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Sustainable Supply Network Configurations Driven by Water Scarcity: Example of End-to-end Beverage Supply Chain

Katya Yatskovskaya *, Jag Srai, Mukesh Kumar

Department of Engineering, University of Cambridge, Cambridge, UK

*ey232@cam.ac.uk, jss46@cam.ac.uk, mk501 cam.ac.uk

Abstract

Economies around the world are facing disruptive risks from water scarcity resulting in adverse effects on local communities, ecosystems, and industrial growth. Leading corporations and academia have recognised natural resource scarcity is becoming a “critical supply chain risk factor for the foreseeable future” (p.158, Bell et al., 2012), with many firms deploying water scarcity mitigation practices into their corporate sustainability strategies. In this context, the academic community has emphasised urgency and a need for systematic approaches and transformation of corporate water strategies. However, industrial water requirements vary depending on product-production process attributes and supply network structure and thus corporate natural resource scarcity mitigation strategies will depend on specific contexts.
This study explores the relationship between natural resource scarcity driven supply network configurational attributes, mitigation approaches, and capabilities that determines the water scarcity challenges for an organisation. The work proposes a conceptual framework that is further tested in the end-to-end case study of a beverage company.

Keywords: Sustainable; Supply Network; Configuration; Capabilities; Water Scarcity

1. Introduction

Global supply networks (SNs), are increasingly experiencing resource constraints for commodities such as water in a growing number of locations. This has been brought about by the intensification of local resource consumption in order to supply regional and global markets due to business expansion.
As a result, water scarcity (WS) becomes a global challenge as water consumption exceeds water availability by a ratio of about three to one (WBCSD, 2012). Water quantity and water quality are impacted by both global and local factors that carry potential risks for a sustainable future in which businesses operate. This increases the dependency of the firm on its suppliers, legislation, the physical features of the location, and water management systems available on the market and in the particular region, which in turn raises stakeholders’ interest in efficient corporate water management practices.
Conventionally, industries such as food and beverage have a high dependency on water resources due to agricultural base of their raw materials that on average consume over 70 per cent of water globally (FAO, 2007). Over the last decade, several large multinational companies in this sector have become increasingly vulnerable to water-related risks in their production operations, which have all led to changes within the firms’ SNs. For example, for companies such as Coca-Cola (India) and PepsiCo resource scarcity has caused plant shutdowns, for Starbucks (California) it has resulted in the plant relocation, and for other companies this has spurred an introduction of water scarcity mitigation practices.
This empirical evidence suggests that natural resource scarcity (NRS) in combination with location-specific contingency factors can impose a significant risk on supply networks (SNs), particularly, due to the failure of the management to address resource availability issues promptly (Bell et al., 2013). Therefore, in order to reduce such risks organisations, have to adopt efficient forecasting methods (Chopra and Sodhi, 2004) and align business strategies with sustainable SN strategies by incorporating sustainable water management (SWM) programmes into their corporate social responsibility and environmental management agenda. This in turn can increase supply chain (SC) performance (Yatskovskaya and Srai, 2017) of a firm and help it gain competitive advantage (Brown, 1992).
As SNs disruptions caused by declining water supply represents an increasing concern for multinational organisations more attention should be paid towards water efficiency initiatives to develop systematic proactive approaches for WS mitigation that can help to reduce resource dependencies. Currently, large portion of multinational organisations with wide SN structure consider developing capabilities for water stress mitigation (Black & Veatch, 2016). However, a number of studies (PwC, 2011; KPMG, 2012; WBCSD; 2012) have demonstrated that organisations still “have not yet implemented any comprehensive strategies in to address the associated issues” (p.2, Kalaitzi et al., 2018).
The present research contributes in filling this gap, by developing a conceptual framework, which aims to improve the understanding of how NRS affects companies’ resource mitigation approaches, which are linked to SSN capabilities and configurational opportunities.

