Proceeding of Industrial Engineering and Service Science , **2013**

Eco-Efficiency Production-Consumption For Sustainable Food Security: A Proposed Framework

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ABSTRACT

Eco-efficiency production-consumption is an eco-efficiency measurement with production-consumption as a whole system approach. A remarkable achievement has been reached in sustainable development at production side and widen to consumption side. However, those of achievements are growing in unbalanced condition. High demand of eco-products has negated the resource efficiencies achieved. Trend in organic foods has increased imported organic ones and results in higher emissions. Dealing with environmental system means dealing with a complex one, conventional measurement designs sometimes do not give information about something within and between production-consumption sub systems and how it affects the overall performance. The aim of this paper is to propose a dynamic eco-efficiency production-consumption framework design as an extension of previous framework of sustainable food security measurement. By modifying it into dynamic eco-efficiency measurement framework, proposed framework offers better understanding of variable measured relationships that could help decision makers established their policies.
Keywords**:** *Dynamic, Eco-efficiency, Performance, Sustainable, Food Security*

1. Introduction

Eco-efficiency is a sustainability performance measurement by using ratio of economic performance to its ecology performance. Proposed by World Business Council of Sustainable Development (WBCSD) at Earth Summit Rio de Janeiro 1992 as accountability of industrialist to environment degradation, eco-efficiency has appeared to be a win-win solution for realization of sustainable development. With that of principle, eco-efficiency become wide spread accepted by companies for sustainable development assessment and extended to broader level of economic activities, such as in regional or national level [1, 2].

As rising population growth, focus of environmental researches are widen to consumption side under the concept of Sustainable Consumption, whereas consumption side are blamed on the negation of resource efficiency achievement through their increasing demand namely rebound effect [3-5]. The challenge is more than just doing cleaner production, saving energy and water. At the same time, consuming products efficiently and do not speed up more productions has to be integrated fashion with the sustainable production. We need production and consumption as a whole system concerned [4]. However, dealing with environmental system of production-consumption means dealing with complex, time dependent and dynamic system. Strategy implemented on the production-consumption system based on conventional performance measurement sometime doesn't appropriate the objectives decided. Conventional performance measurement results are mostly used for controlling tools rather than improvement tools. An explicit description of system response to every changing condition is needed to support goal achievement effectively [6, 7].

This paper objective is developing dynamic eco-efficiency production-consumption conceptual framework to overcome the challenge of environmental complex system problem. Dynamic eco-efficiency of production-consumption is eco-efficiency measurement combined with system dynamic principles approach for production-consumption system. The differences with previous concepts built by [8, 9] are explicit description and inclusion of time dependence relationship within production and consumption in development of eco-efficiency measurement.

In this paper, the conceptual framework would be built on the implementation to measurement of sustainable food security. Eco-efficiency assessment of sustainable food security conducted based on food system that consists of food production, distribution and consumption and relates to food security measurement dimensions.

2. Eco-Efficiency of Sustainable Food Security

Officially, the term eco-efficiency is then defined by the World Business Council of Sustainable Development (WBCSD) in Rio de Janeiro Earth Summit in 1992 as [10]:
"Eco-efficiency is achieved by the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity".

The essence of this definition is "satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity". While protecting environment is considered as the extended cost, this term tries to clarify that protecting environment could be a profit for the business.

Generally, eco-efficiency can be quantified as the ratio of value added to its environmental impact. It can be represented as:

$$\text{Eco - efficiency} = \frac{\text{Product or Service Value}}{\text{Environmental Influence}} \quad (1)$$

Derived from simple efficiency formula, output/input, (1) illustrates economic and environmental performance represented by numerator and denominator above. Product or service value as output representing economic performance refers to the value of the product and service produced by a company, the sector or the overall economic activity. While the denominator environmental influence as the input is the effect on the environment per unit of the product or service that is produced. Each numerator and denominator are measured based on indicators which is determined correspond to unit economic activity measured.

