

IDE Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 573

**The Environment Dimension of
Food Supply Chain Analysis**

Lei LEI*

March 2016

Abstract

The paper reviews relevant literature studying the environmental impacts of food supply chain from production to each stage throughout the supply chain. With limited data and information, to better understand these impacts, a concrete example of the tea supply chain in China is provided. The tea supply chain is analyzed from the environmental prospective, with potential pollutants being identified at each stage of the supply chain. As an example of the food supply chain in a developing country, some unique features of the developing economies are taken into consideration when concluding the implications.

Keywords: environment, supply chain analysis, development

JEL classification: F18, F64, Q01

* Research Fellow, Business and Industry Studies Group, Inter-disciplinary Studies Center, IDE (Lei_Lei@ide.go.jp)

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

The views expressed in this publication are those of the author(s). Publication does not imply endorsement by the Institute of Developing Economies of any of the views expressed within.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

©2016 by Institute of Developing Economies, JETRO

No part of this publication may be reproduced without the prior permission of the IDE-JETRO.

The Environment Dimension of Food Supply Chain Analysis

1. Introduction

Food production and consumption have significant environmental impacts (Tukker and Jansen 2006; Stoessel et al. 2012). The increasing food demand due to population boost in 1960-1970s led to the “Green Revolution” in the agriculture industry (Conway and Barbier 1988; Tilman et al. 2002). Greater amount of fertilizer, pesticide, water, new crop strains and other technical innovations were adopted in the revolution to reduce hunger, improve nutrition, and spare natural ecosystems. The global per capita food supply was increased to feed the increasing world population. However, despite the impressive effective results, meanwhile there came the problems of equity, stability and sustainability (Conway and Barbier 1988). The world population by 2050 is projected to be about 9,000 million (Tilman et al. 2002). A sustainable agriculture is crucial to meet the food demand challenge.

A sustainable agriculture system works in harmony with the natural environment (Sustainable Organization). However the unsustainable agriculture will degrades natural capital, loss of topsoil, waste and pollution of water, nutrient loss, and extinction of species. Continually-used, non-rotated, and over-applied with manure and chemical fertilizers land would have unhealthy soil. Cattle rising sector also pollutes air, water and soil from animal manure. With the development of food supply chain, the process of storage, transportation, packaging, and processing also generate greenhouse gas that associates with climate change. This is the so- called food’s carbon footprint.

With increasing attention of the environmental impact of agri-food industry, a lot of research has been done from various perspectives. Differing from previous ones, this paper aims to provide a case analysis of the environmental impact of food supply chain. With reference to the prevailing literature in the relevant field, the case study could serve as a concrete and vivid example to understand the environmental impacts. The goal is to firstly summarize relevant literature for a comprehensive idea of the issue, secondly analyze the environmental impacts of food supply chain using an example from developing countries. Most previous research focused on developed countries, where there are well-developed food supply chains. The research results could differ in the case of developing countries, where most farm and food enterprises are small to medium sized and less integrated. At the end, implications for retailers making purchasing decisions and improving the supply chain management; and for policy makers implementing agriculture related policies are concluded.

Based on the definition of a supply chain, the food supply chain is a network of labor and production processes whose result is a finished agri-food commodity (Lei 2016). This paper focuses on the environmental impacts in each stage of the production process and the directly and indirectly generated pollution. A case of the tea sector in China is being discussed. The tea sector is selected to be discussed here as an example of economic crop, and it has relatively more positive environmental impacts. The organic and conventional tea supply chains are compared to study the environmental impacts.

The paper is based on desktop study and field investigation. The desktop study provides overview and background introduction of each food supply chain. With the basic information, specific case analysis is conducted to observe details in reality.

However, given the limitation in data and information, more research on quantifying the pollution in each stage are needed in the future to identify the most environmental devastating stage in the food supply chain. This could give more clear guidance and reference for supply chain governors and for policy makers for their purchasing and development strategies.

