

Climate Change Adaptation and Disaster Reduction Risk Applying Method in Industrial Supply Chain Process

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ABSTRACT

The paper examines the relevance of the climate change adaptation and disaster reduction risk for supply chain processes in industry. Through a structured review of academic literature two primary challenges are highlighted: first, non-consistency method in integrating formal attribution of climate change adaptation and disaster reduction risk, and second in impacting with changing ecological environment and unpredictable natural disasters for supply chain processes in industry can be described as unavoidable. In examining these two challenges, we arrive at a climate change adaptation framework for industry supply chain as well as a framework of integrated climate change adaptation and disaster reduction risk for industry cluster. In offering this viewpoint, related climate change adaptation and disaster reduction risk, a comprehensive risk and adaptation management approach is proposed as a practical framing for above two challenges to address climate change impacts and risks for supply chain processes in industry as well as promote the ability of risk and adaptation management in industrial operation process.

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Introduction

The last two decades have seen growing importance placed on research in nature disaster impacting. It was not only from human society but also from industry in supply chain processes [1,2]. Therefore, climate change risk assessment and climate change adaptation planning have become issues that policy makers must urgently pay attention to now [1]. With the applying method of climate change risk assesses and adaptation management have become increasingly sophisticated, the continuing improvements and to have led to many new and fascinating applications in the adaptation-related applications in UK Climate Impacts Programme (UKCIP), United Nations Development Programme-Adaptation Policy Frameworks (UNDP-APF), NI188 (National Indicator 188 Planning), Climate-ADAPT, local climate adaptation plan as well as Taiwan Integrated Research Programme on Climate Change Adaptation Technology (TaiCCAT) [3-7].

The UNFCCC adaptation framework is a basis step process to help national adapt under climate change [8]. UKCIP Adaptation Wizard is a 5-step process to help organization adapt to climate change, it's also a guide to useful information for industry. UNDP-APF can be used by countries to both evaluate and complement existing planning processes to address climate change adaptation. NI188 is to embed the management of climate risks and opportunities across the local authority and partners services and to take appropriate adaptive actions where required. Climate-ADAPT is an online platform, providing access to supports governmental decision-makers developing/implementing climate change adaptation strategies, policies and actions. Local climate adaptation plan was developed by the New York City Panel on Climate Change that is an 8-step process to found that a process-based approach to developing climate resiliency that monitors and readdresses climate challenges through time is more likely to succeed than "one-off" technical solutions. In addition, TaiCCAT is a 7-step process to explore and to conduct adequate knowledge of climate change and adaptation strategies for decision-making supports. As this review has shown (see table 1), climate change risk assesses and adaptation management has been conducted with national, local government, countries and organization, emphasis with decision-making process.

Table 1: Reviews of climate change risk assess and adaptation management step

Step	UKCIP a	UNFCCC b	UNDP -APF c	NI188 d	Climate-ADAPT e	Local climate adaptation plan f	TaiCCAT g
1	Getting start	Assess impacts, vulnerability and risks	Defined scope	Getting start	Prepare the basis for adaptation	Defined current and future hazards	Established a working group
2	Assessing current climate vulnerability	Plan for adaptation	Assessing current vulnerability	Public commitment and assessment impact	Assess the risks and vulnerabilities of climate change	Conduct inventory of infrastructure and assets	Analyzing climate change trends and impacts
3	Analyzing future climate vulnerability	Implement adaptation measures	Analyzing future climate risk	Comprehensive risk assessment	Defined adaptation options	Characterize risk of climate change on infrastructure	Clarify key impact and vulnerability
4	Evaluating adaptation options	Monitor and evaluate adaptation	Building adaptation strategy	Overall adaptation action plan	Evaluating adaptation options	Develop initial adaptation strategies	Analyzing vulnerability
5	Monitor and review		Continuous adaptation process	Continued Implementation, monitor and review	Implementation	Identify opportunities for coordination	Analyzing key impact issue
6					Monitor and evaluation	Link strategies to capital and rehabilitation cycles	Review existing policies and related plans
7						Prepare and implement adaptation plans	Proposed climate change adaptation strategy and action plan
8						Monitor and reassess	

For industrial supply chain processes, Sussman and Freed proposed three types for climate change risk will be impact industry that include core operations risk, value chain risk and economy and infrastructure risk, it is not only directly affect industrial operations but also indirect impact on the upstream and downstream supply chain activities [1,9]. While considerable attention has been paid in research issues to intergrade climate change adaptation and disaster reduction risk, unfortunately, non-consistency method in climate change risk assess and adaptation management [10-12].

