The State of Global Sustainable Food Production, Green Supply Chain Management and Decision Making: A Multidisciplinary Review

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ABSTRACT

This review aims to promote a discussion about the development of a new global supply chain structure, as emergent economies such as the BRICS (Brazil, Russia, India, China and South Africa) are coming to the scene. In this review we try to understand the dynamic processes of global food distribution and its logistics taking into account the impact of emergent economies. As XXI century society faces an increasing global population that imposes a greater challenge for self-sustainable food production, quality and distribution. How then we cope with such great supply demands? In support to UN-FAO goal of reducing the number of undernourished people in a global scale, we discuss important topics depicting the intricate components of a green supply chain and highlight the available strategies and scientific models for decision making. In order to achieve a sustainable global food secure state, this review presents facts about the global state of sustainable food production system, fishery, energy intensity, freshwater availability and ecological footprints; together with some scientific suggestions for supply chain management and decision making.

Keywords: food distribution, supply chain management, sustainability and decision making.

1- INTRODUCTION

1.1- SUSTAINABLE FOOD PRODUCTION AND ITS DISTRIBUTION

The research in food production and logistics distribution is a very complex topic and the decision processes required to deal with such subject reveals an intricate summation of variables. It is then, of primary importance, that all the components (or concepts) of such complex web be discussed.

As depicted by Gómez *et al*. (2011) it is necessary the use of transdisciplinary and rigorous models in the conceptualization of a realistic framework in dealing with food production and its distribution to consumers or as also called, food value chains (FVCs) that includes: *energy*, *environment*, *consumer*, *farmworker health and safety*, *economic cost* and *distributional equity*; also reported by Reardon and Timmer (2012).

Food together with energy, are very important limiting factors constraining human life quality and development. Be Vier (2012) reported that only 20% of the global population has access to the, so called: *global food system*. The 20% fraction refers to the global population that earns more than US$10 dollars a day.

Although, a significant progress was observed between the periods of 1979-81 and 1997-99, where the incidence of undernourishment dropped from 20 to 17%, as reported by UN-FAO (United Nations-Food and Agriculture Organization) “The State of Food and agriculture 2002” *http://www.fao.org/docrep/004/y6000e/y6000e00.htm*; which represents a total of 39 million people; the present global crisis impact over the incidence of undernourishment is still to be measured.

The same UN-FAO publication points the sub-Saharan Africa as the region that demands more attention followed by the Asian and the Pacific region, with a significant progress in the Latin America and the Caribbean followed by Near East and North Africa; at the present, these regions are out of the BRICS and developed countries’ dynamic commerce, with the exception of Latin America that would, somehow, benefit from the Brazilian economic development, Neves (2010).

The *global food system* is related to the production, processing and distribution of food in a global scale as reported by Reardon and Timmer (2012). In their review, Reardon and Timmer (2012) analysed the food system economy for the last 60 years

in the United States of America and developing countries and its impact in the future of food industry.

A part of the global consolidation of the American system, where superstores transform the food industry, as reported by Goldman *et al.* (2002) the big question remains unanswered, that is: How to transform the food industry, incorporating all the benefits the American system can provide, and at the same time, guaranteeing a sustainable production system that takes the environment into account?

One could ask why the American system? It is in fact a good question. Cotterill (1997) brings a very interesting discussion about the future of food distribution systems comparing the American model with the so called UK's model.

The discussion can be even broader if someone wants to include nascent models such as Chinese or Indian, but because of the size and the capital involved in the American and European markets, it is reasonable to assume an integrative tendency of fusion between the American and UK's model incorporating new features from the emergent markets, (see topic 1.3 on this review).

1.2- SUSTAINABILITY

To start talking about sustainability it seems fair to refer to Daly and Farley (2011) where several relevant concepts are defined and are the basic steps to understand sustainability.

It is of fundamental importance to define *sustainability* in such complex topic as in *food production system.* The concept of sustainability in the food production system by Brklacich *et al.* (1991) incorporates six other components to the *supra-referred* by Gómez *et al*. (2011) and Reardon and Timmer (2012) they are: *environmental accounting,* where the biophysical aspects of production are taken into account; *sustained yield,* with some changes in the interpretation by agronomists; sustained yield is an expression used in the forest and fishery industry, where environmental maintenance underpins long-term socioeconomic development.

Another concept used in food production and logistics distribution is the expression *Carrying capacity*, although it is a controversial concept imported from population biology, it refers to the maximum capacity an environment can support, as referred by

Brown *et al.* (1987) and Brklacich *et al.* (1991).

Production unit viability is related to economic performance and viability of local farmers. Among all the components regarding the concept of sustainability in the food production system, *production unit viability* is the one takes local and social values in a context where strong rural communities and development strategies can be performed (Brklacich *et al.*, 1991).

Product supply and security are related to procedures that guarantee the food supply on a continual basis relative to costumers demand for domestic food production and accessibility to food stocks and availability such as in the fishery industry (Brklacich *et al.*, 1991).

The last component of sustainability in the food production system, as seeing by Brklacich *et al.* (1991) is *equity*, which refers to a fair access to production opportunities and an equilibrated distribution system that meets the needs of the present consumption, without compromising the future generations demand.