2. Literature review

Global in SNs, are increasingly experiencing resource constraints for commodities in a growing number of locations. This has been brought about by the intensification of local resource consumption in order to supply regional and global markets. The Food and Agriculture Organisation of the United Nations have projected that 1.8 billion people will be living in regions with absolute water scarcity by 2025. BP has estimated that the world will run out of oil by 2067 and coal demand will exceed its supply within next 114 years (Taticchi, 2017). Recent studies highlight an increasing concern of the global organisations regarding resource scarcity problems. For instance, the survey by PwC (2017) showed that 77 to 75 per cent of respondents expressed concerned about "the scarcity of minerals and metals and a scarce energy supply, followed by water by 57% of respondents and land by 35% of respondents" (p.8, PwC, 2011). These pressures from the NRS have a potential impact on SNs disruptions that can lead to decrease of operating income, higher cost of RMs, limited growth rates, increase in operation costs, and reputational damage.

In order to sustain a long-term competitiveness, companies develop SN strategies (Ivanov et al., 2010) as part of overall business strategy. These strategies are formed to respond uncertainties brought about by changes in the business environment. A SC strategy represents an alignment of the firm's operations with the market place requirements (Christoper at al., 2006). Literature analysis indicates a range of NRS mitigation strategies, including (1) inventory decisions through safety stock buffers or multiple production facilities establishment (Goetschalckx et al., 2013); (2) sourcing methods such as multiple sourcing, decoupling points, postponement (Oke and Gopalakrishnan, 2012); (3) suppliers coordination and control including cooperation that aim at improved SN visibility, vertical integration, contracts, agreements to maintain excess capacity in all stages, and imposing contractual requirements on suppliers (Manuj and Mentzer, 2008); (4) avoidance and substitution strategies including refrainment of specific product/material, supplier, geographical market/market segment (Manuj and Mentzer, 2008). Hence, the only attempt to categorise WS mitigation strategies was made in the work by Bell et al. (2012). The reviewed literature, however, demonstrates a lack of studies in SCM field with a focus on SN design, based on NRS phenomena. Particularly, there is no theories that integrate WS risk and the firm's resource dependency to the SSN configuration and SSN capabilities development that goes beyond direct operations (Bell et al., 2012; Yatskovskaya and Srai, 2017).

3. Method

3.1. *Framework development*

The study employs an extensive literature review process covering three major literature domains - natural resource scarcity, SN capabilities, and SN configurations to propose a research a conceptual framework.

In WS context to minimise resource dependency level adjusting to environmental uncertainties, the firm might employ three water scarcity mitigation approaches that shape SSN configurations and SSN capabilities (Srai, et al., 2013; Brusset & Teller, 2017). These WS mitigation approaches were identified based on the studies by Bell et al., (2012), and Yatskovskaya et al., (2016) and include (1) *resource awareness* approach, which presents the knowledge the organisation develops regarding water availability for its manufacturing operations, in its facility locations, and in its SNs, including resource availability assessment and supplier and product environmental impact evaluation; (2) *resource sustainment* approach aims at efficient and effective use of the resources in direct operations and through the whole value chain, e.g. resource consumption minimisation and sustainable use of resources; and (3) *resource conservation* approach that secures and supports NRS availability and sufficient resource quality through various resource conservation methods together with value chain integration. The latter includes water avoidance, substitution, replenishment and circularity approaches. Operationalisation of these approaches is conventionally performed through SSN capabilities development.

Develop such approaches the company employs certain WS mitigation capabilities that are developed in order to address environmental, social, and economic effects on the business environment. Capabilities vary depending on their levels. For instance, *static capabilities* are referred as ordinary capabilities the firm develops in order to improve the processes by which existing capabilities are utilised (Beske, 2012). These include corporate manuals, guidance, and administrative coordination. While *dynamic capabilities* the organisation develops in order to adjust to rapidly changing external conditions continuously improving already existing resources and routines (Mintzberg at al., 1998). These capabilities lead to long or short term sustainable competitive advantages through strategic routine process, product developments, and new supplier integration practice developments that can subsequently alter SN configurational attributes. This study also distinguishes transformational and meta-capability levels. Their primary difference is that *transformational capabilities* are adopted by the firm in order to proactively tackle sustainability issues in SNs. This is capabilities are directly linked to the development of SN configurational attributes that lead to SN reconfiguration and are deployed when the organisation develops and adopts disruptive technologies. *Meta-capability* not intended to reflect a specific capability level, but rather refer to an ability to influence other capabilities development and inform the SSN configurational attributes (Srai et al., 2013). Meta-capability describes with the process of obtaining reliable information regarding NRS levels and associated risks and can have static, dynamic, and transformational features. The current study identifies five clusters of sustainable capabilities, to respond to the business strategy and facilitate SN reconfiguration (Srai et al., 2013), including:

- *Sustainable SN design* capability cluster results in optimal facilities location and allocation, supplier selection, suppliers' base optimisation in order to reduce impact on NRS, SWM strategies that are supported through SN coordination, and sustainability decision support tools. The later are characterised by certain capability type, information technologies (IT) / decision support systems (DSS) meta-capability, that is focused on evaluation of risk related to resource availability.
- *Network connectivity* capability presents operational connectedness of upstream and downstream SN actors, which includes supplier collaboration (joint work on NRS mitigation planning) and integration, supplier certification, level of trust, and durability of the relationship.
- *Network efficiency* capability focuses on innovative practices, technological advancements, and more informed decisions in production processes aiming at environmental impact minimisation include resource consumption efficiency, and resource conservation (Matopolous, 2015). The development of the informed decisions here is influenced by IT/DSS meta-capability.
- *Network process and reporting* capability illustrates processes to achieve agility and flexibility of the operations. It encompasses suppliers, employees, and consumers development processes to facilitate mitigation of NRS (Beske, 2012). It also facilitates total productive maintain support through the employment of sustainability tools, metrics and reporting mechanisms.
- *Product* capability enables better sustainable product design, sustainable materials selection, and product sustainability assessment to reduce reliance on scarce resources.

SCM literature emphasises that the capability development process facilitates organisational learning, which in turn influences organisational strategies development or environmental adaptation (Mintzberg at al., 1998). These strategies are developed in order to adjust to changes in the business environment and are focused on the resources and markets. The latter is observed when the firm transitions through a sequence of stable states with periodic transformation and referred as configurations. The literature analysis shows limited research in NRS mitigation through sustainable SN design (Bell, 2012). The dynamism of the SN configuration is dictated by nature of the NRS, particularly dynamic changes in the natural resource status and changing demand levels. Adjusting to such changes, the firm transitions from one stable state to another by developing new strategies that lead to transformation (Mintzberg at al., 1998). Based on the work by Srai and Gregory (2008) the current study distinguishes four SN configurational attributes. These include *SN structure* that is characterised by SN locations, SN partners, and SN sourcing; the *product design* attribute is defined by sustainable technologies and design characteristics; the *unit of operation* attribute is defined by the process material and information flow, supported by the information systems, which is demonstrated through information channels and tools, and; the *SN coordination and governance* attribute is presented by contractual mechanisms, and levels of transparency. The aforementioned SN configurational attributes can be defined as characteristics of SSN, simultaneous change of which leads to SSN reconfiguration.

Integrating all aforementioned elements, including SSN capabilities, SSN configurational attributes and SSN configurational archetypes in the WS context the conceptual framework is proposed (Figure 1).

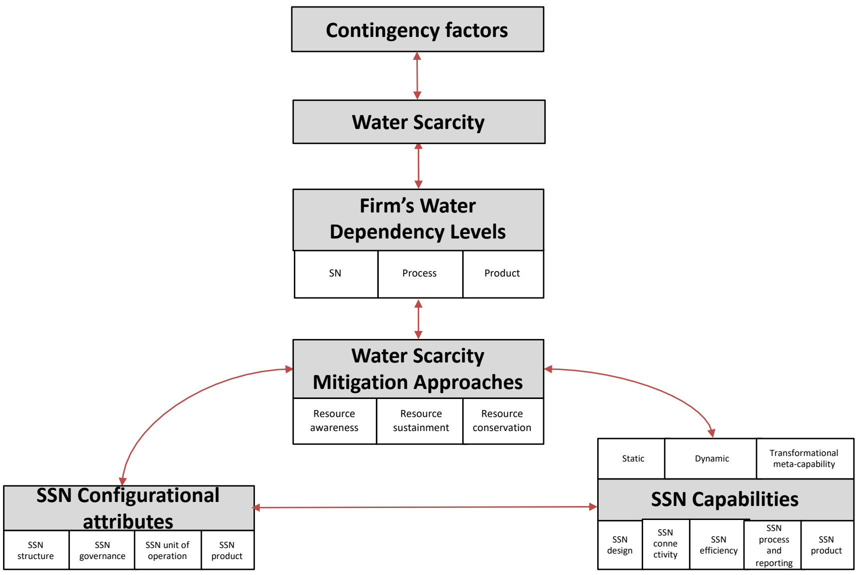

Figure 1. Conceptual framework.