This paper will posit that applying method of risk and adaptation management with development as its foundation and which addresses the root causes of climate impact and risk can contribute significantly to the resilience of industrial supply chain processes. However, to implement comprehensive risk and adaptation management approach to avoid, minimize and address climate change impact and reducing risk in industrial supply chains processes policy and decision-makers will need to better understand what risk and adaptation means for industrial policy and supply chain processes. This paper will unpack some of the challenge, impact, risk and applying method that will need to be considered by industrial supply chains process as they develop and implement method of climate change adaptation and disaster reduction risk management to avoid, minimize and address climate change impact and reducing risk.

Value and challenge of climate change adaptation and disaster reduction risk

The Intergovernmental Panel on Climate Change (IPCC) announced in 2014 the IPCC Fifth Assessment Report that increased global greenhouse gas emissions will exacerbate global climate change and lead to extreme weather events. The frequency of occurrence increases, and many ecosystems and human systems have significant vulnerabilities and exposures to current climate change. Climate change will amplify existing risks to natural and human systems and generate new risks, and the risks are unevenly distributed, usually the impact of vulnerable groups and communities is greater. International scholars have also pointed out that climate change is harmful to social systems and reduces disaster resilience [13]. In the face of more uncertain disasters, people are often the most vulnerable [14]. In view of this, IPCC’s 2012 “Managing the Risk of Extreme Events to Advance Climate Change Adaptation” and “IPCC Fifth Assessment Report” emphasizes the application of risk assessment to different Climate change threatens scenarios to assess future risks and impacts of climate change, and emphasizes that mitigation and adaptation are strategies that complement and manage climate change risks. Table 2 shows values and challenges of climate change adaptation and reducing disaster risk.

Table 2: shows values and challenges of climate change adaptation and reducing disaster risk

Item	Introduction	Review
Value and Challenges of CCA and DRR Integration in Important International Agreement	<p>UNISDR adopted the Sendai Framework for Disaster Risk Reduction (SFDRR) in 2015 as an important milestone. However, SFDRR still has no explanation on how to establish and maintain cross-sectoral consistency and coordination between CCA and DRR.</p> <p>The 2015 UN Sustainable Development Summit passed 17 Sustainable Development Goals (SDGs), and its thirteenth goal, "Emergency action to respond to climate change and its impact," may support Integrating CCA and DRR does not explain how to integrate CCA and DRR.</p>	<p>UNISDR, 2015 NCDR, 2015</p> <p>UN Sustainable Development Summit, 2015</p>
The value and challenges of international research on CCA and DRR integration	<p>CCA is regarded as one of the DRR rings</p> <p>Adjusting the core business of DRR and incorporating it into the new theme of CCA is in response to the mainstream of climate change.</p> <p>Different government agencies, policy planning, research communities and implementation areas, assessment methods, technology, language, and assessment programs are also different, and institutional, fiscal, and political barriers will inhibit CCA and DRR integration.</p>	<p>Kelman et al., 2010 Mercer, 2010 Kelman, 2015</p> <p>Begum et al. 2014 Rivera et al., 2014 Forino et al., 2015 Roberts et al., 2018</p> <p>Birkmann et al., 2010 Gero et al., 2011b Djalante et al., 2012</p>

In addition, from the domestic and international adaptation implementation structure and steps (see Table 1) also reflects the trend of integrating climate change adaptation to reducing disaster risk [10-12,14-19]. However, there is very limited study on consistency method in integrating formal attribution of climate change adaptation and disaster reduction risk.

