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Crop-Industry Relevance Index: Assessment Model for Tanzania

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Abstract: The interdependence between agriculture and industry sectors has increased in developing countries where smallholder farmers dominate agricultural production. However, methodology for assessing the contribution of smallholder farmers to the industrialization is lacking. The current paper presents the developed crop-industry relevance index (CIRI) framework used to analyze crop production and gauge the contribution of smallholder farming in industrial development in Tanzania. The study employed the Analytic Hierarchy Process (AHP) to derive weights for constructing the CIRI. The study defined five criteria that represents characteristics of crop types defining the crop industry relevance. The pairwise matrix representing value judgement on the contribution of different crop types to the industrialization were established. The normalization procedure resulted to derivation of weights. Consistency analysis performed to check the consistency in the value judgement on role of different crop types on industrialization. The results are that, the consistency ratio was 0.0318 implying robust weight values. Finding are that, the contribution of smallholder farmers to the production of industrial relevant crops is estimated to be 20% in year 2014. The estimated industrial value is mainly contributed by maize, paddy, cassava, cotton, sugarcane and sunflower. The implication is that while maize, cassava and paddy are produced primarily for food, there is emerging importance in the industrial development. Effort to enhance crop production focusing these crops beers dual benefits in the country.

Keywords: Crop-Industry Relevance Index Framework, Smallholder Farmers, Industrial Development

1. Introduction

Agriculture is still considered as the main driver of economic growth of many of the countries in sub-Saharan Africa (SSA) in terms of employment opportunities and provision of food. It is regarded as the main source of employment and staple food needs. The sector has direct effects on economic development, food security and poverty alleviation [20, 22, 23, 25] and provision of raw materials. Smallholder farmers dominate agriculture in most developing countries in terms of involvement and it is considered to contribute significantly to livelihood and welfare of rural households and the economy [2, 23].

In Tanzania, agriculture sector is among the priority sectors identified to drive the move towards economic transformation to reach middle income status by 2025 [18]. Currently, this sector contributes to the general economy to the tune 23% of the GDP far higher than 5.5% contribution of manufacturing sector to the GDP (Figure 2). The sector is potential to the industrial development and is contributing about 65% of inputs used in the manufacturing sector in Tanzania. Employment opportunities in the sector benefits nearly 67% of rural people. Foreign currency inflows in Tanzania to large extent are manifested from agriculture sector to the tune of 30% of export earnings and therefore foreign currency. Tanzania is a fast-growing economy in SSA in the recent years. The GDP growth has increased to average of 7% per year in the last 10 years (Figure 1) and the per capita income increased from USD 200 million to USD 1,043 million in 2014 [18].

Currently the government of Tanzania is implementing industrialization plan to achieve economic transformation and human development. The Plan is targeting to achieve agricultural transformation by year 2020. In this plan, eight (8) priority crops identified[1] for industrial development and

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1 These crops include grapes, pulses, floriculture, sunflower, maize, paddy, simsim, cotton and sisal.

the target is to achieve the sector real growth rate of 7.6%, GDP share of 24.9%; share of total exports of 24.9% and share of total employment of 56.5% in 2020. The development Vision envisions "a Tanzanian economy that has been transformed from a low productivity agriculture economy to a semi- industrialized one led by modernized and highly productive agricultural economy." The key questions at the moment is: Does the industrialization implementation is taking the right pace? How is the agriculture transformation and commercialization are aligned with the industrialization? The exposition here is that when industrialization takes place at the right direction, expectation is that the role of agriculture sector on the economy will be reducing gradually overtaken by the manufacturing sector. The nature of this transformation is what the National Development Vision 2025 set to achieve.
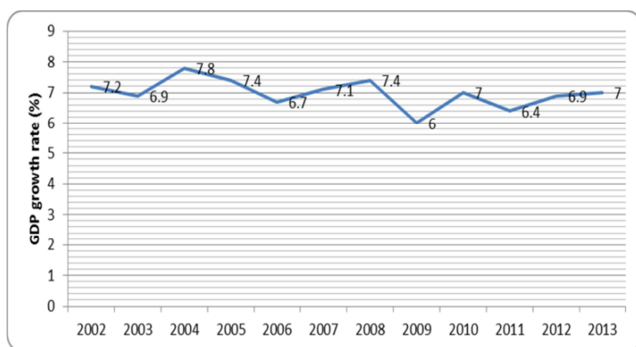
Source: [13].

