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Integrated Supply Network Maturity Model: Water Scarcity Perspective

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Abstract: Today's supply chains (SCs) are more than ever prone to disruptions caused by natural and man-made events with water scarcity identified as one of the highest impact events among these. Leading businesses, understanding that natural resource scarcity (NRS) has become a critical supply chain risk factor, extensively incorporate sustainable water management programmes into their corporate social responsibility and environmental management agenda. The question of how industries can efficiently evaluate the progress of these water scarcity mitigation practices, however, remains open. In order to address this question, the present study proposes a conceptual maturity model. The model is rooted in strategies for water scarcity mitigation using a framework developed by Yatskovskaya and Srai and develops an extensive literature review of recent publications on maturity frameworks in the fields of sustainability and operations management. In order to test the proposed proposed, model an exploratory case study with a leading pharmaceutical company was conducted. The proposed maturity model presents an evaluation tool that allows systematic assessment and visualisation of organisational routines and practices relevant to sustainable manufacturing in the context of water scarcity. This model was designed to help illustrate mitigation capabilities evolution over time, where future state desired capabilities were considered through alternative supply network (SN) configurations, network structure, process flow, product architecture, and supply partnerships.

Keywords: sustainable supply networks; maturity model; mitigation capabilities; water scarcity

1. Introduction

Sustainable development has become a dominant topic in various studies [1], through different industry sectors, where the main focus is on the interaction of business strategies with the biophysical environment One of the elements of such an environment are natural resources. Water scarcity is shaped by a number of inter-connected determinants including technology, environment (climate change, biodiversity loss), society (population increase, globalisation, and urbanisation), policy [2], and economics (consumption patterns, industrialisation). When natural resource scarcity urges firms are forced to develop contingency plans to sustain their business continuity. One of the supporting mechanisms that allow firm's operations stability is the development of water scarcity mitigation capabilities. A capability building process is a complex system that embraces different skills, expertise, and knowledge that are exercised through organisational processes [3]. Capabilities enable organisations to coordinate their activities and make use of their assets [4].

The progress toward continuous sustainable development is critical for business survival [5]. Thus, firms have to regularly improve and develop acquired mitigation strategies in order to respond to the pressures from the constantly changing business environments. In the context of natural resource scarcity, assessing mitigation capability development processes and scoping the future steps for the sustainability performance improvement is fundamental and should be closely and continually monitored. Evidently, the development of the supply chains (SC) capability evaluation tools present a nascent area of research.

The capability maturity model introduces the mechanisms to evaluate strengths and weaknesses of adopted mitigation capabilities in supply network (SNs) [6]. The capability maturity model allows internal and external benchmarking of the firm's competencies [7]. The tool is conventionally applied to assess and compare the progress of the employed mitigation capabilities against standards and the best available practices, which enable decision-makers to appraise organisational efforts, to identify the current position in the sustainable development, and to propose further steps to achieve a targeted level in sustainable capability development. Application of the capability maturity model has become one of the major elements that triggers SN transformation, from the current state capabilities to the future state desired capabilities, through the prism of organisational routines, network structure, process flow, product architecture, and supply partnerships.

The current work, by proposing a water scarcity evaluation maturity model aims, to answer the question of whether water scarcity capabilities can be evaluated in a systematic manner by proposing a water scarcity evaluation maturity model. The study makes an attempted to bridge a gap between the SC literature domains, namely SN capability development and SN configurations, from the resource scarcity perspective. A large number of studies have been focused on capability building process, and a considerable amount of work has been conducted with respect to SN configurational aspects, but there is little evidence suggesting the alignment of these two elements. This work extends the priviously developed structural capabilities perspective [3,8] to the natural resource scarcity context to propose a capability maturity model.

The proposed maturity capability framework presents an integrated model that provides a mechanism to evaluate the current level of operational development and to propose further steps toward water scarcity mitigation excellence for internal and external users. The model was tested utilising a pharmaceutical industry case example. Preliminary results demonstrate the validity of the proposed model.

This paper is organised as follows. First, the literature on SN capabilities and water scarcity mitigation strategies is reviewed, and existing maturity models are analysed. Then, the research approach in terms of capability maturity model development stages is described, and the proposed SN capability maturity model is presented. This initial maturity model is then tested in a selected firm by means of an exploratory case study, followed by a discussion of the outcomes. Conclusions are drawn in terms of theoretical contribution, practical benefits from the application of the proposed maturity model, and potential directions for future research.

2. Literature Review

Operating in a natural-resource-constrained environment businesses are forced to mitigate and adapt [1]. Water scarcity risk alleviation presents a highly complicated issue. Emerging from an imbalance in resource supply and demand the water scarcity phenomenon is also shaped by a number of inter-connected socio-economic, political, and environmental elements, which in turn increases the uncertainty levels in the business environment. Water-scarcity induced factors are further discussed.

The global population is expected to increase to 9.8 billion by 2050 [9]. This situation leads to increased pressures on water availability to meet increased agricultural demand. The situation becomes even more complicated due to increasing incomes that lead to changing consumption patterns toward water-intensive production. While growing levels of urbanisation and industrialisation contribute to the problem of resource availability, they also influence water quality due to toxic discharges from cities and upstream industries that contaminate water sources [10].

Weak water regulations and policies in certain countries have already brought about severe water scarcity problems affecting local communities and industries [3]. This situation is particularly acute in developing regions where agricultural policies are more focused on agricultural productivity and intensification, conventionally by means of water resources [11].

On top of these factors, climate change is projected to contribute to water scarcity by leaving more than 40 percent of the world's population by 2050 in severe water stress conditions [12]. In addition, extreme weather events impose significant pressures on water availability and security. For instance, events such as El Niño and La Niña have potentially catastrophic impacts on water availability [10]. A combination of climate change and extreme weather events is likely to lead to an exacerbation of demand for water resources [13].

Changing levels of water availability driven by aforementioned factors make water scarcity a multi-dimensional dynamic problem. Companies operating in such environments are at risk of their operations disruption, constraints to growth, and even loss of business. As such, in order to support stability in their business operations firms are forced to develop effective SN approaches under vigorous business strategies [14] that are supported by consecutive processes of SN mitigation capability development.

The process of SN capability building in the context of a natural-resource-constrained environment can further result in SC configuration and reconfiguration opportunities in order to support the firm's sustainable development. SN capabilities present a complex bundle of skills and accumulated knowledge that is exercised through tangible or intangible firm-specific organisational processes and developed over time in order to sustain competitive advantages [4,15]. Recently there has been growing interest in sustainable supply network design with an emphasis on addressing social, economic, and ecological effects on the business environment. In order to adjust to this constantly changing corporate environment, firms develop dynamic capabilities that lead to long- or short-term sustainable competitive advantages [16–22]. A number of studies in the SC sustainability literature domain have been focused on static capabilities and dynamic capabilities [16,21–27]. However, the only attempt to classify a broad range of these sustainable dynamic capabilities is made in the work by Srai et al. [15] where a classification of sustainable dynamic capabilities is presented as five SC dynamic capability clusters:

- sustainable supply network (SSN) strategic design capabilities that affect the structure, complexity, location, SN dispersion, and level of SC integration [28,29]
- network connectivity capabilities determined by the operational connectedness of upstream and downstream SN actors [15,30,31]
- network efficiency capabilities determined by the ability to efficiently measure environmental impacts and to discover and implement new production technologies in order to minimise the impacts of production processes [32]
- network process development and reporting capabilities, which refers to the process of measuring, reporting, and disclosing the firm's progress toward their sustainable development goal to internal and external shareholders [15]
- product/service enhancement capabilities, which within a sustainability context, brings innovation components through R&D into a product design and technology application in order to reduce reliance on scarce resources and materials [15].