Environmentally speaking, Brklacich *et al.* (1991) highlight *soil erosion*, *climate changes*, *acidic precipitation*, and *desertification* as the major factors threatening the sustainability in food production system; see also Lal (1991) *on soil structure and sustainability*. To measure *sustainability*, Liverman *et al.* (1988) pointed erosion and population as categories and physical quality of life index and energy imports indicators.

In order to measure *sustainability*, Gong and Lin (2000) created an indicator system designed based on 12 *functional* indicators and 45 *element* indicators to access the progress for Sustainable Development for Agricultural Region (SDAR).

Working with *computation decision support models* and *result analysis*, Gong and Lin (2000) found constraining factors restricting the development of a sustainable agricultural practice they are: "*the development of population, potential grain output, relationship between population and land, the status and spatial distribution of environmental quality, the comprehensive development* and *the regionalization of the capacity of sustainable development*.".
To achieve this result, Gong and Lin (2000) considered data from distinct sources, such as: investigation data, statistical, spatial distribution and remote sense imaging; all integrated in the OpenEnvi system applied to decision support models.

As referred initially, *food production* and *logistics distribution* are very complex topics and the understanding of such complexity revealed in several analyses, where regional particularities are taken into account, given us an impression that a consensual global model for *food production* and *logistics distribution* cannot be achieved.

In practical ways, one example of non-sustainable source is the case of *phosphorus*. The global demand of *phosphorus* is expected to increase constantly but the production peak is estimated to be reached by 2030, for reserves expected to last between 50 and 100 years, Cordell *et al.* (2009). It can be seeing as a local problem where the supply of *phosphorus* impacts the local farmers, but it will impact the global food supply once it is considered in a broader model and it will cause an impact with a certain level of significance.

In this sense, it is important to considerate all possible variable that could cause significantly affect an eventual global model for food distribution, and then, accessing the global state of reserves, natural resources and other parameters, will give us a better perspective of the state of food security in a sustainable context.

1.3- STATE OF THE GLOBAL FOOD PRODUCTION AND SECURITY

Based on data from UN-FAO (United Nations-Food and Agriculture Organization) over one billion people have no access to a safe food supply, and the problem is related to food access and distribution; in order to guarantee safe food supply it is necessary to efficiently coordinate the food availability with accessibility, utility and stability through distribution.

The literature about sustainability in agriculture is vast and the subject sustainability seems to be already consolidated in the agricultural field since the 1990's. As published by Lal (1991) sustainability in agriculture is a popular theme among researchers, financiers and policy makers. Lal also highlights the importance of soil structure for agricultural sustainability in a *local*, *regional* and *global scale*.

Despite of the broad number of publications in *agricultural sustainability*, we would like to emphasize the logistic aspect of *food distribution* and how the global system of food distribution imposes new rules on the *sustainable food productive system*, and

the consolidation of *green supply chains*.

A recent review Reardon and Timmer (2012) discuss the economics of *food revolution*, fact that is happening in the United States (US) for more than a century and in developing countries in the last 30 years; they also report a rapid consolidation of the food industry in the US, a tendency that should be followed by developing countries.

To guarantee a *safe food supply* in a global scale it is important to have a better understanding of the dynamic of the food system and its components, such as: *determinants of its structure, its behaviour* and *outcomes* in its distinct scales. Safe food supply still needs a more comprehensive analytical framework and needs to be linked to basic economic theories, together with the *behaviour of the decision makers* that composes the supply chain (Reardon and Timmer, 2012).

Gómez *et al.* (2011) brings a positive movement towards global food system initiative, suggesting the *integration of disciplinary evidences* to be applied in a more rigorous context in evaluating the multidimensional performance of the food value chains (FVCs).

Gómez *et al.* (2011) brought a consistent approach based on six principles to support the design of a better food safe supply in a global scale, they are: *focus in local market*, *improve quality of production* and *distribution decisions*, *improve marketing*, *reduce losses post-production*, *maintenance of local natural resources* and *attestation of compliance*; that not exclude smallholders from high value markets.

Also, Gómez *et al.* (2011) pointed out the lack of knowledge in *food value chains* in developing countries that make a functional global food system difficult to implement, together with the need of an inclusive transdisciplinary framework considering: *environmental*, *economic* and *social aspects of food production*; also, the need of using *complex scientific models* and a better *inclusive communication system*.

Based on the proposed by Gómez *et al.* (2011) we then consider the *environmental* aspect in a global context, through the so called *ecological footprint*.

1.4- ECOLOGICAL FOOTPRINT

It is interesting how updated the article published by Canel and Khumawala (1996)

sounds even being published 17 years ago. The discussion about *Facility Location* (FL) and *International Facility Location* (IFL) clearly shows the necessity of a *global environmental awareness*. Markets trespass international borders and even make the borders to disappear, as an example of the European Union where it is difficult to imagine a product from a member's country causing an environmental damage, without the block to be aware of.

