What if there were no food aid and food import: food insufficiency in Africa from the perspective of self-sufficiency

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Abstract: Recognizing and understanding food insufficiency and its diversity dynamic variation patterns among countries is beneficial to regulate policies to improve food sufficiency, especially for Africa where poverty is also a problem. This paper explicitly assesses food insufficiency, using land resources carrying capacity, basing on the ability of self-produced food feeding its population in Africa at spatial and temporal scale, and identifies countries’ variation patterns basing on five and a half decades. This study demonstrates that although production of cereals improved in total Africa, it cannot satisfy the consumption for its population, get rise that food insufficiency wasn’t improve with the production growth. Africa has been in chronic food insufficiency, and food insufficiency fluctuated around grade III. Basing on the range of circumstances of the countries, large-scale food insufficiency covers 1961(1961-1963), 1970(1969-1971), 1980 (1979-1981), 1990(1989-1991), 2010(2009-2011), and 2015(2014-2016). Over 70 percent of African countries was in food insufficiency, even 60 percent of the countries were in grade I, while, only the minority of countries had enough food. Especially in 1980 and 2000, less than 15 percent of the countries were in food sufficiency (between concluded). Basing on the sub-area of FAO for Africa, it had more food sufficiency in eastern Africa and western Africa, moderate amount located at northern Africa, southern Africa had much less, and central Africa had the least, which was almost the whole central Africa. According to dynamic changes of food insufficiency in African countries chronologically, four categories (No.i - iv) of 10 small classes were made. Solutions were proposed to meet the 2030 Agenda, basing on the categories of dynamic change pattern of food insufficiency in Africa, including science-based approach to increase production, reasonable allocation on food aid and import, and population growth and family planning, etc.

1. Introduction

Food security is a growing concern worldwide [1], FAO had triggered great hopes in food security in Africa as early as 1970s [2-4], unit of analysis ranges of which from the world in total, to a country, a region, down to a community, a household or a single individual [5-7], however, about 825 million people still live in extreme poverty and 800 million still suffer from hunger [8]. Africa has been in food insecurity, and is likely to be worsening with climate change and population growth [9-10]. Ways
of achieving food security for Africa was proposed, including buffer climate change by water harvesting or vapor shift, rain fed smallholder farmers shifting to farming systems, increasing regional food trade, and push-pull innovation etc. [9, 11-13].

While, after a prolonged decline, hunger in Africa remains the region with the high PoU, which are derived from official country data on food supply, food consumption, and energy needs [14-15]. Most African countries are far from self-sufficient in meeting their food consumption [16]. Also, comparing to the Millennium Development Goals, the pace of reduction of food insecurity in Africa has been too slow to achieve the target, and more than 40 percent of the population in sub-Saharan Africa still lives in extreme poverty in 2015[8]. Commonly, food self-sufficiency is not an essential precondition for food security, but for low-income developing countries like Africa, it is of great concern, as the lack of adequate foreign exchange reserves to pay for food imports and infrastructure [17-18]. Especially in the wake of international food crisis with reasons like climate extremes or oil crisis, when food self-sufficiency gained increased attention in a number of countries, as countries sought to buffer themselves from volatility on world food markets [15, 19]. So, whether food self-sufficient can be achieved on existing agricultural land or not is of great significance to food security in Africa [12], which was always affected by factors including farmland change, soil texture, stemborer pests, striga weeds and degraded soils, climate change, drought, violence etc. [20-23]. Even though Africa has benefit from a wide range of new technologies and interventions from both internal and external development assistance seeking to improve the production of cereals [10, 24], the truth is, a high number of Africans still remain vulnerable to hunger, and food aid has remained one of the main strategies of assisting the hungry in Africa [10, 25].