This work was further extended by Yatskovskaya and Srai, [3] to the natural resource scarcity field to propose a classification and alignment of water stress mitigation capabilities with SC structural clusters that subsequently form SN mitigation strategies of resource allocation, resource sustainment, and resource utilisation (Figure 1). A *resource allocation strategy* allows for building flexibility when designing a product and related processes. This strategy is utilised to identify where and how resources are used in terms of physical site location and the resources required for product manufacturing. A *resource sustainment strategy* secures and supports natural resource scarcity availability and sufficient resource quality. These strategies include resource conservation approaches together with value chain integration. A *resource utilisation strategy* is employed to provide an efficient and effective use of resources at the site level and through the whole value chain.

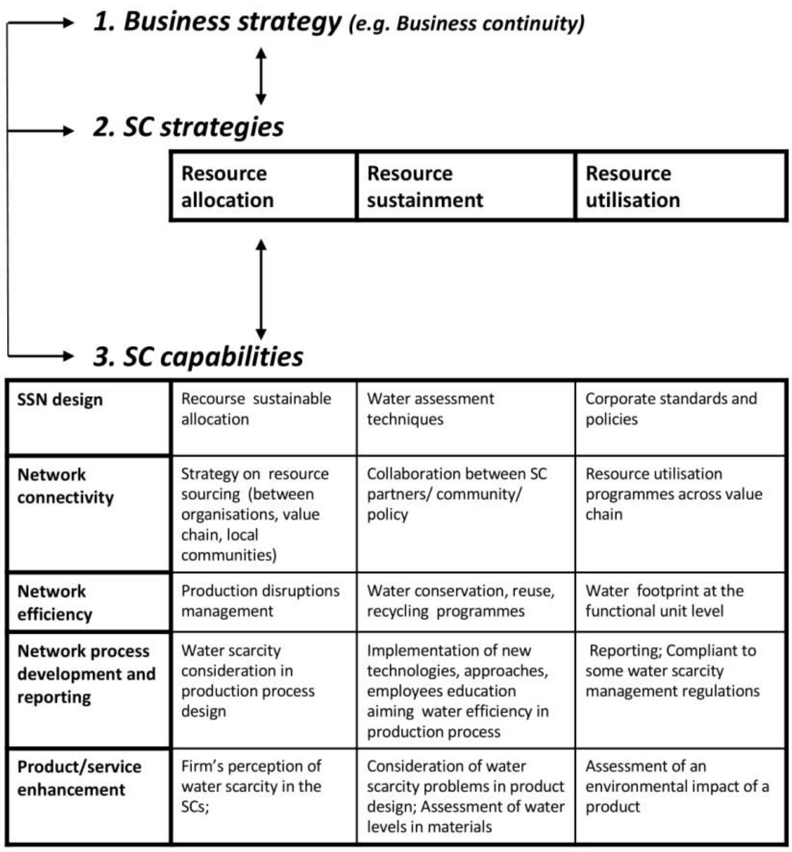

Figure 1. Populated natural resource scarcity (NRS) mitigation capabilities framework (Adapted from Yatskovskaya and Srai [3]).

The current study is built on work developed by Yatskovskaya and Srai [3] to propose an integrated capability maturity model within a water scarcity context. Conventionally, mitigation capabilities are deeply embedded into organisational practices and might be hard to identify and assess [4]. In order to achieve a continuous sustainable performance, SN mitigation capability development processes should be closely monitored throughout the firm's SNs. Thus, measuring sustainability performance is central in evaluating current responses to pressures from business environments and in analysing future mitigation opportunities. In the context of water scarcity, an assessment of the mitigation capability development process is fundamental and should be closely and continually evaluated.

2.1. Maturity Frameworks

In developing current and future state dynamic capabilities for water stress mitigation, firms undergo a capability evaluation process. One of the most widely accepted capability assessment methods is an application of the capability maturity model. The capability maturity model is conventionally designed to evaluate 'the development of an entity over time' [33]. In the sustainability context, a capability maturity model represents a descriptive tool that is employed to guide a firm's performance improvement over time or a comparative tool that evaluates the processes and compares it with the best practice or standard to enable both internal and external benchmarking [6].

The concept of maturity was firstly introduced by Humphrey (1987) [34] with an aim to improve the performance of software processes, where 'the progress towards goal achievement comes in stages' (p. 272, [35]). Conventionally, maturity models present a grid, where the attributes are evaluated through a number of subsequent levels. The series of maturity levels assume that the attribute development process undergoes each step in an evolving manner [36].

This maturity model approach was later adopted by many disciplines including operations management, systems engineering, software engineering, project management, risk management, systems acquisition, information technology, services and personnel management, construction development, and adjacent fields [6,15].

In the operations management field, adoption of the maturity models started with the growth of global competition as it became increasingly important for the firm to be able to develop and deploy strategic assets—capabilities—in order to gain competitive advantages. Organisations have started extending their view of the firm beyond the firm boundaries in order to form a competitive network of companies [35]. Thus, a new task of an alignment of strategic capabilities beyond the firm's boundaries covering end-to-end SNs has emerged. Since the adoption of the process view of the firm, organisations have become extremely interested in maturity model development and applications. The 'processes' here are considered as assets that can be developed as they mature. Maturity models considered the process to have a lifecycle that can be 'assessed by the extent to which the process is explicitly defined, managed, measured and controlled' (p. 272, [35]). As these processes mature, the firm's focus moves from internally-focused to an externally-focused perspective [35]. Maturity models have been further successfully employed to measure the initial state and progress of the firm's SC sustainability. A holistic upstream and downstream view of SCs makes maturity analysis of SC sustainability an important element that supports the business strategy of organisations and drives SC innovation by continuous improvement [37]. Maturity models are 'strategic tools for diagnosis and improvement of SC operations' (p. 3, [6]) allowing stakeholders to understand the current level of SC sustainability and suggesting the subsequent actions required to progress in sustainable development [36,38].

Conventionally, maturity capability models incorporate a number of key process areas and several maturity stages or levels of development [39]. A key process area presents a cluster of related activities aimed at achieving a set of goals. A maturity level refers to collections of key process areas and represents the major characteristics of the business processes of the firm [39]. For each level of maturity, the firm establishes a higher level of process capability or ability to manage its business processes [35]. In the context of sustainability, the concept of stages represents a scheme that supports the development and establishment of the organisation's state with regard to sustainability strategies for SC development [40,41]. The higher the level of maturity the more capable the firm is at utilising sustainability principles in their SNs.

The majority of maturity models are empirical studies [8,42] employing qualitative assessments [15,43,44] that are defined through statements and additional disruptive information to capture the stages of capability evolution, quantitative approaches [45], and mixed methods [46]. Nevertheless, a conceptual work is not that frequent in this field [6,36,47,48]. The designed maturity models vary based on their scope, which determines the degree of the model's application within its domain. The maturity models range from generic ones, which are applied to most organisational processes, to specialised models that are employed to assess a specific process within the firm [49].

Studies by Paulk et al. [50] and Humphrey [34] put forward a five-stage maturity model for software process maturity assessment. Applying a maturity model framework, international standards such as ISO/IEC 15504 were developed to propose an assessment tool for information technology processes evaluation. In the project management field, the maturity models were applied to investigate the relationships between software development activities, process maturity, and project performance [51]. The work by Robinson et al. [52] considers model development for the construction industry from the perspective of knowledge management maturity. Sarshar et al. [53] developed a maturity model for the construction industry assessing organisational processes management. This was further extended in the work by Meng et al. [39], who proposed a maturity model specifically focused on an evaluation of the relationships within the industry. The discipline of education also accommodates process improvement maturity frameworks within the context of e-learning [54] and computing education [55].

