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Breaking the silos: Bridging the resource nexus in the textile industry when adapting to Zero Liquid Discharge

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DEPARTMENT OF
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INSTITUTIONEN FÖR
GEOVETENSKAPER

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Content

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Abstract: The concept of resource nexus is an acknowledgement of the interconnections between the uses of natural resources. This research will further the work done on the resource nexus by examining the multiple effects of measures taken in the Indian textile industry to lower the costs incurred due to the implementation of Zero Liquid Discharge (ZLD). ZLD combines a variety of technologies to cease the discharge of untreated water from production processes to the surrounding area. The paper will, based on surveys answered by an IKEA supplier and four of IKEA's sub-suppliers of textile in India, present a multiple case study of possible multiple effects of projects undertaken to lower the increased cost of manufacturing with ZLD. Building on the multiple case study, and marrying it with the knowledge of the multiple benefits of energy efficiency improvements, the Value Added Water (VAW) tool, and the rebound effect, this paper constructs and offers a Multiple Effects Framework (MEF) for measures taken in factories as a response to the increased cost of manufacturing with ZLD. The framework handles both quantifiable and non-quantifiable multiple effects of measures taken, such as changes in resource use (water, energy, chemicals, materials), productivity and work environment. The MEF aggregates a more comprehensive picture of the overall effects of measures taken to adapt to the increased costs associated with ZLD in the textile supply chain, and can to a certain extent be applied to other factories facing a future mandate for ZLD. When changed accordingly, the framework can also be applied to other situations and industries as a decision-making and evaluation tool. In order to deepen the understanding of customer expectations and future trends, interviews were made with IKEA co-workers and a consultant involved with the factories investigated. Lessons learnt by IKEA and the consultant regarding ZLD implementation and the resource nexus are presented for internalization by factories, customers and authorities.

Keywords: Sustainable development, resource nexus, rebound effect, multiple benefits, multiple effects, textile industry, Zero Liquid Discharge (ZLD)

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Summary: Natural resources such as water, energy and chemicals are not isolated. They interact with, and affect, each other. This means that our use of natural resources equally is affected by this interconnection. The concept of resource nexus is an acknowledgement of these interconnections between natural resources. This research will further the work done on the resource nexus by examining the multiple effects of projects undertaken in the textile industry to lower the increased costs incurred through the implementation of Zero Liquid Discharge (ZLD). ZLD is where factories significantly lower their discharge of untreated water used in the production process. The paper will, based on surveys answered by textile suppliers in IKEA's Indian supply chain, present a multiple case study of multiple effects of projects undertaken to lower the increased manufacturing cost incurred due to the implementation of ZLD. Building on the multiple case study, and marrying it with the knowledge of the multiple benefits of energy efficiency improvements, the Value Added Water (VAW) tool, and the rebound effect, this paper constructs and offers a Multiple Effects Framework (MEF) for measures taken in factories as a response to the increased manufacturing cost resulting from the use of ZLD. The MEF aggregates a more comprehensive picture of the overall effects of measures taken to adapt to the increased costs associated with ZLD in the textile supply chain, and can to a certain extent be applied to other factories facing a future mandate for ZLD. When changed accordingly, the framework can also be applied to other situations and industries as a decision-making and evaluation tool. In order to deepen the understanding of customer expectations and future trends, interviews were made with IKEA co-workers and a consultant involved with the factories investigated. Lessons learnt by IKEA and the consultant regarding ZLD implementation and the resource nexus are presented for internalization by factories, customers and authorities.

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Prologue

As an energy professional, I became more and more frustrated with the fact that I seem to be working in a silo, not understanding how energy efficiency affects other resource efficiency. I also saw that the same thing was happening in the water sector, albeit not to the same extent. I wanted to bring light from what we've achieved in the energy sector and apply it to the water sector, as well as to all other natural resource sectors. Resources are very rarely used in isolation from each other, and understanding these complex interrelationships is crucial in order to make appropriate decisions.

This is my attempt at bridging the different natural resource sectors and creating a more complete understanding of the resources that make businesses and societies thrive. Likewise, I want to bring light on the multitude of effects resulting from any given change in industry, which if quantified and monetized could lead to better informed decisions and prioritizations from a business perspective.

1. Introduction

1.1. Background

The use of one natural resource affects the use of other resources, sometimes through increasing its use, and sometimes through decreasing it. For example, a significant amount of water is needed to provide the energy we use, and a significant amount of energy is needed to provide the water we use. The interrelation between natural resources is referred to as the resource nexus, and it is essential to understand in order for, amongst others, industry to be part of a sustainable future. Since resources are closely interlinked, it's imperative to consider how an industrial investment aimed at improving the efficiency of one specific resource affects the efficient use of other resources. It's therefore important that industry leaders, experts and policy-makers in different fields understand the interconnectedness between resources and learn how to prioritize between them. The isolated resource-specific silos which experts and policy-makers find themselves in need to be broken in order to ensure overall resource efficiency. It's simply not sufficient to consider energy, water, and other resources in isolation. Breaking down resource management silos means increased cooperation between natural resource sectors in order to create a better prioritized and overall efficient resource use.

Likewise, it's important to acknowledge the business reality in which companies find themselves. We need to understand the full implications of a project or an investment in resource efficiency, or any other type of project, in terms of positive and negative effects on production costs and soft issues such as maintenance and work environment. By gaining a better understanding of the full implications of an investment, overall resource efficiency and cost effectiveness can be ensured. If a deeper analysis of an investment reveals a greater financial cost-saving than previously expected, investments in for example resource efficiency will become more attractive to companies. If, on the contrary, a deeper analysis of an investment in resource efficiency presents a higher cost than expected, and if there is an unintentional increase in the use of another resource, authorities responsible for encouraging resource efficiency can act by providing support. In certain cases, it might also be necessary to prioritize between the efficiency of different resources when a trade-off between these is required.

There are already some methods for calculating the different costs and benefits associated with an investment in a sustainable change in industrial production. One of those is Environmental Management Accounting (EMA). EMA "…represents a combined approach which provides for the transition of data from financial accounting and cost accounting to increase material efficiency, reduce environmental impacts and risks and reduce costs of environmental protection…EMA is particularly valuable for internal environmental management initiatives…" (Jasch, 2008, p. 33). This research paper finds that the EMA is an important and useful tool, however it seems to require a lot of effort by industrial users, thus making it less convenient for them to use. This research also finds that EMA takes an environmental rather than investment entry-point, which might exclude investments not focusing on environmental issues (but which still affect resource use), from being fully analysed. This paper attempts at constructing and offering a low-effort approach for industries to integrate multiple effects into investment decisions regarding projects for lowering the increased cost due to Zero Liquid Discharge (ZLD) implementation, as explained below.

