EGU General Assembly 2019,
Session HS5.4.3/ERE8.2:
Integrated Assessment of water - food - energy nexuses (co-organized)

Reformulation of Agricultural Sustainability*

Nikos Pelekanos, Konstantinos Papoulakos, Georgios T. Manolis and Dionysia Panagoulia

Contact info: nikospel11@gmail.com - Presenting author: Nikos Pelekanos

Department of Water Resources & Environmental Engineering, School of Civil Engineering, National Technical University of Athens, Greece

1. Abstract

All definitions of Agricultural sustainability agree on that it has economic, environmental and social aspects while the economic aspect is examined taking into consideration viability in strictly microeconomic terms. Energy input is usually analyzed into Labor, Machinery, Fuel, Nitrogen, Phosphorus, Potassium, Seeds, Irrigation, Herbicides, Insecticides, Electricity and Transport. However, in most countries under food stress labor input is high while agricultural production has low contribution from the rest of the energy input variables which impacts productivity in a negative way. Since most of these countries have negative trade balances and foreign exchange shortages, economic viability must be augmented in a way that influences these national account balances which impede the viability of microeconomic aspect examined usually. The augmentation methodology proposed is the redefinition of cultivated land by the obligatory inclusion, as an integrated component, of additional land where biomass/biofuel cultivation takes place. The target of this redefinition is (a) to cover the cost of the rest of the energy input variables by a crop which reduces imported fuel and allows for the foreign exchange earned to be transferred to the import of these missing quantities while retaining the same level of imports (b) to lower in a sustainably stable way crop prices in general and (c) to insulate crop production from the local and local fluctuations of energy cost. The pros and cons in terms of general sustainability are examined.

2. Introduction

General WEF Sustainability [1], [2], [3], [4] includes Agricultural Sustainability [5], [6], [7], [8], [9], [10], [11] whose increase is tied up with a corresponding Sustainable Food Security increase [12], [13], [14], [15]. The operational diagram connecting these global processes is as below, where Supply connects to Demand via Trade Policy interfacing with the Region/Country level which may rely in part upon some form of Open Market Operations. This leaves open the matter of what policy should be followed at Region/Country level so as to control the impact of the critical interface formed, which may, under adverse economic conditions, be inimical to the localized economies.

