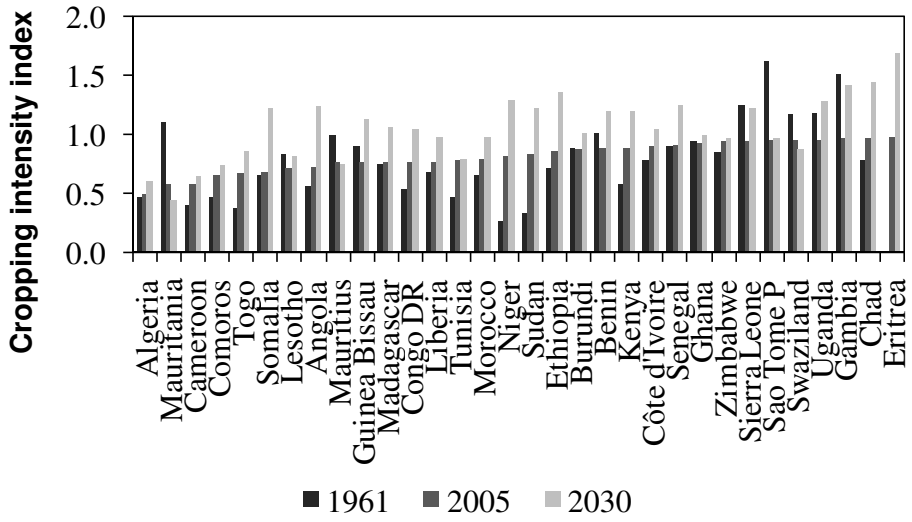

Figure 5a. Change in cropping intensity in intermediate CI between 1961 and 2030 (CI is a multiple of 100 when in percentage).

Countries with intermediate cropping intensity

More than 60% of countries in Sub-Saharan Africa have intermediate level of cropping intensity, that is, between 50 and 100% in 2003 fall in this group. Figure 5a clearly shows the change in CI in this group between 1961 and 2003 and future CI in 2030 if cereal yield is kept at 2003 level. Major increases in CI were observed in Niger, Ethiopia, Democratic Republic of Congo (DRC), Sudan and Kenya, countries which had population more than 10 million people in 2003.

Expansion of agriculture into land areas occupied by forests or grazing lands is feasible only in few land abundant countries in central and western Africa like DRC and CAR. Scarcity of land was observed predominantly in small countries like Mauritius, Sierra Leone and Eritrea in the past. In this kind of countries, strategy of land expansion has little bearing compared to yield improvement or enhancing cereal importing capabilities (Figure 5b).

Figure 5c shows historical and future cereal yield growth under the assumptions in the model. As a result of initially low cereal yield, most of the countries in the group seems to have the potential to improve cereal yield through better use of agricultural inputs.

Like group 1 countries, the cereal yield needed to keep harvesting land at 2003 level will not surpass 4 t/ha in 2030 in this group too. Beside small countries, which