Climate Impact and Risk of Industrial Supply Chain Process

In the face of climate change adaptation, the industry needs to understand the risk categories of climate change impacts, including value-chain risk, covering physical risks (such as infrastructure or supply chain operation related losses) and price risks (for example: Increased price volatility in raw materials or other commodities) and production risks (eg, core products become unpopular or even reduced in sales), and external-stakeholder risk, covering surveillance risks (eg, climate change with government actions), goodwill risks (eg company-specific behaviors or policies, public perception of the industry as a whole) and normative risks (eg CDP and performance index). However, the above risks may vary depending on the management of each industry and the mode of production, geographic location, and target market [23]. Furthermore, industrial decision makers are faced with the impacts and risks of climate change, and they need to know the answers to the following core questions, including: the potential climate risks and losses related to climate change in the coming decades? How much potential losses are estimated? Is it possible to implement adaptation measures to avoid losses? Is it necessary for the government to invest in funds to develop relevant adaptation actions and whether cost-effectiveness of implementation measures is cost effective [1].

The industrial supply chain process is vulnerable to the impacts and risks brought by climate change, including: the intensity and frequency of extreme weather events (such as floods or typhoons), local weather patterns (such as strong winds, high temperatures, etc.), rainfall patterns change water shortages and different risks

such as disease transmission, causing climate change and supply chain operations to interact. Table 3 shows the climate change impact and risk in the industrial supply chain process.

Table 3: Climate change impact and risk in the industrial supply chain process

Supply chain Process	Climate change impact and risk
Operating	Asset loss Liability risk Factory production line disruption Reduced production efficiency Equipment maintenance costs increase
Transportation	Operator pays compensation Customer pays compensation
Warehousing and storage	Infrastructure, personnel, communications, supplies and other vulnerabilities
Wholesale and trade	Downstream demand for information transparency increases Consumer goods production costs and price increases Declining demand for consumer goods
Consumer service	product design Packaging Materials

Operating

The impacts and risks of climate change affect the operating departments. The production sector is vulnerable to physical risks such as extreme weather events and rising sea levels. In terms of supply chain, manufacturing operations may lead to closure of production plants and loss of assets. Responsibility risks, disruption of factory production lines, reduced production efficiency, and increased equipment maintenance costs. In addition, the use of raw materials in the factory is vulnerable to precipitation patterns and water shortages, which may increase operating costs

and may result in water rights competition with the surrounding communities and other operating sites [24].

Transportation

Logistics transportation is an important factor in the production line process [25]. Additional costs may be incurred due to climate risks. For example, extreme weather events may affect the speed of logistics and transportation, especially in a short period of time. Heavy rain/strong rainfall may affect the operation of the transportation infrastructure, which may affect the driving speed and lead to delayed delivery of products. Pay compensation to operators and customers [24,26].

Warehousing and Storage

In the supply chain system in response to climate change issues, warehousing and storage is a part that cannot be ignored. For example, extreme weather events may affect the flooding, collapse or inability of the warehouse, affecting the work efficiency and life safety of the staff, and indirectly causing the impact of climate change. Others such as infrastructure operations, communications equipment, and supplies will also be affected [24].

Wholesale and trade

Extreme weather events also affect the infrastructure, equipment and import and export processes related to industrial wholesale and retail, while downstream manufacturers may require suppliers to provide transparency information and strengthen additional response measures to avoid transaction risks, resulting in higher supplier costs. Increasing product prices, leading to a decline in demand for consumer goods [24].

Consumer service

Product consumption has a significant impact on environmental and climate change [27]. Several research reports have studied the reduction of product design and packaging materials, and lacked the discussion on the impact and risk of climate change. However, this paper looks at the adaptation of the manufacturing industry in response to climate change from the supply chain. Consumer service is the final stage of the supply chain system. If it is impacted by extreme weather, its product design and material packaging will still have an impact [24].

Applying Method of Risk and Adaptation Management

World Economic Forum released The Global Risks Report 2018, which mentions that the risk associated with climate change has been one of the top five risks of significant and potentially significant impacts for the sixth consecutive year [28]. In the real world, the extreme climate events and natural disasters caused by climate change actually prove the conclusions of the risk report, which is also the challenge facing the industry. Research indicates that there are three types of climate change risk that affect industries, including: core operations risk, value chain risk, and economics and infrastructure [9]. (economy and infrastructure risk), in addition to directly affecting industrial operations, will also indirectly impact the activities of the upstream and downstream supply chains of the industry.