Within the SN sustainability context, however, maturity models are categorised according to sustainability dimensions (triple bottom line including environmental, societal, and economic) and SC levels (micro level—process; meso level—firm-specific; macro level—SN) [6]. Within the industrial sustainability field, maturity models with environmental scopes are dominant; however, there remains evidence of holistic views on sustainability elements. For instance, Standing and Jackson [47], examining the notion of sustainability in the process information systems management context, propose a set of guiding sustainability principles that are portrayed through a sustainability maturity model. Sustainability in remanufacturing is covered in a study by Golinska and Kuebler [56], where a five stage maturity model that incorporates all three sustainability aspects is developed to provide cross-company valid sustainability assessment criteria. Kurnia et al. [38] consider a four-step model for capability assessment integrated into sustainable practices across SN. Srai et al. [15] also employ an SN perspective for model development to assess the notion of sustainability based on five clusters of capability across five maturity levels. A network level study by Reefke et al. [36] introduces a six-stage maturity model for all elements of sustainability assessment in SCs. Edgeman and Eskilsen [48] develop a five-step firm-level model assessing sustainability for innovation technologies development. Similarly, Okogwu et al. [43] develop a four-level evaluation tool that allows (i) an assessment of maturity levels attained by the organisation in reporting sustainability initiatives across their SNs and (ii) continuous improvement of these reporting initiatives. Baumgartner and Ebner [41] incorporate an assessment of sustainability in SN reporting into an evaluation of corporate sustainability strategies and propose a four-level maturity model to provide six assessment elements: innovation and technology, collaboration, knowledge management, processes, purchase, and sustainability reporting. Silvius and Schipper [57] consider the practical implications of a maturity model for sustainability assessment in projects and project management including all three sustainability dimensions. Machado et al. [58] extend the perspective of sustainability to trace the firm's sustainable operation evolution, and a maturity framework is built to support processes of evaluation and management of sustainability operations.

A three-stage work by Closs et al. [27] integrates all sustainability elements, primarily focusing on the environmental aspects of sustainability at the firm level. Babin and Nicholson [46] introduced a three-step maturity model with an environmental scope for the sustainability of global information technologies. Hynds et al. [45] introduced an environmental sustainability assessment of the process for new product development. Jabbour et al. [59] introduced a firm environmental management assessment, applying a three-level model. Pigosso et al. [44] present an eco-design maturity model for the assessment of eco-design processes. The study explores the integration of the environmental aspects of the product development and supporting processes, and the authors suggest a suitable set of sustainable eco-design options. An environmental maturity model developed by Doss et al. (2017) [60] considers the firm's organisational processes improvement through a five-phase paradigm. Zhao et al. [37] mainly focus on SC performance. The proposed integrated four-stage maturity model includes an additional three sub-models, where evaluation takes place, based on three dimensions: environmental, resource, and management.

The current study proposes an integrated capability maturity model that includes five sub-models. The proposed maturity model incorporates SN structural clusters [15] and water scarcity mitigation strategies [3,26] for subsequent sustainable SN configuration. A process of capability maturity model building is described in the next section.

3. Methodology

3.1. Maturity Model Development

The methodological development used here aims to advance our understanding of how water scarcity capability development process can be evaluated. The study follows the research approach outlined in Figure 2.

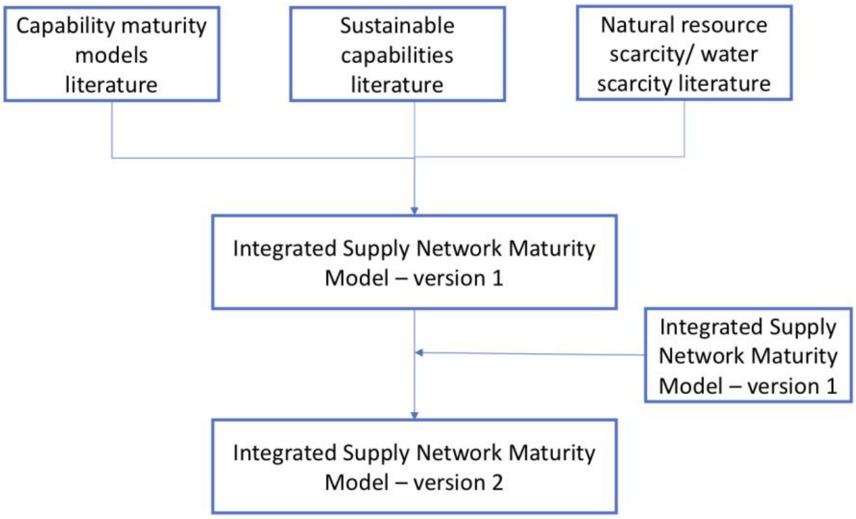

Figure 2. Research approach.

The developed research framework intends to bridge supply chain (SC) capabilities and resource scarcity literature domains in order to propose a capability evaluation maturity model. The model was also tested utilising a case study approach. The conceptualisation of the resource management strategies applied to SN structural dimensions is employed to enable the identification of maturity dimensions and levels for water scarcity mitigation. This study adopts the principles of a design science approach, rooted in information systems research, involving the building and evaluation of an artefact [38,61]. The artefact presents a problem-solving paradigm that contains ideas, practices, and capabilities through which subsequent analysis, management, design, and implementation takes place in order to effectively and efficiently achieve the user's goals [61].

The building phase of the design research approach, applied in the current work involves building an integrated framework that evaluates SN mitigation capability maturity in the context of water scarcity. The framework is developed based on studies by Srai et al. [15] and Yatskovskaya and Srai [3], where five SN structural capability clusters are aligned with three water scarcity mitigation strategies, supported by a comprehensive literature review of relevant publications in the field of sustainability (Table 1). The literature sources are selected by searching for recent papers related to sustainable SCs/SNs, sustainability maturity and capability maturity frameworks utilising search tools such as Google Scholar, SCOPUS and Emerald Insight. Although the aim was not to conduct a systematic literature review, searches were done strategically to identify papers using the keywords 'maturity models/framework' OR 'supply chain maturity models' AND 'sustainability'. The papers identified to be the most relevant were reviewed to inform the different components of the maturity model.

One of the aims of the literature review process is to analyse and align five SN domains and its sub-domains (mitigation capabilities) with existing studies on maturity capability models. The core structural element of each maturity model considered is a progressive sequence of steps/phases that are designed to track changes of the capability maturing processes from the initial stage to the maturity stage. Each level of maturity characterises the state of the system [6,62] and presents an 'evolutionary plateau of process improvement' (p. 311, [36]). Conventionally, studies employ a Likert-like scale where attributes of the maturity model are scored according to their progress level. A commonly used number of levels ranges from three to six [6,15]. Each level of maturity here includes a description of key processes, level characteristics, systems deployed, performance standards targeted, and main activities. Following these principles, the current work has identified leading papers in maturity model development relating to sustainability within an SN capability development process. Based on these studies descriptions of the qualitative assessments for mitigation capability maturity levels were assigned according to SN capability cluster and water scarcity mitigation strategy (Table 1).