2. Literature review

With rapid economic growth, increasing attention is paid to the issue of sustainable development in terms of food (health) and environment (Lei and Shimokawa 2015). Research has been done to study the impact of agriculture production on environment issues as specific as soil, water, and air quality and climate change (Conway and Barbier 1988; Hanley and Spash 1993; Smith 1995; Tilman et al. 2002; Zhu and Chen 2002; Mittler 2006). For example, the heavy usage of Nitrogen fertilizer resulted in high concentration of nitrogen in water and soil surface in China since 1980s (Zhu and Chen 2002). The United States also paid huge amount environmental costs for public health, pesticide resistance in pests, crop losses, bird losses and groundwater and soil contaminations due to the application of pesticides (Pimentel 2005). Further researches related the rural development with environment, arguing for a more balanced development strategy (Lele 1991; Alaston et al. 1995; Reardon and Vosti 1995; Adams 2003). Public sectors have made efforts to seeking such a strategy in agriculture and rural development. For example, the European Union implemented the Agri-environment schemes in the late 1980s to promote environmentally-friendly farming techniques to farmers by giving direct payment (MacDonald et al. 2000, Kleijin et al. 2001).

With technology advancement, development of transportation, and globalization, food supply chain becomes popular in the agri-food industry. In the context of supply chain, the environment issues are not only limited to the production stage but expanded through to each stage of the chain. From farm to table, the longer the supply chain is, the more pollution is involved in the process. When food being grown and transported thousands of miles in trade, the issues of greenhouse gas emissions and climate change

come out that requires ecological footprint calculation (Goessling et al. 2002; Pratt 2013). In the literature of food tourism and supply chain management, shortening food supply chains and encouraging local food can be a potential solution. Environmental wise, shortening the food supply chain could reduce food miles, save energy, and enhance biodiversity from farm to table; economically wise, it helps the small to medium size enterprises (SMEs) to retain added value in the region, increase and sustain local employment, and promote local tourism (Green and Dougherty 2009). However other studies show the localization of food supply chain may not necessarily reduce environment pressure for a sustainable agriculture development (Ibery and Maye 2005, Born and Purcell 2006, Stoessel et al. 2012). Stoessel et al. (2012) used life cycle inventories (LCI) methods to study the fruit and vegetable supply chains in Switzerland. They found consuming seasonal fruits and vegetables and avoid using airplane for transport can reduce the environmental impact by the most. Localizing food supply chain only helps in reducing the carbon footprint.

The longer the food supply chain, the more likely it pollutes environment. In order to be transported for long distance, agri-food products needs better package, cold chain transportation, faster vehicle and bigger storage facilities. All these require more materials and energy generating more greenhouse gas emission. The longer the food supply chain also leads to the scale production of certain agricultural products that could result in loss of diversification of the local ecological system. In addition, purchasing/importing the agricultural products from foreign regions could also cause problems disturbing the bio-ecological system. For example, the sanitary and

phytosanitary problems not only matter for food safety issues but also have bio-diversification concerns.

However the globalization of the food supply chain— global food value chain might benefit developing countries economically. In addition there are many other positive spillovers in the global value-adding process. When developing countries export their agri-food products, particularly to developed countries, along with the increased revenue, there can be products quality improvement, capacity enhancement, management knowledge sharing and technological advancement.

Longer or shorter food supply chain, which is better? To achieve a sustainable agricultural and environmental development, further research is needed. Both quantitative and qualitative studies are useful to tackle down the question and find a balanced solution.

As mentioned in Section 1, with limited data and information, this paper provides only qualitative analysis based on desktop study and field investigation. It aims to arouse attention to the environmental impact of the food supply chain. Analysis from the economic prospective are not going to be discussed much. The paper presents one case in Section 3. With general background introduction of the sector and the farm/enterprise, detailed supply chain analysis from the prospective of environmental impacts are conducted. Key problems and important issues are identified. In Section 4, implication for both relevant private and public sectors are concluded.

3. Case study- tea supply chain in China

1) General background of china tea production

As a major tea consuming and producing country, China has been famous for its tea products and exports since thousand years ago. Chinese tea can be classified into basic tea (tea leaves) and reprocess tea (reprocess tea leaves mixed with other herbal or fruit). The basic tea can be differentiated into six types (green, black, oolong, white, yellow and dark tea) based on different production methods. Tea production requires immediate processing after removing the tea leaves from trees. Most tea farms are facilitated with basic processing equipment, as most simple as the basket plates used for tea leaves sun-drying. The environmental impacts in the tea production process may vary according to different drying methods for later processing and production. The specific impacts will be discussed later.

Tea are produced mainly in south China, from north of Yangtze River to Hainan island and from the west mountainous region to the east coastal region. Famous tea production regions in China are Zhejiang, Anhui, Fujian and Yunnan provinces. The tea produced from these places is famous not only because of the premium quality but also the associated historical and cultural value. The tea is associated with the special local environment. These famous tea producing regions generally have better green coverage and sound water resource.