ZLD is an ambitious measure to completely cease the discharge of untreated water from a factory, and it is a legal requirement in the Indian state of Tamil Nadu, which is where the factories in this study are located. The forced instalment of ZLD in the Tamil Nadu region tends to create a difficult financial burden on the textile factories. This is a result of the changed resource use in production after the instalment of ZLD. When firms are forced to adapt to ZLD, their energy costs increase since almost all of the water used in production needs to be treated and reused, which requires a lot of energy. Thus, by lowering the outlet of untreated water, energy use spikes. The increased energy costs hamper the competitiveness of these firms, and necessitates resource efficiency measures (Sustainability Outlook, 2015a). The Swedish International Water Institute (SIWI) has through its program Swedish Textile Water Initiative (STWI) started an analysis of how the cost-cutting projects following ZLD implementation impact chemical, electrical and thermal resource use in the textile industry. This research will further the work done by STWI through compiling the multiple effects, both in terms of resource use and other effects, experienced by five textile factories in the furniture retailer IKEA's supply chain in India as a result of projects undertaken to lower the cost that the implementation of ZLD incurred.

A confidential report from the STWI programme states that in the Tirupur region (in Tamil Nadu, India) where industries are mandated to use ZLD, efforts made to improve water efficiency (i.e. lower the use of water flowing through the process) result in lower energy and chemical use due to the water-energy-chemical nexus. Since it ties in with energy and chemical costs, water efficiency becomes critical for lowering the increased costs of using ZLD (i.e. not discharging any water from the plant). A challenge which is presented in that STWI report is the fact that since production is the main focus for these factories, anything that distracts them from this, such as resource optimisation, does not receive the attention that it needs. The report stresses the need for a way to connect resource savings with production goals. Currently, only a few factories in the programme see the long-term benefits of resource efficiency, while others are acting short-term. In order to motivate more factories to consider long-term benefits, there needs to be a connection between business decisions and efficient resource use (STWI, 2015). This research attempts to provide that connection between resource optimisation and business decisions through highlighting the multiple effects of changes in production.

1.2. Research aim

This research will attempt to ease the transition to ZLD for firms about to face a ZLD mandate, using two approaches. First, it will provide a tool which can be used to better understand the full implications of projects undertaken to lower the financial burden of ZLD, while offering a better understanding of the resource nexus in textile industries. Secondly, it presents lessons learned in the implementation of ZLD for textile factories, and suggests ways in which purchasing brands and authorities may support a successful transition to ZLD.

Through analysing the multiple effects experienced by these factories, this paper aims to create a framework for both financially quantifiable and non-quantifiable multiple effects of cost-cutting measures for the textile factories examined. The framework will contain an analysis of resource use as well as additional effects such as impact on maintenance, productivity and working environment. It will draw on the work done on multiple benefits of energy efficiency and complement it by considering not only benefits, but also adverse effects such as increased resource use, in order to get a better overall understanding of the investment at hand. It will also consider the rebound effect, in other words the increase in resource use after the efficiency has been improved, which can be viewed as positive or negative depending on the perspective taken. Furthermore, it integrates the Value Added Water (VAW) tool from the water management sector in order to assign water a fairer price from both a business and sustainability perspective. The outcome is a new decision-making and evaluation tool called the Multiple Effects Framework (MEF). Although based on a small number of factories, the MEF may be applied to other textile factories which are mandated to use ZLD. This could help them make more informed decisions, optimize resource use and prioritize between investments.

By doing the above, this paper wishes to explore actual economic potentials for companies who consider social and environmental factors along with their business operations. By taking the business perspective, there is limited consideration for the environmental and social benefits which do not directly impact the company at hand. The idea is to only present the business case as faced by the company, which might make the framework more applicable and trustworthy for profit-driven companies.

1.3. Research questions

The research questions for this paper are: What financially quantifiable and non-quantifiable effects have resulted from measures taken to lower the increased costs incurred due to ZLD regulation on the chosen five textile factories in Tamil Nadu, India? How can the findings from the above question be concretized into a framework for application by industry? What lessons learned are there for Indian textile factories who are about to face ZLD regulation, policy-makers who are about to impose it, and the factories' customers?

1.4. Delimitations

This paper focuses on projects and investments related to water management due to the financial undervaluation of water. By clarifying for all the benefits and costs of investing in better water management, a more proper value of water can be developed. The textile industry was chosen as research subject since this is a sector where water is of clear relevance for the management teams. Within the textile industry, a focus on projects to lower increased manufacturing costs due to the implementation of ZLD was chosen since this is a typical example of where projects or investments in water management affect other resource uses. The paper has chosen to investigate firms which have all been subjected to ZLD, since this creates a neutral platform to investigate effects. To be clear, the research does not investigate the resource nexus and multiple effects of ZLD implementation, but instead of the measures taken after the implementation of ZLD in order to lower the increased costs that it entails.

This research is not of technical nature, but rather of an investment decision approach and will therefore not provide a deep technical analysis. The choice of case study subjects is a result of recommendations from SIWI and IKEA in terms of applicability and accessibility. Although arguing for applying the resource nexus concept to all resource use, this paper places special focus on water and energy, which are devoted their own theoretical sections. Chemical use is closely tied to water and energy use in the textile industry, and will therefore be included in the study. However, since there is a literature gap on chemicals in relation to the resource nexus in industry, there will not be a theoretical review for this specific resource.

1.5. Paper set-up

The paper will first go through the different theoretical concepts which are relevant to the research. It will then go on to account for the methods chosen to answer the research questions. Following that, the results are presented, and subsequently analysed and discussed with reference to the theoretical background. The final conclusion accounts for the most important insights and contributions from the research, along with recommendations for further research.

2. Theoretical framework

This section will explain the key theoretical concepts on which the research is based. It will start by handling the basis for this study, i.e. the resource nexus. It will then go on to explain the value of water and the multiple benefits of water efficiency. This will then be connected to the much more developed concept of the multiple benefits of energy efficiency, which this paper will later apply to the textile industry and the resources used there. This theory section will go on to present the complexities of the rebound effect, and then give a background to the concept of Zero Liquid Discharge (ZLD), which is what caused the need for resource efficiency measures for the factories studied. Finally, it will go through the theories which might change our understanding of investment decision-making.

2.1. Resource nexus

Andrews-Speed et al (2012, p. 5) define the resource nexus as comprising "…the numerous linkages between different natural resources and raw materials that arise from economic, political, social, and natural processes." Fig. 1 illustrates the linkages between five resources; however, this concept applies to all resources.

