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Hindsight and foresight about sweetpotato production and consumption

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Comments are invited.

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Hindsight and foresight about sweetpotato production and consumption

INTRODUCTION

Sweetpotato is widely known for its high productivity per unit of time and broad adaptability over space. Although 'only' a secondary food crop in most developing countries where it is grown, its potential was judged to be sufficient to warrant an international research effort beginning at IITA and continuing at CIP since 1988. CIP-related technological change in sweetpotato figures prominently in several of the success stories documented by CIP and its partners in the 1990s and early 2000s. Indeed, the use of an innovative root seed system for the vegetation propagation of sweetpotato in two provinces of China was CIP's largest economic impact out of fourteen rate-of-return studies (Fuglie *et al*., 1999). Orange-fleshed sweetpotato cultivars have also shown to be important potential vehicles for improving Vitamin A status in children (Low *et al*., 2007a). As such, orange-fleshed sweetpotato became a key fixture in the Harvest Plus Challenge Program of the CGIAR and subsequently with the Bill and Melinda Gastes Foundation funded Sweetpotato for Security and Health in Africa (SASHA) with good prospects for success in improving micro-nutrient outcomes in the near term (Low *et al*., 2007a).

Like any crop, sweetpotato suffers from a number of drawbacks. In times of scarcity, war, and famine, it is an ideal crop characterized by heavy biomass production in a short-period of time with a high harvest index if locally adapted cultivars are chosen. The crop is almost deceptively simple to grow. In times of plenty, unlike some other root and tubers, such as potato and yam, the demand for sweetpotato declines. It is often regarded as an inferior commodity and a proportional rise in household income tends to be accompanied by a fall in consumption. Furthermore, it is not as versatile as other crops, such as maize and cassava, in its post-harvest utilization (Walker and Fuglie, 2006). Many products can be made from sweetpotato but (outside China) few so far have been able to compete commercially with like products from other commodities. Given its high transport cost in fresh form and its limited scope for commercial processed products, specialization and international trade are probably not important sources of growth.

Urbanization can result in a sharp fall in sweetpotato consumption as it is stigmatized as a poor persons' food. For example, IFPRI analysis of household expenditure survey data shows a steep decline in consumption from about 500 grams/person/day in rural areas to slightly less than 100 grams/person/day in urban areas in Rwanda (Thiele *et al.*, 2008). In contrast, potato consumption per person per day increases from about 200 to 400 grams with urbanization. Because of its nutritional and visual attributes, orange-fleshed sweetpotato may be able to make a dent in this large rural-urban disparity in consumption, and in general, sweetpotatoes' diminishing importance in good times and in urban areas has highlighted the role of value chain analysis to illuminate perspective solutions to enhance the crop's contribution to alleviate both Vitamin A Deficiency and poverty.

Sweetpotato also suffers from a dearth of economic analysis compared to other root and tuber crops such as potato (Horton, 1987 and Walker *et al.,* 1999). Selected biological scientists, nutritionists, and anthropologists are some of the major advocates for the crop, but sweetpotato has not captured the hearts and minds of many economists. In this paper, we try to fill one gap in the literature by analyzing the recent manifestations of sweetpotato's dynamism over space and time. We update several recent trends in the first section of the paper. Our treatment of trends and the literature is not exhaustive, but is highly selective and in the spirit of a rapid appraisal from an agricultural research perspective. This rendering of trends sets the stage for the second section: determining the correspondence between predictions and results from sweetpotato global and regional/country projections that are presented in Scott *et al*. (2000). The implications of these findings are discussed in a concluding section.

IDENTIFYING RELEVANT TRENDS IN SWEETPOTATO PRODUCTION

FAOSTAT furnishes the raw material for much of the analysis in this section. We begin with the dynamics of sweetpotato production in China, the largest producing-country by several orders of magnitude, and end with an examination of sweetpotato productivity in Sub-Saharan Africa, a region of increasing relative importance but one beleaguered by problems in data reliability.

The stagnancy of and impending decline in sweetpotato production in China

During the 20th century, China accounted for the bulk of global sweetpotato production, and its dominance continues today. Over the past 50 years, China's 80% share of global production has stayed relatively constant. But this seemingly unchanged relative importance in global production masks several of the dynamic aspects of sweetpotato output and consumption in China. Since the early 1960s, sweetpotato-growing area has declined from more than 10 to less than 5 million hectares today (Figure 1) as substantial cultivable land was released for substitute crops and activities.

Five segments of this declining trend in area are visible (or are speculated on) in Figure 1. In 1961 and 1962, sweetpotato area may have reached a high because of famine conditions imposed by Mao's forced procurement of food crops in rural areas. Presumably, sweetpotatoes were more difficult to procure than cereals that were exported to Russia in exchange for heavy arms. More than 30 million rural Chinese died in Mao's famine of the late 1950s and early 1960s. Forced procurement of cereals should have led to increased plantings of sweetpotatoes even in a communal agricultural system known for its brutality. Hence, we would expect to see a rise in sweetpotato growing area during and after this self-inflicted catastrophe. It is likely that the experience of suffering Mao's famine resulted in greater area planted in and reliance on sweetpotato than would otherwise have been the case in the 1960s and even into the early 1970s.

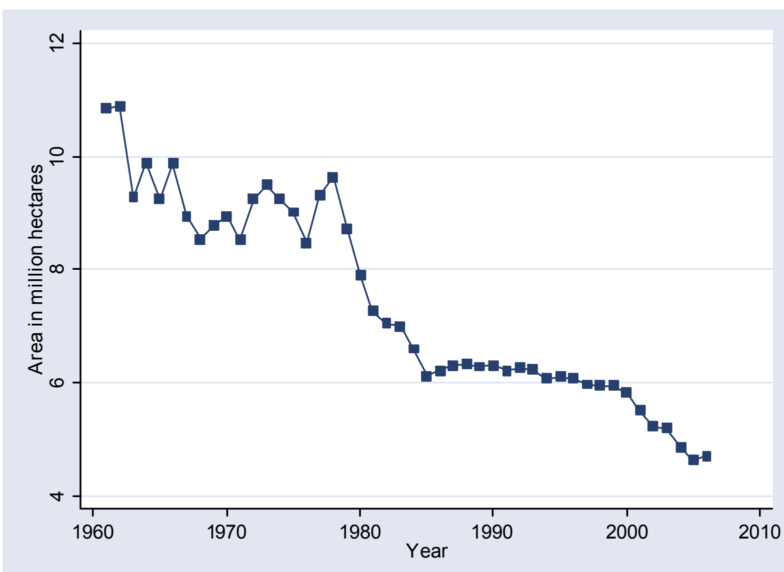


Figure 1.
Sweetpotato area in China from 1961-2006.

Immediately prior to and during the Cultural Revolution, sweetpotato-harvested area oscillated between 8 and 10 million hectares. But these data from the mid-1960s to the mid-1970s should be taken with a grain of salt. Agricultural estimates during the Cultural Revolution are viewed as unreliable (Gitomer, 1996).