According to the World tea production and trade report from Food and Agriculture Organization of the United Nations (FAO) and the China's tea sustainability report from Social Research Institute (SRI), about two thirds of China's tea output is

consumed domestically. Green tea is the most consumed type, followed by flower tea and oolong tea. Tea is also being exported as the fifth of the top agricultural products in China. Table 1 shows the tea production and trade data of China from 2003 to 2011. Guangdong, Zhejiang, Anhui, and Fujian are the top tea exporting provinces in China. Major destinations are Africa, Asia, and Europe, specifically Morocco, Japan, Uzbekistan, USA, and Russia in those regions. One major challenge the Chinese tea exports face is the sanitary and phytosanitary barriers that set up the specific chemical residue level of the products. For example, Europe implemented new pesticide regulations that decreased black tea exports to the European markets since the 1990s. The chemical residue on tea products are usually from pesticides and fertilizers applied in the production. These chemical may affect not only food safety but also the environment in the production region, as well as tea farm labor health.

2) Tea supply chain structure and governance

Tea supply chain in China is composed with following players: grower, processor, refinery (for mass-produced tea bags/drinks), dealer/exporter, and finally to consumer. For domestic consumed tea, the distance between grower and consumer is very short (Chan 2009). Tea growers can provide tea directly to consumers. Tea leaves are picked up from tea trees to be first processed into crude tea. Crude tea is further refined to premium high-quality tea or refined as ingredients to be mixed up with other tea (different in variety, producing time, producing season, or producing place) to maintain a consistent flavor for mass-produced tea bags or tea drinks. In the case of vertically integrated supply chain, grower, processor, and refinery are three-in-one. The premium high-quality tea can be sold directly to consumers by growers in their own stores, via tea

fairs or expositions or via the internet. It can also be sold to supermarket or wholesaler through dealers. The refined tea leaves for ingredient are sold to tea brand companies or exporters in the case of international markets.

To understand the supply chain governance is important to predict the future development of the supply chain and the upgrading potential of stakeholders. The domestic tea supply chain in China has been heavily influenced by the government since 1950s. The Chinese government has regulated the tea supply and directed the tea consumption. For example, the “eight-point code to cut bureaucracy and maintain close ties with the people” implemented in 2012 decreased the demand for premium tea (Lei 2016). Therefore government as the external player governs the domestic tea supply chain in China.

The Chinese tea supply chain for the international market is mainly shaped by international famous tea branders such as Lipton who has very powerful purchase capacity. These international famous branders cater the consumers in their own countries, mostly in Europe and the U.S.. The consumers in developed countries pay attention not only to food safety but also to environment, labor welfare and sustainable development. Pressed by the consumers, the branders tend to deprive the bargaining powers of tea suppliers in developing countries. The tea suppliers in developing countries don't know how to improve their bargaining power by using the pressure from consumers in developed countries due to lack of communication (Chen 2009).

The tea supply chain in China has the feature of most developing countries: such as small to medium size farmers, intensive government involvement, and lacking of

bargaining power with international buyers. In addition, with limited capacity of each stakeholder on the supply chain, the supply chain is less vertically integrated compared to the supply chain in developed countries. However, the domestic tea supply chain in China is a little different in this case given the short-distance from grower to consumer. This is because of the “local” feature of the tea products in China. Especially for the premium quality tea, Chinese consumers tend to consume tea from the local. Local tea is considered as the best and most special. Tea products are highly associated with geographical factors in China.

However, the tea supply chain for exports is another story. Most Chinese tea exporters are exporting tea leaves ingredient for mass production as tea bags or drinks for markets in developed countries. Chinese branded premium tea leaves as basic tea products are rare to see in the exports markets. One major reason is that tea producers in China has less control of the international tea supply chain. Further development is needed for future upgrading.

To what extent will the governance and structure features of the tea supply chain affect the environmental impacts? It will be discussed next.

3) Environmental impacts on the supply chain

Tea production requires certain environmental conditions such as suitable climate, soil, and water as most agricultural products. Once the tea production takes place, it also affects and re-shapes the local environment. In this sub-section, the environmental impacts of the tea supply chain is being discussed. Attentions will be paid especially from the prospective of the governance and structure features of the tea supply chain in China.

Figure 1 shows the summary of the environmental impacts of the tea supply chains. Details on each stage are discussed below.