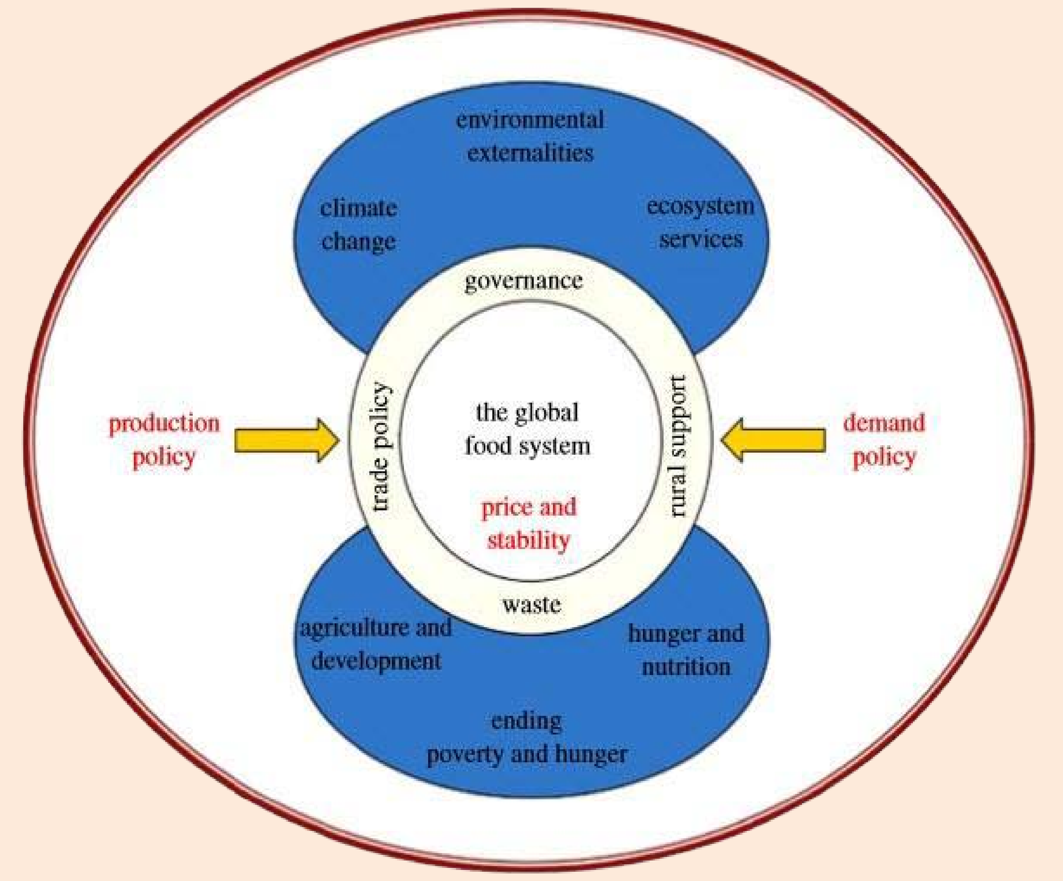

Figure 1: Modified from [16]

3. Objectives

We examine the component of General WEF Sustainability, Agricultural Sustainability, with the aim of zeroing Imported Agricultural Products and increasing Imported Agricultural Energy Input [17], [18], [19], [20], [21], [22], [23] at Region/Country level which should occur under the constraint of influencing positively the country's existing foreign trade balance X-M.

This implies that in terms of Agricultural Energy Input, $E_{AGRICULTURAL\ ENERGY}$, only the imported part, E_{IMPORT}, are taken into primary consideration, i.e. the sum of Machinery (E_1), Fuel (E_2), Nitrogen (E_3), Phosphorus (E_4), Potassium (E_5), Seeds (E_6), Herbicides (E_7), Insecticides (E_8), Electricity (E_9) and Transport (E_{10}) while the local provenance components, E_{LOCAL}, Labor (E_{11}) and Irrigation(E_{12}), are of secondary consideration.

The result sought is region/country level Agricultural Self-Sufficiency by economic policies that are endogenous within this level by restricting this application to cases where the Region/Country is structurally weak in the main economic variables involved in the formation of trade balance X-M. There is a wave of support for region/country Agricultural Self-Sufficiency [24], [25], [26], [27], [28], [29].The main line of reasoning rests on the Trade Dependency generated by Food Insufficiency [30] which, coupled with the weak geopolitical position of most of the importing countries, creates a perpetual state of comparative disadvantage with respect to the food exporting countries.

**This research is formulated from the "Agricultural Self-Sufficiency: An Economic Analysis with Application to African LDCs" by Kalomoira Zisopoulou, Nikos Pelekanos, Konstantinos Papoulakos, Georgios T. Manolis and Dionysia Panagoulia (work in progress).*

4. Materials & Methods