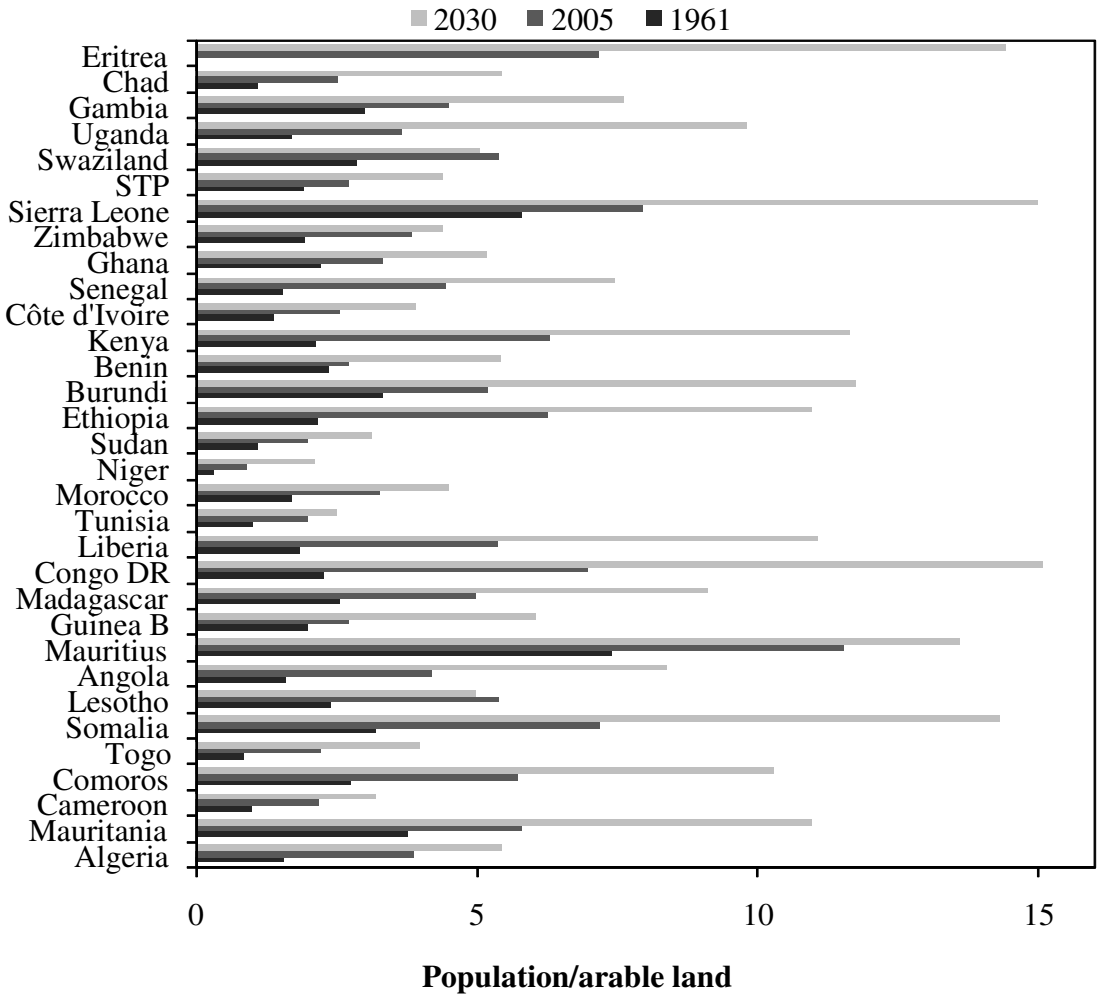

Figure 5b. Change in population per arable land density in intermediate cropping intensity countries between 1961 and 2030.

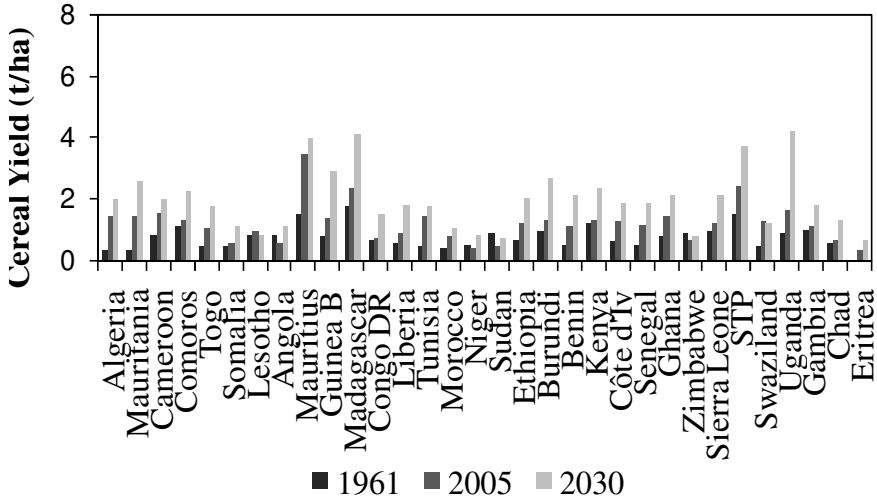

Figure 5c. Cereal yield change in intermediate CI countries between 1961 and 2030.