Following the advent of the household responsibility system in 1978, sweetpotato area began to fall sharply from 9.6 million hectares to 6.1 million hectares in 1985. In this short span of seven years when communal cultivation was largely replaced by production on private plots, the rate of decline in sweetpotato-growing area was 6.5% per annum. Declining area translated into markedly decreased production in several provinces (Gitomer, 1996). The speedy transition to a market economy resulted in a loss of about one-third of sweetpotato-growing area that subsequently stabilized at 6 million hectares from 1985 to 1999.

In the early 2000s, growing area again declined at a more moderate, but still noticeable, pace. The substitution of grains for sweetpotato in pig feed and the decrease in fresh consumption per capita are hypothesized to be the main drivers for the last segment of this trend.

Of the five trend segments, perhaps the most difficult to explain is the stabilization of growing area from the mid 1980s throughout the 1990s. Because of increased yields (with the exception of a sharp hypothesized weather-induced fall in 1997), total production was rising in the late 1980s and early 1990s. Thus, the FAOSTAT time-series data suggest a period of firm demand sandwiched between two periods of weak demand. Nevertheless, demand was not sufficiently strong in the 1990s to arrest the general decline in sweetpotato production per capita from about 130 kgs in the 1960s and early 1970s to about 70 kgs now.

The national decline in sweetpotato-growing area is confirmed at the provincial level. Although we do not have access to time series data at the provincial level for sweetpotato, ERS of the USDA has assembled secondary agricultural data for China on their website. One of the data sets refers to tubers, which for all intents and purposes, covers potatoes, sweetpotatoes, and minor amounts of other root crops. From Gitomer (1996), it is possible to separate Chinese provinces into three groups: (1) those that do not produce potatoes, (2) those that do not produce sweetpotatoes, and (3) those that produce appreciable quantities of both crops. In the early 1990s, three of the four largest sweetpotato-growing provinces, Shandong, Henan, and Anhui, belonged to the first group. Therefore, we are confident that for these provinces the information in the tuber data set applies almost entirely to sweetpotatoes. Shandong and Anhui have also benefited from CIP-related virus-testing technology that was instrumental in the establishment of a 'virus-free' (root) propagation system that was mentioned at the outset of this report. Shandong is the heaviest yielding provincial producer.

All of these three lowland provinces have experienced robust rates of economic growth, and sweetpotato area has steadily declined to levels of less than 500,000 hectares (Figure 2). Although yields have secularly increased in the three provinces, the pace of area decline has exceeded productivity growth; therefore, production has also declined. The excellent productivity performance in Shandong has not protected it from declining production caused by increasingly weak demand for the crop on the richer coast. It is very likely that in the poorer interior provinces, the decline in area has not been as sharp and that production is still increasing.

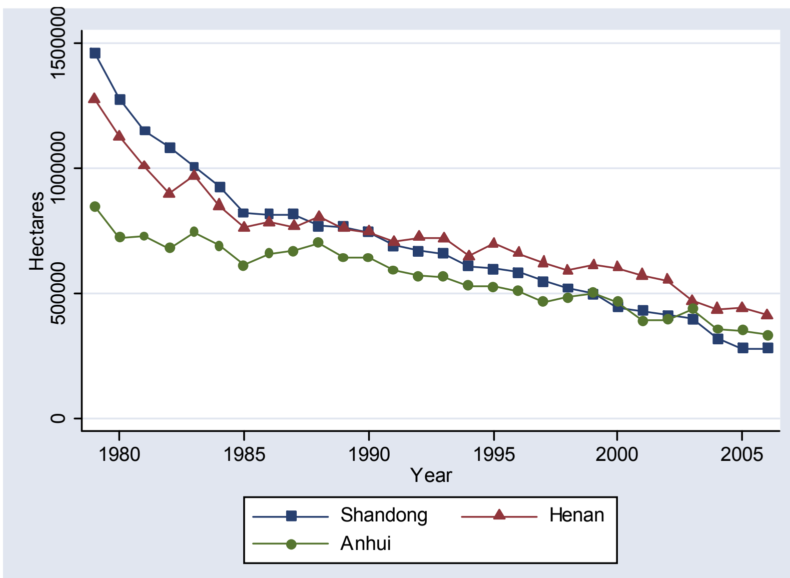


Figure 2. Sweetpotato cultivated area in Shandong, Henan, and Anhui provinces in China from 1979 to 2006. Source: USDA/ERS 2008b.

The rise of sweetpotato in Sub-Saharan Africa and its fall in Asia (outside of China)

Apart from its prominent role in China, fifty years ago sweetpotato was very much an Asian food crop of major importance in a handful of small countries and of secondary importance in well-defined regions of more countries. Japan was a distant second to China in the production of sweetpotato, but Japan's output exceeded that of any other country by a considerable margin. During the 1960s, total production of sweetpotato in Sub-Saharan Africa was indistinguishable from the total output of Latin America (Figure 3). The rest of Asia, outside China and Japan, produced about twice as much sweetpotato as either Sub-Saharan Africa or Latin America.

The relative regional importance of sweetpotatoes has changed considerably in the past five decades if one excludes China from the analysis. The 1960s were ushered in by plummeting sweetpotato area in Japan (Figure 4). Area fell abruptly during the 1960s, a continuation of a trend since post World War II. By 1973, the fall in area was halted as area declined gently thereafter. Increasing prosperity in the post-war era and the absence of preferential government protection hastened the demise of sweetpotato as a secondary food crop. The production data suggest that sweetpotato has achieved a natural low-level equilibrium as a specialty food in Japanese culture. By the late 1960s, the total output of Sub-Saharan Africa had 'crossed over' the national sweetpotato production of Japan.

Figure 3.
Sweetpotato production in Sub-Saharan Africa, Japan, Latin America and the Rest of Asia (Outside of China) from 1961-2006.