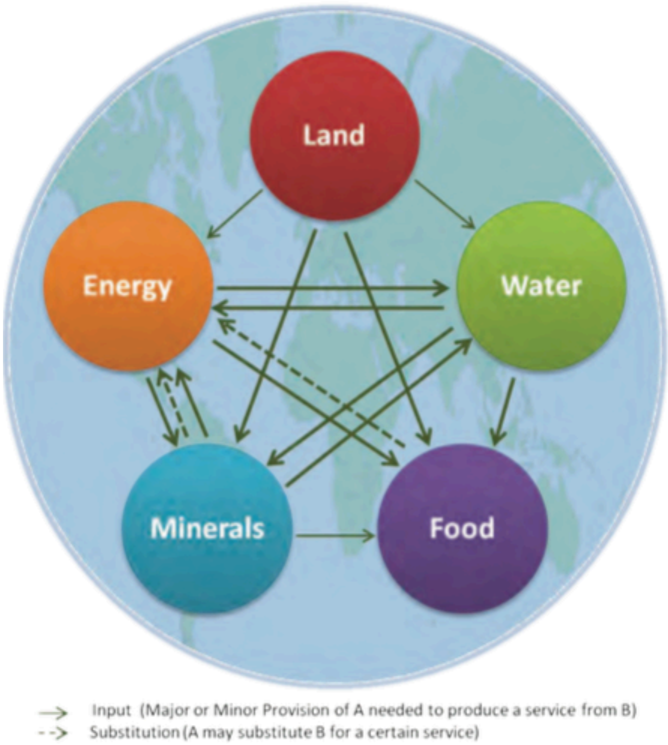

Fig. 1. The resource nexus (Andrews-Speed et al., 2012, p. 7)

Unfortunately, far from all apply the resource nexus concept to resource management and research. Semertzidis (2015) clearly shows his frustration with the way science in the past centuries has focused on isolated issues rather than the complexity that bounds these issues together. He argues that through adhering to reductionism, our understanding of the complicated problems that we face is inadequate. In turn, that means that our reactions to these may be misinformed. Semertzidis therefore argues for the use of the resource nexus concept in order to create synergies and make the most efficient trade-offs for sustainability.

Apart from reducing the risks related to focusing on isolated resource problems, Semertzidis (2015) even argues that taking a resource nexus approach can lead to an improved resource use through recycling and reuse, lowered consumption, increased efficiency etc. All this may happen solely through acknowledging the links between resource issues and acting upon them. He further argues that there is a need for tools and knowledge of the resource nexus to guide political discussions. At the same time, we need to be aware of the fact that the resource-nexus, i.e. the connections between resources; changes along with prices, technologies, behaviours etc. We therefore need to continuously update our tools and our understanding of the nexus.

There is now a growing understanding of the importance of the water-energy nexus. These are the two resources that are most often mentioned related to the resource nexus. The Gulbenkian Think Tank on Water and the Future of Humanity (2014) argues that water and energy are closely interlinked in a water-energy nexus, since in order to produce the clean water we need, energy is required. Likewise, to produce liquid fuels and electricity, water is needed. This means that when planning for the infrastructure and use of one of these resources, the other also needs to be considered. Managing these two resources separately is less efficient than managing them collectively.

Fig. 2 below shows the relationship between energy and water in the production of available energy and water from their raw states. The figure clearly shows how interlinked these two resources are. For example, water is used to transport energy, and energy is used to treat water. The dotted lines refer to situations where additional energy or water is required. By analysing these two resource systems together, it is easier to identify possible efficiency measures, leading to lower costs, less resource use and decreased emissions (Gulbenkian Think Tank on Water and the Future of Humanity, 2014).

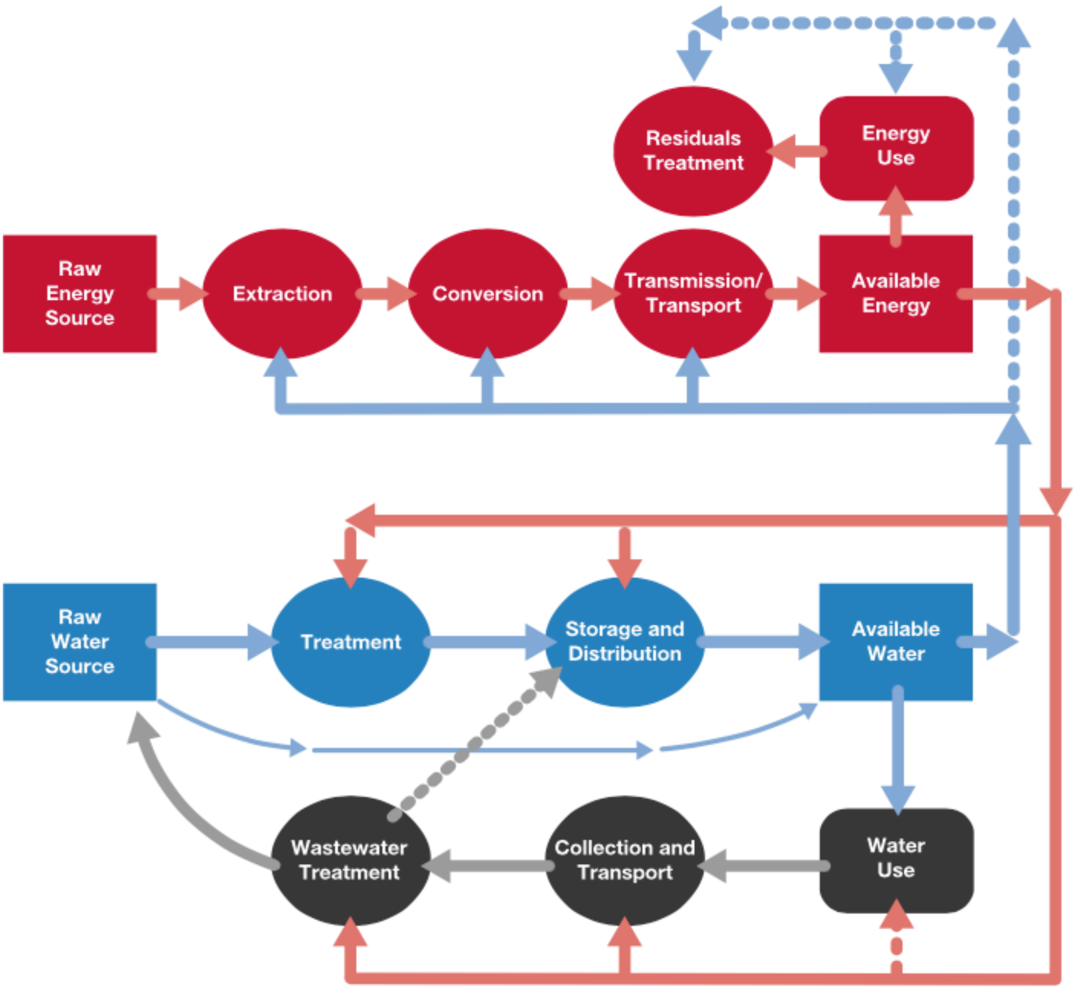

Fig. 2. The relationship between water and energy systems (Gulbenkian Think Tank on Water and the Future of Humanity, 2014, p. 173)

Since this research is focused on the resource nexus within the individual industrial firm, the above figure does not fully represent the system model within the case study subjects. However, from Fig. 2, one can draw the conclusion that wastewater treatment requires additional energy inputs, which is highly relevant for this paper.

Referring to the water-energy nexus and the lack of cooperation between the energy and water sectors, the Stockholm International Water Institute (SIWI) stated in their conclusions from the World Water Week 2014 that "…once and for all, we need to break out of silos." They go on to argue that we still know very little about the water-energy nexus, and we need more concrete examples and more data in different sectors and at different scales (Stockholm International Water Institute, 2014, p. 9). This research aims to add to the knowledge on the resource nexus in general, not only the water-energy nexus.