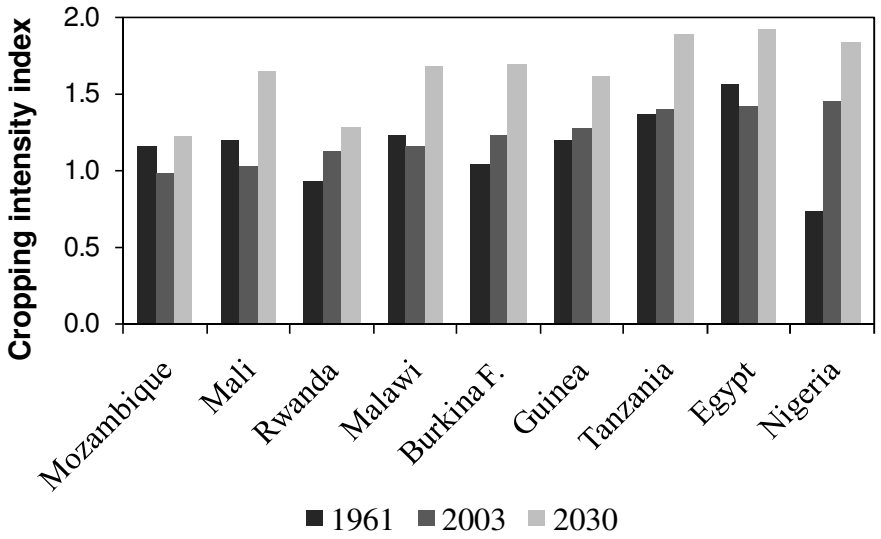

Figure 6a. Change in cropping intensity in countries with higher CI ((CI is a multiple of 100 when in percentage).

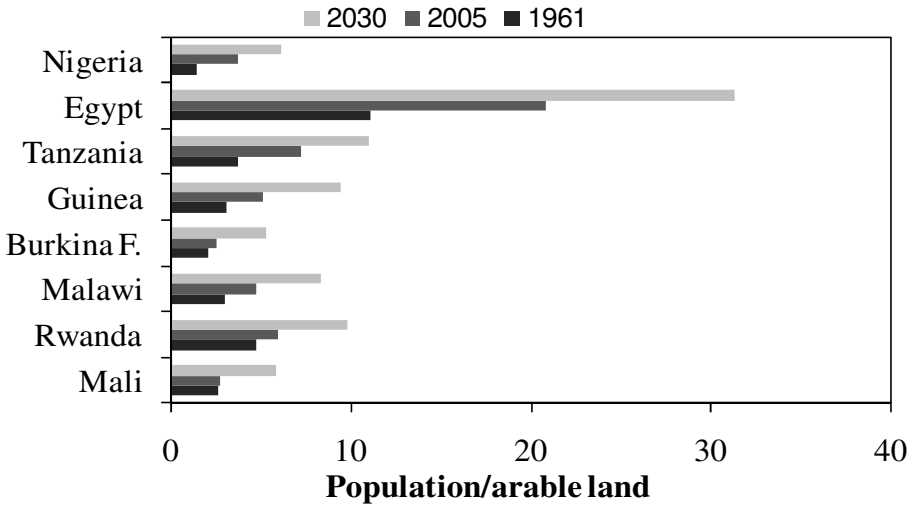

Figure 6b. Change in population per arable land density in high cropping intensity countries between 1961 and 2030.

normally are constrained by scarcity of arable land, only Madagascar and Uganda need to improve the yield to this level. More than 60% of the countries in this group could maintain base year harvesting or cropping intensity by increasing cereal yield up to 2 t/ha by 2030.

Countries with high cropping intensity

Figure 6a shows that all countries except Rwanda and Nigeria had experienced some level of double cropping since 1961. This group is characterized by having a large population. All nine countries in the group have population more than 10 million people. Between 1961 and 2003 cropping intensity has declined in Egypt, Mozambique, Malawi and Mali; whereas, it has increased in Nigeria, Rwanda and Burkina Faso.