Figure 1. *Tanzania: Real GDP growth 2002-2013 (at 2001 constant prices).*
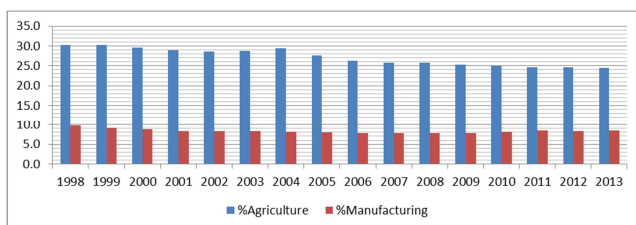
Figure 2. *Percentage contribution of agriculture and manufacturing to the GDP.*

The rest of the paper is organized as follow: section two presents review of relevant literature on crop production and industrial relationships risk. Section three presents conceptual framework governing the analysis of crop industry relevance index. In section four is the methodology and data for measuring CIRI. Finally, in section five, the paper present conclusion and policy implication from the study findings.

2. Review of Relevant Literature on Agriculture Transformation and Industrialization

It is well established and that dual economic models are in place to depict the relationship between agriculture and industry sectors and that these sectors are complementary to one another[2]. Agricultural transformation for industrialization is discussed based on the linkage between agriculture and industries. There is clearly established interdependency status between agriculture and industrial sectors. Such interdependence is such that the growth of agriculture requires inputs from industry sector (fertilizers, insecticide, pesticides and other production inputs), likewise, the growth of industrial sector too relay on inputs from agriculture sector. Thus, increased agricultural demands for industrial products are an impetus for the industrial development to meet these demands. It is sufficient to argue that industry is developed through agriculture and agriculture is developed through industry. For industrial sector to prosper it require key inputs such as raw materials and in most cases these raw materials come from agriculture sector for agro based industries. While raw materials are provided from the agricultural sector to industrial sector, these produces are being processed (value addition). In addition, agriculture sector provide food to the people including industrial workers, almost all edible products like supplies cereals, vegetables come from agricultural produce. Humans need food for survival and thus, for industrial operators to continue they need food from agricultural sector. In addition, industrial growth depends on an increase in purchasing power of the agricultural sector for industrial commodities and supply of raw materials for industrial processing [9]. Sound transformation in agriculture and both backward and forward linked sectors is crucial.

Evidence is plenty on industrial development through transformation of agriculture took place in China, Vietnam, India, Malaysia [9, 12, 21]. There are key issues that are needed for a country to achieve industrial development from agriculture transformation. Experience from countries achieved industrialization through agriculture points out on the need for agro science and technology advancement; crop diversification-shifting to high value crop; increased people's income and standard of living; and effective integration of farmers with local and international markets. These happened in Asian countries and serves as learning lessons to African countries. In China for example, the contribution of agro processing sector to the China's economic and social development cannot be over looked. Following success in agricultural reform, rapid growth of agricultural sector and the marked increase in Chinese people's income resulted to growth of the agro processing industries in China. With increased people's income and living standards, a consumer demand for unprocessed agricultural products declines, meanwhile the demand for intermediate products from agro-processing sector increase rapidly and thus the realization of agricultural sector growth/transformation. In China after realizing increased income and standard of living,

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2 For this fact it is uncommon to raise the growth of one sector without the improvement of the growth of other sector, since these sectors have impacts to another sector.

consumer demand for unprocessed agricultural products declined, meanwhile the demand for intermediate products from agro-processing sector raised rapidly and therefore, making the latter the driving force for agricultural sector growth/transformation [27].