The top-level descriptors of the maturity stage were assigned for SN clusters according to the proposed model of Srai et al. [15]. As a result, the proposed mitigation capability assessment is based on five levels of maturity. Levels of capability maturity were numbered and described according to their level of progression. Examples of an alignment of existing studies with SN structural clusters and sub-domains are further provided. By evaluating supply network design clusters under resource allocation, resource sustainment, and resource utilisation strategies, an assessment of water resource allocation strategies, employment of water assessment tools and programmes, and the development of corporate water policies and standards throughout the supply network can be undertaken.

Built on related studies to evaluate SN design clusters, maturity levels are described [27,36,38,43,46] and assigned [15]. For the network connectivity cluster an assessment of related capabilities can be undertaken using three water mitigation strategies: resource sourcing between SN partners, collaboration with SN partners regarding water scarcity management, and programmes or standards for the assessment of sustainable water utilisation in SNs [27,37–39,41,43,46]. The network efficiency cluster is characterised by mitigation capabilities such as water scarcity mitigation strategies readiness, availability of water conservation programmes, and water foot printing through SNs [27,46,56]. The network process cluster employs three main mitigation capabilities developed for water scarcity mitigation strategies: consideration of water minimisation in the production process design; implementation of new technologies, approaches, and employee education programmes that aim at water efficiency in the production process; and water management information disclosure and reporting [37,38,43,45,46,48,56,59]. The last cluster, network product design, includes capability dimensions such as water reduction at the product design stage, water conservation through materials employed that are assessed and minimised, and product environmental impact assessment and eco-design [37,41,44,46,56].

As a result, an empirical framework that contains five clusters and multiple (15) sub-dimensions and descriptive assessments with measurements was developed. In order to verify the framework and illustrate its applicability model testing and analysis were further conducted.

Table 1. Maturity model and the related supply network (SN) clusters associations.

SN Attribute Cluster	Water Scarcity Mitigation Strategy	Mitigation Capabilities	Ref.	Maturity Levels					
				1	2	3	4	5	6
SN design			[15]	Initial	Limited	Defined/Systematic	Managed	Mastered	
	Resource allocation	Recourse sustainable allocation in SNs; facilities location accordingly	[27]	Reactor	Contributor	Innovator			
	Resource sustainment	Water assessment tools/methods/data collection	[38]	Non-existent/ Unaware	Low/Unprepared	Moderate/Committed	High/Advanced		
	Resource utilisation	.6 Environmental strategies, corporate water policies of resource utilisation/global standards	[46]	Early stage	Aspiring to improve	Mature			
			[36]	Unaware/ non-complained	Ad hoc/basic compliance	Defined/compliance	Linked/Exceed compliance	Integrated/Proactive	Extended/ sustainability leadership
			[43]	Defined	Measure and manage	Improve and change			
SN connectivity			[15]	No coherent strategy	Piecemeal coordination	Systematic coordination	Network coordination	Cross enterprise and broader level regional alignment and coordination	
	.5 Resource allocation	.5 Strategy on resource sourcing (between organisations, value chain, local communities)	[27]	Reactor	Contributor	Innovator			
			[46]	Early stage	Aspiring to improve	Mature			
	Resource sustainment	Collaboration between SC partners/ community/policy	[41]	Beginning	Elementary	Satisfying	Sophisticated		
			[39]	1	2	3	4		
			[43]	Defined	Measure and manage	Improve and change			
	.5 Resource utilisation	Resource utilisation programmes across value chain	[37]	1	2	3	4		
			[38]	Non-existent/Unaware	Low/Unprepared	Moderate/Committed	High/Advanced		
SN efficiency			[15]	Baseline	Reactive problem solving	Systematic development of programme	Network development	Cross-enterprise collaboration	

Table 1. *Cont.*

SN Attribute Cluster	Water Scarcity Mitigation Strategy	Mitigation Capabilities	Ref.	Maturity Levels					
				1	2	3	4	5	6
	Resource allocation	Water scarcity mitigations strategies readiness	[56]	Process not existing/not relevant	Process existing but not transparent	Existing KPI for the process. Single optimization methods	Advanced optimisation methods	Advanced optimisation management methods	
	Resource sustainment	Water conservation, reuse, recycling programmes	[46]	Early stage	Aspiring to improve	Mature			
			[27]	Reactor	Contributor	Innovator			
	Resource utilisation	Water foot printing throughout SNs/ resource efficiency	[56]	Process not existing/not relevant	Process existing but not transparent	Existing KPI for the process. Single optimization methods	Advanced optimisation methods	Advanced optimisation management methods	
Network process			[15]	Baseline	Functional integration	Internal integration	External integration	Cross-enterprise collaboration	
	Resource allocation	Water scarcity consideration in production process design	[41]	Beginning	Elementary	Satisfying	Sophisticated		
	Resource sustainment	Implementation of new technologies (innovations), approaches, employees' education aiming water efficiency in production process	[56]	Process not existing/not relevant	Process existing but not transparent	Existing KPI for the process. Single optimization methods	Advanced optimisation methods	Advanced optimisation management methods	
			[46]	Early stage	Aspiring to improve	Mature			
			[38]	Non-existent/Unaware	Low/Unprepared	Moderate/Committed	High/Advanced		
			[41]	Beginning	Elementary	Satisfying	Sophisticated		
			[48]	Low innovation awareness	Sporadic/reactive innovation	Early systematic innovation	Aligned and partial integrated innovation culture and innovation processes	Well integrated culture of innovation and innovation processes	

Table 1. *Cont.*

SN Attribute Cluster	Water Scarcity Mitigation Strategy	Mitigation Capabilities	Ref.	Maturity Levels					
				1	2	3	4	5	6
			[45]	Beginning	Improving	Succeeding	Leading		
			[38]	Non-existent/Unaware	Low/Unprepared	Moderate/Committed	High/Advanced		
			[41]	Beginning	Elementary	Satisfying	Sophisticated		
			[37]	1	2	3	4		
			[59]	Reactive	Preventive	Proactive			
			[43]	Defined	Measure and manage	Improve and change			
Network product			[15]	Informal	Functional/formal	Project excellence	Collaborative		
	Resource allocation	Firm's perception of water scarcity in the SCs	[37]	1	2	3	4		
	.5 Resource sustainment	.5 Water scarcity problems in product design; Assessment of water levels in materials	[45]	Beginning	Improving	Succeeding	Leading		
			[56]	Process not existing/not relevant	Process existing but not transparent	Existing KPI for the process. Single optimization methods	Advanced optimisation methods	Advanced optimisation management methods	
			[41]	Beginning	Elementary	Satisfying	Sophisticated		
			[44]	1	2	3	4	5	
	.5 Resource utilisation	.5 Assessment of an environmental impact of a product	[44]	1	2	3	4	5	
			[41]	Beginning	Elementary	Satisfying	Sophisticated		

3.2. Model Testing

In order to test the proposed framework, an exploratory case study was conducted. The case study approach was chosen due to the exploratory nature of the study. Selection of the exploratory case company was determined according to the level of interest of the multinational organisation in tackling water scarcity problems in its global operations. Our case study was informed by a large multinational organisation within the pharmaceutical industry sector, with wide supply networks and some manufacturing operations located in water-stressed regions. Semi-structured interviews were conducted with the Senior Sustainability Manager of the organisation. Due to a non-disclosure agreement, the company and the identity of the interviewee were kept anonymised. The interviews were arranged in several sessions with a total duration of five hours. The first four sessions were employed to inform and describe the dimensions of the framework, while the final session served to validate the whole framework. The data gathered was complemented with secondary sources, including company reports, news sources, and sustainability reports. The interviews were recorded and transcribed for subsequent analysis.