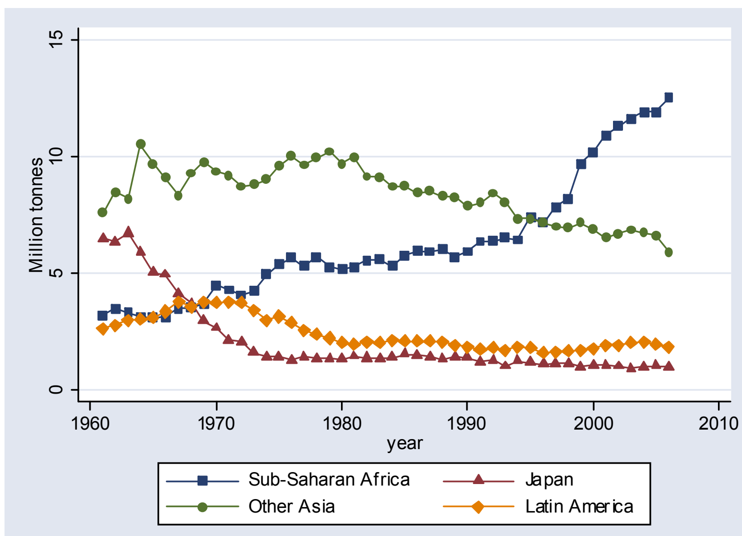
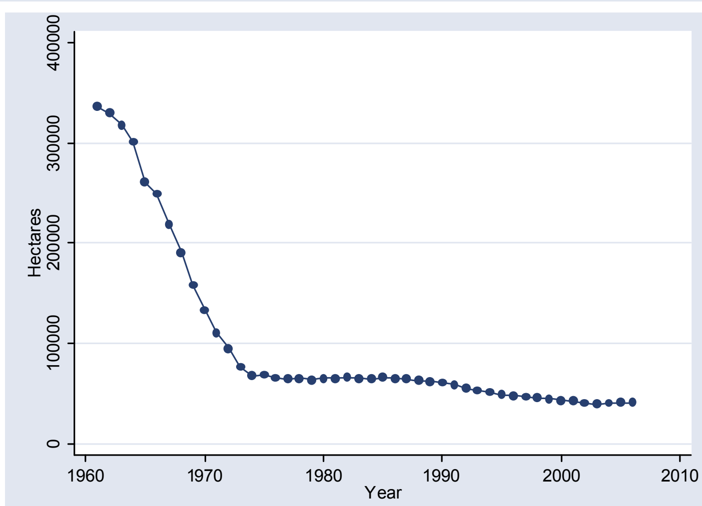


Figure 4.
Area of sweetpotato in Japan from 1961 to 2006.



It took about 30 more years for Sub-Saharan Africa to reach its next cross-over point: to exceed the total output of the rest of Asia (apart from Japan and China). Since the 1980s, the production record for sweetpotato has been spotty in Asia with many countries experiencing stagnating or declining production. Among 17 producers with more than 1,000 tonnes production annually in the rest of Asia, only five have exceeded a 2.0% growth rate in national production from 1985-2005. These five are Cambodia, Laos, Myanmar, North Korea, and East Timor. During the period of analysis, all of these countries have experienced widespread strife and gross mismanagement or have recovered from civil war. Peace and prosperity do not seem to bode well for growth of sweetpotato in Asia.

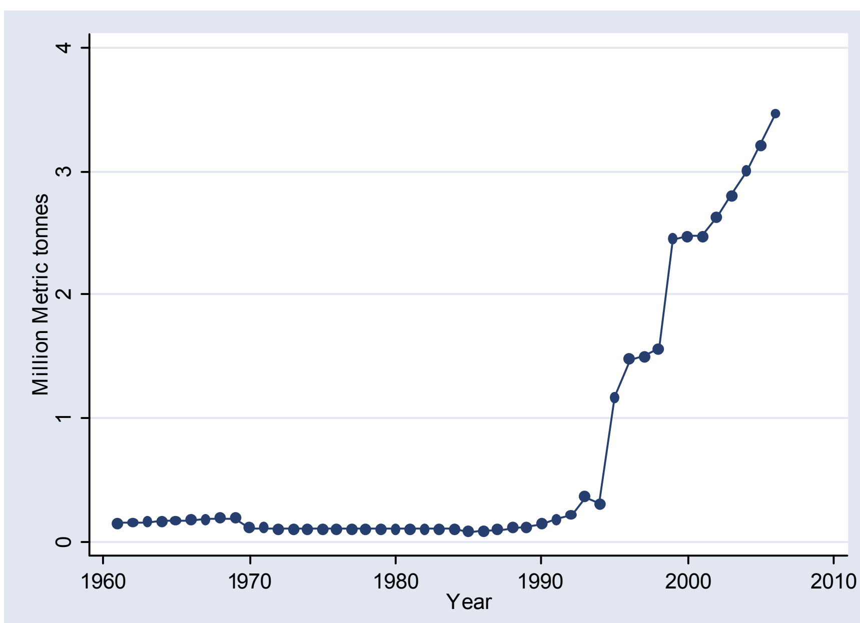
From the early 1960s to the mid-1990s, sweetpotato output steadily expanded in Sub-Saharan Africa. About half of the 35 countries that produced more than 1,000 tonnes annually in 1993 attained growth rates superior to 2%. Since 1993 (that marked the genocide in Rwanda), growth in sweetpotato production seems to have ratcheted up a notch in Figure 3. In this second period from 1993 to 2005, robust growth is more heavily concentrated in a handful of countries. Angola, Ethiopia, Tanzania, and Nigeria were characterized by annul growth rates exceeding 6% per annum. The cessation of hostilities in Angola fueled an expansion in cultivated area, or agricultural statistics on root and tuber crops became more reliable, as large increases in production and area were also reported in potatoes. Strong growth in Ethiopia and Tanzania could also be real. But Nigeria's annual 11% rate of growth in sweetpotato production is suspect. Production supposedly increased tenfold from about 300,000 metric tonnes in 1993 to over 3,000,000 metric tonnes in 2006.

The above data may reflect the state of disarray of agricultural statistics in Nigeria rather than the growth performance of sweetpotato in the country. The magnitude of the problem of statistical reliability of root and tuber data in Nigeria is conveyed by the simple inspection of the graph (Figure 5) of national production over time. Connecting the dots is not that difficult in Figure 5 as there are no fluctuations around trend. In the 1960s, production was adjusted upwards by 5,000 metric tonnes each year from a base of about 150,000 metric tonnes in 1961. (Earlier versions of FAO's production yearbook in the 1970s show substantially smaller estimates than the present-day electronic FAOSTAT data set). In 1970, as estimated production was reaching 200,000 metric tonnes a downward adjustment took place. Subsequently, production was anchored at 100,000 tonnes and stayed there until 1984 when the crop suffered another slight downward adjustment.

The national production estimate then increased by 10,000 tonnes between 1986 and 1989. From 1990 to 1994, the estimates take on an aura of credibility as there is no discernible pattern in the numbers. In 1995, a massive upward adjustment took place and, more recently, the series seems to have reverted back to the earlier style of increasing the estimate—in this case by 200,000 tonnes per annum—by a fixed amount each year.

Excluding the Nigerian data from the estimates for SSA dampens the conclusion in Figure 3 but does not markedly change its character. Sweetpotato is increasingly an African crop of secondary food importance in many countries and regions and a staple food crop in selected niches. Moreover, sweetpotato production is severely underestimated in several countries in Sub-Saharan Africa (Low *et al*., 2007b). For example, a nationally representative rural household income survey indicated that sweetpotato-cultivated area for Mozambique in 2002 exceeded 90,000 hectares, tenfold the comparable estimate from FAOSTAT of only 9,000 hectares. Later national surveys are consistent with somewhat lower estimates of sweetpotato area and production than what obtained in 2002, but those estimates in 2003, 2005, and 2006 are still several magnitudes greater than that given in FAOSTAT which has not varied from 8 to 9 thousand hectares since 1969.