2.2. Value of water and the multiple benefits of water efficiency

Since water is a key resource investigated in this paper on the resource nexus, it is essential to discuss its value and the multiple benefits of improved water efficiency. Water is, albeit being so critical for human survival and development, undervalued. How is this possible? Water has no substitute, which means that its' intrinsic value has not been reflected in water prices, at the same time as it tends to be subsidized. Compared to other natural resources, it is therefore cheap in relative terms. As a consequence, consumption of fresh water is greater than its replenishment (Seneviratne, 2007). As the World Business Council for a Sustainable Development (2005, p. 1) says, water in many areas finds itself in a triple paradox, where it's "…scarce, cheap, and wasted." They also argue that without water, there is no business.

According to Seneviratne (2007), for the average manufacturing firm, the utility cost of water is about 1-2% of the turnover. However, these are only the visible costs of water. Hidden costs include maintenance costs, cleaning costs, chemical treatment, electricity etc. Fig. 3 below shows how water charges are only the tip of the iceberg of the total cost of water.

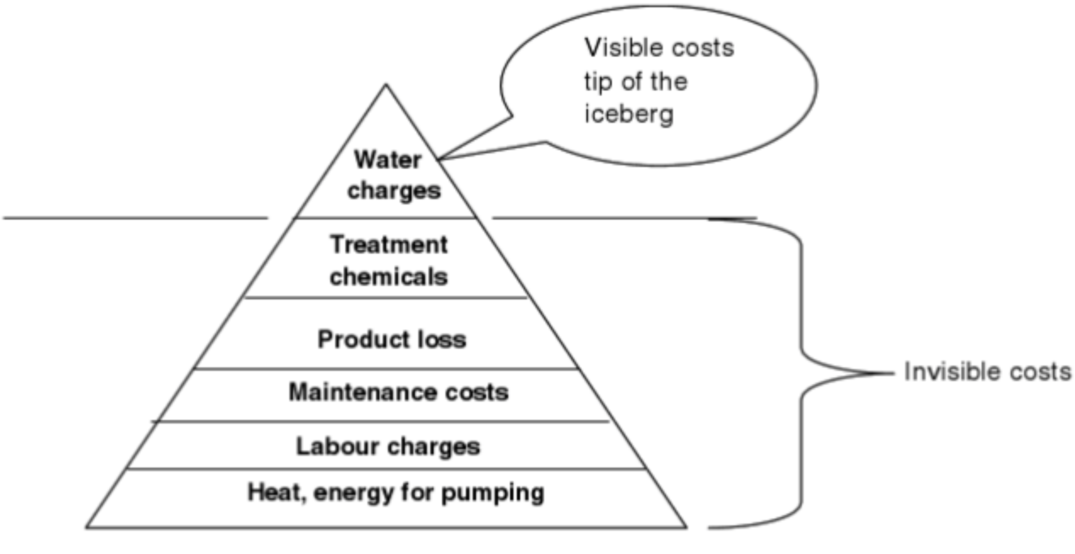

Fig. 3. The visible and invisible costs of water (Seneviratne, 2007, p. 19)

These invisible costs of water can be compared to the growing understanding of the multiple benefits of energy efficiency, as will be described in the next section.

Seneviratne (2007) further argues that improved water efficiency also improves production efficiency for industrial firms. Additional water is made available to accommodate more production, and additional water does not need to be purchased. Likewise, improved water efficiency reduces the need to invest in infrastructure (e.g. tanks and pipes) when increasing production.

Due to the undervalued price of water, it is very important to identify and account for all savings, costs and risks associated with an investment in water efficiency.

Unfortunately, both tangible and intangible benefits and costs of investing in water efficiency are rarely accounted for in investment decision-making. These are for example future water prices or some types of pollution tax. In other words, it is important to account for the risks and benefits of not investing as well as investing in the water efficiency project at hand. Another example is the security of water supply- if the firm has expansion plans then they need to make sure that the water efficiency will be adequate to provide enough water. Some factors which also need to be included in the investment decision are farther removed from production itself. These can be for example lowered transportation costs, improved sales, improved image and better labour relations. The hidden costs of either investing or not can be identified through interviews, measurement, using billing data etc. (Seneviratne, 2007). This again ties to the literature and research done on the multiple benefits of investments in energy efficiency, as described in the next subheading.

Gleick et al (2011) argues that ignoring what he calls co-benefits, or multiple benefits as a lot of research refers to it, of improved water efficiency is dangerous as it reduces complex real-world problems to fit incomplete theoretical frameworks. Although referring to the multiple benefits of improved water efficiency in the agricultural sector, this paper argues that the multiple benefits mentioned by Gleick et al can also be applied to industrial settings. For example, they mention the multiple benefits of reduced energy use and less dependence on an unreliable water source, which are both applicable to industrial settings. An earlier paper by Gleick (2003) on urban efficiency improvements argued that the energy savings from improved water efficiency could be substantial from a financial point of view, and often even exceed the financial savings from improved water efficiency. Unfortunately, these other savings are more often than not ignored when planning for more efficient water use. This is a key argument for this paper.

As argued by the Stockholm International Water Institute (2014), the water sector can learn from the energy sector in terms of how to monetise resource use and make it understandable for most. The water sector has not come very far in this aspect, whereas the energy sector has easily applicable tools for acknowledging energy use. This difference is also visible in the literature review of these concepts. While there is an abundance of literature on energy efficiency, the same does not hold true for water efficiency. Most of the literature on water efficiency is devoted to agricultural water use. Unfortunately, there is not much literature on water efficiency in industry. This research attempts at drawing lessons from the energy sector and applying it to the water sector for better water valuation.

Sustainability Outlook (2015b) has created a concept and a tool aimed at increasing the understanding of the value of water in an industrial setting. It’s called “Value Added Water” (VAW), and by highlighting the hidden costs of water, it strengthens the business case for water efficiency. In industrial settings, water is used both for processing and as a material input to products. In the textile industry specifically, water has three main responsibilities; to carry heat, to carry chemicals and to dissolve impurities. This means that at different stages of production, the process water holds different resources, thus changing its financial worth. Water which at source has a low value increases in value due to the addition of the expensive resources of energy and chemicals. Examples of this is energy added to water to convert it to steam, and the energy and chemicals added to water for water treatment. The water now becomes a resource of high value. The VAW takes on a systems approach and regards industrial water as a carrier of valuable resources. Fig. 4 below explains this approach graphically.