There is no standard of eco-efficiency ratio or indicator used for any economic activity. The ratio and indicator could be adapted to unit activity measured that assesses economic performance to its environmental impact. Nevertheless, for macro or meso level of economic activity, European Environment Agency (EEA) suggested using ratio of more welfare to less nature [11].

For sustainable food security, this paper uses ratio of food security achievement to its environmental influence as represented as:

$$\text{Eco - efficiency of food security} = \frac{\text{Food security}}{\text{Environmental Influence}} \quad (2)$$

Equation (2) above describes: numerator food security refers to food security achievement which is measured by four indicators of Food Availability, Food Access, Food Utility and Food Stability. Denominator environmental influence refers to environmental impact of food security achievement with production-consumption point-of-view.

3. Food Security in Food System Point-of-View

Food security is a performance measurement tool designed to measure the capability of a region can provide food with some of criteria determined by FAO. Definition of food security inaugurated by the FAO World Food Summit in 1996 was the latest definitions, most detailed and most widely accepted to be the foundation of any policy of FAO to date, namely [12]:"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

The definition above then can be assessed by four dimensions of food security: food availability, food access, food utility, food stability [13]. Food availability refers to the supply side of the food and is determined by the level of food production, stock levels and trade. Although trade is one of important way to achieve food availability, for sustainable food security purpose, food availability is expected to be achieved by local production. Food access refers to the individual access to the right to food in accordance with the required nutrients. Food utility refers to the utilization of food through appropriate diet, clean water, sanitation and health care to achieve good nutrition where all physiological needs are met. Food stability refers to the stability of the three dimensional above. It can be said, this dimension refers to how to keep the other three dimensions can be available any time obtaining.

There is no consensus about definition of food system in detail. Some literatures outline in general sight that food system is a 'field to fork', 'field to table', or 'field to plate' process of food[14, 15]. In this paper it is defined as all the process of food life-cycle including producing or agricultural growing, food processing, packaging and distribution, preparation and consuming.

Assessing food security in food system point-of view means assessing these of 4 dimensions into food system related for each dimension. This assessment has been developed into a framework of Global Environment Change And Food Security (GECAFS) by [8, 9] as described in Figure 1.

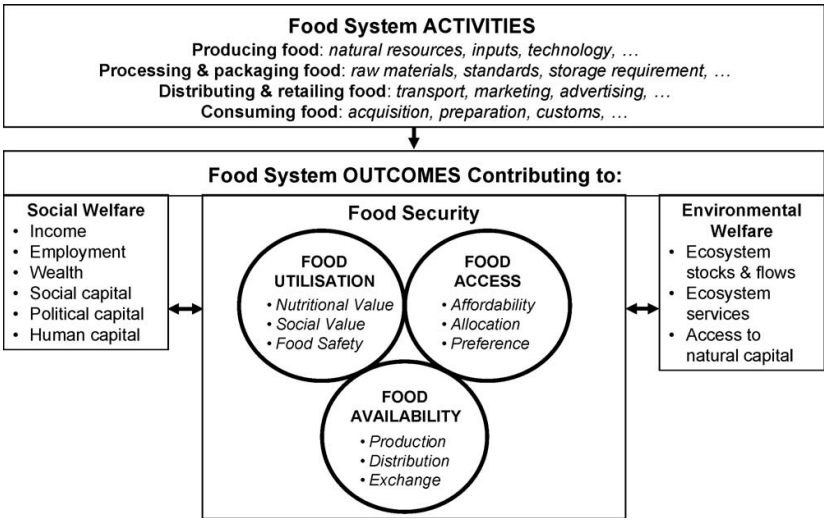

Figure 1. GECAFS Framework
Souce: Ericksen (2008)

Framework described Figure 1 identifies food system contribution to food security measurement with drivers of social welfare and environmental security.