Egypt has had the highest cropping intensity since 1961 which slightly declined over the years which could be attributed to scarcity of water. Egypt's cereal demand was, therefore, met largely through cereal yield improvement which was one of the highest in the world (Figure 6c) and cereal import growth (Figure 3). Between 1961 and 2003 its cereal yield grew from 2.9 to 7.5 t/ha.

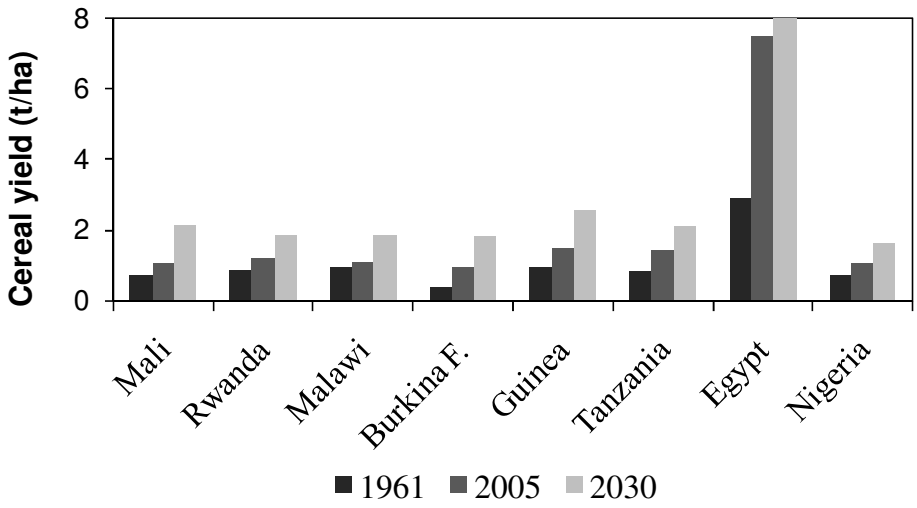

Figure 6c. Cereal yield change in high CI countries between 1961 and 2030.

With no prospect of expanding cereal harvesting land, Egypt will face the daunting challenge of increasing cereal yield to more than 10 t/ha which could hardly be made possible.

Nigeria, on the other hand, experienced the highest increase in cropping intensity and population per arable land density between 1961 and 2003 (Figures 6a and b). Its cereal harvest has not been growing in proportion to population growth; therefore, it had to rely on increasing its cereal import to meet domestic demand.

The countries in this group have different possibilities to supply their cereal demand. Guinea, Mozambique and Mali have sufficient water resource to expand their arable land and/or increase level of double cropping. Nigeria, Burkina Faso and Malawi which are constrained by availability of water could potentially improve cereal yield rather than expand harvesting land.

The prospect of converting lands under other crops to cereal in Egypt is highly unlikely as the demand for fruits, oil crops, sugar and others will continue to remain high. Improving cereal yield could also hardly be achieved since it has already approached the maximum agronomic yield of more than 7 t/ha in 2003 which is more than twice the world average. Therefore, the only viable option for Egypt to increase its future cereal supply lies on increasing its annual net cereal import. This could readily be achieved as long as it maintains past trend of economic growth. On the positive side, the rate of population growth in Egypt has been gradually declining and is projected by UN to decline further. Moreover, this decline besides its saturating per capita cereal consumption could help constrain growth of cereal demand. Nonetheless, with a population of more than 100 million in 2030, Egypt's cereal demand and supply system will face one of the biggest challenges in Africa.

Nigeria also has one of the largest population and cereal demand. Between 1961 and 2003, Nigerian population grew from 42 to 134 million. During this period cereal production grew by 0.25% less than population growth. However, the per capita cereal supply grew by annual rate of 0.1% as a result of cereal import growth. The cereal import grew from 100 thousand tons in 1961 to 4 million tons in 2003. To supply the future cereal demand, Nigeria has a wide range of options. Firstly, it could readily improve cereal yield by improving use of chemical fertilizer. Secondly, its present economic growth could increase cereal import at the international market. What is difficult to achieve in Nigeria is expansion of cereal cropping land because of the already high CI and absence of abundant water resource for irrigation.

