

Challenges and innovations in achieving zero hunger and environmental sustainability through the lens of sub-Saharan Africa

Moses Okello¹ , Jimmy Lamo²,
Mildred Ochwo-Ssemakula³ and Francis Onyilo⁴

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Abstract

Achieving zero hunger by 2030 often raises the issue of environmental protection or sustainable social development among policy makers due to the environmental footprint of intensifying agricultural production across the continent. Sub-Saharan Africa (SSA) has one of the fastgrowing populations with more than half of the global growth between now and 2050. The challenge now lies in feeding the ever-growing population that is exerting pressure on the limited available resources. Doubling the agricultural productivity of small-scale farmers by 2030 (SDG 2.3) remains a daunting task for researcher and policy makers to address on the continent that now relies much on imports of food. Exploitation of the untapped massive land resources for agricultural production poses threats to sustainability. However, the challenges of global warming cannot be left out of this discussion since it has direct impact on future productivity on the continent. Climate change that has been projected to mostly affect the poorer countries also present trials to the food system through increased diseases and weather extremes of floods and droughts. Questions are yet to be answered on which tradeoffs and synergies if any need to be made to achieve zero hunger in Africa by 2030. This synopsis critically breaks down the conflicts, tradeoffs and synergies of how a continent with such massive agricultural production potential can navigate sustainably to achieve zero hunger, self-sufficiency and exports prospects while conserving the environment and natural resources. Evident deployment of new and improved technologies especially advanced biotechnology tools will be critical in achieving zero hunger by 2030. The adaptation needs of the continent are broad including institutional, social, physical and infrastructural needs, ecosystem services and environmental needs, and financial and capacity uncertain impacts.

Keywords

SGDs, climate change, food security, sub-Saharan Africa, innovations, resilience and sustainability

The food security and SDGs 2.3./15.2. in SSA

Agriculture is the primary sector of almost every African economy (Ba, 2016; Saghir, 2014; Valentini et al., 2014). About 65% of the total labor force in Africa is employed in the agriculture sector, which contributes about 32% of the continent's gross domestic product (GDP), reflecting the relatively low productivity in the sector (Ba, 2016; Chauvin et al., 2012). Agricultural land expansion (extensification) has been an important component of production growth in places such as Africa and Latin America (Herrero et al., 2016; Tilman et al., 2011). Production in Africa could also be increased by agricultural intensification (i.e. achieving higher yields through increased inputs, improved agronomic practices, improved crop varieties, and other innovations) (Hickman et al., 2011; Tilman et al., 2011). In developing countries, agriculture is a crucial sector for

driving the green economy (Musvoto et al., 2015). However, land clearing, soil cultivation, and the manufacture and use of nitrogen (N) fertilizer all emit greenhouse gases [GHG] (Tilman et al., 2011). This highlights the conflicts of achieving sustainably food production with minimum

¹ Department of Crop Science, Faculty of Agriculture and Environmental Sciences, Muni University, Arua, Uganda

² National Agricultural Research Organization (NARO), Uganda

³ College of Agricultural and Environmental Sciences Makerere University, Uganda

⁴ Faculty of Agriculture and Environmental Sciences (FAES), Muni University of Technoscience, Uganda

Corresponding author:

Moses Okello, Department of Crop Science, Faculty of Agriculture and Environmental Sciences, Muni University, P.O. Box 725, Arua, Uganda.
Email: moseso847@gmail.com

environmental footprint. The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. There are 17 SDGs integrated implying they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. The SDG 2.3 undertakes that by 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment. SDG 15 which encompasses life on land seeks to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements and the indicators include forest area as a proportion of total land area. 15.2: implies by 2020 to promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally measurable by progress toward sustainable forest management.

Generalizing SDGs has always been an imprecise analogy in reality to the different geographical challenges across the globe. With 11 seasons to go to the 2030 targets, the narrative of achieving zero hunger is a daunting task. The agricultural sector in Africa employs 65–70 percent of Africa's labor force and typically accounts for 30–40 percent of GDP (Unlocking Africa's Agricultural Potential. An Action Agenda for Transformation). More than 70 percent of the continent's poorest populations live in rural areas and agriculture is their most important economic activity. Furthermore, the poverty-reduction elasticity of agricultural growth is up to four times higher than that of non-agricultural growth.