Qualitative coding was used to analyse the interviews. Thematic analysis was used to identify relevant topics emerging from the data. Through two iterations of coding, the elements of the framework were refined. The results of the analysis are presented in the following section.

4. Analysis

During the exploratory case study, maturity model refinement and testing took place. As a result, the questions that researchers provided regarding the defined maturity dimensions were clarified and reformulated. Integrated findings across the exploratory case study were recorded (Figure 3) and analysed. The table provides an overview of the current state of the mitigation capabilities of the pharmaceutical firm and suggests further possible developments and improvements for these capabilities.

The framework (Figure 1) incorporates the top-level common descriptors for each maturity level that is assigned according to its mitigation capability under specific mitigation strategies and SN configuration clusters. For practical purposes the dimensions maturity model employed were further clarified. The study extended its focus beyond the top-level descriptors and the assigned dimensions. The model uses a scale of five levels of maturity for each SN domain, which is characterised by a top-level common descriptor to provide an alignment of each level of maturity in each sub-domain. This facilitates a comparison between the line items in the model. A comprehensive version of the framework that contains five clusters is thus developed, which includes multiple (15) sub-dimensions and descriptive assessments with measurements (Appendix A). Examples of each cluster with sub-dimension descriptions according to their maturity levels are further discussed.

SN structural cluster	**Static**	**Static**	**Static**	**Static**	**Dynamic**
SSN design	**1– Initial**	**2 – Limited**	**3 – Defined/Systematic**	**4 – Managed**	**5- Mastered**
1.Resource allocation	No strategy of resource sustainable allocation	Firm still doesn't have resource allocation strategy, but follows certain criteria (not standardised/not defined	Set of rules (internal) was established for resource allocation criteria. Application of these rules only through few functional units	Building redundancy and flexibility through resource allocation. Strategies are fully integrated through value chains	Strategic plant allocation, sourcing, relocation;
2. Resource sustainment	No water assessment tools, method, technology. No environmental strategies	Not clearly defined; initial attempts to assess resource availability; assessment is underway in few areas of SC; environmental strategies are not clearly defined yet	General awareness of water assessment tools/techniques . Employment of water assessment tools for major operational locations ("black box"/"fixed box" tools). Environmental sustainment strategies are developed and adopted for major water risk areas	Technology tracking; environmental strategies fully deployed as part of corporate sustainability strategy; on-going refinement and adjustment of tools. (Go beyond "black box") for major suppliers in water scarcity risk areas. Continuous improvement of WA approaches	New technology tracking; innovation management; Well-defined, innovative water assessment approach is fully deployed across end-2-end SC (application of "open box tools")
3. Resource utilisation	No corporate water policies of resource utilisation	Water utilisation polices are not well defined and disintegrated	Set of rules and corporate standards is defined and used intra-firm for water stress hotspots	Close-loop SC design; water use efficiency for plants. Global sustainability standards adoption; rules and standards of sustainable water management are widely used across value-chain	Strategic integration of water management into corporate polices and management for intra-/inter -firm
Network connectivity	**No coherent strategy**	**Piecemeal coordination**	**Systematic coordination**	**Network coordination**	**Cross enterprise and broader level regional alignment and coordination**
1. Resource allocation	No strategy on resource sourcing (between organisations, value chain, local communities)	Initial steps to engage with suppliers for resource sourcing in for some of the locations in case of resource scarcity	Defined strategy for sustainable resource sourcing	Effective and efficient resource sharing; flexibility of changing suppliers	Investment in water offsetting programmes for watershed,; resource sharing with local community
2. Resource sustainment	No collaboration: SC partners, community, policy	Limited collaboration	Well defined collaborative programmes . Top suppliers engagement	Collaboration with value chain partners for reduction of raw material consumption; Stakeholder/community/policy engagement; Cross-functional teams installations	Business continuity planning with the firm and SC; Supplier/employee training programmes; Full water stress management collaboration
3. Resource utilisation	No resource utilisation programmes across value chain	Not well defined programmes for suppliers water assessment; Assessment happens only when resource level is critical and threatening sustainable production operations	Well defined suppliers assessment standard for resource utilisation	CSR programmes for resource management; Key performance indicators for suppliers	Corporate indicator exceeding the standards of water intake/wastewater discharge
Network efficiency	**Baseline**	**Reactive problem solving**	**Systematic development of programme**	**Network development**	**Cross-enterprise collaboration**
1. Resource allocation	Production disruptions caused by resource scarcity are not managed	Production disruptions are mitigated at some of the functional units but there is still no corporate mitigation strategy in place	Corporate water stress mitigation strategies in place and systematically employed across all functional units	Ability to map risks (direct and indirect); production disruption minimisation through substitution of the resource supplier. Corporate water stress mitigation strategies employed across value chain	Participation in various water stress mitigation programmes (local and global), capital investments in infrastructure
2. Resource sustainment	Water conservation, reuse, recycling programmes are not employed yet	Recycle and conservation programmes are implemented only when company is forced by regulations, standards in few functional units	Recycled and conservation programmes are initiated and developed through the most of functional units	Improved tools for management processes; conservation programmes, recovery, recycling, emissions management; shift from an inter-firm to an intra - SC level of water management	Water neutral. Support local communities with extra resources replenished. Capital investments in technology (reclamation, water usage minimisation)
3. Resource utilisation	Water footprint of functional units is not traced	Water footprint of certain functional units (hotspots) is monitored	Water foot printing and water footprint minimisation is part of corporate environmental strategy	Water footprint minimisation in direct and supply chains; lean manufacturing processes	Ability to adapt to environmental changes rapidly and accurately; broad strategy on resource substitution/avoidance where it is possible through the whole value chain
Network process	**Baseline**	**Functional integration**	**Internal integration**	**External integration**	**Cross-enterprise collaboration**
1. Resource allocation	Water scarcity consideration in production design doesn't occur	New process design – water minimisation (recycling) for some of the manufacturing locations	New process design – water minimisation (recycling) for all manufacturing locations	Water minimisation through new processes implementation; recycling as a part of product/service design	Minimisation of water via process design; work place design (minimise water consumption); ability to meet regulatory and taxation changes
2. Resource sustainment	Implementation of new technologies and approaches for water minimisation in the process design and Employees training doesn't occur	Implementation of new technologies and approaches for water minimisation in the process design takes place only in a few functional units; Employees training is minimal or doesn't occur	Implementation of new technologies and approaches for water minimisation in the process design takes place through all functional units; Employees training about the ways to minimize water takes place, but not standardised yet. Firm tries to minimise water consumption via efficient work place design at some functional units	Implementation of new technologies and approaches for water minimisation in the process design takes place not only inside the firm but main suppliers are engaged; Employees training programmes are well defined and standardised; . Firm tries to minimise water consumption via efficient work place design cross organisation	Implementation of new technologies and approaches for water minimisation in the process design is highly integrated practice through the whole value chain; Employees training programmes are state of art; Work places are design wit consideration of water efficiency
3. Resource utilisation	No reporting/No information disclosure to stakeholders; SC are unaware and non-compliant to any regulations	Limited internal reporting; integration of environmental sustainability into product design due to standards/regulation requirements; Basic level regulations compliance	Wider internal reporting; comprehensive sustainable water management performance measurement system in place; Full compliance with regulations.	Sustainable operations management; product and process traceability for government regulations; integration of the reporting programmes (GRI), external reporting participating in GRI, CDP, ISO, UN global compact; Full compliance with regulations.	Participation in all GRI, CDP, ISO, UN global compact. Sustainable water management is a fully integrated concept; Full compliance with regulations.
Network product	**Informal**	**Functional/formal**	**Project excellence**	**Portfolio excellence**	**Collaborative**
1. Resource allocation	Water perceived as a plentiful resource; no consideration is given to new processes in product design	Water reduction is included in some of the products design/redesign;	Water reduction aspect is included in all product design/redesign	Water minimisation through new process implementation. New technologies, innovative processes for water minimisation	Integration of water scarcity aspects in sustainable product design through collaborative effort with supply network partners
2. Resource sustainment	Water in materials employed is not assessed;	Materials consideration is applied only in a few functional units;	New materials with low water footprint are considered for product design. Materials assessment is employed through all functional units;	Material efficiency; reduction of product environmental impact via informal material selection; material substitution where it s possible;	Innovative processes minimising efficient water consumption for manufacturing product application;
3. Resource utilisation	Product environmental impact is not assessed	Environmental impact of a critical (hot-spot) product is assessed (New Products)	Environmental impact of all products is assessed	Environmental impact of all products is continuously minimised	Eco design; sustainable product design

Figure 3. Application of the maturity model: A case study.