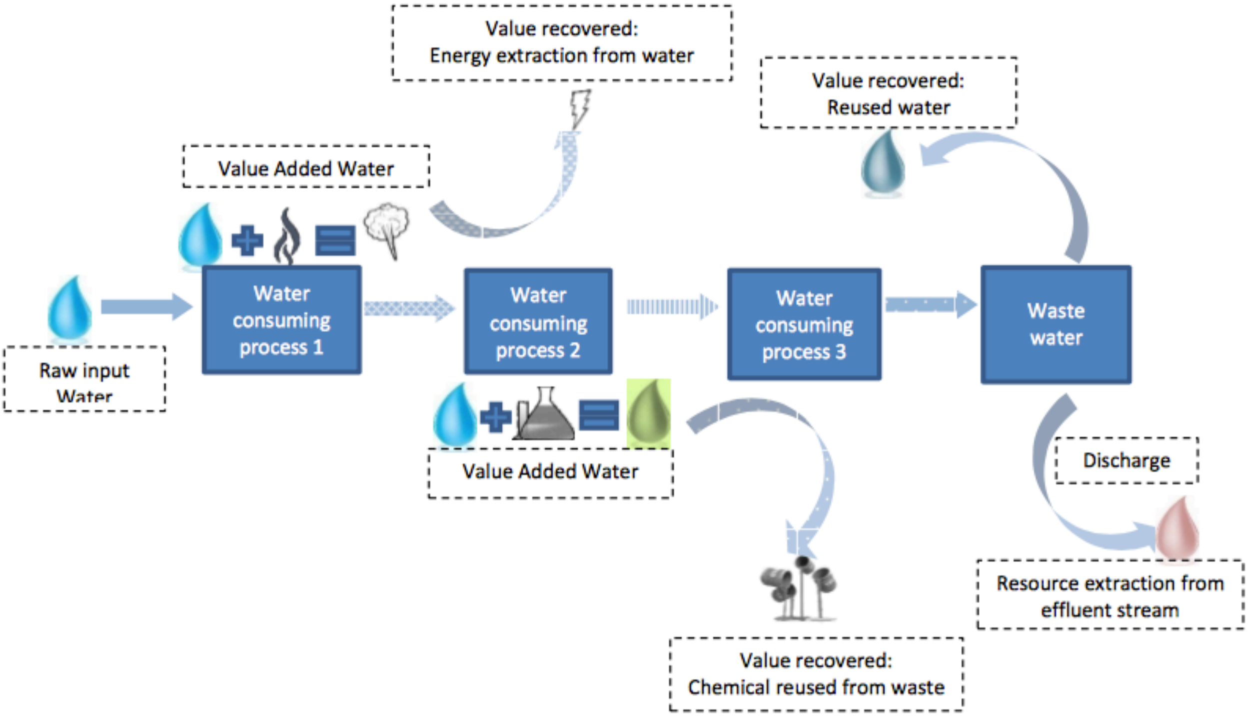

Fig. 4. The Value Added Water (VAW) concept (Sustainability Outlook, 2015b, p. 4)

Using the VAW approach means that the various resources used in the production process are seen as part of nexus relationships. It also means that the multiple benefits of water efficiency can be identified. It helps pinpoint where in the process that water holds the greatest value, and where efficiency measures should be prioritized. By considering the interconnectedness of different resources, the saving of resources such as chemicals, electricity and thermal energy becomes less about decreasing simply that resource, but instead decreasing the amount of water carrying these resources. In other words, it aids in making the energy-chemical-water nexus more visible to industry (Sustainability Outlook, 2015b).

2.3. Multiple benefits of energy efficiency

While there is little literature on the multiple benefits of industrial water efficiency, research on the multiple benefits of industrial energy efficiency is growing in numbers. Below follows a review of this literature which will subsequently be used by this research in order to apply the concept of multiple benefits to investments in other resource efficiency. Although not used as an official term for the concept, this research employs the term and abbreviation of

Multiple Benefits of Energy Efficiency Improvements Framework (MBEEIF) in the analysis and discussion section.

The International Energy Agency (IEA) defines multiple benefits as a term aiming to "…capture a reality that is often overlooked: investment in energy efficiency can provide many different benefits to many different stakeholders." (IEA, 2014, p. 18). IEA has created a model which shows the various benefit-areas from energy efficiency improvements, as seen in Fig. 5.

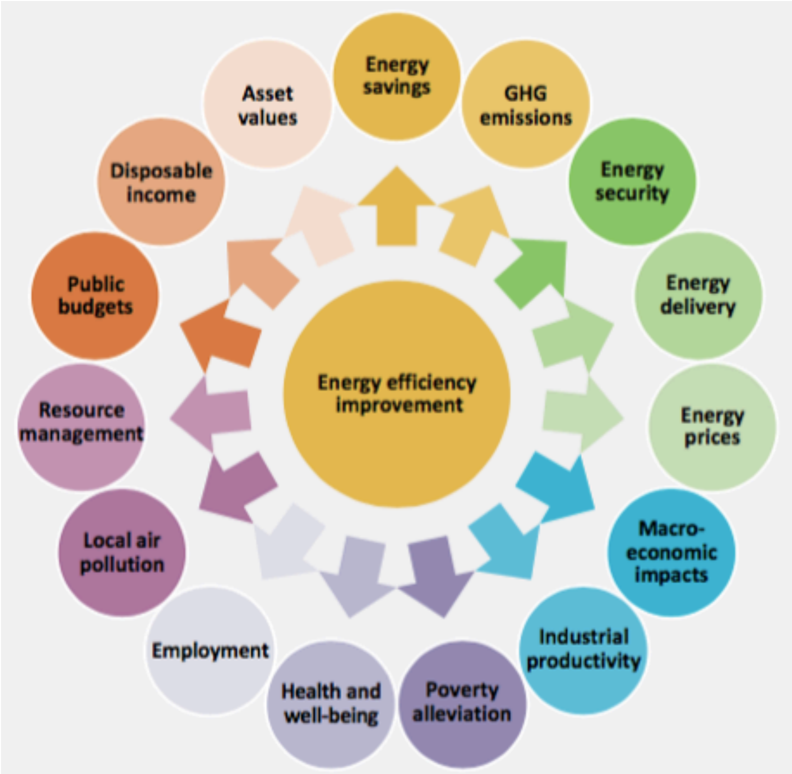

Fig. 5. The multiple benefits of energy efficiency improvements (IEA, 2014, p. 20)

In order to limit this paper to the resource nexus in the industrial setting, it will focus on resource management, industrial productivity and health and wellbeing, as mentioned in the above figure.

When delving into literature on the multiple benefits of industrial energy efficiency, the term 'non-energy benefits' is commonly used to describe this phenomenon. As stated by Worrell (2003, p. 1082),

> Certain technologies that are identified as being 'energy-efficient' because they reduce the use of energy will bring a number of additional enhancements to the production process. These improvements, including lower maintenance costs, increased production yield, safer working conditions, and many others, are collectively referred to as 'productivity benefits' or 'non-energy benefits… because in addition to reducing energy, they all increase the productivity of the firm.

In other words, the non-energy benefits are beneficial to the firm as they enhance productivity.

What then are these non-energy benefits? Worrell et al (2003) provides a model for categorizing and identifying non-energy benefits as seen in Fig. 6.

Non-energy benefits from efficiency improvements

Waste	Emissions	Operation and maintenance
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/machinery
Materials reduction		Reductions in labor requirements
Production	**Working environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased reliability in production	Improved air quality	Improved worker morale

Fig. 6. Non-energy benefits from energy efficiency improvements in industry (Worrell et al., 2003, p. 1083)

This research proposes that this type of categorization and identification of multiple benefits is also applicable to other resource efficiency investments in industry.

So is there research to support the existence of multiple benefits in industrial energy efficiency investments? Hall and Roth (2003) found that what they refer to as non-energy benefits, as mentioned above, are more significant in terms of financial saving than is the lowered energy cost due to the efficiency measure. In fact, they found this non-energy benefit factor to be 2.5, meaning that multiple benefits of an investment account for 2.5 times as much financial saving as the energy saved itself. Thus, when adding this non-energy benefit factor to an investment decision regarding energy efficiency, the payback time is greatly reduced due to the higher financial return.