There is a vast literature about models to solve IFL such as: Canel and Khumawala (1996) *on capacitated and uncapacitated period IFL problems*; see also the review by Lucas and Chhajed (2004) *on location analysis applied to agriculture* and Lippmann (2001) on *location and supply chain environmental management*.

Tomich *et al* (2011) published a multidisciplinary review focusing on *agroecology* considering the effects of the global change. Considering *agroecology* from the scientific point of view, Tomich *et al* (2011) define *agroecology* as: "*the science of applying ecological concepts and principles to the design and management of sustainable food system.*". The question here is how *agroecology* can contribute to a *global food supply chain* in a *sustainable* way?

In this important review Tomich *et al.* (2011) highlighted that *agrobiodiversity* is a well-established value for agricultural production and it contributes to stabilize the productive system through agroecological practices for managing farms and fields. They also pointed that alternative energy sources and reduction on the use of synthetic nitrogen fertilizer (N) impacts the environment positively.

For Tomich *et al.* (2011) if organic agriculture is going to suffice the global food needs still remains uncertain.

Another important concept that will be decisive on the establishment of the future green supply chain is the carbon footprint or CO_2 footprint. In this review we consider the definition proposed by Wiedmann and Minx (2008) that is: *"The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."*.

Another topic referred on the FAO report is the need to recover degraded areas, but despite of an increase in the natural heritage reserves of global importance from 131 to 133 million/ha in developing countries, which include the BRICS, it still doesn't

reflect the restoration of degraded areas, once the creation of reserves has been concentrated in transforming natural forests and shrubs into reserves, as reported at the "The State of Food and agriculture 2002" Part III, on: *http://www.fao.org/docrep/004/y6000e/y6000e00.htm*.

See also, Lee (2011) on *integrating carbon footprint in supply chain management*; González-Ramírez *et al*. (2012) on *designing carbon contracts such as: per-tonne, output-based-offset (OBO) principal-agent-contract and dynamic abatement cost model*; Tseng *et al.* (2013) on *sustainable consumption and production (SCP) as a multidisciplinary opportunity for innovativeness in industries.*

1.5- STATE OF THE GLOBAL AQUACULTURE AND FISHERIES

In the website of *http://www.fao.org* it is possible to find updated information about the global state of aquaculture and fisheries. The report is designated: *Report of the Workshop to Develop an FAO Strategy for Assessing the State of Inland Capture Fishery Resources, Rome, in December 2011. Event called: FAO Fisheries and Aquaculture Report No.1016 in Rome containing 37 pages.* It is a response to the lack of information about the so called inland fisheries that are of vital importance to the livelihoods of people in many parts of the world. It is estimated that, globally, lakes, reservoirs and wetlands sum a total area of 7.8 million km^2.

Another source of information to the global state of aquaculture and fisheries is the FAO Aquaculture Newsletter *No* 48 December 2011 at: *http://www.fao.org/docrep/015/i2647e/i2647e.pdf*; where the *recommended priority areas were: Farming systems, genetic improvement, aquatic animal health* and *response to climate change.*

See also: *http://www.fao.org/cofi/34736-07ac23d09354a6895cd0a3a71486cfe2f.pdf*; referent to the Report of the 6th session of the SUB-COMMITTEE ON AQUACULTURE Cape Town, South Africa; March 2012. In this document *aquaculture* appears as the fastest growing food producing sector in the world; that contributes with 50% of the global food fish supplies and it is a sector from the global food system that will improve food and add nutritional security in a global scale.
Following the tendency of a *global food supply chain*, *aquaculture* that was seeing as a local and regional practice has become more international than national; following the ideas of *integration* of García-Dastugue and Lambert (2003); Goldman *et al.* (2002)

and others.

The greatest possible contribution from aquaculture is the association with the creation of hydroelectric plants and the generation of massive inundated areas. In countries where desert areas or semi-desert areas are present, the implementation of cultures such as aquaculture can solve several problems at the same time, such as: implementation of a *local economy*, *water supply*, *energy generation*, *food security* and *reduction of desertified areas*, which could impact positively the effects of global warming (see topic 1.7).

In 2009 Ahumada and Villalobos published a review in which the expression *agri-food chain* appears. It is also the first publication to refer to *storability of products* rather than citing *perishable* and *non-perishable* products. In their review Ahumada and Villalobos (2009) also refer to previous review such as: Glen (1987) on *crops and livestock production models* and Lowe and Preckel (2004) on *modelling in crop planning and agribusiness*.

1.6- STATE OF THE GLOBAL FRESH WATER ECOSYSTEMS

Scarcity of water has no boundaries and it is present in arid and semi-arid regions as well present in areas of humid tropics and temperate zone that are densely populated. The number of people suffering from relative lack of water supply could reach 5.7 billion, as referred by Vörösmarty *et al.* (2008) and more than 2 billion as referred by Oki and Kanae (2006) considering the renewable freshwater resources (RFWR).

Schwarzenbach *et al.* (2006) reported that 1/5 of the world's population has no access to safe potable water, and 2/5 suffers the consequences of unappropriated sanitation. Pathogens in water are responsible for more than 2 million deaths annually, mostly children under 5 years of age. Moreover, 1/3 of the available renewable freshwater is designated to agricultural, industrial, and domestic practices.