Figure 5. Sweetpotato production in Nigeria from 1961-2006.



Malawi is another case where sweetpotato's influence is severely underestimated in FAOSTAT. Sweetpotatoes are reported under potatoes, and the bulk of potatoes are sweetpotatoes. Malawi is also an example of robust growth in root and tuber output as 'potato' production increased by sixfold, i.e., 1.5 million metric tons, between 1993 and 2005.

The explosion of root crop production in Sub-Saharan Africa in FAOSTAT

The strong growth registered by sweetpotato in Sub-Saharan in Figure 3 pales in comparison to the production performance estimated for yams and cassava in the FAOSTAT data base (Figure 6). Yam production suddenly took off in the mid-1980s and now approaches 50 million tonnes. Cassava was not far behind yams. According to FAOSTAT, production of cassava tripled between 1972 and 2006. In the past two decades, estimated productivity growth in both crops has been remarkable. Yam production grew at 8.5% annually; cassava production increased at a rate of 3.85%. Between 1986 and 2006, the estimated growth rate in yam production in Sub-Saharan Africa almost doubled the growth rate of global soybean production. Such alarmingly high estimated growth rates are feasible if the commodity started from a very small base. But yams began from a sizeable base of 8-9 million tonnes in the mid-1980s reflecting its importance in the humid tropics of several countries in West Africa.

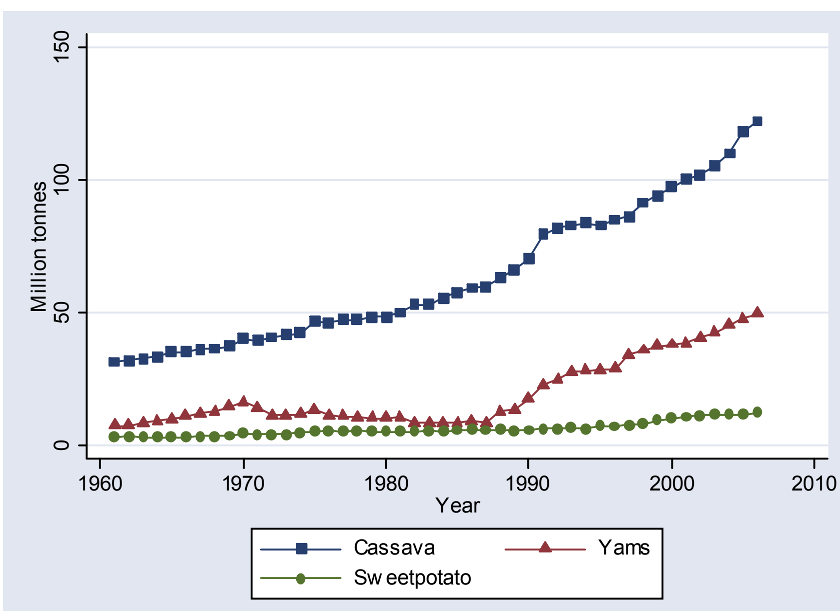


Figure 6. Production of cassava, yams, and sweetpotato in Sub-Saharan Africa from 1961-2006.

Again, among all producing countries, Nigeria is the main source of production growth and presently accounts for more than 70% of yam global production that is increasingly concentrated in the humid tropics of West Africa. So, conclusions about rates of growth should be tempered by doubts about reliability of numbers reported here. Benin, Ghana, and the Cote d' Ivoire are also characterized by a strong growth performance in FAOSTAT.

Six of the seven very high growth performers in FAOSTAT in cassava production also belong to Sub-Saharan Africa. They include Angola, Benin, Ghana, Malawi, Mozambique, and Nigeria all of whom had growth rates superior to 5% per annum since 1985. Like yams, some of this growth in production was likely real. Malawi is a case where a greater reliance on cassava in the recent past is well documented. As mentioned earlier, the end of a civil war could also spark an increase in area cultivated as households can freely cultivate their fields. Angola could be such a case as marked rises in estimated production coincided with the return of peace to the countryside. But much of this apparent growth only reflects adjustments in statistics that probably underestimated the importance of root crops in the past. For example, estimated cassava production in Mozambique jumped from about 6 million tonnes to 11 million tonnes between 2004 and 2005 and 2006 when estimated yield were revised upwards from less than 6 t/ha to over 10 t/ha. Weather-related events or technological change are not plausible explanations for such a large fluctuation or growth-related increase in production. Given that about 1.5 million households rely on cassava as their staple food crop, a national production estimate of 11 million tonnes is equivalent to about 7.3 tonnes of per household production. This rough amount translates into per capita household availability of about 800 kgs after accounting for storage losses and marketed surplus which is small. But per capita consumption of cassava is substantially lower than this level of availability. Moreover, the modal cassava-growing area is only about the equivalent of 0.25 hectares in a pure stand. Few households have stands greater than 1.00 hectares. Existing levels of cassava productivity and cultivated area result in production estimates that fall well short of 7.3 tonnes per household. National survey results show that production estimates are notoriously sensitive to questions about the periodicity of harvest. Asking questions on a daily or weekly basis in the harvesting season will result in significantly larger estimates than inquiring about production from monthly harvests. Multiple harvests at the end of the primary growing season and piecemeal harvests at other times complicate the estimation process particularly in oral estimates from largely single interview surveys. For Mozambique, the national estimate of 11 million tonnes of cassava production is not credible, and underscores the need for research on statistical estimation of root crop production in the Africa context of multiple intra-seasonal and piece-meal harvests.

The declining trend of sweetpotato yields in Sub-Saharan Africa and the responsiveness of sweetpotato to technological change

Almost all the increase in sweetpotato production in Sub-Saharan Africa is attributed to area expansion. Weighted mean yield has oscillated in a narrow band of 4.5-6.5 t/ha and has declined slightly over time (Figure 7). Declining yields are certainly possible. Sweetpotato could be planted with constant technology on land characterized by shorter fallowing stemming from increased population pressure. But increased land scarcity could also result in higher yields (Boserup, 1965 and Tiffen, 1994). Area expansion into more marginal land could also contribute to declining yield.

Low and declining yields are clearly not the norm in all countries. In Kenya, sweetpotato is mainly cultivated on mid-elevation land with higher yield potential that is reflected in Figure 7.

Yield performance in other countries is significantly harder to explain. For example, sweetpotato productivity suddenly crashed in Tanzania in the late 1960s and only started to recover in the early 1980s. 'Recovered' is too strong a word because the national estimates of yield of sweetpotato in Tanzania have been pitiful, varying between 1.2 and 2.0 tonnes per ha. The area cultivated to sweetpotato warrants scrutiny in Tanzania in what is largely a home-garden context.