Unfortunately, companies don’t tend to include this factor in their investment decisions. Nehler et al (2014) analysed whether or not multiple benefits of industrial energy efficiency can be found in Swedish industry. It was found that companies do in fact experience multiple benefits of industrial energy efficiency, however companies rarely monetize these in order to integrate them into the investment decision. Interviews showed that the underlying reasons for this was a lack of metering and a lack of information. Thus, by improving the access to information about the value of acknowledging the multiple benefits of energy efficiency investments, these investments are more likely to be accepted due to a higher return on investment, and thus a shorter payback time. This paper argues that the same logic can be applied to investments in other types of resource efficiency in industrial settings.

With specific reference to the textile industry, Hasanbeigi and Price (2015) argue that emerging technologies aimed at improving energy efficiency in the textile industry may lead to multiple benefits such as improved human health and less air pollution. The cost-effectiveness of these emerging technologies would improve if these multiple benefits were quantified and monetized. This would be important for the development of these emerging technologies since their initial cost tend to be rather high before they have reached a higher rate of adoption.

Finman and Laitner (2001) also argue that it's important to be able to quantify and monetize non-energy benefits in order to make them part of an investment decision. Unfortunately however, as shown in Rasmussen's (2014, p. 738) model (Fig. 7) of the relationship between the quantifiability and the timeframe of non-energy benefits, far from all non-energy benefits are easily quantifiable.

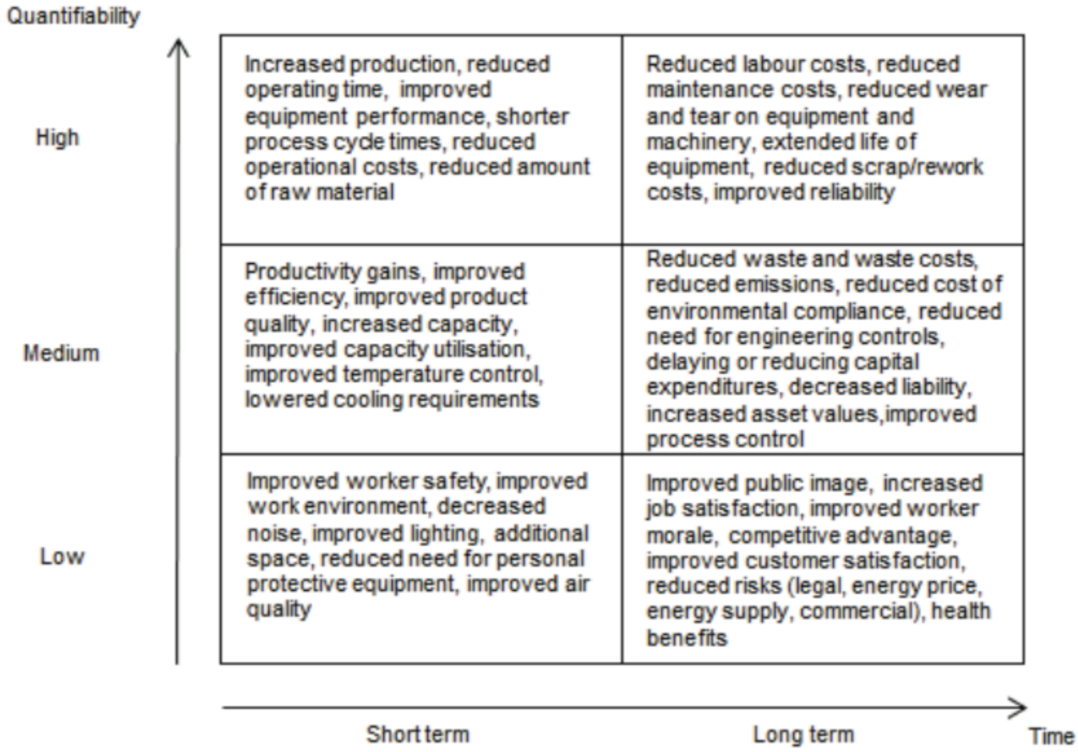

Fig. 7. Matrix showing the relationship between quantifiability and timeframe for industrial non-energy benefits (Rasmussen, 2014, p. 738)

Through using this framework, firms can more easily detect which non-energy benefits are quantifiable, and thus include them in the investment decision calculation. This paper again argues that this framework can be applicable to other resource efficiencies as well.

In an attempt to facilitate for companies to understand how to quantify and monetize the seemingly unquantifiable multiple benefits (or as they refer to it, non-energy benefits) of energy efficiency, Nehler and Rasmussen (2015, p. 9) created a table (Fig. 8) with possible methods for measuring these.

Type of benefit	Measured/monetised by	Type of benefit	Measured/monetised by
Increased production/productivity	Indicator – kWh/ton output produced, measuring produced output	*Safety*	Less sick leave, reduced rehabilitation costs
Fewer production disruptions	Know the cost of disrupting a production line, reference cost	*Reduced material costs*	Less material used, reduced scrap
Extended life of equipment	Reduced need for labour due to reduced need for maintenance, lower demand for electricity, LCC analysis	*Reduced need for cooling*	Pinch analysis, know the cost of cooling water, fewer cooling facilities
Improved product quality	Reduced material costs due to reduced scrap, fewer complaints/returns	*Reduced emissions*	Price of emission allowances, reduced cost of replacing filters
Reduced hazardous waste	Cost of disposal	*Reduced noise*	Reduced costs of silencers and noise enclosures
Reduced waste	Cost of disposal, reduced need for cooling water, landfill closure	*Reduced need for labour*	Reduced salary costs
Reduced maintenance	Maintenance costs	*Improved air quality*	Fewer production failures, improved quality
Use of waste heat/fuel/gas	Possible to track through measurement, reduced need for/cost of oil	*Improved temperature control*	Improved quality, increased productivity
Improved worker morale	Less sick leave, increased productivity, indicator – man-hours/produced output	*Improved lighting*	Costs of exchange and maintenance

Fig. 8. Possible methods for measuring non-energy benefits in industry (Nehler and Rasmussen, 2015, p. 9)

They continued to argue that by measuring seemingly immeasurable benefits, these are able to be brought up in the investment assessment. Those multiple benefits which are not easily quantifiable can be measured through other more measurable benefits. In other words, indirect multiple benefits are measurable through their effect on direct multiple benefits. However, since the timeframe for these indirect effects tends to be variable, the perspective of time should be accounted for when quantifying multiple benefits. The risk of double-counting multiple benefits can be decreased by assigning the benefits to specific investments. This research argues that some of these methods of measurement could also be applicable to a more general resource efficiency multiple effects framework.