The way proposed is to substitute part of Oil Imports by Government subsidized locally produced biofuel. The import cost saved from this substitution will be transferred to the import account for agricultural E IMPORT which will lead to crop intensification and/or increase of cultivated areas under sustainability restrictions[18], [20], [23], [31], [32], [33], [34], [35], [36]. This will leave the size of the trade balance initially invariant and, as biofuel production is stabilized at a level where the intensification/cultivated area increase eradicates Agricultural Imports, the trade balance will be reduced.

In essence, the Central Government borrows from the Central Bank a sum of money S0 in LCU which is enough to start off the agricultural production of biofuel land and its processing into a quantity Q of biodiesel / fuel on Government owned land after a period of 18 months . This quantity Q should be sufficient to finance the crop intensification and/or increase of cultivated areas into Government owned land under sustainability restrictions to the degree that, after an additional 18 month period, the targeted agricultural imports Q AGRICULTURAL IMPORTS will be replaced with local production leading to Agricultural Self-Sufficiency. Part of S0 will be converted into foreign exchange, S0 EXCHANGE, which will cause a "bump" M0 = S0 EXCHANGE in the negative trade balance X-M and will probably be carried over as additional external public debt. The annual production of Q would entail the following costs QC:

a. The energy input components of Agricultural Production, EIMPORT (where Machinery will be replaced by repair costs) and ELOCAL
b. The energy inputs of processing into biodiesel / fuel E PROCESSING IMPORT and E PROCESSING LOCAL
c. The S0 amortization comprised of S0 EXCHANGE AMORT and S0 LOCAL AMORT