4.1. Sustainable SN Design

This cluster contains sub-elements—capabilities—determined by water scarcity mitigation strategies. A water allocation strategy employs sustainable resource allocation within SNs and capabilities to sustainably locate a firm's facilities. A mature organisation is driven by strategic plans regarding their water sourcing options and the best allocation opportunities of the scarce resource through their SNs. In addition, the firm will address water scarcity problems through sustainable facility location and dispersion. For example, the capacity of the plant will be dictated by the amount of water available at its physical location. A water sustainment strategy incorporates capabilities to employ and utilise water scarcity assessment tools, methods, and datasets. The mature organisation is expected to develop an ability to track new water assessment technologies and tools and to innovate in water scarcity levels assessment and management throughout their SNs. At this stage, the firm fully understands their employed water assessment tools and even has an ability to develop its own assessment tools. Adopting a resource utilisation approach the firm develops environmental strategies and corporate water policies for efficient and effective resource utilisation. Within this context global standards of water management can be adopted. The mature firm is expected to demonstrate a strategic integration of water management approaches complying or even exceeding global sustainability standards.

4.2. Network Connectivity

This domain reflects the extent to which networks of organisations are connected in terms of the utilisation water scarcity mitigation approaches. Mitigation capabilities emerging from this cluster include strategies on resource sourcing inside the organisation, between organisations, across value chains, and between other water resource stakeholders e.g., local communities; the level of collaboration regarding water scarcity problems with SN partners, communities, and policymakers; the extent to which SN partners comply with corporate water management programmes. A mature organisation is expected to demonstrate that they continuously invest in water offsetting programmes for a watershed. The firm provides excessive water management training programmes for suppliers. A water stress management collaboration is established across end-to-end SCs. The firm deploys cross-value chain sustainable water management indicators that exceed the standards of water intake and wastewater discharge.

4.3. Network Efficiency

Within the network, efficiency domain desired capabilities include various mitigation programmes e.g., recycling and reuse, water foot printing across the network of organisations, and water scarcity mitigation solutions readiness. A mature company is expected to demonstrate participation in various water stress mitigation programmes at the local and global levels and capital investments in water infrastructures at the operations' locations. The company should aim to become water-neutral. Local communities should be provided with extra water resources through water replenishment and recovery, which is possible with capital investments in up-to-date water efficiency and reclamation technologies. Thus, the firm can adapt to environmental changes rapidly and accurately. A mature organisation has well-developed resource substitution and scarce resource avoidance programmes in place within their SNs.

4.4. Network Process Development and Reporting

This cluster includes capabilities that enable traceability and transparency of the firm's regulations compliance with regard to water-efficient processes and shows the progress of water management strategies through information disclosure and reporting. This cluster employs capabilities for effective water usage through the application of water-efficient technologies in the process design and extensive water minimisation training programmes at the workplace for employees. The mature organisation will demonstrate high performance in water scarcity management by applying a water-efficient manufacturing process design through the employment of state-of-the-art technologies. The firm will also standardise employee training programmes to be applied through all functional units. These standardised programmes can be utilised to help cross-value chain partners. The organisation will widely implement water minimisation strategies through efficient workplace design. The mature organisation will have a highly developed adaptability to changing regulatory and taxation requirements. The mature firm will report to highly recognised reporting initiatives e.g., GRI, CDP, and ISO. Sustainable water management at this stage becomes a fully integrated concept.

4.5. Network Product Enhancement

The final domain of the sustainable SN maturity refers to innovative process integration into a product design to achieve water resource minimisation. Water efficiency in product design of the mature organisation is achieved through a collaborative effort with the SN partners. A mature organisation highly monitors the environmental impact of their products, aiming at a sustainable product design, such as eco-design, zero-impact design, and water-neutral products.

Second, the results from the maturity model testing phase were analysed. The analysis has facilitated the framework validation in terms of its applicability and refinement. The outcomes of the analysis are illustrated.

In our case study, the company's choice of the manufacturing locations was historically driven primarily by proximity to the market and the problem of resource scarcity was not taken into account when production sites were designed. Some of the sites, however, were later strategically set in areas less affected by water scarcity. The decision to locate production operations in these regions was partially driven by resource availability. However, the company states '[W]e don't (built our sites) yet (according to water stress level). We should but we don't actually physically do that yet'. The analysis has also shown that the firm has already experienced problems with water supply by wrongly locating their new production site in the water-scarce region. This mistake has resulted in the excessive cost of their new facility.

The analysis has also shown that key raw material suppliers of this firm tend to be located in regions of water scarcity. Here, suppliers, sometimes even farmers, lack an understanding of the local resource scarcity situation and available water scarcity mitigation practices, which in turn brings pressure to the manufacturing organisation. As a result, the firm is forced to mitigate water scarcity problems not only at the organisational level but also within extended SNs. For this purpose, the firm extensively employs publicly accessible water availability assessment tools. The employed tools help the company to monitor the current level of water availability throughout the firm's manufacturing operations locations and suppliers' locations, as well as facilitate an assessment of possible risks due to future water availability and subsequent mitigation solutions development. One of the mitigation strategies developed by the firm is the introduction of water stewardship programmes and guidance that is developed with accordance to global programmes by the Alliance of Water Stewardship and CEO Water Mandate, which helps key raw material suppliers to evaluate their operations affected by water stress and facilitates design of continuous improvement strategies. In addition to that, the firm employs "water Kaizen [which] is an audit programme for efficient water use, [which is] rolled out in our supply network, whenever there is a problem'. When there is a risk of materials supply halting or a regulatory burden increase in a certain location, the firm employs sustainable resource sourcing programmes that allow the company to switch from one supplier to another. The organisation has five backup suppliers for each key raw material and contractual agreements in place to provide an alternative water supply within 48 h in case of any disruption events, e.g., supplying water with tankers. 'For expensive medically critical materials, it will be two supplies and one backup as minimum'—stated one industrial expert.

In order to sustain continuous operations, the firm has to be as flexible as possible and as cost-efficient as possible. To achieve this, a collaboration between SN partners should be developed and constantly improved. For instance, the organisation provides all their suppliers with a checklist, guidance, and recommendations to assess water scarcity risks in their SNs to help develop water management projects and to provide knowledge about existing water efficient technologies. This, in turn, facilitates a shift from intra-firm to cross-value chain water conservation programme applications. The company develops initiatives to engage a community, policy, and other stakeholders operating in the natural resource-scarce regions in joint efforts toward water scarcity mitigation.