4. Eco-efficiency Based on System Dynamic

System dynamic approach on environmental issues was first performed in 1972 in the book Limits to Growth to describe the simulated world began in 1900-2100 with 12 scenarios and analyze its response to environmental conditions [16]. In connection with the determination of the policy environment, [17] identified that the system dynamic used in the environmental impact assessment, solid waste management, analysis of greenhouse gas emissions and global warming, water resources planning, environmental planning and management, environmental sustainability, ecological modeling and so on. According to its function, in the field of environmental system dynamic approach is widely used in analyzing the effects of policies in the field of environment in the span of the next few years [18], then began to be integrated with environmental performance measurement systems such as the study by [19, 20] with the consideration that the performance measurement system is the basis for policy-making in determining the next strategy. In this study, system dynamic will be used in systemic approach to eco-efficiency performance measure.

Eco-efficiency is one of the performance measurement tool used to measure the level of sustainability or the sustainability of an activity. This measurement uses a process approach to activities taking into account the economic and ecological performance in the form of a ratio of value added to the economy gained as a result of environmental pressures. Increasing complexity of the systems involved in an activity, the measurement of eco-efficiency by the narrow limits of a system can not represent the actual system sustainability. Here a holistic approach or whole on a system is needed to be able to measure the level of sustainability of actual system.

Eco-efficiency measurements with system dynamic approach is based on a review that the system dynamic approach is needed to be able to complete the performance measures with an explanation of the relationship between the factors that affect performance, trade-offs that occur between these factors and the behavior of the system using causal loop diagrams and stock and flow diagram in response to policies that have been taken at the time when the next performance monitoring policy implementation strategies. System dynamic approach would also explain the non-linear interactions, delay, feedback loops and other elements that refer to the dynamic complexity of using quantitative simulation. This is what can not be done by ordinary measurement system performance, such as: Total Quality Management

(TQM), Just in Time (JIT), Return on investment (ROI), return on assets (ROA), return on sales (ROS). During its development, performance measurement systems began to be integrated with the management strategy to be able to analyze the strategies that have been taken based on the results of measurements to allow for the development of dynamic management [6, 7, 21, 22].

5. Framework development

Prior to the establishment of a conceptual framework studies, four dimensions of Food Security will be divided based approach to food system in the viewpoint Production, Distribution and Consumption, as in Figure 2. Figure 2 describes dimensions of Food Security from the perspective of Production-Consumption. The division based on the point of view of production and consumption will determine the measure of each dimension of food security ranging from sub system production, distribution and consumption.

In accordance with the definition of each dimension of food security, the food availability will be measured by indicators of sub-systems of food production, food access indicators will be measured based on the sub-system of food distribution, and food utility will be measured based on the indicators of food consumption. Then the framework can be describe as Figure 3.

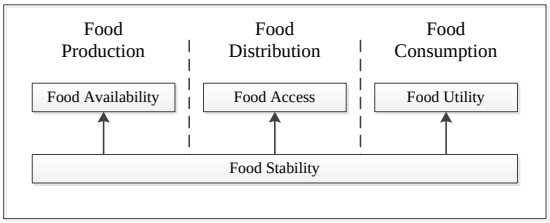

Figure 2. Relationship of Dimensions of Food Security and Food System

Figure 3 describes framework of dynamic eco-efficiency of sustainable food security. Conducting the overall measurement of sustainable food security eco-efficiency, indicators of food security achievement and environmental influence are defined by performing the influence relationship within subsystem of food system and subsystem of food security dimensions. This description of relationship supports the identification of intervention actors of the system that can be used as the indicator.