Therefore QC can be expressed as QC = QC EXCHANGE + QC LOCAL where QC EXCHANGE = EIMPORT + EPROCESSING IMPORT + S0 EXCHANGEAMORT and QC LOCAL= ELOCAL + EPROCESSING LOCAL + S0 LOCAL AMORT. Assuming that the Government will sell at a price equal or lower to QC the lowest price it can charge will be QC EXCHANGE so as to maximize the M reduction and reduce the X – M negative balance. At the same time oil imports $P_{OIL\ EXCHANGE}\ Q_{OIL}$ will be reduced to POILEXCHANGE (Q_{OIL}- Q) and the import cost of Agricultural Products, PAG PROD EXCHANGE QAGRICULTURAL IMPORTS , will become zero. Hence

CHANGE OF M TO M-ΔM

$$\Delta M = P_{OIL\ EXCHANGE}\ Q + P_{AG\ PROD\ EXCHANGE}\ Q_{AGRICULTURAL\ IMPORTS} - Q_{C\ EXCHANGE} > 0$$

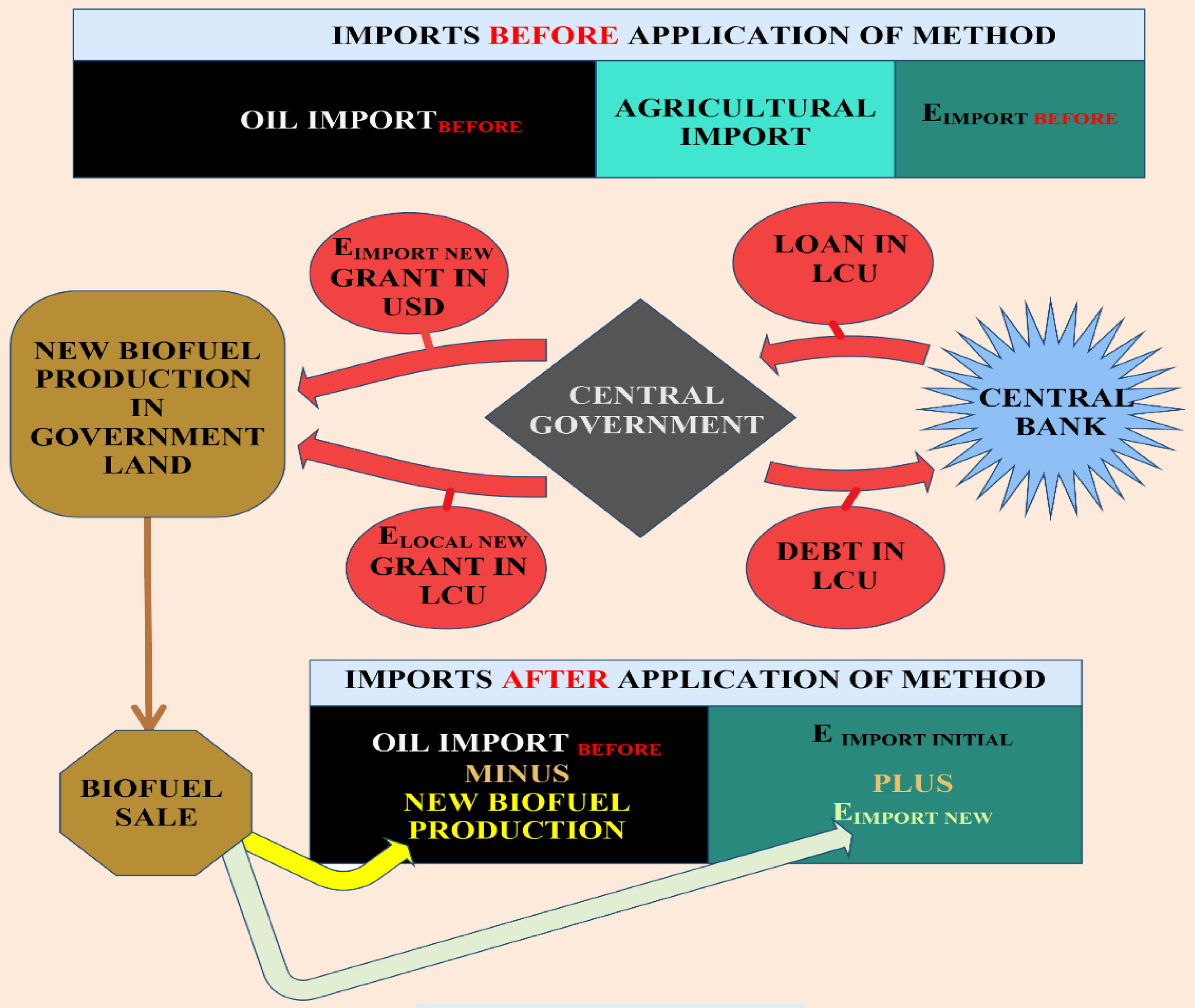

Figure 2: Method Flow Diagram

5. Notes

- The term X-M, which is deemed to be negative, is a component of GDP in expenditure form and for ease can be written as - |X-M| so the GDP equation changes From Y=C+I+G- |X-M| to Y'=Y+ΔM i.e. GDP increases.
- The loan S0 may be covered by an issue of Narrow Money (M0) by the Central Bank, if the IMF allows it, which will be sequestered and not put into circulation and therefore inflation is not influenced.
- This method avoids the "Dutch Disease", the real exchange rate appreciation and higher domestic inflation triggered by increased raw materials exports [37].

6. Results & Application to African Less Developed Countries (LDCs)

The African LDCs [38] of interest are Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, D. R. of the Congo, Djibouti, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Togo, Uganda, U. R. of Tanzania and Zimbabwe. In terms of employment in the Agricultural Sector, between 2000 and 2018, general employment numbers increased by 72.3% and employment numbers in Agriculture increased by 64.13% [39], [40]. In contrast, in World Trend 2000-2018, general employment numbers increased by 25.8% and employment numbers in Agriculture decreased from 39% to 26% which raised the African LDCs Agricultural labor force participation from 12% to 22%. In the period 2000-2016 Agricultural Land increased by 19.82%, Cropland by 43.70%, Land 19.82%, Cropland by 43.70%, Land by 46.94% and Permanent Crops by 20.28%.