In addition, climate change adaptation policies may affect the operation of the industry in an indirect way. The industry should regard climate change as a market issue and generate a ripple effect throughout the value chain, especially when the industry begins to formulate a climate [29]. When changing the adaptation policy, think about market issues and related market strategies [29,30]. It can be seen that the industrial operation process is indirectly affected by climate change, so it can be considered from the

industrial supply chain and explore its practices in response to climate change risks and adaptation management.

According to McKinnon, the vulnerability of the supply chain to extreme weather patterns (eg floods) over the past 40 years indicates that climate change shocks increase the uncertainty of the supply chain system, and climate change will also affect the level of industrial operations management [31]. For example, the flooding in some industries in Thailand caused the disruption of production lines in some industries, but the continuity of the flow of products in the supply chain system, resulting in insufficient inventory, delays in logistics and transportation, congestion in transportation roads, and cost fluctuations [32].

Therefore, in the face of the impacts and risks of climate change, the industry must establish an early warning mechanism and a response approach for operational projects that may be affected by climate change. In addition to production line disruptions, the logistics of all assets, raw materials and finished products in the entire supply chain system is susceptible to extreme weather and requires higher insurance costs. Therefore, the industry can adopt the practice of extending insurance to pass on the risk of supply chain assets. In addition, insurance companies may also face liability insurance risks for third-party claims due to climate change effects, which may be third-party injuries or property losses caused by the insured's fault [33].

Climate Change Adaptation Framework for Industrial Supply Chain Process

Industrial activities are linked through international supply chains. In the face of the impact of climate change, it may also be easy to influence upstream and downstream suppliers. Therefore, it is important to re-examine supply chain activities and prioritize specific adaptation actions. Sheffi and Rice believe that the company has a supply chain resilience in the face of climate risks, and can quickly restore its original configuration in the supply chain after being hit by earthquakes, floods, hurricanes, tornadoes, tsunamis, etc [34]. Adaptability to the path of disaster recovery through assistance from different participants in the supply chain network [28,35,36]. Therefore, establishing the resilience of the industry in the face of climate risks is an important key to the supply chain. The World Business Council for Sustainable Development (WBCSD) collects relevant information from members of the committee and proposes to establish a global supply chain resilience report [1]. Establish a framework for standard climate risk and adaptive resilience assessment methods, including: Step 1: Mapping the supply chain system and identifying key functions; Step 2: Determining weather-related disasters; Step 3: Defining climate change vulnerability and assessing climate risks; Step 4: Establish the adaptive resilience option; and Step 5: Monitor the simulation and review, similar to the concept of climate change risk assessment and adaptation management step at home and abroad (see table 1). In fact, the elements of the supply chain system combination may face more different vulnerabilities and risks, and there may be various potential resilience adaptation options that can be used in the disaster recovery process.

According to Table 3, the industry should evaluate the climate change impacts and risks in the process of industrial supply chain from the perspective of the overall supply chain of Operation, Transportation, Warehousing and storage, Wholesale and trade, and Consumer service. This paper attempt to through a system structured to development a climate change adaptation (CCA) for industry under climate change impact to respond in supply chain process. Concept framework for industrial supply chain process is

shown as figure 1, as well as apply in the case of electric vehicle lithium ion battery supply chain process (see figure 2) that future to understand how to use the figure 1 in the industrial supply chain process. If the CCA concept framework for industrial supply chain process used for this case can, in fact, be used to apply other industries, the CCA concept framework can become a much needed tool in future related-researches.