2.4. Rebound effect

While the use of energy, water and other resources should aim to be more efficient, efficiency doesn't always mean reduced use of a resource. As mentioned by Broberg et al (2015, p. 26) regarding energy efficiency, "Increased energy efficiency can stimulate new demand for energy that counteracts the energy-saving potential. This so-called rebound effect can partially or wholly offset, or in worst case even outweigh, the energy-saving effect of energy efficiency measures." There is no universally accepted definition for the rebound effect, owing partly to the fact that investigations of its relevance are still undergoing, using different metrics and scopes. It's an abstract concept which is hard to measure, and is therefore rarely incorporated in policy-making although research shows that this would be advisable. The rebound effect can be measured at different levels, ranging from the rebound effect for a firm at micro level to the rebound effect for society, called the economy-wide rebound effect. For example, in a certain scenario improved energy efficiency leads to increased economic activity, which in turn leads to a more significant rebound effect (Broberg et al., 2015).

At the producing firm level, improved energy efficiency can mean an increased use of energy, better productivity and a larger output. This in turn can have an impact on economy-wide energy use. Within firms, energy savings tend to be calculated using engineering models which do not take into account any economic reaction to the saved energy. Energy-economic models better show the economic response of the improved energy efficiency, and thus provide a truer picture of actual energy saved (Sorrell, 2014).

Saunders (2013) conducted research involving historical energy efficiency data from 30 different productive sectors in the US. He found that the rebound effect is significant overall, and more so in certain sectors. He argues that there is enough evidence to support that the rebound effect should be included in energy use forecasts, meaning that forecasts of future energy use in the climate change debate are incorrect when not considering the rebound effect. For the purpose of this paper, the economy-wide rebound effect is too wide a scope, however it is important to mention in order to recommend further research on societal impacts. As this paper will argue, it is important to also incorporate the rebound effect on the resource nexus at the micro level.

This paper is especially interested in the effects on other resource use and other activities when changing the use of one particular resource. As shown by Carter (2010), when for example switching electricity source from coal or natural gas to renewable electricity such as concentrating solar power technologies, more water tends to be used.

2.5. Zero Liquid Discharge

By 2050, Indian water demand will exceed supply. This leads to a huge risk for businesses dependent on water resources. However, industries in India do not yet consider water as a resource risk due to the low cost of water. The cost of water doesn’t account for the scarcity, demand, and invaluable character of water for Indian industry. The effect of this, a possible water resource shortage, would lead to either interim or permanent closure of factories. While some of this has already been experienced through temporary shut-downs, under-utilization of the installed capacity and halted expansion plans, this has not been significant enough to reach a more appropriate price of water in India (Sustainability Outlook, 2015a).

This research is investigating the effects of measures taken to decrease the cost of operating with Zero Liquid Discharge (ZLD). ZLD is a combination of techniques that allow for water used in production to circulate within the factory instead of being discharged to the surrounding area. From a sustainability perspective, ZLD is favourable in areas which face water stress, since it greatly reduces the amount of fresh water being used by factories, and can instead be used for irrigation and drinking. In 2008, ZLD was mandated for the textile industry in the Indian state of Tamil Nadu. Since factories in Tamil Nadu failed to convert into ZLD production, all factories were shut down in 2011 until they would comply. Due to the costs of ZLD, many factories were forced to remain closed or left the region (ibid.).

ZLD is a combination of using all or some of the following technologies: Effluent Treatment Plant (ETP), Reverse Osmosis (RO), Ultra Filtration (UF), Multi Effect Evaporator (MEE), Forced Evaporator (FE) and Crystalizer. The ZLD value chain can be seen in Fig. 9.

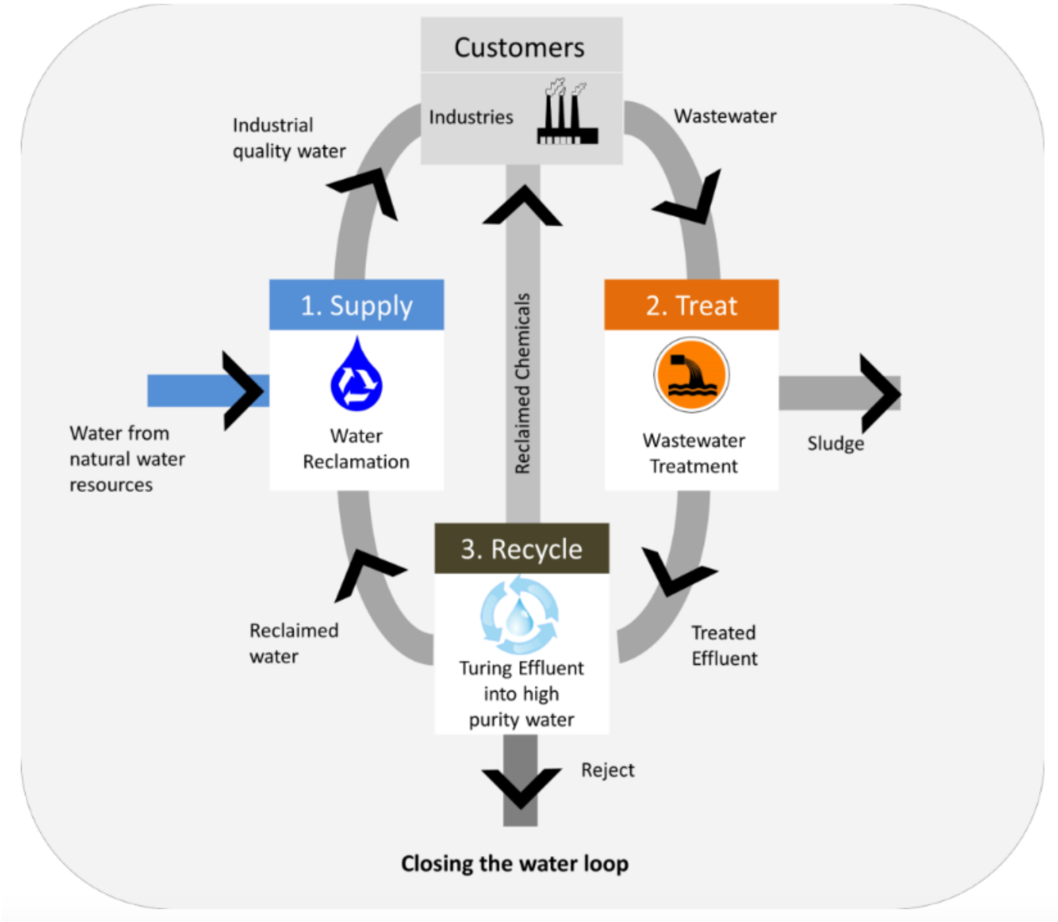

Fig. 9. The Zero Liquid Discharge value chain (Sustainability Outlook, 2015a, p. 6)

There's only one problem- operating ZLD is extremely costly. The primary reason for this is that in order to purify the used water to the level that it can be reused in production, a lot of energy is required. Energy is used in all the different components of the ZLD system. The two most used techniques for ZLD are evaporation and reverse osmosis, which both use a large amount of both thermal and electrical energy. The greatest financial impact is on the dyeing and colouring parts of the textile value chain. Their production cost increases by 6-10% due to ZLD (ibid.).