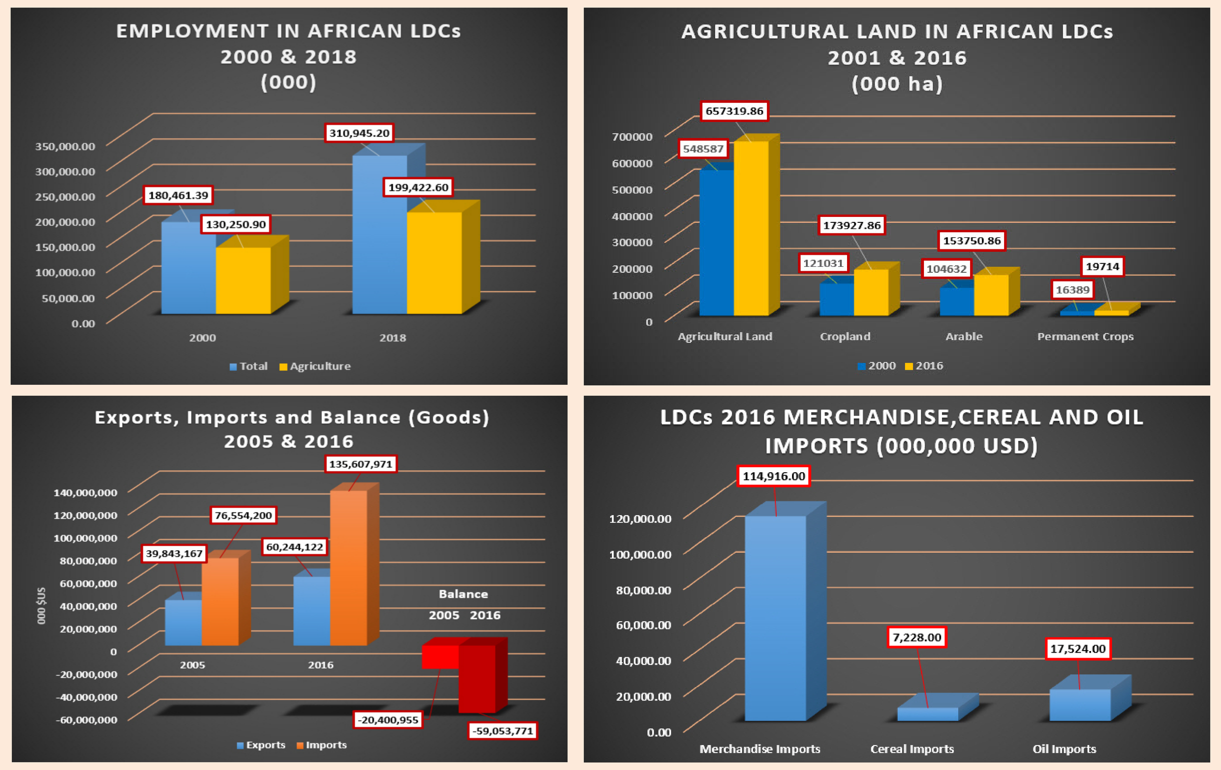

Figure 3 (up left), 4 (up right), 5 (down left), 6 (down right)

However, in terms of distribution of Agricultural Land, Cropland and Arable Land increased by only 4.4% and Permanent Crops remained static, while the ratio Permanent Crops/Cropland, 13.54% and11.34%, is both small and declining [41], [42]. Still the figures show enormous potential for expansion [43].

While Exports/Imports dropped by 10% in the period 2005-2016, from 2005 at 66.13% to 56.45% in 2016, the balance deficit increased by 189% in the same period [44], [45].Cereals are selected as the object of Agricultural Import [46]and are compared to Oil and Merchandise Imports.

7. Conclusions

A new system, which promotes Agricultural Self-sufficiency by eliminating Agricultural Imports and at the same time decreases the trade deficit by using biofuel production as an intermediating mechanism, which decreases oil imports, was developed at first approximation. A partial application on African LDCs demonstrated that there is an objective for this system and further development and research is warranted.