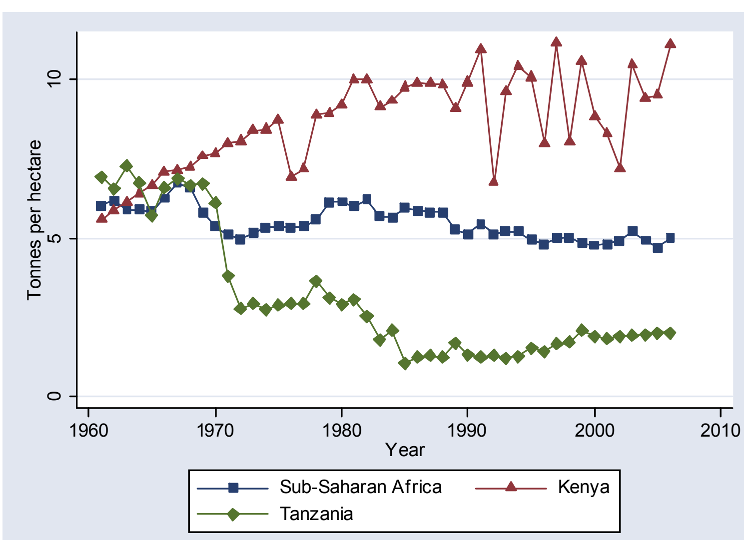


Figure 7. Weighted average yield of sweetpotato in Sub-Saharan Africa from 1961-2006.

A significant negative association between area and yield is one of the interesting features of the sweetpotato data in Sub-Saharan Africa in FAOSTAT for several notable countries. An abrupt fall in yield occurs when the area data start to change. In Angola, sweetpotato yield fell from about 8 t/ha to 4 t/ha in 2000 when area planted to the crop began to surge upwards. In Cameroon, sweetpotato-growing area increased sharply in 2002 and estimated yield fell from 6.5 t/ha to 4.5 t/ha. In Nigeria, area increased by more than 500,000 hectares between 1998 and 1999; yields fell from 5.5 t/ha to 3.5 t/ha. In Tanzania, area increased by 50% between 1970 and 1971 and, concomitantly, estimated yields dropped from 6.1 to 3.8 t/ha as depicted in Figure 7. Not all countries conform to this pattern. Kenya, Rwanda, and Ethiopia are characterized by a strong positive association between area and yield. But enough of them do to impart to a significant negative association between area and yield in a fixed effects model with country as the fixed effect. One could argue that area expansion results in less productivity as sweetpotato is planted on more marginal land. However, this argument would need to be supported by some empirical effect to show that marginalization in terms of land quality was taking place.

A more likely scenario is that yield is revised downward when area is structurally adjusted upwards. Decision makers who make the adjustment concede that area is increasing but are unwilling to tolerate the consequences of greatly increased production. Revising yield downward makes the area adjustment upward more tolerable. Whatever the case, the manipulation of the yield estimates downwards (without any empirical basis) contributes substantially to a record of stagnant or even diminishing productivity.

The problem of a negative trend in yield coupled with a negative association between yield and area over time within a country appears to be peculiar to sweetpotato. Weighted average cassava yields in Sub-Saharan Africa are trending upwards and the same tendency applies to yams with the exception of an unexpected dip in productivity in the 1980s (Figure 8). In Nigeria, yam area doubled between 1980 and 1981 when yield was inexplicably halved from 10.5 t/ha in 1980 to 5.5 t/ha in 1981. In contrast, the cassava data in FAOSTAT show relatively few of the spurts in area and breaks in productivity that characterize the sweetpotato estimates.

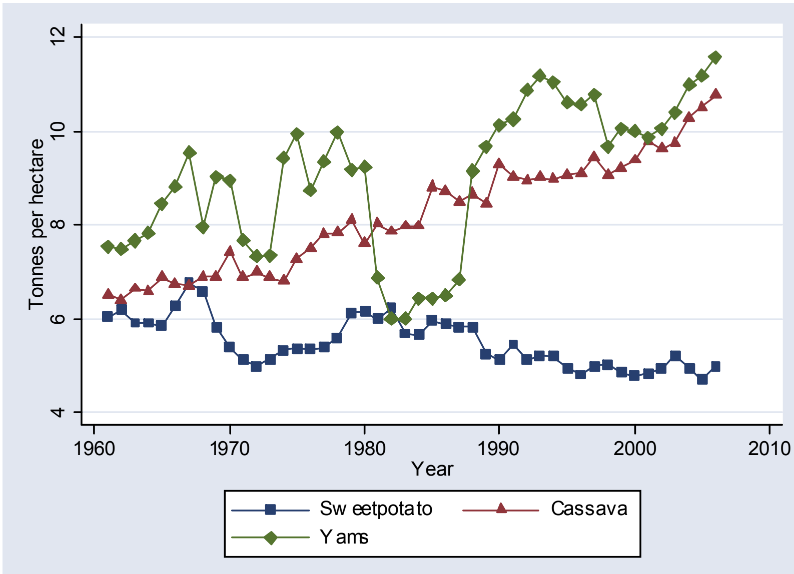


Figure 8.
Weighted average sweetpotato, cassava, and yam yields in Sub-Saharan Africa from 1961-2006.

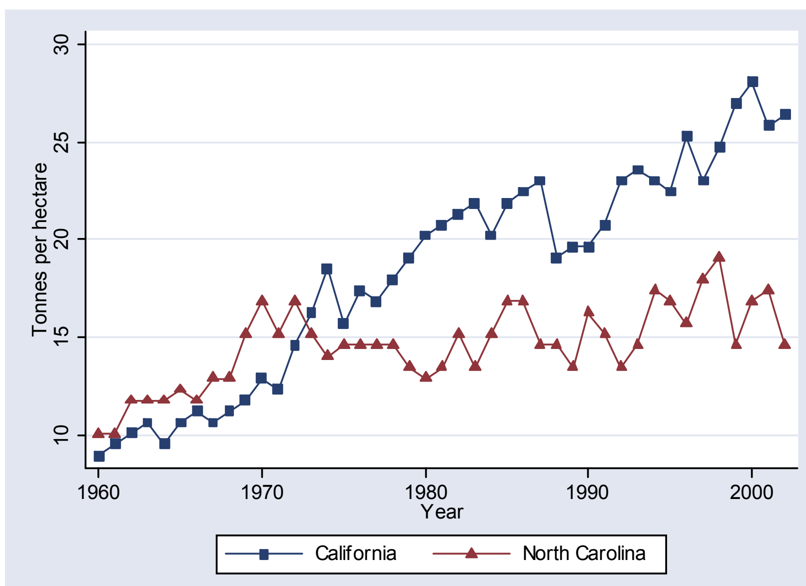
Although the FAOSTAT data on root crop productivity in Sub-Saharan Africa are not reliable and are, at best, informed guesstimates, they give the impression that a root crop like sweetpotato is resistant to technological change. However, wide adaptability and yield stability do not imply unresponsiveness to crop management, input intensification, and technological change. Moreover, intensifying production may not make sense to farmers who view markets for sweetpotato as thin. The absence of indicators of technological change in the secondary production data is likely to be conditioned by factors restricting market demand particularly if farmers with greater seasonal production were unsuccessful in marketing a highly perishable crop.