In Vietnam, the government through the Decree No. 210/2013/NĐ-CP (dated December 19, 2013), supports 70% of funding for implementation research to create new technologies; 30% of the funding to carry pilot production applying new technology. These efforts encourage

investments in applying high technology in agriculture. Comparing Tanzania and Vietnam, in the 1990, the GDP of Tanzania and that of Vietnam (USD 6.47 billion) had no much difference. However, the Vietnamese economy has grown to USD 186 billion in 2014 this is almost 4 times that of Tanzania (Figure 3). Evidence on impressive smallholder transformation to rural industrial development in Vietnam and Malaysia inspires development practitioners in sub-Saharan Africa and Tanzania in particular. Figure 3 depicts the GDP trend for Tanzania and other selected countries.
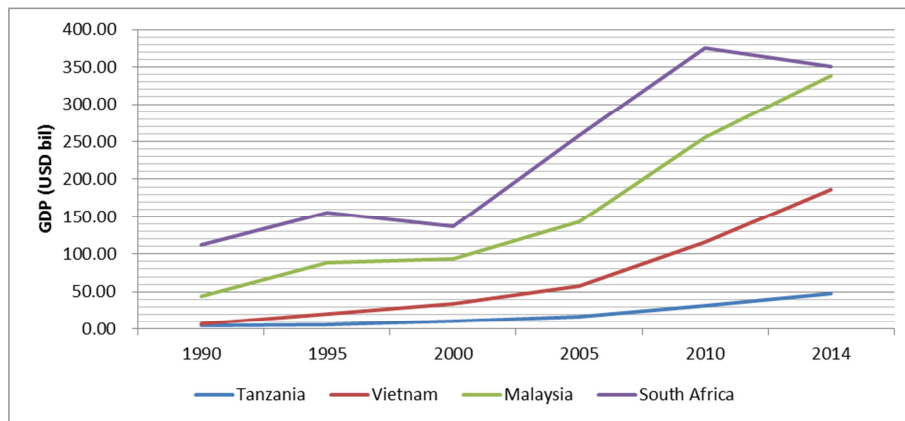

Figure 3. GDP trend for Tanzania, Vietnam, Malaysia and South Africa.

As noted above, industrialization growth reaches a stage where the contribution of agriculture sector on the economy decreases. Trend analysis of agriculture contribution to the GDP for countries that have realized industrialization shows a declining trend of the role of agriculture. In Table 1, all three developed countries have a declining contribution of agriculture to the GDP. This means that with industrialization, processing industries are more effective and what is added in the GDP from industries outweigh the contribution of agriculture sector. Tanzania is still in the infant stage of industrialization and therefore agriculture sector is contributing significantly on the economy. The GDP is receiving significant contribution from the industrial sector for countries with significant industrial development (Table 2).

Table 1. Contribution of agriculture sector on the GDP.

YEARS	Tanzania	Vietnam	India	Malaysia
1990	45.96	38.74	29.02	15.22
1995	47.14	27.18	26.26	12.95
2000	33.48	22.74	23.02	8.60
2005	30.46	19.30	18.81	8.26
2010	32.00	18.38	18.88	10.09
2014	31.01	17.70	17.39	8.87

Table 2. Contribution of industries on GDP.

YEARS	Tanzania	Vietnam	Malaysia	India	South Africa
1990	9.27	22.67	42.20	26.49	40.10
1995	7.17	28.76	41.40	27.40	34.87
2000	9.39	34.20	48.32	26.00	31.89
2005	7.77	38.13	45.93	28.13	30.28
2010	7.36	32.13	37.80	32.43	30.16
2014	6.00	33.21	37.17	30.01	29.73