At the process level, the firm adopts a new process design that involves water minimisation through water recycling and reuse. To achieve these new technologies and innovative processes are adopted. The firm continuously seeks possible alternative water minimisation solutions, e.g., the development of water-neutral processes. Recently the company has introduced water filtering and leak monitoring programmes to their sites. In designing the product, the company pays particular attention to water minimisation, assessing the individual footprints of each raw materials employed and utilising specially in-house developed LCIAs for more than 330 materials. Unfortunately, only some functional units and selected critical products undergo environmental impact assessment.

During the exploratory case study, a maturity model refinement and testing took place. As a result, the questions that researchers provided regarding the defined maturity dimensions were clarified and reformulated. Integrated findings across of the exploratory case study are provided in Figure 3. The table provides an overview of the current state of the mitigation capabilities of the pharmaceutical firm and suggests further possible developments and improvements for these capabilities.

The maturity model building phase has resulted in the introduction of an integrated evaluation instrument (Appendix A), which includes three strategies and multiple capabilities.

5. Discussion

A great proportion of studies in the area of sustainable maturity mode development are mainly focused on a limited number of sustainable capabilities. For instance, work by Edgeman and Eskilsen [48] is focused on the assessment of innovation technology sustainability. Okogwu et al. [43] and Baumgartner and Ebner [41] consider the maturity of sustainability initiatives reporting. Sustainability assessment in projects and project management is provided in the work by Silvius and Schipper [57]. Similarly, many studies are focused on only one element of the triple bottom line approach. For example, the environmental aspect of sustainability assessment was evaluated in studies by Closs et al. [27], Babin and Nicholson [46], Hynds et al. [45], Jabbour et al. [59], Pigossi et al. [44], Doss et al. [60], and Zhao et al. [37]. Only a limited number of articles are focused on the integrated assessment of multiple capabilities that are evaluated based on societal, economic, and economic criteria of sustainability.

Current work proposes an integrated maturity framework that incorporates 15 capability dimensions under three mitigation strategies for environmental, societal, and economic assessments of water scarcity mitigation maturity. The water scarcity mitigation maturity framework is the novel research in the field of SC capabilities, particularly in maturity model design that is focused on a natural resource scarcity assessment. The proposed mitigation capability maturity framework developed is based on the proposition that global SNs serving geographically dispersed markets face the problem of water availability. By mitigating this problem, the company acquires specific capabilities under vigorous SC strategies. This study suggests that when the firm undergoes a maturing process, SN mitigation capabilities should be evaluated in a structural manner to inform SN design and subsequent reconfiguration.

This study indicates a distinction in capability types for the evaluation process. The capabilities vary from static to dynamic [3], suggesting that a firm that develops water stress mitigation excellence would be able to demonstrate the highest maturity level, signalised by dynamic capabilities acquisition. The SN configurational dimensions are presented through five configurational clusters [15]. Each cluster refers to one of the SC mitigation strategies for water scarcity mitigation [3]. The application of the model by the firm is suggested to provide companies with information about existing vulnerabilities and to propose further mitigation solutions that can be expressed by means of sustainable SN configurations.

The proposed maturity model is tested through an exploratory case study of the multinational organisation within the pharmaceutical industry in order to confirm the validity of the model and suggest future directions as presented in Figure 3. From drawing on the empirical evidence collected from semi-structured interviews and complementary secondary sources, it is evident that the organisation has a strong interest in the problem of water scarcity mitigation. The overall company performs well in mitigation water scarcity. However, these measures are performed only 'for critical areas and critical products'. Most of the capabilities developed vary between second and fourth levels of maturity. Five of the mitigation strategies that rank the highest in their level of maturity are primarily in network efficiency and network process development and reporting clusters, which mean that these two clusters in the SN structure are sufficiently developed. The organisation adopts water stewardship strategies such as recovering rainwater, recharging aquifers, etc. for the sites that are critical or when a significant water reduction target is set. The analysis has shown that the firm experiences a misalignment of business strategies with supply chain strategies that might be a result of lack of internal coordination between functional units. The next step for the firm would be acquiring dynamic capabilities in order to achieve the highest maturity level. In order to achieve a sustainable SC performance, the firm ought to put a significant effort in developing these clusters it scores the lowest. Overall, the case study shows the current level of the firm's capability development and highlights a number of steps required to attain higher maturity level capabilities in order to achieve a desirable performance.

6. Conclusions

An assessment of water scarcity mitigation capabilities in SNs is an emerging area of SC research. This is supported by an extensive literature review process and tested through an exploratory case study. This paper makes an attempt to bridge the gap in the sustainable SC literature by integrating strategies for water scarcity mitigation [3] and SN capabilities for the capability maturity model building. The proposed model is built upon three literature domains. Natural resource scarcity emphasises the importance of sustaining resource availability to meet growing demand from a long-term perspective [10]. This incorporates SN capability theory, which emphasises new process developments to sustain long and short-term competitive advantages along with SC performance development. These all results in SN configurational opportunities to achieve water scarcity mitigation excellence.

In the SC literature, a large number of studies are focused on the capability building process. A considerable amount of studies has been conducted with respect to SN configurational aspects. Hence, there is little evidence suggesting the alignment of these two elements. This work extends the structural capabilities perspective [3,16] to the natural resource scarcity context to propose an integrated sustainable capability maturity model. The model is designed to assess complex multi-dimensional SNs within a water scarcity context based on weighted metrics. The ability to integrate sustainable water management dimensions into broader SN capability dimensions enables these two aspects to be considered in a more holistic manner.

Here a maturity model is developed, capturing water mitigation approaches, and is used to identify current capabilities and future ambitions. The future state desired capabilities are considered both in terms of the organisational routines required to comply with mitigation strategies, but also in alternative SN configurations; network structure, process flow, product architecture, and supply partnerships that are aligned with the resource scarcity view. The proposed maturity capability framework also makes a clear distinction between static and dynamic capability types, emphasising that more mature mitigation practices are conventionally comprised of dynamic water mitigation strategies. Proposed maturity framework presents an integrated model that provides a mechanism to evaluate the current level of operational development and to propose further steps toward water scarcity mitigation excellence for internal and external users.

Initial testing of the maturity model in the exploratory case study of a multinational organisation is presented, demonstrating the feasibility and utility of the approach for industrial implication. The maturity model can be used in order to identify the current level of water scarcity mitigation practices employed and scoping potential SN configurational pathways for the industrial sustainable water management. The case study shows that the firm primarily develops static capabilities (Figure 3) with a capability maturity levels range from 2 to 4. However, the organisation has strong ambitions to develop dynamic mitigation capabilities (level five) in the future.

The proposed framework is empirically shown to be a water scarcity mitigation capabilities evaluation instrument. This sustainability assessment approach can be employed in association with other performance measurement methods. The proposed maturity model is a suitable tool for measuring water scarcity sustainable mitigation practices and is also applied as a precursor to delivering more advanced performance.

7. Limitations and Future Work

This study provides is an initial attempt to propose a maturity model for mitigation capability development progress assessment. The model was built primarily based on a literature review process and tested utilising one industrial case. Further testing of the model in different industry sectors utilising a case-study approach will enrich the results and thus render the model robust. The development of the quantitative assessments utilising statistical or mixed methods will increase the reliability and validity of the model. The current limitations of the work provide directions for future research.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Water Mitigation Maturity Model

Table A1. Water mitigation maturity model.