Yield responsiveness is documented in the developed country production conditions of the United States and Japan. Both countries presently plant about the same area to sweetpotato. In the United States, sweetpotato production has become increasing specialized in two growing states, North Carolina and California. Rain-fed production is the norm in North Carolina; production in California is fully irrigated. Productivity in North Carolina rapidly attained a level of 15 t/ha during the 1960s but since then productivity growth appears to be constrained by less than adequate water availability (Figure 9). The North Carolina situation probably applies to sweetpotato growing conditions in many developing countries: good prospects for early productivity gains with effective agricultural research and extension and reasonably efficient input supply but diminishing growth over time as the crop is constrained by water availability.

With adequate water, the California experience suggests that sustained growth in productivity is possible.

The productivity performance of sweetpotato in Japan is also consistent with sustained growth over a long period of time (Figure 10). In China, sweetpotato productivity is higher than potato productivity although the conventional wisdom is that potato is more responsive to inputs, management, and technological change. Both crops are produced largely in more marginal upland conditions in China, but the potato-growing environments are less hospitable to production as drought is a frequent visitor to western and northern China. Potato is widely regarded as a drought tolerant crop in China. But Figure 10 amply demonstrates that starting from a low base of 5.0 t/ha in the early 1960s, the productivity record of yield growth in sweetpotato in China is strong.

Figure 9.
Yields of sweetpotato in California and North Carolina from 1960-2002. Source: USDA/ERS 2008b.



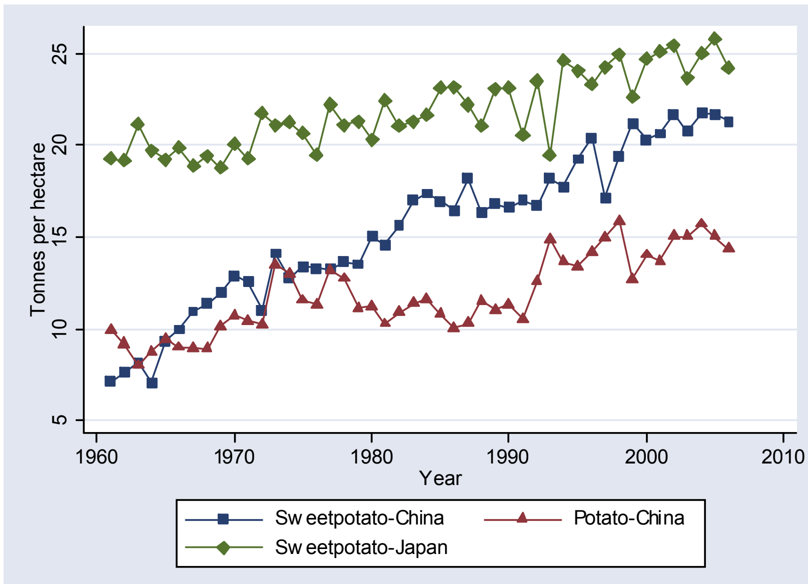


Figure 10.
Yields of sweetpotato in Japan and China and yields of potato in China from 1961 to 2006.

COMPARING TRENDS IN SWEETPOTATO PRODUCTION WITH PROJECTIONS IN THE IMPACT MODEL

An informative way to discuss trends in global, regional, and national sweetpotato production is to compare past projections with emerging reality. Such a comparison helps in the identification of conventional wisdom when projections predicted the future well and of surprises when projections deviated markedly from reality. Validating projections also contributes to more knowledgeable predictions from future modeling exercises.

Comparing trends and projections generates valuable information when the model is rigorous in terms of its assumptions and is specific with regard to disaggregation so that a coherent story can be told to begin to explain matches to and departures from reality. One modeling effort that satisfied the requirements of rigor and specificity for our purposes of providing a valuable point of reference for documenting trends in potato production was the IFPRI IMPACT model. This general equilibrium model combined commodity expertise with a tested global commodity modeling framework with a focus on the production and use of four root and tuber crops in eight developing country regions and in developed countries as a whole (Scott *et al.,* 2000).

The methods that we deployed to compare the IMPACT predictions to the FAOSTAT estimates are described in a companion paper on potatoes (Walker *et al.,* 20011). The period 1992-1994 (1993) was used as a baseline and projections were made on production and use to 2020 for both base and high demand scenarios. For comparative purposes, we draw mainly on the period from 1988-1990 to 2003-2005 for estimating trends. Specifically, we juxtapose projections for 2004 from the IMPACT Model with estimated production in 2004 from the FAOSTAT data, which are also the primary data source for the IMPACT model.

The information discussed in the first section on trends provides a useful backdrop to our comparative matching of predictions with reality. From the set of eight developing countries/regions that are described in Scott et al. (2000), we focus on (1) China, (2) Southeast Asia, and (3) Sub-Saharan Africa that collectively account for over 95% of global sweetpotato production. These regions are highlighted in the tables that follow.

Projected and estimated levels of production are compared in Table 1. Projected and estimated growth rates are analyzed in Tables 2, 3, and 4. Overall, the IMPACT model over-estimated global sweetpotato production in 2004 by about 14% as production fell short of expectations (Table 1). Five of the eight developing country/regions were characterized by production shortfalls compared to predictions. Estimated production in China was 11% below predicted output; the largest overestimate occurred in Southeast Asia where production contracted between the 1993 baseline and 2004. The IMPACT Model predicted increased production in all eight geographic areas, but production declined in four of the five Asian regions. (These results are substantially different than those for potato where production expanded in all developing country geographic areas (Walker et al. 2008)).

Because IMPACT overestimated growth in production, the high growth scenario was less accurate than the base projection for the commodity as a whole and for most geographic areas. But the differences between the baseline and high growth scenarios were too small to generate marked changes in predictive accuracy.

Sub-Saharan Africa was the main overachiever in Table 1. The IMPACT Model predicted strong growth in sweetpotato production in Sub-Saharan Africa, but the upward shift in that trend that is visible in Figure 2 from the mid-1990s onwards was not anticipated. Overall, the Model correctly predicted that Sub-Saharan Africa would proportionately experience more growth than any other geographic region.

Table 1. Comparing projected to actual levels of production for sweetpotato in 2004.