In general, there are three types of tea farms according to their geographical locations. Tea farms are located on plain, hill, and mountain areas. According to Chen (2009), tea from the mountain region has the best quality and the highest price. Driven by the profit, tea grower tend to build the tea farm in the mountainous area. By doing so, forests and vegetation are damaged and destroyed to different extents. For example, many forest resources have been destroyed for the development of tea farms in Yunan province since 1950s. The common practice is that tea grower sets fire in the mountain to remove the vegetation and develops the land into tea growing farms. Before the tea trees mature, soil of the tea farmland is completely exposed. By regularly loosening soil for tea tree plantation, the cohesion of the soil is eroded which can lead to soil erosion. According to statistics of Fujian province, where the tea farms are mostly in the mountain area, over 50% of the total tea growing area suffered from soil erosion since 2006. Soil erosion also reduces the nutrition of the soil. Therefore huge amount of fertilizer is applied to the land. However if too much fertilizer is being applied, the soil will be hardened resulting in low yield. The soil erosion and over-fertilizing form a circle for tea grower in mountain area.

For a new tea farm, it takes about 3 years for tea baby trees to mature for tea leaves harvesting. During the 3-year growing period, fertilizer is applied. Pesticides are usually applied about 4 or 5 times per year. From July to September, the most risky season attracting pests, it is applied once a month. From September till the next spring, tea trees will be in rest for the next production and harvest round. In this stage, chemical

residue in the soil and the air contamination when the spraying the chemicals are the two major sources of pollution. In addition, the larger the tea garden size is and the more machines being used in the production will have the more greenhouse gas emission. In addition, tea farms are usually scattered and mixed with farmland. The pesticides used on the neighboring farmland also pollute tea farms.

Despite the environmental impacts in the long run, the tea grower also loses profit because of the high level of chemical residues on the tea products. The Chinese tea growers are not very sensitive to changes in the international residue standards for exported agricultural products because of lack of information and techniques. Recently due to the rising price of fertilizers, pesticides, as well as organic tea, many tea growers in China are interested in adopting organic farming. However, most small to medium size farmers cannot afford the cost of transition, for about 3 years. Other relevant capacity expansions are also needed.

In the processing and refinery stages, the environmental impacts are mainly air and water pollutions (Chen 2009). Air pollution is from the coal used as fuel in the processing factories. Coal combustion generates harmful gases such as CO₂ and SO₂, as well as fly ashes. The fly ashes can pollute the tea products and such pollution cannot be removed by processing. Wastewater comes from tea washing and workshop cleaning. Most tea processing factories discharge the wastewater directly into nearby fields without any treatment. The nearby fields are polluted in this way. Processing factories that rely on wood as fuel usually cause vegetation damage. For example, about 14.5 thousand cubic meters of forest wood is consumed by local tea processing factories every year in

Yichang city of Hubei province. The diminishing of forest results in soil erosion, landslide, and mud-rock slide in the mountain area.

In the refinery stage, there are also noise and dust pollutions. Usually there are many machines in operation in refineries given the mass production feature. Noise in workshop can reach 70 to 85 db. The screening process generates dust that can be harmful for workers work in the factories and the surrounding air quality.

When the finished tea sold to dealers, the major pollution comes from greenhouse gas emission in transportation. The further away the wholesaler or retailer or exporter is located, the more pollution can be generated from the transportation process. In addition, the premium quality tea is usually packed in small vacuumed plastic packs or metal cans. The former package material is not very environmental friendly. In order to demonstrate the premium quality to sell at a high price, tea suppliers tend to over pack their tea products. The sales price of over-packaging is paid by consumers, however the real price of it is paid by everyone including both producers and consumers on the supply chain. The refined tea leaves for mass production is usually packed with less packaging materials in bulk with plastic packs and paper boxes for transportation. For China's case, the tea ingredients for mass production are mostly shipped abroad for foreign drink companies. The long shipment requires sound packaging that is humid proof to maintain the quality of tea leaves. The shipment either by sea or air also contributes to the greenhouse gas emission.

The short tea supply chain for domestic market may have less pollution for the environment. However, the high demand of premium tea results in increasing tea

production that may lead to destroy of forest and vegetation. As the governance of the supply chain of domestic market, the government's anti-corruption policy has shrunk the premium tea market which may indirectly affects the related environmental impacts in the tea supply chain.

The long tea supply chain for exports market has a larger environmental impact of greenhouse gas emission. Motivated by the profits and the opportunities of accessing to the international markets, the tea exports from China are likely to continue. In the process, if the Chinese tea suppliers can move up along the value chain or have more bargaining power in the current supply chain, the tea supply chain may develop into more environmental protection and sustainable development oriented.