3.2. *Framework testing*

In order to test the proposed conceptual framework an end-to-end SN case study of one of the largest alcoholic beverage producers in the world with an annual revenue of over $4.8 billion, based on sales of over 33 million barrels of beer and other malt beverages, is conducted. This case is designed to provide a sufficient breadth of analysis whilst also serving as a prototype case for testing the validity of the proposed conceptual framework. The data collection methods include secondary data collection methods and semi-structured interviews with farmers from different geographical regions (North America and Eastern Europe), a global beverage packaging materials supplier (Europe), a number of sustainability executives in the global beverage manufacturing company (North America), and a domestic retailer (UK). The analysis of water scarcity mitigation approaches from is explored from the perspective of a focal company, a beer manufacturer, that integrates water scarcity mitigation approaches into SN capabilities and SN configurational attributes to perform certain SN mitigation strategies, which are supported by the SN members.

4. Discussion

Beer products are highly water intensive "Water makes up 94 to 96% of beer" (DIWR). As well as being a key ingredient, water is used at almost every step of the production process. Aiming to reduce product water intensity the firm has set a goal to reach 2.8ha per a litre of beer by 2025. In order to reach that aim, the enterprise pays particular attention to improving the manufacturing process by means of a circular management approach. This is linked to the 'SSN efficiency' capability within resource sustainment and conservation approaches, including water recycling, reduction, and recovery. For instance, the company reuses water from the pasteuriser when cleaning the cans by using more focused and efficient flash pasteurisation. The firm recovers water from steam in boilers, and minimises water consumption through improved sanitation procedures, such as the replacement of caustic with chlorine dioxide sanitation product, which has enabled a reduction of rinsing required from six to three times. B1 has also developed new water-free processes, which are enabled by the resource conservation approach. These include application of a dry oil, a type of olive oil extract on plastic conveyor belts, which allows bottles to slide without any extra liquid assistance, and the installation of toilets without water flush. B1 optimises manufacturing processes through the batch size reduction allowing for more precise production amounts. B1 has introduced some changes to its WS assessment through 'SSN design IT/DSS' meta-capability enabled by a resource awareness approach. This includes continuous improvement of water assessment processes and alignment of the KPIs employed across its business. When identified NRS risks lie beyond firm boundaries B1 tries to engage with its value chain partners in water scarcity mitigation. One such mitigation approach is sustainable sourcing, whereby the firm sources "100% of barley and hops from suppliers who grow and deliver embracing [corporate] sustainability standards" (DIWR). B1 invests in the development programmes for its suppliers, employees, and end consumers developing the 'SSN process and reporting' cluster within resource sustainment approach. For instance, barley farmers are encouraged to report weekly on their water usage per ha of land and participate in a barley growers' group for the exchange of water scarcity mitigation practices. The firm also provides some technological and financial incentives for its farmers. When the firm is unable to perform large scale NRS conservation approaches it develops 'SSN connectivity' capability engaging with a broader level SN stakeholder. B1 forms a 'consumer development' dynamic capability, engaging with the downstream SN partners through consumer education programmes. Product sustainability is highlighted in the most recent marketing campaign and television slots. B1 develops 'SSN product capability', incorporating new sustainable raw materials in to the product design. The firm has its own barley breeding programme that aims to minimise the water intensity of RMs. As a result, a new barley variety, allowing higher yield with the same water input, was introduced.