	Production (million mt)				Difference (%)	
Country/ region	**1993 baseline revised**	**2004 base projection**	**2004 high growth projection**	**2004 actual**	**With base projection**	**With high growth projection**
Developing	125.1	143.4	146.6	121.0	-14.4	-16.9
China	108.7	116.3	119.2	104.6	-11.2	-13.9
Other East Asia	0.5	0.6	0.6	0.7	18.7	17.1
India	1.2	1.2	1.3	0.9	-21.6	-25.9
Other South Asia	0.5	0.6	0.6	0.4	-39.5	-43.6
Southeast Asia	5.8	6.7	6.8	4.8	-39.1	-42.1
Latin America	1.8	2.1	2.1	2.0	-2.5	-5.0
WANA	0.2	0.2	0.2	0.3	22.7	21.0
Sub-Saharan Africa	6.4	8.6	8.8	11.8	27.2	25.7
Developed	1.9	1.9	2.0	2.0	3.7	1.2
World	127.0	145.3	148.6	127.4	-14.0	-16.7

Source: Constructed from Scott, et al., 2000, and FAOSTAT data.

The results in Table 1 are cast in terms of predicted and actual growth rates in Table 2, but these results are slightly different because the base for the actual growth rates is 1988-1990. Across the nine geographic areas (including developed countries as a separate area), a range of growth rates prevailed. During the recent past, sweetpotato production has stagnated in China and in developed countries, mainly Japan and the United States, and has mildly increased in Latin America.

Negative growth rates prevailed in much of the rest of Asia. Several of the positive outliers in the rest of Asia were noted in the first section. The main producing countries that were associated with negative growth included South Korea in Other East Asia, Bangladesh in Other South Asia, and Indonesia and Vietnam in Southeast Asia.

From the perspective of economic welfare, the negative growth rates in sweetpotato production in the rest of Asia could be a good sign or a cause for concern. For example, in India, sweetpotato production is heavily concentrated in the poorer states in the predominantly tribal districts of

East India. If the absence of growth in Table 2 is attributed to improved economic outcomes that benefit poor people who in turn plant less sweetpotato because they can now afford other commodities, then lack of growth in sweetpotato production is not an economic worry. If lack of growth is attributed to negligible or even negative changes in productivity in a stagnating economy, then the absence of production growth marks a lost opportunity and should be regarded as a cause for concern in agricultural research and development.

The growth performance of sweetpotato significantly exceeded the IMPACT modelers' expectations in the WANA region and in Sub-Saharan Africa. The high-growth countries in Sub-Saharan Africa were discussed in the earlier section. In the WANA region, Egypt accounted for most of the robust growth with an estimated rate that exceeded 10% per annum from a small base. Growth of production is fueled by an active export trade to the EC.

Table 2. Comparing growth rates for sweetpotato production by region.

	Growth rates in % per annum		
Country/ region	**Base projection**	**High growth projection**	**Actual (1988-1990 to 2003-2005)**
Developing	1.25	1.45	0.24
China	0.62	0.84	0.00
Other East Asia	1.18	1.36	-0.40
India	0.12	0.44	-1.39
Other South Asia	1.00	1.27	-3.06
Southeast Asia	1.29	1.49	-0.88
Latin America	1.19	1.41	0.23
WANA	1.35	1.55	7.32
Sub-Saharan Africa	2.71	2.90	4.66
Developed	0.12	0.36	0.00
World	1.23	1.44	0.23

Source: Constructed from Scott, et al., 2000 and FAOSTAT data.

The results from the IMPACT Model were consistent with declines in sweetpotato-cultivated area in China, India, Latin America, and Developed Countries (Table 3). The actual reductions in area were substantially more sizable than those inferred from the Model's results. Most importantly, the recent sharp reduction in sweetpotato-growing area described in Figure 1 for China was not foreseen. Such a reduction was likely not anticipated because the Model was estimated during the 'stabilization' segment of the trend in area which had yet to embark on a sharper downward descent.

The actual estimates confirm the positive direction of the Model's predictions for area increases in Sub-Saharan Africa and in the WANA region. Again, the magnitude of these changes greatly exceeded the results from the baseline projection or even from the high growth projection. Weighted average area growth exceeded 5% in both regions (Table 3).

In only two of the regions, Other South Asia and Southeast Asia did the Model results not agree with the sign of the change in area. In both of these regions, the Model's results were synonymous with a forecast of a small increase in area. The main sources of disagreement were Bangladesh in Other South Asia and Vietnam in Southeast Asia. Since a recent peak in 1992, sweetpotato-growing area in Vietnam has declined steeply. The downturn in Bangladesh has been more gradual.

Turning to yield growth, the results of the baseline projections generated annual growth rate estimates ranging from 0.22% in Developed Countries to 1.25% in Southeast Asia (Table 4). Negative growth in productivity was not envisaged in the baseline projections, but weighted average yields declined from 1989 to 2004 in three of nine geographic regions including Sub-Saharan Africa that was extensively discussed in the previous section. The estimated growth rate in yield in Table 4 was highest in China that symmetrically offset its negative growth rate in area in Table 3. With hindsight, higher yield estimates in China and the Developed Countries were more predictable than the negative growth in productivity turned in by Sub-Saharan Africa. Nevertheless, a growth rate in yield of 1.16% seems unduly ambitious for Sub-Saharan Africa because the best and perhaps the only source of increased productivity in sweetpotato in many locales is varietal change with improved planting material a possibility under more market favourable conditions. Cash-starved households that grow the crop are unlikely to intensify production and invest in yield-enhancing inputs.

Table 3. Comparing growth rates for sweetpotato area by region.

	Growth rates in % per annum		
Country/ region	**Base projection**	**High growth projection**	**Actual (1988-1990 to 2003-2005)**
Developing	0.27	0.35	0.00
China	-0.39	-0.36	-1.69
Other East Asia	0.30	0.44	0.77
India	-0.16	-0.04	-2.70
Other South Asia	0.10	0.22	-2.60
Southeast Asia	0.04	0.15	-1.69
Latin America	-0.23	-0.10	-0.63
WANA	0.13	0.22	5.75
Sub-Saharan Africa	1.16	1.26	5.46
Developed	-0.09	0.06	-1.41
World	0.27	0.34	-0.01

Source: Constructed from Scott, et al., 2000 and FAOSTAT data.

Table 4. Comparing growth rates for sweetpotato productivity (yield) by region.

	Growth rates in % per annum		
Country/ region	**Base projection**	**High growth projection**	**Actual (1988-1990 to 2003-2005)**
Developing	0.97	1.10	0.26
China	1.02	1.20	1.69
Other East Asia	0.89	0.92	-1.77
India	0.29	0.48	0.74
Other South Asia	0.90	1.05	-0.83
Southeast Asia	1.25	1.34	0.71
Latin America	1.43	1.51	0.93
WANA	1.46	1.33	1.19
Sub-Saharan Africa	0.97	1.62	-0.90
Developed	0.22	0.30	0.77
World	0.96	1.09	0.26

Source: Constructed from Scott, et al., 2000 and FAOSTAT data.

This section would be incomplete without some discussion of the latest estimates for sweetpotato from IFPRI's IMPACT Model (M. Rosegrant, personal communication, 2008). Projections take place in a more disaggregate setting of countries or small groups of countries, they are made to 2050. As before, yams are combined with sweetpotatoes in the model. Following Scott *et al.,* 2000, regional rules of thumb are used to weigh each commodity separately. For example in Sub-Saharan Africa, the ratio of the weights is 80:20 yams to sweetpotatoes.