Oki and Kanae (2006) also reported 3800 km^3/year of RFWR is currently used by humans, meaning less than 10% of the maximum available RFWR in the world; with evapo-transpiration as 7600 km^3/year used in agriculture and 14,400 km^3/year used in pasture.

The amount of water that flows mainly through the rivers from continents to the seas is estimated by Oki and Kanae (2006) to be 45,500 km^3/year. The amount of available water by RFWR is supposed to increase as a result of Climate Changes by accelerating the water cycles and by increasing the available RFWR.

1.7- ENERGY INTENSITY IN THE FOOD SYSTEM AND WATER SUPPLY

In a recent review, Pelletier *et al.* (2011) presented facts about the energy consumption in the food system. Although, it is reviewed in a small scale, the Life Cycle Assessment (LCA), referring to the energy used in sectors such as: crops, livestock, aquaculture and fisheries; has the potential to illustrate a global scenario.

This topic bring us the need of incorporating *environmentally friendly* or *ecological concerns* subjects into the discussion of a Green Supply Chain Management (GrSCM) a concept designed during the 1990's and defended by Srivastava (2007). However, an important issue highlighted by Srivastava in his review of 2007, is that "*it is not just about being environment friendly; it is about good business sense and high profits*.", when talking about a global food supply chain (see topic 2).

In an online-publication McMichael *et al.* (2007) bring the importance of transformation in energy production, in order to deal with the reality of global greenhouse-gas emissions.

In the context of energy generation and food production, especially for areas where natural sources are restricted, such water in the Middle East and North Africa, it needs an approach that suffices the clear generation of energy and water supply. The answer for this issue seems to be the concentrating solar power applied in seawater desalination technology.

In the publication of Trieb and Müller-Steinhagen (2008) they highlighted that building water supply based on conventional energy sources could result in a critical situation in the medium and long term future.

Between the Tropic of Cancer and the latitude North 45°30' the solar energy irradiated globally reaches its maximum, creating the desired condition to the application of solar energy associated with seawater desalination, that encompass countries such as:

Spain, Italy Greece, Libya, Egypt, Jordan, Israel, Lebanon, Syria, Iraq, Saudi Arabia, Qatar, Kuwait and others.

In a comparison with the energy content by barrels of crude oil, the region between Tropic of Cancer and the latitude North 45°30' would have a potential energy per km^2/year equivalent to 1.5 million barrels of crude oil as referred by Trieb and Müller-Steinhagen (2008). The technologies applied in generating energy from solar power find a fertile soil in this region of our planet.

The status of development of solar energy technologies can be easily addressed through the seminars promoted by Stanford University at *http://www.youtube.com/watch?v=VJ-YpM8bjlw* through a presentation from Dr. Thomas Mancini from Sandia National Laboratories, where he highlights the present state of concentrating solar power technologies.

In this sense, concentrating solar energy associated with seawater desalination and district cooling becomes a great deal since it solves basic problems such as, water supply, food production, low energy cost and heat sequestration, which could reduce effects of global warming in the region between Tropic of Cancer and the latitude North 45°30'.

Jordan has started the first plant based on concentrating solar energy associated with seawater desalination and district cooling in Aqaba, as referred by Trieb *et al.* (2009). Spain has a plant based on concentrated solar energy in Sierra Nevada and another in Almería, both with the capacity of 50MW each.

As published by UN, the region of Middle East and North Africa is expected to double their population by 2050 and just Egypt counts with 50% of the total population Trieb and Müller-Steinhagen (2008).

It is then quite reasonable to assume the importance of concentrating solar energy as a regional solution for the countries between Tropic of Cancer and the latitude North 45°30', and the positive impact it is going to cause in the global food supply system; most important will be the contribution to the UN-FAO goal of reducing the number of undernourished people in a global scale.

2- GLOBAL SUPPLY CHAIN MANAGEMENT (SCM)

The concept of Supply Chain Management (SCM) is quite broad in the literature and to simplify, it was chosen to narrow the concept in accordance to the proposed by Mentzer *et al.* (2001) and supported by Burgess *et al.* (2006).

In the review of Mentzer *et al.* (2001) SCM is defined as: "…*the systematic, strategic coordination of the traditional business function and the tactics across these business function within a particular company and across business within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply as a whole*…"; Mentzer *et al.* (2001).

The historical evolution to the concept of SCM was well covered by Bechtel and Jayaram (1997) and it is recommended as complementary reference the publications of: Lummus & Vokurka (1999); Lummus *et al.* (2001); Mentzer *et al.* (2001) and Seuring and Müller (2008).

In a very comprehensive review, Burgess *et al.* (2006) say that SCM has developed in "…*narrow functional silos such as purchasing, logistics, IT and marketing*…" That explains the broad conceptualization of SCM and makes it difficult to visualize a clear theoretical framework. It is also possible to see some benefits of such broad nature in SCM theory, which brings *diversity*. However, nowadays, it is important to come with a theoretical framework that includes the so called *sustainable* or *green* values.