Global undernourishment is expected to fall from the 2015 estimate of 11% of populations in developing countries to an estimated 6% in 2030 (FAO, 2015). By 2030, about 75% of populations in developing countries are projected to be living in countries where no more than 5% of people are malnourished, in contrast to the 8% who live in such countries at present. Today, however, most of the world's hungry people are chronically hungry, and they are so hungry because they are chronically poor (African Union Commission et al., 2014). An estimated 78% of the world's poor are heavily dependent on agriculture not only for their food, but also for their livelihoods (FAO, 2015). Agricultural productivity represents, therefore, one of the most powerful tools that exists to end extreme poverty. For instance, in their Development Progress paper examining Thailand's progress in agriculture, Wiggins and Leturque

(2011) show that since 1960, Thailand facilitated the country's transformation into an urbanized economy based on rapid agricultural growth. Growth through agriculture was based on the utilization of underused land and labor, and led to falling poverty from more than 60% in the early 1960s to barely more than 10% in the new century. Specific differences within SSA regarding wealth inequalities is understudied and yet the understanding of the deferent sources of inequality is a necessary step toward the implementation of policies that may foster a sustained and "shared" growth in these countries. Huge number of citizens rely on land for agricultural production but unequal land distribution still remains the oldest form of wealth equality in the African countries.

Africa has about 51 million farms of which 80% (or 41 million) are smaller than 2 ha in size (Lowder et al., 2016), and their numbers are still increasing in most countries (Headey, 2016; Jirstrom et al., 2011). Africa wide, farms smaller than 2 ha produce about 30% of total agricultural output, while farms 4–20 ha produce another 50% (Herrero et al., 2017). However, the available evidence shows that many of these farms are efficient low-cost producers which obtain higher yields, on average, than many larger sized farms, and are quite able to compete in markets given a fair opportunity (Larson et al., 2014).

The potential conflict between protecting forests and food/nutrition security is a particular concern in the light of our existing growth, production and consumption patterns; yet little is known about the nature and extent of the repeatedly claimed incompatibility between these two goals and especially in low-income countries (Economic growth and Environmental Degradation). Policy-makers need to solve these complex equations simultaneously. The holistic nature of SDGs 2.3 and 15.2 involves a lot of interactions meaning that data will have to be exploited extensively to make decisions by the policy makers. These chronicles highlight conflicting policies and tradeoffs in achieving zero hunger while sustaining the environment under the threat of climate change across sub-Saharan Africa (SSA).

“Challenges in fulfilling SDG2.3 and SDG15.2 in developing countries”

There is an outstanding compromise at the core of sustainable development between those who prioritize the environment, those who prioritize social development, and those who prioritize economic development. Globally, this compromise has engaged developed and developing countries in a common endeavor (Convention on Biological Diversity United Nations, 1992). However, tensions have been brewing between the poorer and the richer countries, with the former seeing demands for environmental protection as a threat to their ability to develop, while the rich countries view some of the development in poor countries as a threat to valued environmental resources. In developing countries, especially in SSA, the tensions at the local level still remain and are now even greater. There is greater tension toward compromise to achieving zero hunger at the

essence of sustainable agricultural production and social development.

The current growing African population will demand more land, food and fuel. This calls for new innovative ways to end hunger by increasing per capita farm volumes through use of elite varieties and sustainable water resource and land management. Environmental footprint that comes with a growing population remains a threat to sustainable resource management in the region. Achieving increased farm volumes per capita and especially for indigenous populations will not be any easier in the future than it has been in the past due to these new challenges, biotic and abiotic stresses inclusive.