Poverty and hunger have been problems for long in Africa. On the one hand, Africa has the world’s second largest land area and the world’s second largest population, yet production of cereals was less than 7 % of the world [26], and combating poverty and hunger has been a huge challenge facing African agriculture. On the other hand, agriculture provides a livelihood for more than 65% of the population in Africa, as well as 70% jobs of the labor force, and contributes around 25% of GDP in Africa. Hence, producing more food for a growing population for African agriculture is not only a huge challenge facing for Africa, but also a necessary solution to eliminate poverty and hunger in the world, which has always been a great deal of concern [21, 27-29]. In this paper, we assess food insufficiency and its variation using hrcci (land resources carrying capacity) in Africa based on the ability for food feeding its population, to examine the challenge of food chronic insecurity by measure the relationship between cereals production and population and its progress. Three questions are discussed: (a) which countries are in food insufficiency and which countries have the potential to realize food self-sufficiency. (b) Which countries have the ability to realize the Agenda in 2030? (c) How to realize food security in African countries with a couple of solutions for recommendation.

2. Methodology and data sources

2.1 Data source

In order to be transparent and globally applicable, this paper took advantage of statistics of FAO and World Food Program. To be specific, the production, export, import of cereals and population was FAO statistic, of which, cereals using “cereals, total +(total)” indicator of the “items aggregated” of “crop”, which related to crops harvested for dry grain for harvest area and production data. And food aid of cereals was statistic of World Food Program. Country was the basic analysis unit. Based on data availability, this article summed statistics of South Sudan and Sudan to Sudan (original), and summed the data of Ethiopia and Eritrea to be the data of the republic of Ethiopia for timing analysis. To be noticed, Seychelles, Saint Helena, Mayotte and Equatorial Guinea are lack of data. So, we finally analyzed 52 countries in Africa. In order to ensure typical characteristic, we applied average of continuous three years data of 1961-1963, 1969-1971, 1979-1981, 1989-1991, 1999-2001, 2009-2011, and 2014-2016 to represent the phenomenon in the year of 1961, 1970, 1980, 1990, 2000, 2010, 2015.
2.2 Evaluation model
We focus on the balance or imbalance between population and food to analyze the ability for a region’s food feeding its population to examine food insufficiency grades in Africa [5], which is always called land resources carrying capacity to reflect the relationship between population that a region’s food can supply and its population in reality, and the equation is as below:

\[ lrcci_i = \frac{P_i}{P_{sp_i}} \]  

\[ P_{sp_i} = \frac{F_{pro_i}(n - m + 1)}{\sum^n_m (F_{pro_i} + F_{im_i} + F_{aid_i} - F_{ex_i})/\sum P_i} \]  

Where \( Lrcci \) reflect the degree of closeness and the amount of difference between population and the population for the region’s food can feed, \( i \) represent for region \( I \), \( P \) represents the population in reality, person, \( P_{sp} \) represents the population for the region’s food can feed, person. If \( P>P_{sp} \) it was called overloading, and it is in food insufficiency; If \( P<P_{sp} \) it was called surplus, and it is in food sufficiency; otherwise, it was called balance, it is in between; \( F_{pro} \) represents the production of food, \( F_{im} \) represents the amount of food import, \( F_{aid} \) represents the amount of food aid, \( F_{ex} \) represents the amount of food export, \( n \) and \( m \) represent the starting year and the ending year, respectively. Subtracting food exports from the sum of food production, food import, and food aid represent consumption of cereals, demonstrate the amount of food supply, which method comes from the Regional Bureau for Africa of United Nations Development Programme. 8 grades were classified, and the content was showed in Table 1.

| Range | \( Lrcci \) | State | Food insufficiency | State |
|-------|-------------|-------|-------------------|-------|
| \(-\infty, 0.5] \) | High abundance | VIII | Food insufficiency |
| \(0.5, 0.75] \) | Abundance | VII | |
| \(0.75, 0.875] \) | Surplus | VI | |
| \(0.875, 1] \) | Slight surplus | V | between |
| \(1, 1.125] \) | Critical overloading | IV | |
| \(1.125, 1.25] \) | Light overloading | III | |
| \(1.25, 1.5] \) | Moderate overloading | II | Food insufficiency |
| \(1.5, \infty] \) | Severe overloading | I | |