Burgess *et al.* (2006) also points a need for systematic examination in the methodology related to SCM as it appears to be missing from previous reviews. It is very important to have a convergence of ideas and methods in order to facilitate the *integration* of SCM as a standardized procedure which will culminate in a more effective way to exchange information, accommodate fusions among SCM procedures and warrant the adoption of a discipline of SCM (as discussed in the topic 4 of this review).

In the review of Bechtel and Jayaram (1997) the expression of a *sustainable SCM* appears for the first time related to the example of Xerox, where the material used by the company is monitored in the light of *safe disposal*, *recycling* and *unused materials*.

In an interesting article, Neves (2010) brought expected numbers about the future of global consumption. The increase in demand for food, transportation, consumption of goods, construction, energy demand and people moving from agricultural areas to

cities will require the incorporation of *new technologies* to assist such dynamic logistic process of management.

The dynamic phenomenon of changes in our society is called “speed up” and it has been observed as part of human development even before the French Revolution. Historians report that the so called: “speed-up” process is present in our society since the middle of the eighteenth century (as cited by historians such as Reinhart Koselleck) and referred by Rosa (2003). Rosa (2003) has pointed out that a constant general sense of “speed-up” is perceived from generation after generation.

With the continuous establishment of the XXI century society an ever increasing capacity of information processing will be needed, which will transform the way we do business. For example, in this new environment, managers will select coordination mechanisms from the Internet that better satisfy a variety of business needs, such as *business performance*, *revenue expansion*, *cost reduction* and *the ability to reach new markets* (see topic 4 about Cloud Computing in this review).

In this context, the Internet will allow the online interactions necessary to improve the data acquisition, sharing information, auctions and high connectivity among members of supply chains (García-Dastugue *et al.*, 2003).

The management challenges brought by the globalization, to operators and academics, in the global supply chain, e.g. the transportation of goods from the origin to its destiny of consumption is revised by Meixell and Gargeya (2005); because supply chain management goes beyond national borders, several factors influencing the location decisions have to be taken into account, such as: *cost*, *social and political factors*, *global competition and economic-related factors*, *transportation and climate*, *financial incentives*, *tax structure* and others.

In a practical view, the consolidation of the food industry pointed by Reardon and Timmer (2012) where supermarkets or superstores take over the retail segment, especially in developing regions, as reported by Reardon *et al.* (2003) requires a new strategy and management challenges such as: *changes in the consumer behaviour*, as they require processed food and fresh produce, *delivery*, *credit and infrastructure* as: *air-conditioning*, *parking* and *marketing*.
A good example of such transformation is what is happening in India, where the new economic reality faces the traditional way Indians see their cultural relation with food and food preparation, the same is happening in China, Russia, Brazil and South Africa

with different intensities.

Behind all the challenges brought by the new retail based on supermarkets are the satellite companies, *a cascade effect*, responsible for supplying goods and services, real state, vehicle fleets and etc.

A part of a significant consolidation of the supermarket format as food retail system in emerging markets, the share gain is still restricted, and there is a need for better ways to predict its potential, Goldman *et al.* (2002).

The pattern observed in supermarket diffusion in emerging economies is supported by its consolidation, based on geographic and economic segments, where there is a gain in the market share. Where a distinct separation among economic classes exists, supermarkets tend to be established first in high-income areas.

However, if there is a well-established ethic/cultural distribution, the diffusion rates will vary. The diffusion will cease when the expansion reaches the point where the additional revenues no more justifies the diffusion, Goldman *et al.* (2002).

Such geographical diffusion is causing significant impact in regions such as Africa, Asia and Latin America. The diffusion of supermarket in emerging economies changes the local development models, policies and transforms the agrifood market in terms of rates and depth, as reported by Reardon et al. (2003).

In a small scale, to address the limiting factors restricting the growth and expansion of supermarkets and superstores, Goldman *et al.* (2002) conducted a research which outcome was that perishables is the segment that restricts the supermarket share gains, and points superstores as a more effective environments for perishable products.

The fact perishables are an important limiting factor for supermarket diffusion, *minimizing transportation* and *intensifying local production* becomes of great interest for guaranteeing share gains and as a consequence it creates opportunities for the implementation of a *self-sustainable local system*. This idea supports the *cascade effect* supra-referred.

The self-sustainable system opens the discussion about *green supply chain management*, as extensive reviewed by Srivastava (2007) where he presents a very comprehensive *evolutionary timeline* of green supply chain management.

The definition of *green supply chain management* as stated by Srivastava (2007) is: "*integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of final product to the costumers as well as end0of-life management of the product after its useful life*".

Although, when Srivastava (2007) says that in his review he does not consider the literature related to green logistics, because it may not be significant; it sounds wrong since green logistics incorporates the *basic actor* of a supply chain, that is, as referred above, the *local workers* acting in providing services for *supermarkets* and *super-stores*.

The positive impact of local workers in the supply chain supports the adaptation of *social behaviour* to a new reality imposed by *supermarkets* and *superstores*; especially in emerging economies. The benefit of a *green system* ultimately is revealed by the benefits it brings to a new *local social behaviour/adaptation*.