SN Structural Cluster	Static	Static	Static	Static	Dynamic
SSN design	**1—Initial**	**2—Limited**	**3—Defined/Systematic**	**4—Managed**	**5—Mastered**
1. Resource allocation	No strategy of resource sustainable allocation	Firm still doesn't have resource allocation strategy, but follows certain criteria (not standarised/not defined	Set of rules (internal) was established for resource allocation criteria. Application of these rules only through few functional units	Building redundancy and flexibility through resource allocation. Strategies are fully integrated through value chains	Strategic plant allocation, sourcing, relocation;
2. Resource sustainment	No water assessment tools, method, technology. No environmental strategies	Not clearly defined; initial attempts to assess resource availability; assessment is underway in few areas of SC; environmental strategies are not clearly defined yet	General awareness of water assessment tools/techniques. Employment of water assessment tools for major operational locations ("black box"/" fixed box" tools). Environmental sustainment strategies are developed and adopted for major water risk areas	Technology tracking; environmental strategies fully deployed as part of corporate sustainability strategy; on-going refinement and adjustment of tools. (Go beyond "black box") for major suppliers in water scarcity risk areas. Continuous improvement of WA approaches	New technology tracking; innovation management; Well-defined, innovative water assessment approach is fully deployed across end-2-end SC (application of "open box tools")
3. Resource utilisation	No corporate water policies of resource utilisation	Water utilisation polices are not well defined and disintegrated	Set of rules and corporate standards is defined and used intra-firm for water stress hotspots	Close-loop SC design; water use efficiency for plants. Global sustainability standards adoption; rules and standards of sustainable water management are widely used across value-chain	Strategic integration of water management into corporate polices and management for intra-/inter—firm

Table A1. *Cont.*

SN Structural Cluster	Static	Static	Static	Static	Dynamic
Network connectivity	**No coherent strategy**	**Piecemeal coordination**	**Systematic coordination**	**Network coordination**	**Cross enterprise and broader level regional alignment and coordination**
1. Resource allocation	No strategy on resource sourcing (between organisations, value chain, local communities)	Initial steps to engage with suppliers for resource sourcing in for some of the locations in case of resource scarcity	Defined strategy for sustainable resource sourcing	Effective and efficient resource sharing; flexibility of changing suppliers	Investment in water offsetting programmes for watershed, resource sharing with local community
2. Resource sustainment	No collaboration: SC partners, community, policy	Limited collaboration	Well defined collaborative programmes. Top suppliers engagemen	Collaboration with value chain partners for reduction of raw material consumption; Stakeholder/community/policy engagement; Cross-functional teams installations	Business continuity planning with the firm and SC; Supplier/employee training programmes; Full water stress management collaboration
3. Resource utilisation	No resource utilisation programmes across value chain	Not well defined programmes for suppliers water assessment. Assessment happens only when resource level is critical and threatening sustainable production operations	Well defined suppliers assessment standard for resource utilisation	CSR programmes for resource management; Key performance indicators for suppliers	Corporate indicator exceeding the standards of water intake/wastewater discharge

Table A1. *Cont.*

SN Structural Cluster	Static	Static	Static	Static	Dynamic
Network efficiency	**Baseline**	**Reactive problem solving**	**Systematic development of programme**	**Network development**	**Cross-enterprise collaboration**
1. Resource allocation	Production disruptions caused by resource scarcity are not managed	Production disruptions are mitigated at some of the functional units but there is still no corporate mitigation strategy in place	Corporate water stress mitigation strategies in place and systematically employed across all functional units	Ability to map risks (direct and indirect); production disruption minimisation through substitution of the resource supplier. Corporate water stress mitigation strategies employed across value chain	Participation in various water stress mitigation programmes (local and global), capital investments in infrastructure
2. Resource sustainment	Water conservation, reuse, recycling programmes are not employed yet	Recycle and conservation programmes are implemented only when company is forced by regulations, standards in few functional units	Recycled and conservation programmes are initiated and developed through the most of functional units	Improved tools for management processes; conservation programmes, recovery, recycling, emissions management; shift from an inter-firm to an intra—SC level of water management	Water neutral. Support local communities with extra resources replenished. Capital investments in technology (reclamation, water usage minimisation)
3. Resource utilisation	Water footprint of functional units is not traced	Water footprint of certain functional units (hotspots) is monitored	Water foot printing and water footprint minimisation is part of corporate environmental strategy	Water footprint minimisation in direct and supply chains; lean manufacturing processes	Ability to adapt to environmental changes rapidly and accurately; broad strategy on resource substitution/avoidance where it is possible through the whole value chain

Table A1. *Cont.*

SN Structural Cluster	Static	Static	Static	Static	Dynamic
Network process	**Baseline**	**Functional integration**	**Internal integration**	**External integration**	**Cross-enterprise collaboration**
1. Resource allocation	Water scarcity consideration in production design doesn't occur	New process design—water minimisation (recycling) for some of the manufacturing locations	New process design—water minimisation (recycling) for all manufacturing locations	Water minimisation through new processes implementation; recycling as a part of product/service design;	Minimisation of water via process design; work place design (minimise water consumption); ability to meet regulatory and taxation changes
2. Resource sustainment	Implementation of new technologies and approaches for water minimisation in the process design and Employees training doesn't occur	Implementation of new technologies and approaches for water minimisation in the process design takes place only in a few functional units; Employees training is minimal or doesn't occur	Implementation of new technologies and approaches for water minimisation in the process design takes place through all functional units; Employees training about the ways to minimize water takes place, but not standardised yet. Firm tries to minimise water consumption via efficient work place design at some functional units	Implementation of new technologies and approaches for water minimisation in the process design takes place not only inside the firm but main suppliers are engaged; Employees training programmes are well defined and standardised; Firm tries to minimise water consumption via efficient work place design cross organisation	Implementation of new technologies and approaches for water minimisation in the process design is highly integrated practice through the whole value chain; Employees training programmes are state of art; Work places are design wit consideration of water efficiency
3. Resource utilisation	No reporting/No information disclosure to stakeholders; SC are unaware and non-compliant to any regulations	Limited internal reporting; integration of environmental sustainability into product design due to standards/regulation requirements; Basic level regulations compliance	Wider internal reporting; comprehensive sustainable water management performance measurement system in place; Full compliance with regulations.	Sustainable operations management; product and process traceability for government regulations; integration of the reporting programmes (GRI), external reporting participating in GRI, CDP, ISO, UN global compact; Full compliance with regulations.	Participation in all GRI, CDP, ISO, UN global compact. Sustainable water management is a fully integrated concept; Full compliance with regulations.

Table A1. *Cont.*

SN Structural Cluster	Static	Static	Static	Static	Dynamic
Network product	**Informal**	**Functional/formal**	**Project excellence**	**Portfolio excellence**	**Collaborative**
1. Resource allocation	Water perceived as a plentiful resource; no consideration is given to new processes in product design	Water reduction is included in some of the products design/redesign;	Water reduction aspect is included in all product design/redesign	Water minimisation through new process implementation. New technologies, innovative processes for water minimisation	Integration of water scarcity aspects in sustainable product design through collaborative effort with supply network partners
2. Resource sustainment	Water in materials employed is not assessed;	Materials consideration is applied only in a few functional units;	New materials with low water footprint are considered for product design. Materials assessment is employed through all functional units;	Material efficiency; reduction of product environmental impact via informal material selection; material substitution where its possible;	Innovative processes minimising efficient water consumption for manufacturing product application;
3. Resource utilisation	Product environmental impact is not assessed	Environmental impact of a critical (hot-spot) product is assessed (New Products)	Environmental impact of all products is assessed	Environmental impact of all products is continuously minimised	Eco design; sustainable product design

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