4) Specific case

With the general discussion on the environmental impacts of the tea supply chain, a specific tea supply chain case that has both domestic and international business is presented for further analysis.

To demonstrate the environmental impacts of the tea supply chain in China, a tea company is chosen as an example because of following reasons: a. the company is a former state-owned tea company. It is a good representative of most medium to big size tea companies currently in China. The operation way of such companies still has the trace from the government over-intervened time. It has the characteristics of the government governed supply chain. This is a unique feature of most developing countries. In addition, the government policy and regulations are well-embedded in the company's operation. b. the company has both domestic (premium tea) and exports (refined leaves for mass

production) business; c. the company insists on organic farming; d. the company has mountain tea farmland as the production base.

The tea company is from Fujian province with the production base in the Wuyi Mountain area, one of the famous production area of the mountain tea in China. The company is developed from one of the three biggest state-owned tea factories in China. The tea factory was founded in the 1970s. The government designed it as an export-oriented, international aimed company. During the plan economy period, the state-owned factory accumulated a lot capital endowment by tea exports (monopolized by the government). With abundant capital, the factory has been rapidly growing after the open-market policy in the 1990s. Tea exports is still a major part of the business. In 2000, the organic revolution took place in the international market. The factory has the well-established capacity to export organic tea, catering the increasing international demand. With the sound operation foundation and good business relationships with downstream stakeholders inherited from the state-owned factory, the company has been collocating with the Fujian Tea Company for exporting tea. In addition to the advantages in exports business, the factory masters different types of production methods comprehensively, having the capacity to produce all varieties of tea.

The tea factory was dispatched before 2000. In 2004, the factory became a registered company, becoming independent from the state. In the beginning of the 2010s, a technology company consolidated and regrouped the company as a sub-company with a registered capital of 20 million CNY.

The company now owns a tea farm of 6800 mu (about 453 hectare). In addition, it has collaboration with other production base of 3000 mu (about 200 ha). The production base is spreading in the famous tea production region such as Wuyi Mountain (most), An Xi, and Fu Ding. The average latitude of these production bases is about 800 meter which is the ideal tea planting height. The company produces black tea, green tea, Wuyi special type of oolong tea, Tieguanyin type of oolong tea, and white tea. The annual yield is about 800ton with project investment at 100 million yuan.

As one of the major organic tea suppliers in north Fujian, the company has been pursuing the best products quality. From the input selection, production base management, variety selection, production, innovation, and processing, it implements the strictest standards, combining the traditional tea cultivation methods with modern technology to produce the best quality of tea as well as innovate in new tea flavor. The company has closely worked with local agricultural university for the technology innovation, planting methods and pest controls to prevent any risk of being polluted. It has established the tracking system from the “tea garden to tea cup” for a reliable traceability. The tea products have been well-accepted in the international market, especially in Southeast Asia and Europe. In addition, the company has a research and development team with about 20 experts from universities and research institutes. They are in charge of the new product development. This is partially benefited from its mother company, which has diversified business and is especially competitive in agricultural production technology and new product development. The company is considered as a leading one in the province. It has won couple of best quality and new flavor awards in national-wide tea competitions representing the province.

As a big tea company with sufficient capacity, it has fully adopted organic farming since 2000. The tea farm is well-integrated with nearby environment. The production base, the major one in Wuyi Mountain locates remotely in the high mountain area. The tea production process strictly follows the most strict organic standards and requirements. From input selection, production, process, and refining all details are fully-controlled by the company. There is absolutely no chemical fertilizer or pesticide used in the entire process.

The middle to low grade tea leaves are refined to be exported as ingredients for mass production. The major exporting destinations are developed countries in Europe, North America, and other Asia countries. With the established international market, the company decided to switch the focus to the domestic one where its foundation should be. In addition, the domestic market has big consumption potential. It would like to establish a famous tea brand both domestically and internationally. However, in the international market most Chinese tea suppliers are participating only as material suppliers. In 2012 the domestic business was started. Now it takes up to 30% or 40% of the company's entire business. To promote the organic conception for environment protection and sustainable development, the company came out a customized organic tea program in 2013. Customers rent land in the production base in the mountain area. In a year time, they can enjoy the tea harvested in their own land, produced in the way they required specifically. Given the strict organic farming requirement, the company takes care of the production and processes of the tea upon the customers' preference and guarantees a minimum annual yield. By requesting, consumers can visit the production base and participate in some production stages with the guidance of the company. In terms of the

price of the customized tea, it is not really high. Because there are many hands involved in the traditional tea sales channel that rise the final sales price paid by the consumers. The purpose of the customized program is for establishing a stable consumer source and for promoting the organic concept.