Tanzania also has large population and high cropping intensity. The population of Tanzania has grown from 10 million in 1961 to 39 million in 2003 and is projected to grow to 56 million by 2030. The country has problem of water distribution to expand arable area to uncultivated lands. Cereals import and yield improvement is also limited as a result of low economic growth. Balancing demand and supply of cereals should, therefore, primarily focus on slowing the rate of population growth.

Smaller countries in the group are increasingly becoming self-insufficient in cereal supply in spite of high cropping intensity and cereal yield. The future of cereal supply in these countries will be dependent more on their economic performance and price of cereals in the world market rather than their domestic production. In these countries unchecked population growth will lead to mass migration and internal instability like the one witnessed in the 1994 Rwandan genocide that was partly attributed to scarcity of agricultural land (Verpoorten and Berlage, 2004; Diamond, 2004).

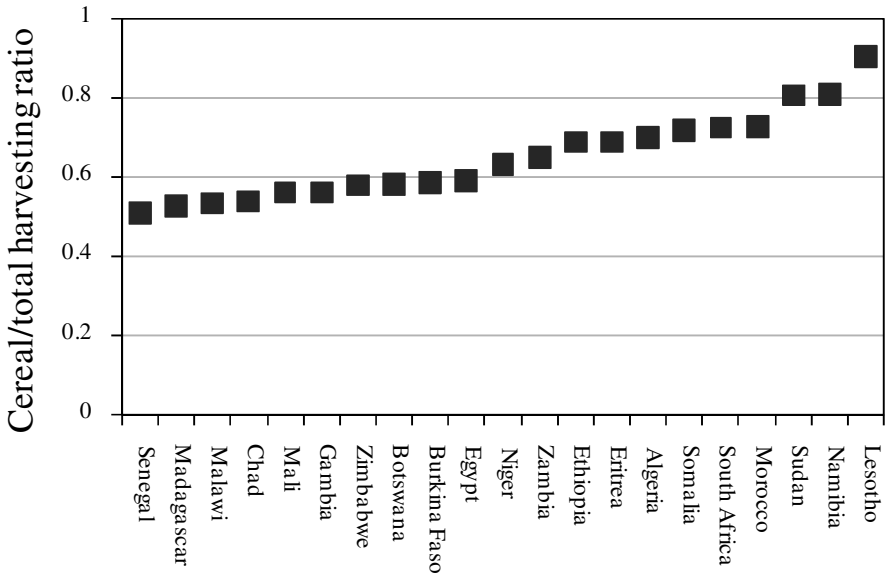

Figure 7. Proportion of harvesting land planted by cereal crops in highly populated countries in 2003.

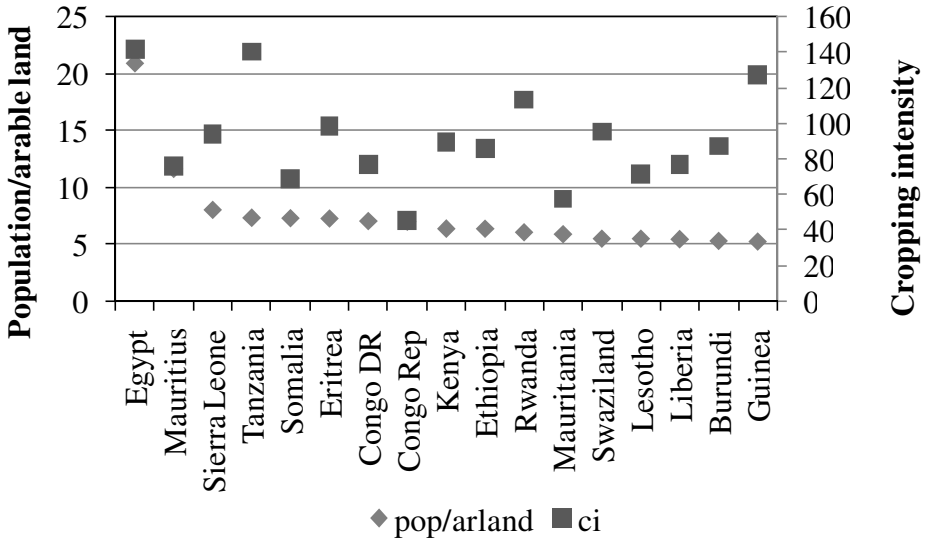

Figure 8. Population-arable land density verses level of cropping intensity in low per capita arable land countries.