On the contrary water resources and land for farming, especially for small-scale farmers, are under far more pressure than in the past and are becoming scarcer, both in quantitative terms (per capita) and qualitative ones. Local food prices are likely to become increasingly chained to highly unstable and volatile global commodity prices, as we have seen in recent global trends (World Agriculture Towards 2030/2050). The scarcity of water and land stems from the changing climate, soil degradation, salinization of irrigated areas, and competition for land uses other than for food production, such as growing cities and protected areas (The State of Food Insecurity in The World). It is usually the poor and most especially women and children who are hit hardest by the scarcity in resources and costs. Women make up 50% of agricultural labor force in sub-Saharan Africa, an increase from about 45% in the 1980 (The Role of Women In Agriculture). They also look after the children and take care of the home; therefore, any scarcity adversely affects them.

Households across Africa spend half of their income on food and are struggling to keep up (Food for Thought: Tackling Child Malnutrition To Unlock Potential and Boost Prosperity). There are also fears that the downward trend of growth of crop yields may not reverse. The tension now is whether the lower yield potential, together with modest increases in cultivated land, is adequate to meet increased demands (The economic lives of small-holder farmers). The continued change in climate is another looming risk that may negatively affect agricultural resources.

Climate change impact

Climate change adds a layer of complexity to the challenge of fulfilling the targets of the Sustainable Development Goals (SDGs). It has been noted that Africa is one of the continents that is most highly affected by climate change for two reasons: its geographical characteristics of having a majority of land lying across the warming tropics, and the limited human, social and economic capacity that African countries have to adapt to the impacts of climate change (Climate change impact and adaptation strategies).

Demographic and economic trends in Africa mean that climate impacts will be intensified; for example, growing populations will increase the demand for water and food, but prolonged extreme events such as droughts will put

additional pressure on already scarce water resources and will reduce crop yields (CDKN, 2014). The region is already suffering from recurring risks to food production, and without adequate measures to adapt, these risks could become more intense under a changing climate; for scenarios approaching 4°C warming, the risk to food security in Africa would be extremely severe, with limited potential for reducing risk through adaptation (Niang et al., 2014). African women are especially vulnerable to the impacts of climate change because they shoulder an enormous, but imprecisely recorded, burden of responsibility for subsistence agriculture, whose productivity can be expected to be adversely affected by climate change and overexploited soil (Viatte et al., 2009).

Agriculture contributes about 20% of the present atmospheric greenhouse gasses (GHGs) concentration (Agriculture's role in greenhouse gas mitigation). Methane (CH₄) and nitrous oxide (N₂O) are the most important GHGs from agriculture, with the global warming potentials (GWP) of 28 and 265 CO₂ equivalents, respectively, on 100-year time horizon (Myhre et al., 2013). The atmospheric concentrations of CH₄ and N₂O have increased rapidly destroying the stratospheric ozone layer, which is harmful to human health (Ravishankara et al., 2009). FAO estimates that production will have to increase by 40% by the end 2030 to meet the demand of ever rising population.

The largest part of GHG emissions in developing countries come from Agriculture, Forestry and Other Land Use (AFOLU) while for the high-income countries GHG emissions are dominated by sources related to energy supply and industry. In history, GHG emissions in Africa as a whole have been dominated by the AFOLU sectors, represented by the difference between carbon sequestered through photosynthetic (forests and savannas) and non-photosynthetic processes (soils and water) (sinks), and carbon released into the atmosphere as a result of agricultural practices, deforestation, fires and forest degradation (sources). They represented 56% of the total emissions in 2016. There is, however, a significant difference between the north African region and sub-Saharan Africa: in the former, AFOLU contributes with a small, negative balance (more sequestration than emissions), in the latter, and even though its relative contribution has decreased thanks to Land Use Change and Forestry (LUCF) activities, it still represents the majority of emissions (56% of the African total in 2016 from 71% in 1990).