The firm sources barley from different suppliers worldwide. In order to show contrasting features of SWM across different geographical regions two barley suppliers from Eastern Europe (Farm1) and North American (Farm2) regions were chosen. For instance, barley is a rain-fed crop in Russia. The farmer in this region doesn't require any technological advances in irrigation but focusing on efficient use of water in pesticides and fertilisers application. Water is sourced from the borehole at the specified tariff. Modifying its 'SN structure' Farm1 employs a specialist that times these crop aids application. The 'SSN process design' allows efficient water utilisation without additional irrigation. The farmer has arm-length contractual agreements, reflected in 'SSN coordination and governance' mechanisms, with the manufacturer that specify obligation of the farmer to provide a certain type and quality of barley. The beer producer controls barley growing process through field visits and harvest and transportation monitoring. The only initiative the beer manufacture provides for the Farm1 is a 'seed credit' that have to be return at the same quantity with a new yield. By contrast, in the USA barley is cultivated in both irrigated and dry-land production areas (AgMRC, 2018). Due to climatic conditions, Farm2 has irrigated barley. In this region water right has a very strong effect on resource sustainability, e.g. 'old-timers' are unwilling to minimise resource consumption. Threatened to lose its water supply Farm2 intensively develops 'SSN connectivity' capability by collaborating with the Nature Conservancy and B1 for NRS improvement.

When it comes to the packaging producer (Pac1) perspective on SWM, it has been identified that WS does not present a major issue. However, in order to cope with growing demands from stakeholders to be water sustainable Pac1 aims to minimise this by 25% by 2020 through various mitigation approaches. For instance, Pac1 develops 'SSN efficiency' capability under resource sustainment approach installing a new equipment that helps to improve water consumption by 30-40% and invests in the retrofits of its old equipment. Pac1 utilises water reuse approaches that include zero-liquid discharge programmes, water circulation, and backflow technologies. For water recycling the firm employs reverse osmosis and ozone instead of chemicals. All these allows 90 % of water reduction particularly at the sites qualified as hotspots. It has been identified that the beverage producer B1 does not ask Pac1 to comply to any particular standard, while requesting environmental impacts measurements such as water.
The study also explores one of the oldest UK retailer's (Ret1) perspectives on SWM. SWM presents an important element of the firm's corporate sustainability strategy. Ret1 water related risks are mainly associated with physical product availability can be significantly affected by the suppliers that are "involved with the area of extreme water stress". In order to evaluate these risks, the firm develops transformational IT/DSS meta-capability that presents a combination of publicly available water assessment tools and water intensity of grocery products mapping. The company reactively mitigates identified risks through SSN design capability introducing sustainability standards for 35 key RMs. Ret1 develops 'SSN connectivity capabilities' through participation in the multi-stakeholder initiatives. When WS threatening sustainable product supply Ret1 employs 'SSN design supply-base optimisation' capability, which allows suppliers back-up from "typically more than one geographical location option" (HSES).
All aforementioned capabilities developed by every SN member in turn facilitate B1's SN reconfiguration. For instance, in order to minimise potential risks, related to barley supply B1 redesigns 'SSN coordination and governance mechanism' attribute developing long-term close partnerships with its RM suppliers, buying "directly from 850 to 860 growers [that] make up to 80% of the barley supply chain" (GSDCR) and contracting "864 independent barley growers" (secondary source). Such governance mechanism, collaboration, and partnering type of relationships allow the firm to perform responsible sourcing when raw material suppliers are selected based on their commitment to the corporate sustainability standard. Interestingly, the company is increasingly dependent on RM supply and yet does not have mechanisms allowing RM supply flexibility explaining this issue as: "During a good year you have surplus and then during a stressed year it might meet our exact need" (DIWR). B1 also forms a joint venture with its Pac1 supplier to enable sustainable NRS management. All these allows SSN transparency and RMs traceability. In order to reduce resource supply dependency from municipal sources, B1 is focused on 'SN structure' re-design through additional water supply infrastructure development via building storage reservoirs, such as lakes, ponds, wells, and wastewater treatment plants construction. B1 also buys water rights also known as "appropriative rights" to ensure sufficient water supply for the manufacturing processes.

5. Conclusion

During the exploratory case study, the proposed framework testing took place. The obtained results from end-to-end beverage SN confirm validity and reliability of proposed conceptual framework (Table 1).

Table 1. SSN capabilities analysis.