3. Conceptual Framework

Crop-industry relevance index (CIRI) in this research means a shift from traditionally grown less industrial relevant crops to production of more industrial relevant crops. Farming activities is well undertaken to address the food question at the household level and the business arena for income generation as enabling factor to farmers to access non-farm products and services necessary to sustain living. CIRI is intended to promote technological innovations for sustainable agriculture and enable farmers to choose crop alternatives for increased and stable productivity and income. General problems facing crop production in developing countries among others, is the lack of reliable market for the crop harvests and consequently multiplicative post-harvest losses emanating from unsuitable or absence of storage facilities. Industrial development is called for to make use of crop harvests to produce new consumable products in the form of value addition. Value addition reduces post-harvest loses and offers wide range of crop utilization along the value chain and consequently the multiplier effect in terms of employment creation and increase crop commercialization. Investments in agro processing firms will go hand in hand with the availability and reliable raw materials from farm related activities.

Investors make decision to invest in particular processing technology by basing on the financial gains reflected by sound financial and economic feasibility of the investments. Viability assessment encompasses the production capacity of the out growers in terms of technological process to meet the quality and quantity desired for the profit realization by the

developers and also the inclusivity growth of the out growers. Farmers' understanding on how each of the crop type is aligning with the industrialization effort in place is key dominant factor for industrial development. Processing of crop products to get secondary consumable products is one form of class of farm-industrial relationship. The crop produces that are turned into energy, provides another aspect for which agriculture and industrial come together.

Effort is made to gauge how stallholder farmers are implementing the aspiration of industrialization in the country. Some crops do not require processing and are consumed or offer the final use service without significant modification through industrial processing. Such crops are characterized to have low industrial relevance. Crops that require processing (semi processing or full industrial processing) are considered to be relevant to industrial development. The intensity and extent to which each crop type play in industrialization differs significantly. The current study is presenting the analytical framework for establishing crop industrial relevance value to be used for gauging the contribution of smallholder farmers in industrial development.

4. Data and Methodology

The study develops an indicator to characterize smallholder farming and the relevance to industrial development in the country. In this paper, methodology for developing crop-industry relevance index (CIRI) is designed by considering the extent of crop diversification by smallholder farmers and the relevance on industrial development. CIRI is dynamic crop diversification index for measuring the extent to which smallholder farmers are engaged in production of industrial relevant crops. The MCA framework is adopted to estimate the contribution or weighting factor of crop types in the crop-industry intensity. Also, the crop diversification approach is adopted to establish the extent and rate of crop diversification which are important inputs in developing the CIRI. The research uses National Agriculture census survey data collected by National Bureau of Statistics for year 2014.

4.1. Procedure for Developing Crop-Industry Relevance Index (CIRI)

The development of the CIRI is based on the amount of Quantity harvested for each crop type with certain degree of relevance to industrial development. The study develops a methodology for establishing crop industry relevance score for decision making on how smallholder farming contributes to industrial development. The CIRI is established by assigning weights to the quantity harvested. The weights are derived from qualitative judgement on how each of the crop is perceived to be relevant to industrial processing.

To develop a crop-industry relevance index we employ the multi-criteria analysis (MCA) tool. MCA methods provide a flexible tool that is able to handle and bring together a wide range of variables in different ways important for mapping out the problem by decision maker [3]. In this study MCA tool is employed using the five variables shown in Table 3. These five variables represent qualitative information on the relationship between the crop type and industrial development (they indicate crop industrial relevance). These characterizations of the criteria are that: whether crop type is able to undergo processing and produce one product (1P), produce two products (2P), produce multiple products (MP), produce energy for industrial use (EN) and source of key raw materials for large manufacturing firms (RA).

Table 3. Variables characterizing crop-industry relevance.

S/N	Variable characteristics	Code	Relevance to industries
1	Produce one product along the value chain	1P	Very low extent
2	Produce two products along the value chain	2P	Low extent
3	Produce more than two products along the value chain	MP	Medium extent
4	Source of energy to manufacturing firms	EN	High extent
5	Source of raw material to manufacturing firms	RA	Very high extent

Source: Own construction.

Table 4. Value judgement for multicriteria analysis.