3- MODELS OF SUPPLY CHAIN MANAGEMENT (SCM) AND DECISION MAKING

In a review covering the period of 1996-2000, Meixell *et al.* (2005) give a description of different approaches of SCM models development. For history and definition of SCM see also Lummus *et al.* (2001).

Meixell *et al.* (2005) review several approaches to SCM models, they are: Canel and Khumawala (1996) *working with IFLP used an un-capacitated and capacitated of mixed integer programming model*; Canel and Das (2002) *integrates global manufacturing and marketing decisions*; Rosenfield (1996) *worked with a model on production and distribution focused on the structure of international locations with some strategies on uncertainty about exchange rates*; Huchzermeier and Cohen (1996) *fused two models, a production-distribution network with an opinion valuation model*, as stated by Meixell *et al.* (2005). For a definition of *uncertainty* see Galbraith (1973).

A part of the great complexity in the supply chain management, there is a general consensus that the "*action of one actor in the chain can influence the cost and value added by all other actors in the chain*" as cited by van der Vorst (2000). This simple

observation results in the fact that an improvement in the chain performance is dependent of *uncertainties* related to the decision making process.

This way of seeing a SCM concurs with Bechtel and Jayaram (1997) in support of the ecological view about business relations. In an interesting review Bechtel and Jayaram (1997) argue that SCM "*crystallizes the business ecosystem idea by providing a process framework that enables firms to engage in co-evolution rather than competition*".

In this context of co-evolution, it is appropriate to refer to the review of Peidro *et al.* (2009) where they refer to: "*…the ultimate success of a firm will depend on its managerial ability to integrate and coordinate the intricate network of business relationship amongst SC (supply chain) members…*".

The complexity of dealing with SCM increases based on the need of managing the supply chain's components as one, and at the same time, understanding the dynamics, each component plays individually in the supply chain; at the same time, taking into account the interaction among them. It creates a very intricate interrelationship and the comprehension of its mechanism is vital to achieve a better price offered to costumers and more revenue at lower overall cost; as reported by Beers *et al.* (1998).

The reduction of uncertainties is related to the availability of information, synchronization and reduction of processes that slow the entire supply chain; Cooper *et al.* (1997).

Also, the development of SCM concept is incorporating the costumer as a key figure as a source of information for various components of the supply chain. Another topic highlighted by Bechtel and Jayaram (1997) is the *systems thinking*, where an holistic optimization of the supply chain is by understanding how decisions made in one specific component of the chain affect the entire system (supply chain).

Cooper *et al.* (1997) makes an important reference to *costumers* in their review (also cited by van der Vorst and Beulens (1999a); together with common definitions of SCM found in the literature, they are:

- *It evolves through several stages of increasing intra - and – inter-organizational integration and coordination; and, in its broadest sense*

and implementation, it spans the entire chain from initial source (supplier's supplier, etc.) to ultimate customers (customer's customer, etc.);

- *It potentially involves many independent organizations. Thus, managing intra- and inter- organizational relationships is of essential importance;*
- *It includes the bidirectional flow of products (material and services) and information, the associated managerial and operational activities.*
- *It seeks to fulfill the goals of providing high customer value with an appropriate use of resources, and build competitive chain advantages.*

van der Vorst and Beulens (1999b) brings the concept of: Efficient Consumer Response (ECR); and points its importance in: *reducing costs*, *removing not necessary activities*, *creating transparency* and *increasing coordination trough Information Technology* (*IT*).

A very detailed review on quantitative models in SCM planning considering *uncertainty* was carried out by Peidro *et al.* (2009). Peidro and colleagues highlighted a taxonomic division for future researchers in the field of '*modeling approach*' of supply chains under *uncertainty*, they are: *analytical approach*, *artificial intelligence-based*, *simulation* and *hybrid approaches*.

As Kaplan wrote in his publication of 1990 and also cited by Gunasekaran and Kobu (2007) "*No measure, no improvement!*". Gunasekaran and Kobu (2007) pointed the importance of measuring the right thing at the right time and emphasize that performance measures and metrics are also a matter of politics, emotions and several other behaviours.

In the context of Gunasekaran and Kobu (2007) publication, performance measures become an important factor for the integration of supply chains, it will be required a more effective communication among supply chain as the global system grows in size and complexity.

The word *integration* is also mentioned by Johnson and Pyke (2000). The context of *integration* however, is going to be more present in future discussions about SCM, because of a common methodology and available information; it will facilitate exchanging of information among supply chains, increasing confiability and, as a consequence, reducing *uncertainties* in the process of decision making; allowing less time and energy in the performance of supply chains, resulting in efficiency and lower cost.

As Kogut (1984) published "… *a company can compete in different strategic groups…global strategy is the creation of operational flexibility to benefit from uncertainty…*" with this words Kogut remind us that we always can look to the same problem from different perspectives; see also Duclos *et al.* (2003) on: *supply chain flexibility model*; Fredericks (2005) on: *inter- and intra-firm flexibility* and Swafford *et al.* (2006) on: *agility and flexibility impact on manufacturing and procurement/sourcing and* see also Kouvelis and Gutierrez (1997) on: *centralized and decentralized decision making applied in production quantities.*

In the publication of Lummus & Vokurka (1999) they refer to the importance of supply chain management during the 1990's and made an interesting observation about integration "…*These organizations have realized that whenever a company deal with another company that performs the next phase of the supply chain, both stand to benefit from the other's success…*".