Approach	Capability cluster	Capability	Definition	Capability level	B1	F1	F2	Pac1	Ret1
Awareness	SSN design	NRS assessment tool/approach	Mechanisms allowing understanding location, product, and process characteristics and associated risks related to NRS	Static	X			X	X
		Continuous improvement of the NRS assessment tool/approach	Mechanisms allowing accuracy and reliability of the information regarding NRS and associated risks	Dynamic	X				
		New NRS internal assessment mechanisms	Company tailored assessment mechanisms allowing tactical decisions making	Transformational	X				
Sustainment		Supplier base selection	Mechanisms allowing sustainable RM sourcing	Dynamic					
		Operational location selection	Mechanisms allowing SSN structure selection based on NRS availability	Transformational	X				
		Sustainability leadership	Mechanism allowing promotion of NRS sustainability practices throughout SN via corporate standard/policy/report	Static	X				X
Conservation	SSN collaboration	Collaboration with 3d parties (industry partners, NGOs, local authorities, universities, consultancies)	Mechanisms allowing collaborative actions with respect to NRS mitigation	Dynamic	X	X	X		X
		Suppliers collaboration	Mechanisms and relationship types allowing collaborative actions with respect to NRS mitigation (e.g. joint venture, long-term relationships, contracts)	Dynamic	X				
Sustainment	SSN process and reporting	Supplier development through: (1) financial incentives	Mechanisms allowing SN agility and flexibility	Dynamic	X				
		(2) sustainable water practices education			X				X
		Employee development: (1) financial incentives		Dynamic	X				
		(2) educational programmes			X			X	
		Consumer development	Mechanisms allowing consumer's education regarding sustainable NRS management	Dynamic	X				
		Sustainability reporting		Dynamic	X	X	X	X	X
Conservation	SSN efficiency	NRS conservation in production operations: (1) resource avoidance enabled by new technologies/approaches	Mechanisms allowing to water availability and quality	Transformational	X				
		(2) waste treatment		Dynamic	X			X	
		(3) circularity, recovery		Transformational				X	
Sustainment		NRS sustainment in the operational process through (1) new technologies application	Mechanism allowing resource minimisation or efficient use of NRS	Transformational	X		X	X	
		(2) new approaches		Dynamic	X	X		X	
Sustainment	SSN product	Access to sustainable raw materials	Mechanisms enables product sustainability	Dynamic improvement	X				

Table 2. SSN configurations analysis.

SN configurational attribute		SN configurational elements	B1's SN
SSN structure	Traditional	• Geographical spread • Infrastructure • Structure • Size	- multi-regional - 31 site (8USA) - municipal water supply - sustainability team - over 17000 employees
	WS context	• Organisational structure • Water supply infrastructure and sources • Waste water treatment infrastructure • Supply base • Financial instruments allowing operations continuity	- - new water supply infrastructure - water rights acquisition - waste water treatment plant construction - 860 growers -
Unit of operation	Traditional	• Type of operational unit • Type of process flow	- mass production - make-to-order
	WS context	• Batch size • Circular water systems • Technologies enabling NRS efficiency • Information systems	- batch size reduction from 1500 to 250 batch barrel - sustainable process design (circularity) - Technology enabled resource efficiency - NRS assessment tools and personnel
Coordination and Governance	Traditional	• SN role • SN relationships	- leader - partnerships and strategic alliances
	WS context	• Type of relationships: contracts, partnerships, joint-ventures long-term collaboration • transparency	- long-term partnerships with RM supply; joint-venture with packaging supply; contracts - high transparency through suppliers' sustainability reporting and corporate standard compliance
SN Product	Traditional	• Product type • SKU variety	- Stable, high volume - Narrow
	WS context	• New sustainable RMs	Sustainable product through WS efficient RMs

The research contributes to Supply Chain Theory development from SN configurational perspective in the WS context. The development of a conceptual framework for sustainable supply network configuration response options driven by NRS considerations, and the identification of capability clusters that support WS mitigation approaches, spanning reactive and proactive mechanisms, provide theoretical and practitioner insights to the emerging operational challenges of water scarcity.

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References

Bell, J.E., Autry, C.W., Mollenkopf, D.A., Thornton, L.M., 2012. A natural resource scarcity typology: theoretical foundations and strategic implications for supply chain management. *Journal of Business Logistics,* Vol. 33 No. 2, pp. 158–166.