Figure 1: CCA concept framework for industrial supply chain process

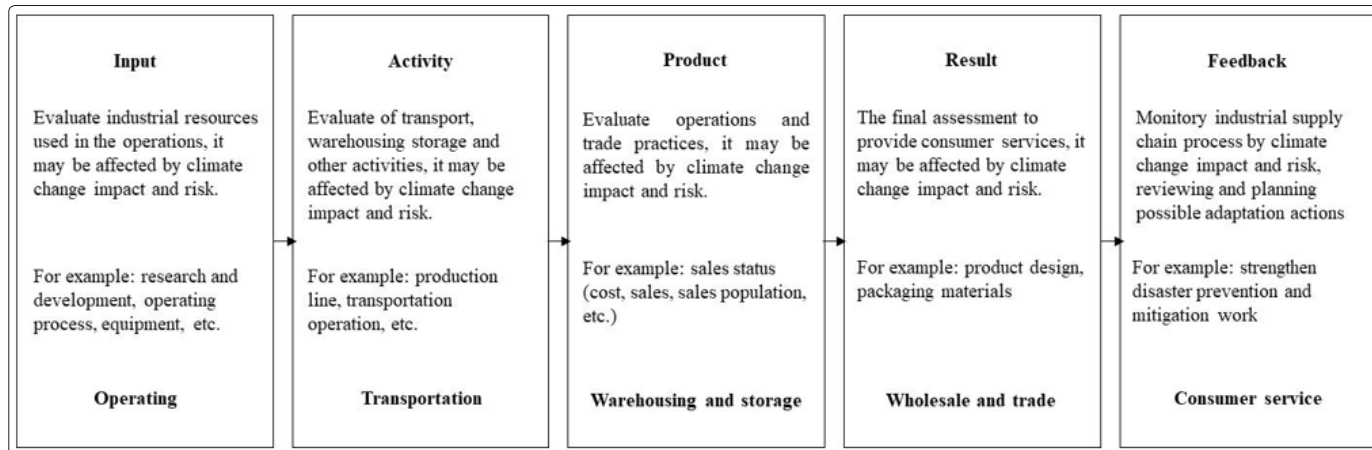
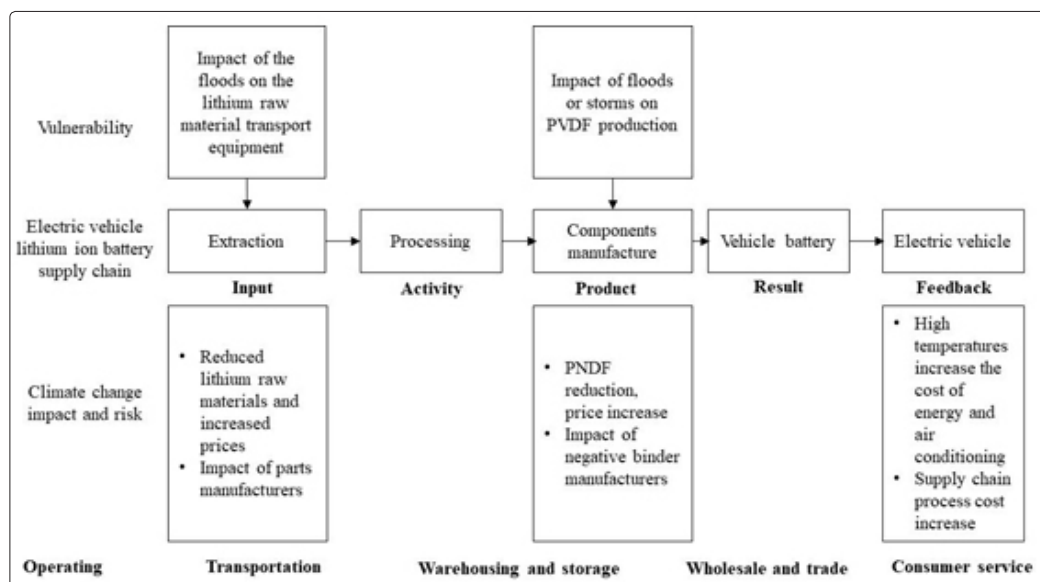


Figure 2: CCA framework for electric vehicle lithium ion battery supply chain process



Integrated Climate Change Adaptation and Disaster Reduction Risk for Industry Cluster