The fate of sweetpotato in China and in Sub-Saharan Africa is of major interest. Sweetpotato demand is forecast to fall from about 40 kgs per capita in 2000 to about 15 kgs per capita in 2050 in China, but total production is expected to rise until 2030 when it reaches its ceiling at about 140 million tonnes. In Sub-Saharan Africa, the decline in per capita demand is very moderate compared to China and total sweetpotato production peaks at about 19 million tonnes in 2040 assuming the weights discussed in the previous paragraph. Production of sweetpotatoes, yams, and cassava increases at about 1.75 per annum until 2040. This envisioned growth rate is substantially less than the robust rates documented in FAOSTAT and described above.

The initial year estimates deviate markedly from FAOSTAT for several countries, particularly Nigeria. The IMPACT Model estimate in 2010 for per capita root crop demand (for the sum of cassava, yams, and sweetpotato) in Nigeria is about 210 kgs which is decidedly inferior to the 600 kgs/person level of production that is currently reported in FAOSTAT. Nigeria, Angola, and Mozambique now have intensities of root crop production that rival those in Paraguay. Yet all three of these countries contain sizeable regions where root crops are not the main food staple. We anticipate a day of reckoning when considerable downward adjustment of root crop areas is carried out in FAOSTAT for some countries and upward adjustments in others to reflect the reality of production and consumption.

Overall the latest IMPACT projections for sweetpotatoes look reasonable. The decline of sweetpotato production in China could be sooner than expected particularly if regional inequalities in economic growth are mitigated over time. The increase in production of sweetpotato in Sub-Saharan Africa could be somewhat greater than expected especially if the IMPACT Model's baseline in 2000 is a more reliable approximation to reality than the FAOSTAT estimates.

CONCLUSIONS AND IMPLICATIONS FOR DATA COLLECTION AND USE

This report has aimed to provide hindsight about recent past trends in global, national, and regional sweetpotato production with an eye towards making more informative assessments about the future. Four trends were discussed: (1) the stagnancy of and impending decline in sweetpotato production in China, (2) the rise of sweetpotato in Sub-Saharan Africa and its recent fall in Asia (outside of China), (3) the explosion of root crop area in Sub-Saharan Africa in FAOSTAT, and (4) the declining trend of sweetpotato productivity in Sub-Saharan Africa and the associated responsiveness of sweetpotato to technological change. Analysis of how well predictions made by Scott et al. (2000) squared with reality showed that the authors were overly optimistic about the prospects for sweetpotato in Asia and were too guarded about the potential for increased production in Sub-Saharan Africa. Although results from both the retrospective analysis of the FAOSTAT data and the comparative evaluation of predictions from the IMPACT

Model broadly point to the same direction, this report begs more questions than it answers not only because of uncertainty about the determinants of change in China, but, more importantly, because of the paucity of reliable data on root and tuber production in Sub-Saharan Africa.

One tipping point was identified: the stagnancy of sweetpotato production in China during the recent past. Soon the annual loss in area will more than offset the annual gain in productivity. Barring an unforeseen catastrophe, that sweetpotato production in China will secularly decrease during the 21st Century seems likely. The question is: how fast will the descent be? Presumably, the use of sweetpotato for pig feed will decline faster than the fall in per capita food consumption. Spatially related information on the demand for sweetpotatoes as food and feed is needed to identify more localized geographic areas where the crop is likely to retain its economic importance so that research and extension can be better targeted to facilitate the transition of a major regional feed and food crop to a more restricted but still important geographic context.

That sweetpotato in particular and root crops in general are becoming more important in Sub-Saharan Africa is also not surprising. But given the lamentable state of agricultural statistics on root and tuber crops, sizeable increases in national secondary data are unlikely to represent real growth although they may compensate for previous underestimates. Moreover, the empirical finding that abrupt increases in sweetpotato-growing area were accompanied by sharp declines in productivity in the same year was surprising and further suggests that large changes in time-series data may not reflect real production consequences.

In spite of inherent difficulties in reliably measuring root crop production, progress can be made on several fronts in both the generation of estimates and their use in Sub-Saharan Africa. Nationally representative rural household surveys complemented by selected measurement on a sub-sample of fields can make a valuable contribution to other sources of information, such as censuses and more focused crop cuts, on root crop production. These surveys are not nearly as evident as Living Standards Measurement Surveys (LSMS) on consumption expenditure, but demand for their conduct is increasing from governments and donors in the pursuit of the Millennium Development Goals. Remote sensing also has an increasing capacity for drawing inferences about cultivated area of crops, such as sweetpotato, that may be planted in pure stands or in well-defined row intercropping patterns in highly localized areas. Consumption estimates from LSMS studies also furnish a means to check on broader regional and national production figures.

Within each of these instruments, considerable scope exists for carrying out methods research to improve the efficiency of root crop production estimates. For instance, oral estimates of production from the previous year's cropping season(s) are the source of production-derived information from national rural household surveys. Changing the time frame in harvesting questions from one day, to one week, to one month, to a whole season can influence production estimates by several orders of magnitude. Verification research on daily and weekly harvests needs to be conducted during the main harvesting season where the root crop figures prominently as a staple. In complementary field studies, greater emphasis should be placed on pitting methods against each other in eliciting information on relative species importance, particularly in plots that are characterized by assortive intercropping where plant populations of several crops seemingly vary without rhyme or reason within the same field.

Cautious pragmatism should replace blind heroism in the use of the root and tuber data in FAOSTAT in Sub-Saharan Africa. This warning applies particularly to modeling applications. When the area of root and tuber crops changes abruptly, say by more than 20%, from one year to the next, the user should pause and ponder whether the change reflected real growth that was underreported in the past or whether the new adjustment is without statistical foundations. An expert panel should be convened to address some of the more dramatic changes, such as sharp rises in area for yams and sweetpotato in Nigeria. Apparently, FAO has no control over the estimates that the national governments provide. However, modelers do not operate under such restrictions, and some of the most egregious errors can be corrected as long as there are well-defined rules for the identification and possible correction of potential errors.

A final implication relates to the non-use of the FAOSTAT data. Because technological change in root crop production in Sub-Saharan Africa is likely to have an incremental impact on production and productivity, it is certain that such an impact will not be reflected in the regional or national statistics on commodity production. For that reason, impact assessment requires highly focused adoption surveys that have the potential to inform on both adoption and economic impact per unit of adoption. In Sub-Saharan Africa as Figure 7 shows, secondary data are likely to be of little assistance in teasing out the productivity impacts of agricultural research.

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The International Potato Center (CIP) works with partners to achieve food security and well-being and gender equity for poor people in root and tuber farming and food systems in the developing world. We do this through research and innovation in science, technology and capacity strengthening.

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Our vision is roots and tubers improving the lives of the poor.

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