Cereal harvesting land

Figure 7 shows the ratio between cereal and total harvesting land (CTR) in highly populated countries where cereal dominated daily nutrition in 2003. It can be observed that most of highly populated countries which face cereal supply problems have CTR value above 0.6 with the exception of Nigeria (and is outside the lower end of the graph) which has low CTR value because it utilizes large portion of its land for production crops other than cereals like starchy crops. The high CTR value in highly populated countries indicates the narrowing of possibility of expanding cereal production for future demand.

Future cereal supply insecurity

Figure 8 shows the level of cropping intensity of 17 countries with population of more than 1 million people

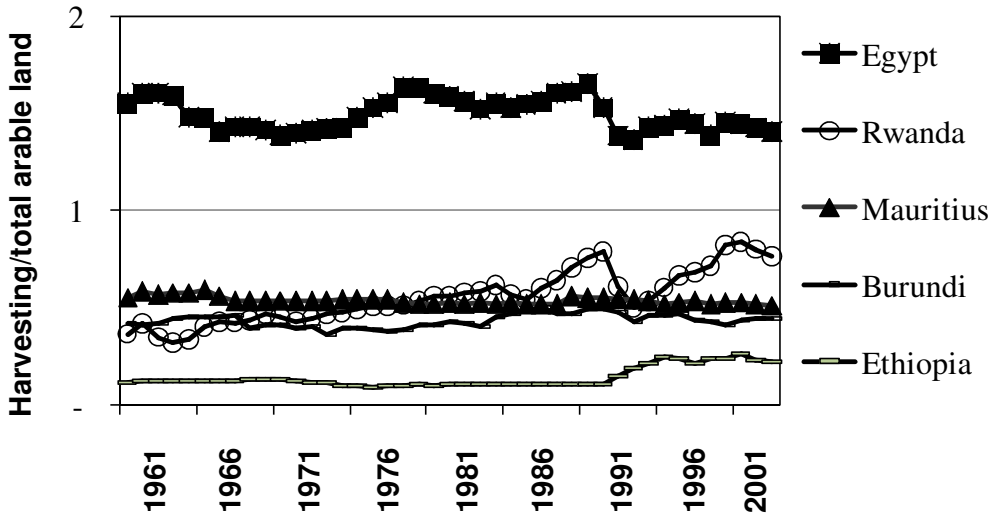

Figure 9. Ratio between harvesting land and actual and potential arable land in 5 high density countries.

that had the highest population/arable land ratio (PAR). Except for Congo Republic, all other countries have cropping intensity above 50% in 2003 and six of these countries surpass the 100% level in the same year. Further analysis of available water resource, per capita GDP and cereal yield has revealed different supply scenarios. Five of these countries, namely: Egypt, Rwanda, Mauritius, Burundi and Ethiopia were found to have the highest cropping intensity even after considering all potential arable lands that include forests and pasture lands (Figure 9).

Of all the countries, Egypt's exceptionally large PAR value made it a conspicuous outlier with proportionally high level of cropping intensity. The country has already been exhaustively using all its available arable lands with more than 50% double cropping in 2003. Cropping intensity has reached its peak level and there seems to be very little room for further intensification. As can be seen from Table 1, Egypt has also one of the least per capita available water in Africa which has been one of the major reasons that constrained expansion of cereal production. Its cereal yield, as discussed above, has also been one of the highest in the world making significant improvement very difficult to achieve. Egypt will probably continue the past trend of expanding cereal import.