Croplands are both a sink and a source of GHG emissions (Kim et al., 2016). It is common practice in much of rural SSA that farmers remove all crop residues after harvest (Suckall et al., 2015). Crop diversity in the continent is more pronounced in West Africa than in other regions and many of the crops planted in this region are unique and not well researched (Tadele, 2017). Cassava is the major crop grown in West Africa (Leff et al., 2004) and the general belief that this crop does not require fertilizer since it can do well in degraded lands, makes farmers barely use fertilizer (Fermont et al., 2010). A mixture of wheat, barley, maize and rice dominates large crop areas in North Africa (Leff et al., 2004). Maize, sorghum, wheat and millet are

common staple crops in Southern Africa (Christiansen, 2008; Tongwane et al., 2016; Wenzel, 2003). The only regions globally where a cereal is not the dominant crop are the Caribbean and central Africa (Leff et al., 2004). Production of cereal crops is the major source of GHG emissions in Africa because of the large areas of lands they occupy when compared to other crops (Tongwane et al., 2016). GHG emissions from croplands in SSA depend on both natural variations associated with climate and soil type and management factors including nutrients (particularly fertilization) and crop type (Kim et al., 2016).

Current understanding of GHG emissions in SSA is particularly limited when compared to the potential the continent has as both a GHG sink and a source (Boateng et al., 2017; Kim et al., 2016). Limited data and information on agricultural production in Africa make it difficult to quantify the contribution that the continent could make toward global mitigation of GHG emissions.

Agricultural emissions in Africa by regions

Agricultural GHG emissions in Africa vary from region to region. In total, agricultural emissions produced in Africa ranged from 0.44 Gt to 0.54 Gt of CO₂e in 1994. The total emissions rapidly increased to between 0.66 and 0.79 Gt in 2010. In the FAO (2017a) database, the only comprehensive source of data for 2014 indicates that the total emissions in that year were approximately 0.87 Gt. These estimates are comparable to those of Valentini et al. (2014) and to global values in Smith et al. (2014). Averaged over the period 2000 to 2010, the African continent is the third highest producer of agricultural GHG emissions behind Asia and the Americas (FAO, 2015; Tubiello et al., 2013).

The emissions presented in this work are exclusive of CO₂ from lime and urea. Agricultural GHG emissions in the continent increased by between 2.9% and 3.1% per annum between 1994 and 2010. These rates of increase are more than double the global average. Between 2000 and 2010, global agricultural emissions increased by 1.1% annually, reaching 4.6 Gt CO₂e in 2010 (Tubiello et al., 2013). Emissions in East Africa increased by 4.7% per year between 1994 and 2014, 2.9% in Southern Africa, 1.2% in Central Africa and 1.1% in North Africa. There was a decrease of 3.0% in annual emissions between 1994 and 2000 in East Africa, and increases of 5.7% in the central part of the continent, 2.2% in the West and 1.8% in the North.

Generally, agricultural emissions in developing countries are increasing at a faster rate than those in developed countries (Tubiello et al., 2013). This annual high rate of increase may make Africa a major producer of emissions in the near future. Emissions of enteric fermentation grew rapidly in Africa between 2000 and 2010 with an average annual rate of 2.4% (Smith et al., 2014).

East Africa is the largest source of the agricultural emissions. Approximately a third of the continent's total agricultural emissions come from this region. As a result of the large livestock population in Ethiopia, a total of 94% of

national agricultural emissions in 2013 were from enteric fermentation (MEF, 2015). In general, Southern Africa produced approximately three tenths of the total emissions from agriculture in Africa in 1994 and 2014. West Africa contributed a fifth of the total GHG emissions while each of Central and North Africa produced nearly a tenth of total GHG emissions from agriculture in Africa. North Africa, the most arid region in the continent, was the lowest overall producer of agriculture emissions in Africa.

In the review of effects climate change on insect herbivores, Temperature is identified as the dominant abiotic factor directly affecting herbivorous insects for example the warm temperatures in SSA due to global warming has led to widespread of fall armyworm which was first identified in 2016.