Beske, P., 2012. Dynamic capabilities and sustainable supply chain management. *International Journal of Physical Distribution and Logistics Management*, Vol. 42, No. 4, pp. 372–387.

Black & Veatch, 2015. *Strategic directions: U.S. water industry report*. Available at: <http://bv.com/reports/2015/water/> (accessed 15.03.2019).

Brown, A.S., 1992. *Total Quality Service – How Organisations Use It to Create a Competitive Advantage*. Prentice-Hall, Scarborough.

Christopher, M., Peck, H., Towill, D., 2006. A taxonomy for selecting global supply chain strategies. *International Journal of Logistics Management*, Vol. 17, No .2, pp. 277–287.

FAO, 2007. *Coping with water scarcity Challenge of the twenty-first century*. Available at: <www.fao.org/nr/water/docs/escarcity.pdf> (accessed 28.10.2018).

Goetschalck, M., Huang, E., Mital, P., 2013. Trading off supply chain risk and efficiency through supply chain design. *Procedia Computer Science*, Vol. 16, pp. 658–667.

Kalaitzi, K., Matopoulos, A., Bourlakis, B., Tate, W., 2018. Supply chain strategies in an era of natural resource scarcity. *International Journal of Operations and Production Management*, Vol. 38, No. 3, pp. 784–809.

KPMG, 2012. *Raw material scarcity and its impact on business*. Available at: <http://www.kpmg.com/NL/nl/IssuesAndInsights/ArticlesPublications/Documents/PDF/Consu mer-Markets/Raw-material-scarcity-def.pdf> (accessed 16.05.2019).

Manuj, I., Mentzer, J.T., 2008. Global supply chain risk management. *Journal of Business Logistics*, Vol. 29, pp. 133–155.

Mintzberg, H., 1998. Covert leadership: notes on managing professionals. *Harvard Business Review*, No. 76, pp. 140–147.

Oke, A., Gopalakrishnan, M., 2009. Managing disruptions in supply chains: A case study of a retail supply chain. *International Journal of Production Economics*, Vol. 118, No. 1, pp. 168–174.

PwC, 2011. Minerals and metals scarcity in manufacturing: The ticking time bomb Sustainable Materials Management. Available at: <http://www.pwc.com/en_GX/gx/sustainability/research-insights/assets/impact-of-minerals- metals-scarcity-on-business.pdf> (accessed 15.05.2019).

Sarni, W., Grant, D., 2018. *Water stewardship and business value*. Routledge, UK.

Srai, J.S., Alinaghian, L.S., Kirkwood, D.A., 2013. Understanding sustainable supply network capabilities of multinationals: a capability maturity model approach. *Proceedings of the Institution of Mechanical Engineers Part B Journal of Engineering Manufacture*, Vol. 227, No. 4, pp. 595–615.

Srai, J.S., Gregory, M.J., 2008. A supply network configuration perspective on international supply chain development. *International Journal of Operations and Production Management*, Vol. 28, No. 5, pp. 386–411.

Stevenson, M., Hendry, L., 2004. *Aggregate Load Oriented Workload Control*. Lancaster University Management School, Working Paper, 2004/023.

Taticchi, P., 2017. *Business must face facts: natural resources are running out*. Available at: <https://www.imperial.ac.uk/business-school/knowledge/strategy-leadership/business-must-face-facts-natural-resources-running/> (accessed 12.05.2019).

World Business Council for Sustainable development (WBCSD), 2012. <Water for Business Initiatives guiding sustainable water management in the private sector>. Available at: <http://www.bcsd.org.tw/sites/default/files/node/domain_tool/678.file.2161.pdf> (accessed 20.01.2019).

Yatskovskaya, E., Srai, J., 2017. Developing a dynamic capabilities approach to risk mitigation strategies driven by water scarcity. *Proceedings to the 24th EurOMA conference,* Edinburgh, UK.

Yatskovskaya, E., Srai, J., Kumar, M., 2018. Integrated supply network maturity model: Water scarcity perspective. *Sustainability*, Vol. 10, No. 3, pp. 1–26.