Rwanda and Burundi, the two small densely populated central African countries that have already been using much of their arable lands, have one of the highest population growths in Africa. They have limited potential arable land and water resource. Their per capita GDP is also in the bottom of the list and could hardly affect cereal import through trade. As indicated in Table 1, they will be forced to continue depending on international cereal food aid. On the contrary, Mauritius could readily meet the domestic cereal demand by importing cereals as a result of favorability of its location for trade as well as its well performing economy (Table 1). Mauritius could also improve its cereal yield and increase its domestic cereal production.

Ethiopia with a population of about 80 million people in 2005 relied largely on expansion of cereal harvesting land since 1961. Its cereal yield did not show much improvement and stays at 1.2 t/ha in 2003. Without further expansion of cereal cropping to lands that are under forest and pasture land use, the country has few easily accessible lands that are suitable for agriculture. Most of its easily accessible and fertile lands have already been over cultivated in the densely populated highlands of the country.

With all available arable, forest and pasture lands put into consideration, only five countries with low per capita harvesting land had more than 20% ratio. Except for Ethiopia, all the four countries have already faced the dual pressure of population and saturated actual and potential arable land. Although, Ethiopian actual arable land has been cultivated near saturation level, it has enough room for expansion to hitherto uncultivated lands except for limitation on availability of renewable water (Table 1). This by itself comes at heavy environmental price and a great deal of uncertainly. Ethiopia's declining per capita water has always been under use conflict for thousands of years among other lower riparian countries like Egypt and Sudan. Although expansion of agricultural lands seems inevitable in Ethiopia, it could not sustain continuation of past trends. The possibility of importing cereal on the international market appears less likely considering past experience and its low per capita GDP. Ethiopia will continue to rely on international cereal aid for

Table 1. Data on productivity, economy and water resource on eleven highly cultivated countries in Africa.

Countries	Cereal yield (t/ha)[a]	Per capita GDP (USD)[b]	Per capita water (M3)[c]	Cereal insecurity indicator[d]
Burundi	1.34	90	460	8.4
Eritrea	0.37	219	1,382	8.4
Rwanda	1.18	208	563	8.0
Tanzania	1.43	288	2,332	7.6
Ethiopia	1.24	106	1,387	7.4
Kenya	1.35	481	860	7.4
Liberia	0.92	152	69,123	7.2
Mauritania	1.45	515	3,610	6.4
Sierra Leone	1.22	202	33,237	6.2
Lesotho	0.94	730	1,687	5.8
Somalia	0.59	100	28,175	5.8
Congo, DR	0.77	119	21,629	5.6
Congo, Rep	0.81	1,118	202,089	5.4
Guinea	1.47	421	23,533	5.2
Egypt	7.52	1,085	773	5.1
Swaziland	1.31	2,317	2785	4.2
Mauritius	3.45	4,893	1,873	2.5

[d]= f(a, b, c), large [d] value meant less food security and small value low food insecurity.

the years to come. The level of cereal aid demand will be much more difficult to meet as the number of people with little access to land increases and dynamics of food price in the world become less predictable.

Conclusion

In most of the countries in Africa the contribution of cereal trade has increased, whereas that of aid has declined. The North African countries have made significant improvement in per capita cereal supply while decline has occurred in South Africa, East Africa and Central African countries. Central African countries have sufficient potential arable land and water to expand cereal harvesting. By 2030, 60% of the countries in Africa require cereal yield under 2t/ha limit further expansion of cereal harvesting land. The three highly populated countries, Egypt, Nigeria, and Ethiopia follow different supply scenarios. Egypt will depend on cereal import through trade. Nigeria will not only depend on cereal import but also could improve cereal yield. On the contrary, Ethiopia will be restricted by its scarce water resource and absence of agricultural inputs like chemical fertilizers to increase cereal production through expansion of harvesting land or improving cereal yield. It is highly likely that it will continue with its external cereal aid dependence. Moreover, unlike the above two populous countries, Ethiopia will face one of the highest challenge in meeting domestic cereal supply in the projected period.

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