Complex interactions of climate change and invasions of locusts in the horn of Africa; Locusts thrive in wet conditions, and outbreaks often follow floods and cyclones. Recently there has been an upsurge in the infestation of locust and other insect pests like fall armyworm due to the impact of climate change on the continent. Heavy rain leads to growth of vegetation in arid areas, providing locusts with the conditions needed to develop and reproduce, according to the World Meteorological Organization (WMO). These widespread rains came in a year of extremes in East Africa. Last year started with a drought, putting more than 45 million people at risk from food insecurity, and ended with abnormally wet conditions. The Horn of Africa was hit by eight cyclones in 2019, the largest number in any year since 1976. Much of African agriculture's vulnerability to climate change lies in the fact that its agricultural systems remain largely rain-fed, with few technological inputs, as the majority of Africa's farmers work on a small-scale or subsistence level and have few financial resources, limited access to infrastructure, and disparate access to information. Persistent poverty and socioeconomic inequality, low levels of development, limited economic capacity as well as governance challenges have further contributed to the continent's limited capacity to adapt to climate change (Shackleton et al., 2015). New risks from climate change are expected to have major negative impacts on agriculture, fisheries, and food security across the region and feedback into development, thereby undermining any progress that has been made to deal with poverty and inequality (Shackleton et al., 2015). Changing climate impacts temperature and precipitation, two very important variables for crop growth. Warming trends have already become evident across the continent, and it is likely that the continent's mean annual temperature will increase by more than 2°C by the end of this century (Niang et al., 2014). These changes have direct impact on biophysical and socioeconomic aspects of agrarian communities which further cast shadows on achieving the SDGs goals 2030 and in the absence of effective adaptation measures, African crop production will significantly reduce.

Examining the sustainability of the food-production system, the trade-offs and/or synergies raise doubts about the possibility of continuing to do what has been done in the past: increasing inputs in production, expanding irrigation

and cultivated land, and long-distance transportation of farm yields. Many scientists, agricultural economists and environmental experts advocate for intensified production that is, above all, sustainable, which raises doubts about whether it will be possible to achieve the quantities of food the world will need for its growing population, given the stringent resource constraints for agricultural production. This is one of the primary reasons for fears that increased volume per capita among smallholder farmers to meet future food and income requirements may conflict with the simultaneous management and sustainability of forests.

Innovations for resilience and sustainability

Agroforestry is one of the most promising climate change adaptation strategies for Africa, as it provides the opportunity to produce assets for farmers, offers climate change mitigation opportunities, and has the potential to promote sustainable production that enhances agroecosystem diversity and resilience (Mbow et al., 2014). A number of successful agroforestry technologies exist that can meet “climate-smart” requirements, such as trees that improve soil, fast-growing trees for fuel wood, indigenous fruit trees to provide added nutrition and income, and trees that can provide medicinal plant products (Mbow et al., 2014; Molua, 2005). However, Mbow et al. (2014) emphasize that there is a need to differentiate between simple agroforestry systems (such as alley cropping, intercropping, and hedgerow systems) and complex agroforestry systems that function like natural forest ecosystems but are integrated into agricultural management systems (Oke and Odebiyi, 2007; Rice, 2008).

As an initiative to address global challenge of climate change, African countries signed up for a massive land restoration program the African Forest Landscape Restoration Initiative (AFR100) which is a country-led effort to bring 100 million hectares of land in Africa into restoration by 2030. It aims to accelerate restoration to enhance food security, increase climate change resilience and mitigation, and combat rural poverty. AFR100 is a partnership of more than 20 African governments and numerous technical and financial partners. Stakeholder engagement is a key principle of AFR100. Engaging all relevant stakeholders in the assessment of restoration opportunities and identification, testing and active upscaling of promising Forest Landscape Restoration (FLR) solutions is considered key for successful restoration. Among many targets the initiative contributes to domestic commitments, the Bonn Challenge, a global commitment to restore 150 million hectares of land around the world by 2020, the New York Declaration on Forests that extends the Bonn Challenge to 350 million hectares by 2030 and the African Resilient Landscapes Initiative (ARLI), an initiative to promote integrated landscape management. These initiatives are part of the synergies that will enable Africa to sustainably achieve self-sufficiency in food production and exports while conserving the environment buffer from climate change impacts.

Greater efforts to shift to restoring forests while sustainably providing food, water and energy in order to eradicate extreme poverty and achieve sustainable economic growth are essential. A growing body of evidence suggests that through afforestation and reforestation, sustainable forest management and reduced deforestation, forests constitute one of the most cost effective, proven mitigation and adaptation options for addressing climate change. The full potential of forests in this function has, however, yet to be harnessed in many parts of the world.