For a more comprehensive discussion about factors affecting the process of decision making and its nature it is recommended the publication of Alas *et al.* (2012).

4- CLOUD COMPUTING AND THE FUTURE OF A DISCIPLINE IN SCM

In times of great uncertainty in the market, as cited by Miller (1977); "…*uncertainty and risk imply divergence of opinion…Since divergence of opinion is likely to increase with risk…*" It seems that information and transparency are essential to reduce *uncertainties*, and as referred by Smith and Huettel (2010) "…*uncertainty reflects the absence of some desired information…*" For a distinction between *uncertainty* and *risk*, refer to Hillson (2006); see also Stevenson and Spring (2007).

Information is of extreme importance in the decision making process, so the impact of new technologies and models, in allowing easier and faster access to information, becomes a necessary topic in the literature.

How to optimize the access to *information*? Well, during the 90's Grid Computing appeared as a result of high demand of computing power and reliable computational system. Companies saw the opportunity and then IBM came with the *Grid and Grow*, Oracle with *Oracle Grid*, SUN *N1 Grid Engine* and others; and then Grid Technology took place. Grid Computing is a decentralized control cluster with a single domain and

a centralized system, where the participants cannot interact directly; as in Weinhardt *et al.* (2009) see also, Weiss (2007).

Cloud Computing (CC) differs from Grid Computing because it is capable of integrating pre-existing technologies in a new model, where *Utility Computing* and *data centers* are combined, as in Weinhardt *et al.* (2009). CC is a faster and efficient model for accessing conveniently, on-demand network services. Cloud service models was described by Williams (2012) as 3 distinct categories, such as: Software as a Service (SaaS), Platform as a service (PaaS) and Infrastructure as a service (Iaas); (*another service provided but not referred by Williams (2012) is the (DaaS) desktop as a Service*) that involves networks, servers, storage, applications, and services.

Some questions arise from the *supra-cited*, they are: How CC will impact SCM? Is CC capable of reducing the uncertainties and risk, in support of decision making processes? Can CC increase access to *information*, and as a consequence, increase the companies' *transparency* and *confidence*?

Cegielski *et al.* (2012) say CC could be especially useful for SCM, where *flexibility* is among the best benefits from CC, see also Kogut (1984). The benefits from CC to SCM are cited by Cegielski *et al.* (2012) as: "*… facilitate scalable on-demand computing power, rapid deployment, reduced support infrastructure ... lower cost to ownership*" see also Duclos *et al.* (2003); Fredericks (2005) and Swafford *et al.* (2006).

Several other publications are emphasizing the incorporation of CC, such as: Mvelase *et al.* (2012) on: *architecture based on service oriented architecture (SOA)*; Dlodlo *et al.* (2012) on: *the state of international internet of things (IoT) integrated data and decision making*; Koslowski and Strüker (2011) on: *enterprise resource planning (EPR) on demand platform;* Buyya *et al.* (2009) on: *information and communications technology (ICT) as the 5th utility after water, electricity, gas and telephony.*

In summary, CC is a flexible IT model integrated component of the Internet and free from vendors and specialized systems that allow free communication and interaction among companies, and the incorporation of such flexible model to SCM will contribute to agility, flexibility, access to information and transparency as fast as the speed of Internet.

CC also opens a new opportunity for schools, the restructuration of their *curricula*, and reduction of complexity resultant from SCMs interactions, since the SCMs will be in the same virtual environment.

4.1- A CURRICULUM FOR A GREEN SUPPLY CHAIN MANAGEMENT

The evolution of supply chain management as a discipline can be followed by the evolution of concepts and paradigm shifts as reported by several authors, such as: Leenders *et al*. (1994) *on SCM has gained a new interpretation when academics and business personnel started viewing the system (supply chain) as one single structure and the customers where included as part of the system*; González *et al*. (2004a) *on shifting from logistics to a broader approach where supply chain management took place*; González *et al*. (2004b) *on Quality Function Deployment (QFD);* González *et al*. (2005) *on Voice of the Costumer (VOC)*. For a better perspective of the concept of QFD, refer to Akao (1997).

In the publication of González *et al*. (2007) a very educational explanation about the evolution of concepts that allowed designing a curriculum for SCM is presented. In this publication they explain the use of concepts such as *Voice of the Costumer* and how students can incorporate this information, creating a framework in SCM.

Neureuther and O'Neill (2011) discuss the implementation of an undergrad program in sustainable supply chain, addressing the needs of the industry to give the students the practice in managing supply chains. Although, the topics highlighted by Neureuther and O'Neill (2011) are of fundamental importance, the definition of *sustainability* was not clear in their discussion.

In a very well elaborated article Johnson and Pyke (2000) describe 12 categories as part of the curriculum in supply chain management, they are: *location*, *transportation and logistics*, *inventory and forecasting*, *marketing and channel restructuring*, *sourcing and supplier management*, *information and electronic mediated environments*, *product design and new product introduction*, *service and after sales support*, *reverse logistics and green issues*, *outsourcing and strategic alliances*, *metrics and incentives and global issues*.