However, in addition to the customized tea part of the domestic business, the regular tea business in the domestic market experienced some difficulties when the “eight-point” anti-bureaucracy and formalism rules were implemented at the end of 2012. The consumption of high priced tea has dropped sharply. Organic tea, as a high-value premium product, its consumption has also been affected. The profit from the high-value premium tea has been the major financial source to maintain the company’s retail stores located in the commercial center of some cities in Fujian province. Hence these retail stores were shut down due to the loss of business.

Given the hard time in the domestic market, now the company mainly faces two big challenges: a. consumers’ recognition in the organic concept; b. difficulties in implementing the organic farm management and traceability system for product quality and environmental concerns. Overall, the company’s tea supply chain is highly integrated in the vertical direction. As the grower, processor, refinery, and dealer as all in one, the company tries to minimize the environmental negative impacts in each stage of the supply chain by strictly implementing organic farming. However, the remote location for organic production at the same time causes increasing transportation costs for consumers to visit and for exporting/selling the tea products. The company is also aware of the environmental unfriendly packaging problem (it is also quite expensive counted as a major input expenditure of the company), however it has no bargaining power in the

domestic supply chain to change the situation. To achieve the sustainable development target, it is very expensive to maintain the current management system following the international standardized ISO and GAP standards.

As a relatively big size tea company in the region, the company is doing relatively well given the harsh domestic market situation with complements from its long- and well-established international business. However, as a representative tea supplier from the developing countries, there remains challenges in both supply chain management and the environmental impacts. The macro environment of the tea sector in China still need improvement for a long-run sustainable development. Luckily the Chinese government has taken action in the 11th Five-year Plan, the Ministry of Agriculture has listed tea as one of the most important four industries supported by the government (Chen 2009). It is aimed to build the tea sector a pillar industry for local economy and establish local capacity to alleviate poverty. In order to achieve a sustainable development, the environmental impacts of the tea supply chain is attached with high attention. The pollution emissions from tea production is addressed in China's legislature system to better regulate the sector. Details are listed in Table 2 for reference.

In addition to the domestic market, by exporting to the international market, the company benefited from keeping compliance to the international standards in organic production and in environmental friendly and sustainable management. The annual inspection and renewal of these certification benefits the company in updating the farming knowledge and skills. The international famous buyers such as Lipton should continue with the strict requirement on product quality and other associated factors for the sustainable development. Meanwhile, it will further benefit the suppliers in

developing countries if they can gain more bargaining powers in the process. However, for other small to medium size tea companies and growers in China, who don't have the capacity to export, more spillover effects are expected from following big and leading firms in the same sector.

4. Conclusion

In the latest sustainable development goal the International Food Research Institute aims to accomplish, over half of which relates to food and nutrition security. Reshaping the global food supply chain seems critical. We need to produce more food using the fewest resources possible and with little waste and loss; provide opportunities for growth, or long-term market-based solutions, that reach poor and marginalized people; and meet current and emerging demand for food without jeopardizing natural resources or contributing to climate change. We must also provide safe, nutritious, and diverse diets while limiting processed foods. We must build a new global food supply chain that is climate-smart, efficient, inclusive, nutrition- and health-driven, sustainable, and business friendly.

Following the motivation, this paper provides a case study of the environmental impacts of the food supply chain of the tea sector in one of the major developing countries, China. The conclusion reached here may not be fully applicable to the global food supply chain. However, a representative case analysis from the poor and marginalized people who usually serve as the upstream in the global food supply chain is helpful to understand the general picture for further analysis.

The paper first went over the related literature in the field. Keeping questions such as whether the food supply chain should be long or short, and how much environmental impacts are in each production stage in mind, the paper discussed an example of the tea supply chain in China. Given the limited data and information, the case study serves as a concrete example to identify the potential environmental impacts along the tea supply

chain in developing countries. Given the characteristics of the food supply chain in developing countries, discussion on the environmental impacts of the supply chain for both domestic and international markets are conducted. In developing countries, it is crucial to pay attention to the environmental impacts in agriculture production and food supply chain management, particularly given the limited capacity in those countries. The government should take the lead as the governance in most food supply chains in developing countries. International influential buyers also play a significant role in it. By importing agricultural ingredients from developing countries. Positive spillovers are expected with better communication with the suppliers in developing countries.