References

[1]IRENA (2015), 'Renewable Energy in the Water, Energy & Food Nexus'
[2]M. Al-Saidi and N. A. Elagib, "Towards understanding the integrative approach of the water, energy and food nexus," Sci. Total Environ., vol. 574, pp. 1131–1139, 2017.
[3]M. Bazilian et al., "Considering the energy, water and food nexus: Towards an integrated modelling approach," Energy Policy, vol. 39, no. 12, pp. 7896–7906, 2011.
[4]K. Zisopoulou et al., "Recasting of the WEF Nexus as an actor with a new economic platform and management model," Energy Policy, vol. 119, no. September 2017, pp. 123–139, 2018.
[5]V. W. Ruttan, "The Transition to Agricultural Sustainability," Proc. Natl. Acad. Sci. USA, vol. 96, no .May, pp. 5960–5967, 1999.
[6]S. von Wirén-Lehr, "Sostenibilidad en la agricultura-una evaluación de los principales conceptos orientados a objetivos para cerrar la brecha entre la teoría y la práctica. Sustainability in agriculture — an evaluation of principal goal-oriented concepts to close the gap," Agric. Ecosyst. Environ., vol. 84,pp.115–129, 2001.
[7]J . Pretty, "Agricultural sustainability: Concepts, principles and evidence," Philos. Trans. R. Soc. B Biol. Sci., vol. 363, no. 1491, pp. 447–465, 2008.
[8]D. R. Lee, "Agricultural & Applied Economics Association Agricultural Sustainability and Technology Adoption : Issues and Policies for Developing Countries Published by : Oxford University Press on behalf of the Agricultural &Applied Economics Association Stable URL," Am. J. Agric. Econ., vol. 87,no.5, p. 11, 2005.
[9]J. Williams et al., "Sustainable intensification of agriculture for human prosperity and global sustainability," Abio, vol. 46, pp. 4–17, 2017.
[10]C. Tayleur et al., "Global Coverage of Agricultural Sustainability Standards, and Their Role in Conserving Biodiversity," Conserv. Lett., vol. 10, no. 5, pp. 610–618, 2017.
[11]B. Talukder, K. W. Hipel, and G. W. vanLoon, "Developing Composite Indicators for Agricultural Sustainability Assessment: Effect of Normalization and Aggregation Techniques" Resources, vol. 6, no. 4, p. 66, 2017.
[12]J. N. Pretty, J. I. L. Morison, and R. E. Hine, "Reducing food poverty by increasing agricultural sustainability in developing countries," Agric. Ecosyst. Environ., vol. 95, pp. 217–234, 2003.
[13]I. Ozturk, "The dynamic relationship between agricultural sustainability and food- energy-water poverty in a panel of selected Sub-Saharan African Countries," Energy Policy, vol.107, no. February, pp. 289–299, 2017.
[14]D. A. Raitzer and M. K. Maredia, "Analysis of agricultural research investment priorities for sustainable poverty reduction in Southeast Asia," Food Policy, vol. 37, no. 4, pp. 412–426, 2012.
[15]L. Christiaensen, L. Demery, and J. Kuhl, "The (evolving) role of agriculture in poverty reduction — An empirical perspective," J. Dev. Econ., vol. 96, no. 2, pp. 239–254, 2011.
[16]H. C. J. Godfray and T. Garnett, "Food security and sustainable intensification," Phil. Trans. R. Soc. B, vol. 369, pp. 1–10, 2014.
[17]J. Beckman, A. Borchers, and C. A. Jones, "Agriculture's Supply and Demand for Energy and Energy Products," 2013.
[18]P. Pellegrini and R.J. Fernández, "Crop intensification, land use, and on-farm energy-use efficiency during the world wide spread of the green revolution," Proc. Natl. Acad. Sci., vol. 115, no.10, pp. 2335–2340, 2018.
[19]M. Pergola et al., "Sustainability evaluation of Sicily's lemon and orange production: Anenergy, economic and environmental analysis," J. Environ. Manage., vol. 128, pp. 674–682, 2013.
[20]B. Petersen and S. Snapp, "What is sustainable intensification? Views from experts," Land use policy, vol. 46, pp. 1–10, 2015.
[21]A. Mohammadshirazi, A. Akram, S. Rafiee, S. H. Mousavi Avval, and E. Bagheri Kalhor, "An analysis of energy use and relation between energy inputs and yield in tangerine production, "Renew. Sustain. Energy Rev., vol.16, no. 7, pp. 4515–4521, 2012.
[22]A. Dorwardand E. Chirwa, "The Malawi agricultural input subsidy programme: 2005/06 to 2008/09," Int. J. Agric. Sustain., vol. 9, no. 1, pp. 232–247, 2011.