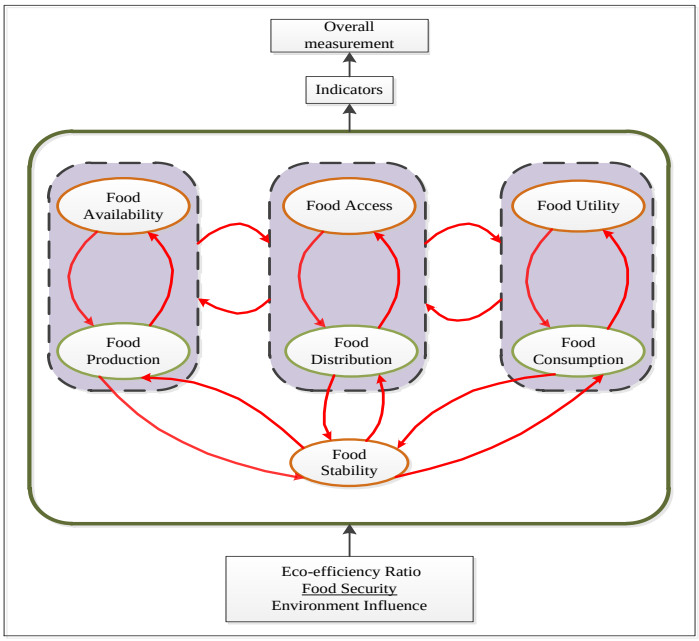

Figure 3. Framework Of Dynamic Eco-Efficiency for Sustainable Food Security Measurement

Following measurement framework designed by [7], relationships between sub systems then support the indicators of eco-efficiency identification by deploying as Figure 4:

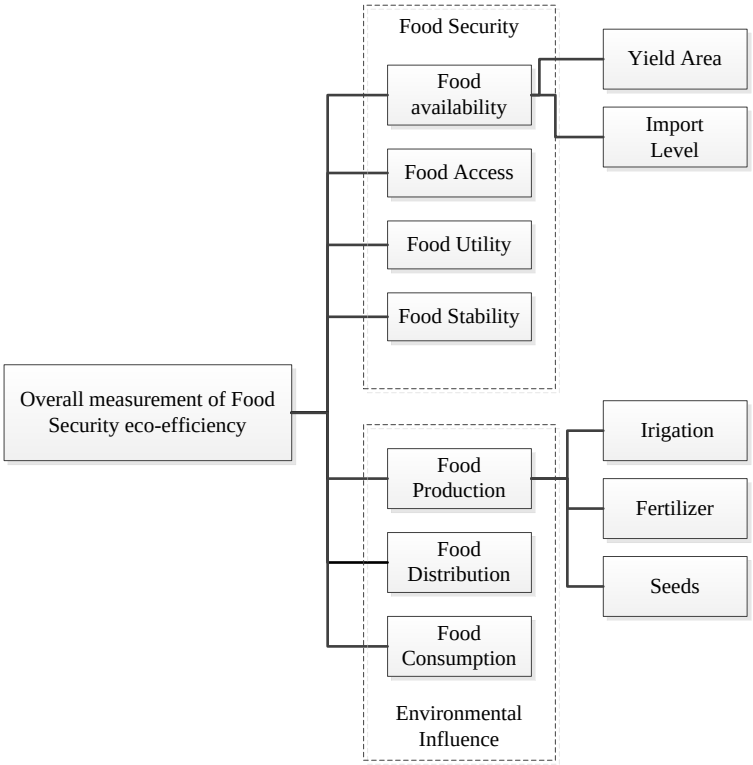

Figure 4. Food Security Eco-efficiency Deployment

As Equation (2), eco-efficiency of food security consists of numerator and denominator indicators. Figure 4 shows the numerator as Food security and Denominator as Environmental Influence indicators deployment refers to Food Availability and relationship with Food Production. Environmental influence is measured by food production influence to environment defined by its irrigation, fertilizer and seeds.

6. Conclusion

This paper objective is to develop a framework of dynamic eco-efficiency for sustainable food security measurement. Eco-efficiency of sustainable food security needs system dynamic combining to cope with complexity, time dependent and dynamic system that can't be cope by ordinary performance measurement. The use of system dynamic supports identification of intervention actors of system that can be used to be the indicator of measurements beside the standard indicators [7].

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