3. Results

3.1 Food insufficiency state in Africa
As was displayed in Figure 1, the curve of population was all above that of \( P_{sp} \), which indicate that the amount of actual population is larger than that of \( P_{sp} \), and the production of cereals in total Africa can not feed its population all. The curve of \( Lrcci \) of Africa fluctuated relative to 1.25, illustrating that in some years, food self-sufficiency was in grade III, and in other years, they were worse than that. \( Lrcci \) was within the range of 1.22-1.62, which was all over 1.125, which was always worse than grades IV, suggesting that the state of food self-sufficiency in Africa, \( Lrcci \) was all population overloading, only from one degree to another. 6 years (in 1962, 1963, 1968, 1970, 1971 and 1975) of \( Lrcci \) was smaller than 1.25 from 1961 to 2015, other years was all over 1.25, even over 1.5 in 1983, 1984, 2000, 2001 years, indicating that the minority of these years was in light overloading, and most of these years was worse than light overloading, of which some was in moderate overloading, even severely overloading appeared.
In Figure 2, we can also see dynamic changes of population, $P_{sp}$ and $lrci$. and the trend of dynamic changes of population, $P_{sp}$ and $lrci$ are different of which, $P_{sp}$ increased fluctuate with growth rate of 2.5%, however, population growth rate was stable with relatively larger amount of 2.7%, resulting in improvement of production can’t satisfy the consumption, and food self-sufficiency wasn’t meet with the production growth.

During 1961-2015, the maximum $lrci$ occurred at 1983, and the minimum $lrci$ happened at 1963. To be specific, $P_{sp}$ at 1983 was a minimum about 0.32 billion, at the same time, population was 0.52 billion, so, if there wasn’t food import and food aid or other approach, it would be food inefficiency for about 0.2 billion people, resulting in grade I of food self-sufficiency, which was a strong food crisis. $P_{sp}$ at 1963 was the maximum about 0.25 billion, yet population was 0.31 billion, hence, production was short for approach to 0.06 billion people, leading to grade III of food self-sufficiency, which was a relatively delicate food crisis.

![Figure 1. $P_{sp}$, $lrci$ and Population in Africa in 1961-2015](image)

3.2 State of food insufficiency in African countries

As was shown in Figure 2, the majority of countries were in different degree of food self-sufficiency in spatial and temporal scale. Large scale of food insufficiency covers the year of 1961, 1970, 1980, 1990, 2000, 2010, and 2015. Over 70 percent of African countries were in food insufficiency, even, 60 percent of the countries were in the degree of grade I. Only the minority of countries had enough food, especially in 1980 and 2000, less than 15 percent of the countries were better than food insufficiency IV. Later in 2015, food insufficiency in Africa turned to be a little better.

As was showed in Table 2 and Figure 2, we made a statistic of state of food security, according to the sub region of FAO for Africa. It had more countries in eastern Africa and western Africa of food insufficiency better than grade IV. Northern Africa had moderate amount, southern Africa had much less, and central Africa had the least, unfortunately, it was almost the whole central Africa.

According to dynamic changes of $lrci$ in 1961, 1970, 1980, 1990, 2010, 2015 of Africa countries, four categories (No.i - iv) of 10 small classes were made (table 3). No.i: Getting better , including turn to [IV-V] and [VI-VIII]; No.ii: Fluctuate, of which fluctuate at [I-III], fluctuate at [IV-V] and [I-III], fluctuate at [I-III] and [VI-VIII], or fluctuate at [I-III], [IV-V], and [VI-VIII]; No.iii: Getting worse, to be specific, including get from grade VII to VI or V, get from [VI-VIII] to [I-III], or get from grade II to I; No.iv: stays in grade I from the beginning to the end, that pressure of strong crisis of food insufficiency was chronic.