Apart of a reasonable coverage of topics in the article of Johnson and Pyke (2000) it did not refers to *sustainability* and *costumers*; these were important topics already highlighted by Bechtel and Jayaram in 1997, three years prior Johnson and Pyke publication in 2000.
Also, the word *sustainable* seems to be still rare from the discussion context of a society that was already emphasizing the ecologically correct practices, although the incorporation of *customers*, as an important figure in an efficient supply chain seems

to be consolidated as in González *et al*. (2004) and González *et al*. (2007).

I*ntegration* is mentioned as part of an introduction to supply chain management curriculum by Johnson and Pyke (2000). The need of a common methodology and available information grows with the complexity of a globalized system and the incorporation of customer's requirements and environmental procedures as a natural tendency for a curriculum about green chain management, as flagged by Canel and Khumawala in 1996, see also Wiedmann and Minx (2008) on *ecological economics*.

With the advent of CC as integrated part of firm's routine, the common environment will create the chance of students to develop the necessary tools for *communication* and *integration* among personnel and, in fact, eliminate the boundaries allowing the improvement of *information* and *trust*. The result will be *agility*, *flexibility* and *low cost*, see also Ying and Li-jun (2012) *on circular economy*.

4.2- "GAPS" IN THE LITERATURE

The gaps in the literature pointed by Gunasekaran and Kobu (2006) are still not covered in the present literature; as a result, a methodological procedure is still missing from the discipline of SCM, causing the inconsistence in the training of new professionals.

The positive impact of models such as: Cloud Computing is still missing from the discussions about Green Supply Chain Management. Cloud Computing is supposed to reduce costs to customers, provide faster and secure services and to be of great aid to decision making processes, requiring less time and energy, Williams (2012).

Calling the missing information in the literature as *gaps* seems to be not always precise. In the applications of Cloud Computing and its impact on GrSCM and education are still foggy. It seems to be just a process of natural evolution of ideas and the attraction of more researchers to the field will soon start producing new literature, then it would be better instead calling missing information as *gaps*, it would be more appropriated to call it *research opportunities*.

Also as mentioned by Simangunsong *et al*. (2012) there is no review that has focused on the *supply chain uncertainty*, which is relevant considering the important role of *uncertainty* in the decision making processes.

So, the suggestion for future reviews could be the impact of new technologies and models that would allow the exchange of *information* in a coherent framework in GrSCM, resulting in *integration* and reduction of *uncertainties*.

5- CONCLUSION

There are no doubts that natural forces are driving the Supply Chain Management field to a green state (GrSCM) where not just the requirements from customers are being incorporated into computational systems as *requirements*, and in this way, designing a new framework towards efficiency and reduction of *uncertainties*. Since the expectations from the end of the chain (customers) can be addressed, local solution will slowly change the way people are used to do business and it will reverberate in a bigger global scale.

The need for knowledge and awareness from agroecology, not just as a discipline but as a practice, will guide the future managers toward a development in harmony with the environment in a global scale through the same *virtual environment*, such as Cloud Computing model.

Also, the need for a sustainable approach is inevitable, taking into account the example of the global state of the fishery industry, where scientific methodology and effective regulations would guarantee the fish stock for future generations, together with well-developed aquaculture programs.

The use of high technological solutions such as concentrated solar energy will solve local problems in a self-sufficient and sustainable way, also helping mitigating factors that contribute to global warming.

New *curricula* will create the environment for *integration*, where not just models such as cloud computing, but also basic needs such as environmental demands (water, CO_2 footprints, energy and others) together will be part of everyday problem and challenges for future students and by considering small local problems we will achieve the UN-FAO goal of reducing the number of undernourished people *globally*.

WEB-PAGE REFERENCE

FAO (Food and Agriculture Organization) entitled “The State of Food and agriculture

2002" *http://www.fao.org/docrep/004/y6000e/y6000e00.htm*.

ABBREVIATIONS

CC: Cloud Computing; **DaaS**: Desktop as a Service; **EPR**: Enterprise Resource Planning; **FAO**: Food and Agriculture Organization; **FL**: Facility Location; **ECR**: Efficient Customer Response; **FVCs:** Food Value Chains; **GrSCM**: Green Supply Chain Management; **HA:** Hectare; **IaaS:** Infrastructure as a service; **ICT**: Information and Communications Technology; **IFL**: International Facility Location; **IFLP**: International Facility Location Problem; **IoT**: internet of things; **IT**: Information Technology; **LCA:** Life Cycle Assessment; **MW**: Megawatt; **OBO**: output-based-offset; **PaaS**: Platform as a service; **QFD**: Quality Function Deployment; **RFWR**: Renewable Freshwater Resources; **SCM**: Supply Chain Management**; SaaS**: Software as a Service; **SCP**: Sustainable Consumption and Production; **SDAR:** Sustainable Development for Agricultural Region; **SOA**: Service Oriented Architecture; **VOC**: Voice of the Costumer.

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