Value	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and Judgment slightly favour one over the other
5	Much more important	Experience and Judgment strongly favour one over the other.
7	Very much important	Experience and Judgment very strongly favour one over the other. Its importance is demonstrated in practice
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity
2,4,6,8	Intermediate value	When compromise is needed for finer resolution

Source: [16].

4.2. Analytic Hierarchy Process for Crop Industry Relevance Indicator (CIRI)

The study follows the multicriteria decision making and uses the Analytic Hierarchy Process (AHP) [16, 17]. Under this framework, the study established the matrix for the five criteria and assigned qualitative judgment on the importance of each criteria over the other (Table 4).

AHP uses these values to determine the priority of each factor. The determination is taking into account the relativeness of any factor to the overall goal of the problem of interest. Normal procedure in the MCA is employed using 5 variables (Table 3) to create the index. The goal of the multicriteria decision in this case is how to enhance industrial development from smallholder farming practices. At first, the study developed a pairwise comparison matrix for qualitative values for or each criterion. Based on the value and definition (Tables 3 & 4), we form the pairwise matrix (Table 5) representing the importance of each criterion over the other criterion on the crop type contribution to the industrial development.

Table 5. Pairwise comparison matrix of criteria for weights generation.

	1P	2P	MP	EN	RA
1P	1	1/2	1/3	1/4	1/5
2P	2	1	1/2	1/3	1/3
MP	3	2	1	1/3	1/2
EN	4	3	3	1	1/2
RA	5	3	2	2	1

Source: Own construction.

From the developed pairwise comparison matrix for each criterion, normalization and averaging of the values in each row to the corresponding rating was performed. The numerical values used in the AHP process as suggested by [15] were applied, and normalization involved the 5 variables with respective qualitative values in terms of contributing to industrial development (Table 6).

Table 6. Weights representing crop industrial relevance value.

	1P	2P	MP	EN	RA	Weight
1P	0.0667	0.0526	0.0488	0.0638	0.0789	0.0622
2P	0.1333	0.1053	0.0732	0.0851	0.1316	0.1057
MP	0.2000	0.2105	0.1463	0.0851	0.1974	0.1679
EN	0.2667	0.3158	0.4390	0.2553	0.1974	0.2948
RA	0.3333	0.3158	0.2927	0.5106	0.3947	0.3694

Source: Own construction.

4.3. Consistency Analysis

The developed weights in Table 6 above are subjected to consistency tests. The study estimates the consistency index and consistency ratio. The study used the random index [16], to estimate the consistency index and consistency ratio using equation $CI = \frac{\lambda_{max} - n}{n - 1}$ Where λ_{max} largest eigen values of the normalized matrix (Table 4), n=the number of items that have been compared and Consistency Ratio (CR) according to the following equation $CR = \frac{CI}{RI}$ where RI is the consistency index for a random square matrix of the same size. The results for consistency analysis (Table 7) indicates that the consistency ratio is 0.0313 which is less than 0.10 implying that, the qualitative judgement in pairwise matrix (Table 5) are consistent and guarantee the use of resulting weights for further analysis.

Table 7. Consistency index, random index and consistency ratio.

index	value
Consistency index	0.03148
Random index	1.11
Consistency ratio	0.0314

Source: [16] and own construction.

4.4. Crop-industry Relevance Index (CIRI)

Using the derived weights (Table 4), the study estimates the crop industrial relevance index (CIRI). The index is used gauge the extent to which smallholder farming to industrial development. The CIRI is estimated by using the estimated parameters in the MCA above are used as weighting factors on quantity harvested to establishing the CIRI. The proposed CIRI model for each year is

$$CIRI = \sum_{i=1}^{m} w_i P_i \qquad (1)$$

Where $P_i = \frac{Q_{ci}}{TQ} =$ ratio of quantity for crop i on total quantity (tons); w_i=weight representing the crop i industrial relevance value estimated using AHP in Table 6. Upon utilizing the quantity harvested (tons) for each crop[3], and weights established, the industrial value for each crop and finally the CIRI is established (Table 8).

Table 8. Crop industry relevance value for year 2014.