| Region     | Grade | 1961 | 1970 | 1980 | 1990 | 2000 | 2010 | 2015 |
|------------|-------|------|------|------|------|------|------|------|
| Western Africa | [I-III] | 13   | 14   | 15   | 12   | 12   | 12   | 12   |
|             | [IV-V]  | 2    | 1    | 0    | 2    | 4    | 0    | 0    |
|             | [VI-VIII] | 1    | 1    | 1    | 2    | 0    | 4    | 4    |
| Southern Africa | [I-III] | 3    | 2    | 4    | 4    | 4    | 4    | 4    |
|              | [IV-V]  | 0    | 2    | 0    | 0    | 0    | 0    | 1    |
Figure 2. Food insufficiency in the 52 countries in Africa at 1961, 1970, 1980, 1990, 2000, 2010, 2015.
### Table 3. Categories with classes of dynamic changes of food insufficiency states

| Category | Classes |
|----------|---------|
| i getting better | 7/countries |
| a Sierra Leone, Togo, Unite republic of Tanzania | turn to \([IV - V]\) |
| b Mali, Guinea and Egypt | turn to \([VI - VIII]\) |
| ii fluctuate | 14/countries |
| c Benin, Guinea-Bissau, Cameroon Tunisia, Gambia, Nigeria, Swaziland Zambia, Ethiopia PDR, South Africa, Burkina Faso, Morocco, Malawi | fluctuate at \([I - III]\) |
| d | fluctuate between \([IV - V]\) and \([I - III]\) |
| e | fluctuate between \([IV - V]\) and \([VI - VIII]\) |
| f Chad | fluctuate among \([I - III]\), \([IV - V]\), and \([VI - VIII]\) |
| ii getting worse | 7/countries |
| g Niger, Madagascar from grade VII to VI or V | Get from \([VI - VIII]\) to \([I - III]\) |
| h Kenya, Lesotho, Zimbabwe | From grade II to I |
| i Senegal, Algeria | |
| iv no improvement | 24/countries |
| j other countries | stay in grade I |

### 4. Discussion

#### 4.1 Which countries can realize 2030 agenda in Africa?

Based on categories with classes of dynamic changes of food insufficiency, we argue that food insufficiency of a country has been in grade IV, or better than grade IV has the potential to make zero hunger vision come true. We can thus divine that country at class a, b, e and g show largest possibility to realize food sufficiency. Also, countries of class d, f, and h have the potential to realize the agenda, only to prepare for and overcome the fluctuate factor like climate change, conflicts etc. Countries of class of i and j may be much harder to reach food sufficiency, which indicate that about half number of African countries may not realize the 2030 agenda, if only no extraordinary efficient way to solve the severe food crisis.

#### 4.2 Which way can African countries try? —category-based solution

In fact, policy frameworks that aim to improve food sufficiency face many uncertainties and often fail [6], and diverse technologies exist in Africa range from mechanical technology to biological and biochemical technology, biotechnology and nanotechnology as well as indigenous technology options [30]. However, not all types of agricultural development are equally effective in improving food sufficiency and promoting broad-based economic development [31], the formulation of effective solution needs adequate information.
For countries which may be much harder to get to food sufficiency (class \(i\) and \(j\)): firstly, food import and food aid will remained the main strategies of assisting the hunger, only it should be associated with both the reasonable allocation of trade and a restriction of the excessive reliance on food aid, which should be managed in order and moderate, such as who receives food, where they are, how much do they want, what type of assistance, and which countries should be the provider [25]. Secondly, technological solutions, such as the push-pull system based on locally available companion plants, climate-adapted companion cropping [13, 24]. Farmers should adopt the technology in drier areas for the study, etc. At the same time, farmers’ perceptions of the benefits of the technology should be improved, because the capacity of farming communities, their know-how and their visionary farming approach play a greater role on their reaching the potential to feed the continent [32]. Thirdly, conflicts can’t be ignored, so putting forward a sustainable conflict resolution agenda should be put forward to dilute local racist sentiment and guiding the whole people to strengthen national consciousness, as well as becoming an equal partner with the West [25]. Last but not the least, population growth and family planning should be paid full attention, especially in central Africa, where the number of undernourished people has doubled since 1990, because of rapid population growth and environmental fragility as well as economic and political upheaval [8].