Long-term climate change and more frequent and more severe extreme weather events, such as changes in climate variables such as temperature, precipitation and extreme weather, are impacting the operational and financial performance of the industry cluster. 'Industry cluster' refers to a group of industries and related institutions that are geographically adjacent or interacting with each other in a specific field, and are linked to each other by commonality or complementarity. The industry cluster is a network of countries, cities, and even neighboring countries or regions. The form of alliances differs depending on the degree of connectivity and complexity. Most members of the industry cluster do not compete directly. Because they have their own service industries, there are still many common needs and opportunities. There are also many limitations and obstacles in terms of management [37]. Therefore, in the face of uncertain climate change shocks and risks, in the category of industrial settlements, the potential impact risk

of the supply chain system is the least known. Including: individual plant business activities, infrastructure damage, business activity project delays, water and energy supply constraints, and production losses, employee health and safety may be threatened, operational and goodwill image may be compromised, financial impact may increase Additional operating and capital cost inputs, as well as loss of operating income [1]. Therefore, the method of integrated climate change adaptation and disaster reduction risk for industry cluster is of great importance and can help the industry supply chain process to implement risk and adaptation management of individual or multi-stakeholders.

University of Cologne Research Team implemented German Research Foundation's German excellence initiative proposed a concept framework for industrial cluster, through the industrial adaptation ability, it views he climate change adaptation (CCA) but also CCA can used to disaster reduction risk (DRR) [38]. However, it has been reported that are based on the concept of climate risk

and adaptation, but the relevance of the climate change adaptation and disaster reduction risk for supply chain processes in industry is still unknown and uninvestigated. This article attempted to refer previous study and consider the climate change risk assess and adaptation management step (see table 1) and the CCA concept framework for industrial supply chain process (see Figure 1). It may lead to a better understanding of framework of integrated CCA and DRR management in industrial supply chain process.

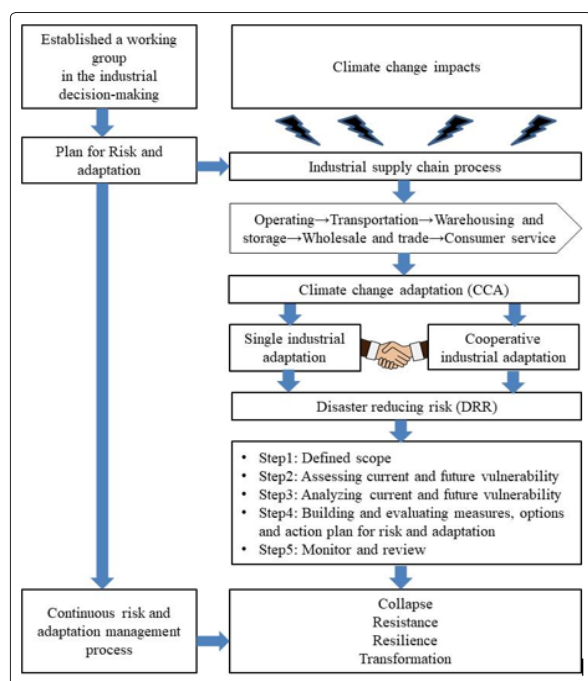


Figure 3: Framework of integrated CCA and DRR for industry cluster

Conclusion

This article contributes to the field's understanding of the applying method on climate change adaptation (CCA) and disaster reduce risk (DRR) management in industrial supply chain process. One is the CCA concept framework for industrial supply chain process (see figure 1), the other one is the framework of integrated CCA and DRR for industry cluster (see figure 3). Both of them could also be applied to improve the industrial decision-making to respond the climate impact and risk as well as a way in the integrated CCA and DRR. In general, they will be useful to provide a simple framework and particularly to the industry among the supply chain process. On a more specific basis, this article provided a consistency method and it could serve to integrated CCA and DRR and to apply in the industrial related-case.

However, the framework is still very much in the concept stage and much more has yet to be done. Much more also needs to be known about the applying method in the CCA and DRR with industrial supply chain process. This article should provide a review and descriptive basis for additional research. There is a continuing need for an adequate theoretical basis for the practical application of risk and adaptation management. In addition, whether this will also apply to applying method in other parts of sectors (ex: energy, house, transportation and agricultural etc.) cannot be determined based on this article. Further research is therefore warranted in different sectors [39].

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