Role of biodiversity in achieving zero hunger

Biodiversity plays a key role in ensuring dietary adequacy. Micronutrient needs for human health cannot be satisfied without animal, fish and plant genetic diversity, species diversity and ecosystem diversity. Pollination leads to higher nutrient content in many crops and fruits. The vast plant genetic resources across Africa still provides for an opportunity to cultivate and maintain a rich diet from the diverse nutrient rich traditional food sources that the communities highly depend on. However, the alarming pace of biodiversity loss and ecosystem degradation makes a compelling case for re-examining agricultural systems and diets. Sustainable diets promote the use of diverse foods, including traditional and local foods, that make use of nutritionally rich species, varieties of plants and breeds of animals, as well as wild, neglected and underutilized species. Sustainable agriculture is key to reversing trends that lead to biodiversity loss, damaged ecosystems, deforestation and the overall deterioration of our natural resources. The model of low input production of diverse dietary source has worked well in SSA which serves as an example for developed countries.

Recommendations

Evidently, new and improved technology is needed for areas with shortages of land or water, or with particular problems of soil or climate. Such areas often have a high concentration of poor people, for whom technology could play a fundamental role in improving food security (Doczi et al., 2014). The FAO suggests that even without significant advances in modern biotechnology, agricultural production could meet expected demand in the years to 2030 (OECD/FAO, 2016). Nevertheless, new techniques of molecular analysis could still provide a much-needed boost to productivity and, therefore, improve the incomes of the poor. New and emerging technologies should not only be accessible, but also affordable and tailored to meet the needs of small-scale farm producers, women and the malnourished (Townsend, 2015). While productivity advances remain vital, they must also be combined with forest restoration and environmental protection. Policy-makers must address the perceived environmental threats from biotechnology. The fear to adopt new technologies can only be changed through engagement of the population by scientists and data driven decision making by the policy makers.

These technologies have a great scope in boosting production across the continent if well adopted and managed.

Africa is exposed to a range of multiple stressors (e.g., poverty, youth unemployment, lack of infrastructure) that interact in complex ways with climate change; therefore, the adaptation needs of the continent are broad, including institutional, social, physical, and infrastructure needs, ecosystem services and environmental needs, and financial and capacity uncertain impacts (New indicators of vulnerability and adaptive capacity).

In some instances, significant implementation challenges related to complex cultural, political, and institutional factors have led to a deficit of adaptive capacity on the continent, thereby reinforcing the need for strong links between adaptation and development plans in essence, the need for low-regrets adaptation strategies that not only buffer impacts from climate change but that also produce long-term development benefits (Niang et al., 2014). No single adaptation strategy exists to meet the needs of all communities and contexts in Africa, and the focus in the 2000s on technological solutions is evolving toward a broader view that highlights the importance of building resilience, through social, institutional, and informational approaches (Chambwera and Anderson, 2011). There is a growing recognition that the poverty and complex livelihood-vulnerability risks faced by many people in Africa are a challenge for adaptation (Tschakert and Dietrich, 2010), and that there is an urgent need to take into account local norms and indigenous knowledge when devising adaptation strategies (Nyong et al., 2007). Needs (Niang et al., 2014). Successful adaptation in the African context is dependent on building systemic resilience.

Conclusion

Ending hunger can be reconciled with environmental sustainability but policy makers will have to solve this complex puzzle simultaneously by critically examining key drivers of agricultural progress, and how they have worked together or in opposition to advance or undermine economic, social and environmental development. Continuous examination of major synergies and trade-offs that are likely in the future by mapping alternative future scenarios and predictive models is key to decision making.

Facilitating informed policy dialogues across SSA that assess policy responses critically to address the negative impacts of SDGs trade-offs, and strengthen synergies in sustainably growing the agricultural sector, poverty reduction and transformation impacts is an important component. Dialogues will enhance the capacities to navigate complexities, collaborate, reflect and learn, and to engage in strategic and political processes (TAP, 2016a).


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ORCID-iD

Moses Okello  <https://orcid.org/0000-0003-4593-3253>

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