Reference

Adams, William Mark. *Green Development: environment and sustainability in the Third World*. Routledge, 2003.

Alaston, J. M., et al. *Science under scarcity: principles and practice for agricultural research evaluation and priority setting*. No. A50 226. ISNAR, The Hague (Países Bajos), 1995.

Born, Branden, and Mark Purcell. "Avoiding the local trap scale and food systems in planning research." *Journal of Planning Education and Research* 26.2 (2006): 195-207.

Can, H. U. A. N. G., and D. E. N. G. Hongbing. "The model of developing low-carbon tourism in the context of leisure economy." *Energy Procedia* 5 (2011): 1974-1978.

Conway, Gordon R., and Edward B. Barbie. "After the Green Revolution: sustainable and equitable agricultural development." *Futures* 20.6 (1988): 651-670.

Green, Gary Paul, and Michael L. Dougherty. "Localizing linkages for food and tourism: Culinary tourism as a community development strategy." *Community Development* 39.3 (2008): 148-158.

Gössling, Stefan, et al. "Food management in tourism: Reducing tourism's carbon 'foodprint'." *Tourism Management* 32.3 (2011): 534-543.

Hanley, Nick, and Clive L. Spash. *Cost-benefit analysis and the environment*. No. P01 176. Aldershot: Edward Elgar, 1993.

Hu, Meng-Lei, et al. "A criteria model of restaurant energy conservation and carbon reduction in Taiwan." *Journal of Sustainable Tourism* 21.5 (2013): 765-779.

Ilbery, Brian, and Damian Maye. "Food supply chains and sustainability: evidence from specialist food producers in the Scottish/English borders." *Land Use Policy* 22.4 (2005): 331-344.

Kleijn, David, et al. "Agri-environment schemes do not effectively protect biodiversity in Dutch agricultural landscapes." *Nature* 413.6857 (2001): 723-725.

Lei, Lei. "Tea Supply Chain in East Asia" IDE Discussion Paper (2016)

Lei, Lei and Satoru Shimokawa. "Dietary Guidelines and Sustainable Food Consumption in China" (2016)

- Lele, Sharachchandra M. "Sustainable development: a critical review." *World development* 19.6 (1991): 607-621.
- Lopez, Ramon. "The environment as a factor of production: the effects of economic growth and trade liberalization." *Journal of Environmental Economics and management* 27.2 (1994): 163-184.
- MacDonald, Donna, et al. "Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response." *Journal of environmental management* 59.1 (2000): 47-69.
- Mittler, Ron. "Abiotic stress, the field environment and stress combination." *Trends in plant science* 11.1 (2006): 15-19.
- Opara, Linus U. "Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects." *Journal of Food Agriculture and Environment* 1 (2003): 101-106.
- Pimentel, David. "Environmental and economic costs of the application of pesticides primarily in the United States." *Environment, development and sustainability* 7.2
- Pratt, Stephen. "Minimising food miles: Issues and outcomes in an ecotourism venture in Fiji." *Journal of Sustainable Tourism* 21.8 (2013): 1148-1165.
- Reardon, Thomas, and Stephen A. Vosti. "Links between rural poverty and the environment in developing countries: asset categories and investment poverty." *World development* 23.9 (1995): 1495-1506.
- Renting, Henk, and Han Wiskerke. "New emerging roles for public institutions and civil society in the promotion of sustainable local agro-food systems." *9th European IFSA symposium*. Vol. 47. 2010.
- Renting, Henk, Terry K. Marsden, and Jo Banks. "Understanding alternative food networks: exploring the role of short food supply chains in rural development." *Environment and planning A* 35.3 (2003): 393-411.
- Smith, Stephen Russel. *Agricultural recycling of sewage sludge and the environment*. CAB international, 1995.
- Stoessel, Franziska, et al. "Life cycle inventory and carbon and water FoodPrint of fruits and vegetables: Application to a Swiss retailer." *Environmental science & technology* 46.6 (2012): 3253-3262.

Tilman, David, et al. "Agricultural sustainability and intensive production practices." *Nature* 418.6898 (2002): 671-677.

Tukker, Arnold, and Bart Jansen. "Environmental impacts of products: A detailed review of studies." *Journal of Industrial Ecology* 10.3 (2006): 159-182.

Van der Vorst, J. G. A. J., et al. "Quality controlled logistics in food supply chain networks: integrated decision-making on quality and logistics to meet advanced customer demands." *Proceedings of the Euroma 2007 conference, Ankara, Turkey*. 2007.