[23]P. C. Struik and T. W. Kuyper, "Sustainable intensification in agriculture: the richer shade of green. A review," Agron. Sustain. Dev., vol. 37, no. 5, 2017.
[24]A. Dunnett et al., "Multi-objective land use allocation modelling for prioritizing climate-smart agricultural interventions," Ecol. Modell., vol. 381, no. December 2017, pp. 23–35,2018.
[25]K. F. Davis, J. A. Gephart, and T. Gunda, "Sustaining food self-sufficiency of a nation: The case of Sri Lankan rice production and related water and fertilizer demands," Ambio,vol. 45, no. 3,pp. 302–312, 2016.
[26]S. Zhan, "Riding on self-sufficiency: Grain policy andthe rise of agrarian capital in China," J. Rural Stud., vol. 54, pp. 151–161, 2017.
[27]L. Sibande, A. Bailey, and S. Davidova, "The impact of farm input subsidies on maize marketing in Malawi," Food Policy, vol. 69, pp. 190–206, 2017.
[28]M. Belem and M. Saqalli, "Development of an integrated generic model for multi-scale assessment of the impacts of agro-ecosystems on major ecosystem services in West Africa," J. Environ. Manage., vol. 202, pp.117–125,2017.
[29]Y. Luan, X. Cui, and M. Ferrat, "Historicaltrends offood self-sufficiency in Africa," Food Secur., vol. 5, no. 3, pp. 393–405, 2013.
[30]M. Porkka, M. Kummu, S. Siebert, and O. Varis, "From food insufficiency towards trade dependency: A historical analysis of global food availability," PLoS One, vol. 8, no. 12, 2013.
[31]H. You and X. Zhang, "Ecoefficiency of Intensive Agricultural Production and Its Influencing Factors in China: An Application of DEA-Tobit Analysis," Discret. Dyn. Nat. Soc., vol. 2016, 2016.
[32]D. Tilman, C. Balzer, J. Hill, and B. L. Befort, "Global food demand and the sustainable intensification of agriculture," Proc. Natl. Acad. Sci., vol. 108, no. 50, pp. 20260–20264, 2011.
[33]N. R. Jordan and A. S. Davis, "Middle-way strategies for sustainable intensification of agriculture," Bioscience, vol. 65, no. 5, pp. 513–519, 2015.
[34]B. Walsh et al., "Assessing the land resource–food price nexus of the Sustainable Development Goals," Sci. Adv., vol. 2, no. 9, p. e1501499, 2016.
[35]A. Wezel, G. Soboksa, S. Mcclelland, F. Delespesse, and A. Boissau, "The blurred boundaries of ecological , sustainable , and agroecological intensification: a review," Agron. Sustain. Dev, vol.35, pp. 1283–1295, 2015.
[36]A. L. Bais-Moleman, C. J. E. Schulp, and P. H. Verburg, "Assessing the environmental impacts of production- and consumption-side measures in sustainable agricultureintensification in theEuropean Union," Geoderma, vol. 338, no. November 2018, pp. 555–567, 2019.
[37]P. Krugman, "The narrow moving band, the Dutch disease, and the competitive consequences of Mrs. Thatcher," J. Dev. Econ., vol. 27, no. 1–2, pp. 41–55, 1987.
[38]FAO, "Low-Income Food-Deficit Countries (LIFDC) - List for 2016," 2017. [Online]. Available: http://www.fao.org/countryprofiles/lifdc/en/. [Accessed: 12-Jan-2019].
[39]The World Bank, "Labor Force," 2018. [Online]. Available: https://data.worldbank.org/indicator/sl.tlf.totl.in?end=2018&start=2000. [Accessed: 19-Jan-2019].
[40]The World Bank, "Employment in agriculture (% of total employment)," 2018. [Online]. Available: https://data.worldbank.org/indicator/sl.agr.empl.zs?end=2018&start=2000. [Accessed: 19-Jan-2019].
[41]The World Bank, "Agricultural land (sq. km)," 2017. [Online]. Available: https://data.worldbank.org/indicator/AG.LND.AGRI.K2?end=2016&start=2000. [Accessed: 21-Jan-2019].[42] FAO,
[42] "FAOSTAT," 2019. [Online]. Available: http://www.fao.org/faostat/en. [Accessed: 19-Jan-2019].
[43]C. Schaffnit-Chatterjee, "Agricultural value chains in Sub-Saharan Africa," 2014.
[44] TradeMap, "Imports, Exports," 2019. [Online]. Available: https://www.trademap.org. [Accessed: 23-Jan-2019].
[45] U.N., "U.N. Comtrade Database," 2019. [Online]. Available: https://comtrade.un.org/data/da. [Accessed: 05-Jan-2019].
[46] Otsuka K, 'Food Insecurity, Income Inequality, and the Changing Comparative Advantage in World Agriculture' (2013) 44 Agricultural Economics (United Kingdom) vol. 44, no. SUPPL1, pp. 7–18, 2013