S/N	Crop name	Weight (w_i)	$P_i(\frac{Q_{ci}}{TQ})$	Industrial value ($w_i P_i$)
1	Amaranth	0.0622	0.000157	0.000010
2	Avocado	0.3694	0.000093	0.000034
3	Bambaranuts	0.1679	0.001871	0.000314
4	Banana	0.1679	0.051846	0.008705
5	Beans	0.1057	0.009364	0.000990
6	Cashew nut	0.3694	0.015880	0.005866
7	Cassava	0.1679	0.090238	0.015151
8	Chickpeas	0.1679	0.001449	0.000243
9	Cinnamon	0.3694	0.000075	0.000028
10	Cloves	0.3694	0.000298	0.000110
11	Coconut	0.0622	0.003933	0.000245
12	Coffee	0.3694	0.008855	0.003271
13	Cotton	0.3694	0.032395	0.011967
14	Cowpeas	0.1057	0.002605	0.000275
15	Finger millet	0.1679	0.003833	0.000644
16	Green gram	0.1057	0.006241	0.000660
17	Groundnut	0.1679	0.021355	0.003586
18	Irish potato	0.1057	0.009625	0.001017
19	Lime	0.0622	0.000204	0.000013
20	Maize	0.1679	0.412376	0.069238
21	Mango	0.3694	0.002673	0.000987
22	Millet	0.1679	0.004248	0.000713
23	Onion	0.0622	0.001233	0.000077
24	Orange	0.3694	0.005881	0.002172
25	Paddy	0.1679	0.138741	0.023295
26	Palm oil	0.3694	0.000117	0.000043
27	Pigeon pea	0.1679	0.007814	0.001312
28	Pineapple	0.1679	0.000880	0.000148
29	Pumpkins	0.0622	0.000912	0.000057
30	Sweet potato	0.1679	0.017311	0.002907
31	Simsim	0.3694	0.015903	0.005875
32	Sisal	0.3694	0.004932	0.001822
33	Sorghum	0.1679	0.031979	0.005369
34	Sugarcane	0.3694	0.040486	0.014956
35	Sunflower	0.3694	0.026271	0.009705

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3 Actual quantity harvested for each crop not reported in this paper.

S/N	Crop name	Weight (w_i)	$P_i(\frac{Q_{ci}}{TQ})$	Industrial value (w_iP_i)
36	Tea	0.3694	0.007569	0.002796
37	Tobacco	0.3694	0.009145	0.003378
38	Tomatoes	0.3694	0.007494	0.002768
39	Wheat	0.3694	0.003717	0.001373
	Total		1.000000	0.202117

Source: Own estimation using [17].

The contribution smallholder farmers to the production of industrial relevant crops is estimated to be only 20% in year 2014. The estimated industrial value is mainly contributed by maize, paddy, cassava, cotton, sugarcane and sunflower.

5. Conclusion and Policy Implications

Effort is made to gauge how stallholder farmers are implementing the aspiration of industrialization in the country. It is clear that some crops do not require processing and are consumed or offer the final use service without significant modification through industrial processing. Such crops are characterized to have low industrial relevance. Crops that require processing (semi processing or full industrial processing) are considered to be relevant to industrial development. The intensity and extent to which each crop type play in industrialization differs significantly. The current study is presenting the analytical framework for establishing crop industrial relevance value to be used for gauging the contribution of smallholder farmers in industrial development. Aspiring for industrial development move should go hand in hand with agricultural transformation. Optimistic mind on industrial development via agricultural transformation is possible in Tanzania. Smallholder farmers in fragmented land holdings offer an avenue for crop diversification and industrialization. Development in agro processing and industrialization in general are facets for increased investments in agriculture science and technology for value addition and post-harvest loss mitigations. Technological innovation is needed to develop modern agro science and technology to replace tradition farming methods. While maize, cassava and paddy are produced primarily for food, there is emerging importance in the industrial development. Effort to enhance crop production focusing these crops beers dual benefits in the country.

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