Zhu, Z. L., and D. L. Chen. "Nitrogen fertilizer use in China—Contributions to food production, impacts on the environment and best management strategies." *Nutrient Cycling in Agroecosystems* 63.2-3 (2002): 117-127.

Figures and Tables

Figure 1 Environmental impacts of the tea supply chain in China

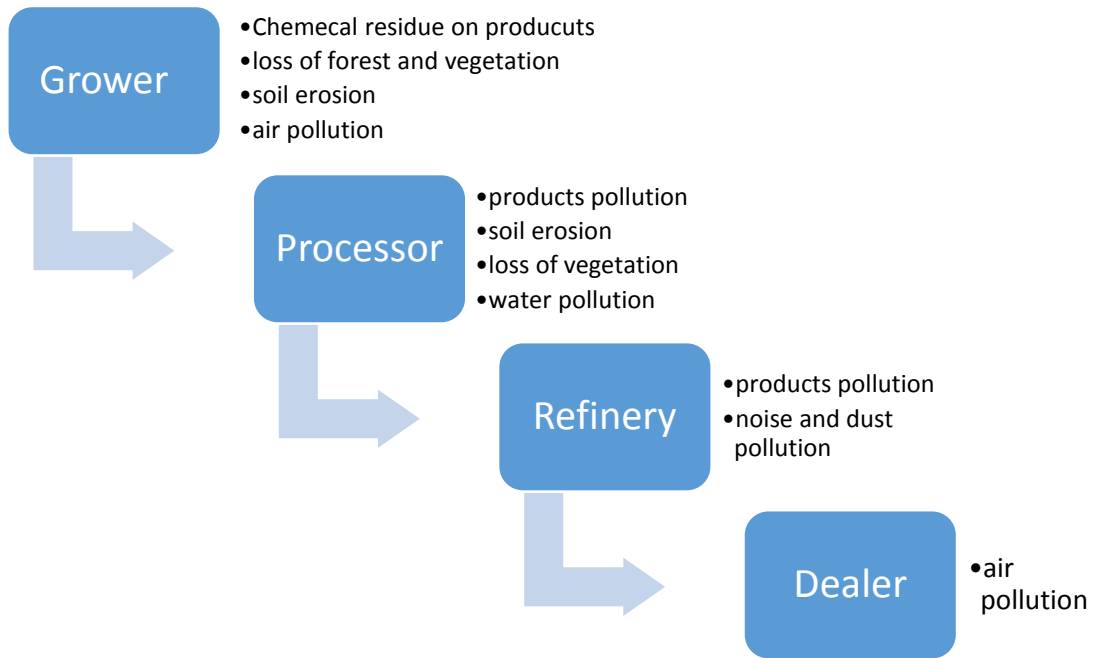


Table 1. Chinese Tea Production and Exports from 2003–2011

Year	Area harvested (Ha)	Yield (Hg/Ha)	Production (Mt)	Export Quantity (tonnes)	Export Value (1000 \$)
2003	925,200	8,302	768,140	259,914	367,187
2004	982,700	8,499	835,230	280,193	436,845
2005	1,041,500	8,976	934,857	286,563	484,211
2006	1100,300	9,343	1,028,000	286,594	546,915
2007	1,242,000	9,384	1,165,500	289,616	604,019
2008	1,283,200	9,801	1,257,600	296,946	682,248
2009	1,306,000	10,406	1,359,000	302,952	704,947
2010	1,405,000	10,320	1,450,000	302,525	784,145
2011	1499,900	10,821	1,623,000	322,580	965,080

Data source: FAO Statistics

Table 2 Legal protection of environment problems of tea production

Stage	Rules
Tea farm	Prohibition of destroying forests to develop tea farms, and developing tea farms at the slope at an angle of over 25 degrees.
Tealeaves	Producers should use fertilizers, pesticides, agricultural films and feed additives scientifically, improve growing techniques, ensure quality and safety of agricultural products and try to turn wastes into resources in agricultural production to prevent environmental pollution. Toxic and hazardous wastes are prohibited from being used as fertilizer. Use of designated outdated pesticides and additives is also prohibited.
Leaves processing	Companies should save energy, reduce emissions and control discharge of major pollutants, and cut pollution to surrounding living environment. Pollution emissions must meet national environmental protection standards.
Tea products	Design of products and packaging should take account of their impact on human health and environment during life style, and give priority to non-toxic and non-hazardous design that is easily degradable and recyclable. Companies should package products scientifically and reduce over-packaging and packing waste.

Source: SRI report 2009