In order to achieve the agenda of 2030 (class \(d\), \(f\), and \(h\)), utilize the policy tools that are available to them in ways that maximize the benefits of greater food self-sufficiency while minimizing the risks of biophysical environment, by introducing strict systems of coordination, rewards and punishments for the protection of natural resources and the control of water sources, and develop deserts by adopting agricultural techniques based on the protection of their ecology, and developing a comprehensive plan for greening the desert and continue to explore the ecological connection between the protection of ecological groundwater and the construction of an oasis. Adaptive technology is necessary to upgrade cereals growth, through on-farm water management strategies, such as reducing soil evaporation (‘vapor shift’) and collecting runoff on cropland and using it during dry spells (‘runoff harvesting’) [11]. Also, exploring and combining all options of more efficient irrigation and/or expansion of irrigated agriculture, of plant breeding and genetic development, and of more effective virtual water trade are needed. To ensure the technology’s long-term sustainability in view of the current and further potential aridification as a consequence of climate change, drought-tolerant crops, border crop and intercrop incorporated into a ‘climate-adapted push–pull’ can overcomes parasitic striga weed Striga hermonthica, stemborers and poor soil fertility, which can provides an opportunity to improve food sufficiency, stimulate economic growth, and alleviate poverty in the region while making agriculture more resilient to climate change [24].

For countries seem to show the largest possibility of zero hunger at Africa (class \(a\), \(b\), \(e\) and \(g\)), policy development and implementation, capacity building and strengthening, R&D investment, adequate infrastructure, as well as the adoption of innovation systems approach are needed [10]. According to the 2030 Agenda for Sustainable Development goals, meeting the dual objectives of food security and ecosystem protection is a major challenge, so, more food should be produced using science-based approach that integrates gender and sustainability like using sustainable intensification (SI) strategies, agricultural intensification etc. [33-34]. Not only to realize food sufficiency for its country, but also to be a food supply for its neighboring countries.

Land, which is the main asset in farming, is typically much more equitably distributed in Africa than human and physical capital [31]. Land resources carrying capacity has been proposed and used way back [2]. Land resources carrying capacity intends to finding out the upper bound of a region to support its population, which is undoubtedly the oldest and still the most influential way to analysis food insufficiency, especially for countries at the same time combating poverty and hunger like Africa or to prepare for other political factors [5]. In this paper, we use \(\text{IREC}\) to evaluate food insufficiency basing on the ability for food feeding its population, our approach does not account for trade data or other food supply except for production. We refer to the lack of food access of the capacity of cereal production, which has benefits in demonstrating the temporal and spatial distribution of the ability for food feeding its population, further research needs to consider more suitable measurement concerning about other factors to comprehensively evaluate, too.
5. Conclusions
Food self-sufficiency gained increased attention after the wake of the 2007–08 international food crises or climate extremes recent years [15]. A detailed and objective assessment of individual countries’ unique circumstances of food self-sufficiency, for example, could help in efforts to carve out policy space within countries to invest in their domestic agricultural capacity. This study demonstrate that Africa has been in chronic food insufficiency, and given the range of circumstances facing in different countries of Africa, which can incorporate sufficient flexibility to enable countries to utilize the policy tools that are available to them in ways that maximize the benefits of greater food self-sufficiency while minimizing the risks associated with both the restriction of trade and food aid. Results reveal that although production of cereals improved in total Africa, it can not satisfy for the consumption of its population, get rise that insecurity wasn’t improve with the production growth.

This study provides insight about the challenge in meeting the 2030 Agenda due to historic and present scenarios of food self-sufficiency, which is more about a country’s domestic capacity for food production than it is about a rejection of food trade. We made four categories including food insufficiency getting better, fluctuate, getting worse, and no obvious improvement in food insufficiency, and categories with sub-class. Basing on the categories, measurement was proposed to reduce food insufficiency.

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