When the cost of production increases due to the implementation of ZLD, the factories which are subjected to ZLD become less cost competitive than companies in areas where ZLD is not mandated. Fig. 10 shows the difference in production cost with and without ZLD. The graph shows both textile processing and paper and pulp which is another industry mandated to use ZLD in certain regions of India (ibid.).

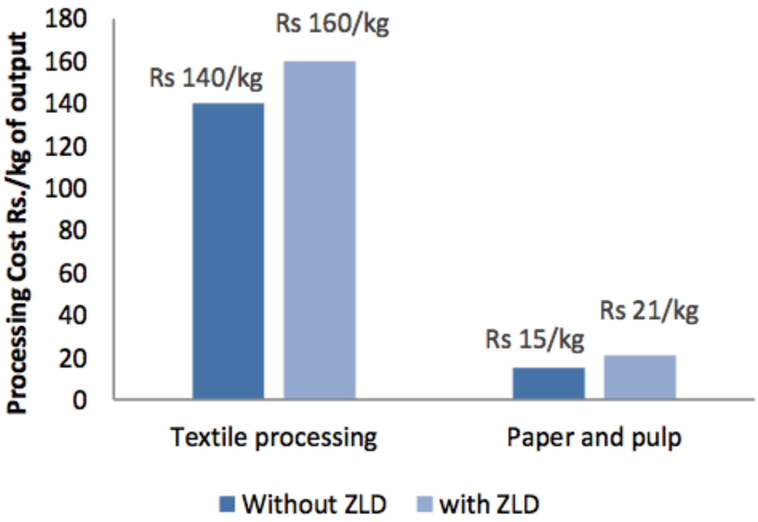

Fig. 10. Comparing the production cost for ZLD and non-ZLD factories (Sustainability Outlook, 2015a, p. 3)

The capital expenditure (CAPEX) for ZLD is not high when compared to the operating expenditures (OPEX). This is due to the high energy use. The CAPEX of ZLD (for a typical 1 million litres/day factory) in India is approximately 60,000,000 INR (equivalent to approximately 800,000 EUR). The OPEX for running production with ZLD during 6 years is as much as 3 times the cost of CAPEX, as represented in Fig. 11 (ibid.).

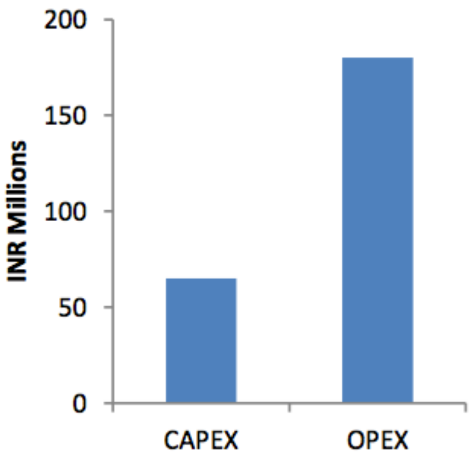

Fig. 11. The approximate cost of operating a ZLD system for a 1 million litres/day factory for 6 years in India (Sustainability Outlook, 2015a, p. 10)

ZLD in the dyeing industry leads to savings of both water and salts used in production. Fresh water is priced at INR 70/kL (1kL is 1000 litres), thus a complete water saving would entail a saving of INR 70/kL. However, limits to the ZLD technology mean that only about 80-95% of the water is recovered, bringing down the total financial saving from decreased fresh water purchasing to 40-60

INR/kL. The second resource being saved, salt, is purchased at a cost of INR 10/kL. Between 95-98% of the salt is recovered in ZLD, meaning a cost saving of INR 15-60/kL. Unfortunately, these resource savings do not offset the entire financial cost that ZLD entails. When taking into account these resource savings, the price of water is INR 30-70/kL when using a Central Effluent Treatment Plant (CETP), and INR 120-130/kL when using an Independent Effluent Treatment Plant (IETP) (ibid.).

Although there is a heavy financial burden for the dyeing and colouring factories in the textile supply chain, very little of this cost is transferred to the final customer. The selling price of a shirt produced with ZLD would be increased by less than 1%. The cost difference between ZLD and non-ZLD manufacturing is represented in Fig. 12. (ibid.).

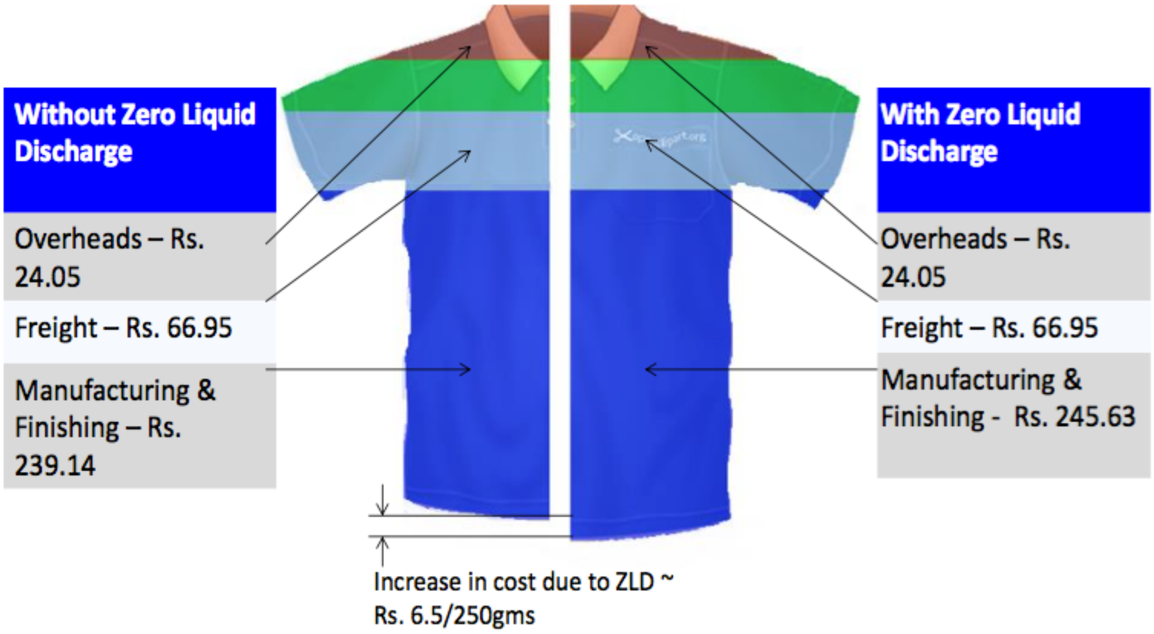

Fig. 12. Comparing manufacturing costs between ZLD and non-ZLD factories (Sustainability Outlook, 2015a, p. 10)

This additional cost of ZLD would need to be transferred to the final customer in order to sustain the factories financially, however factories and purchasing brands are yet to agree on this (ibid.).

Since ZLD is very expensive for factories, Sustainability Outlook (2015a) believe that legislation is the best driver of its implementation, both within India and globally. More and more industries in India can expect to have ZLD imposed on them. Those Indian states which they believe will have ZLD mandated in the near future tend to suffer from water scarcity and a high level of industrial water pollution. The map below (Fig. 13) shows both those states which already have ZLD as state legislation, and those who are likely to introduce it.

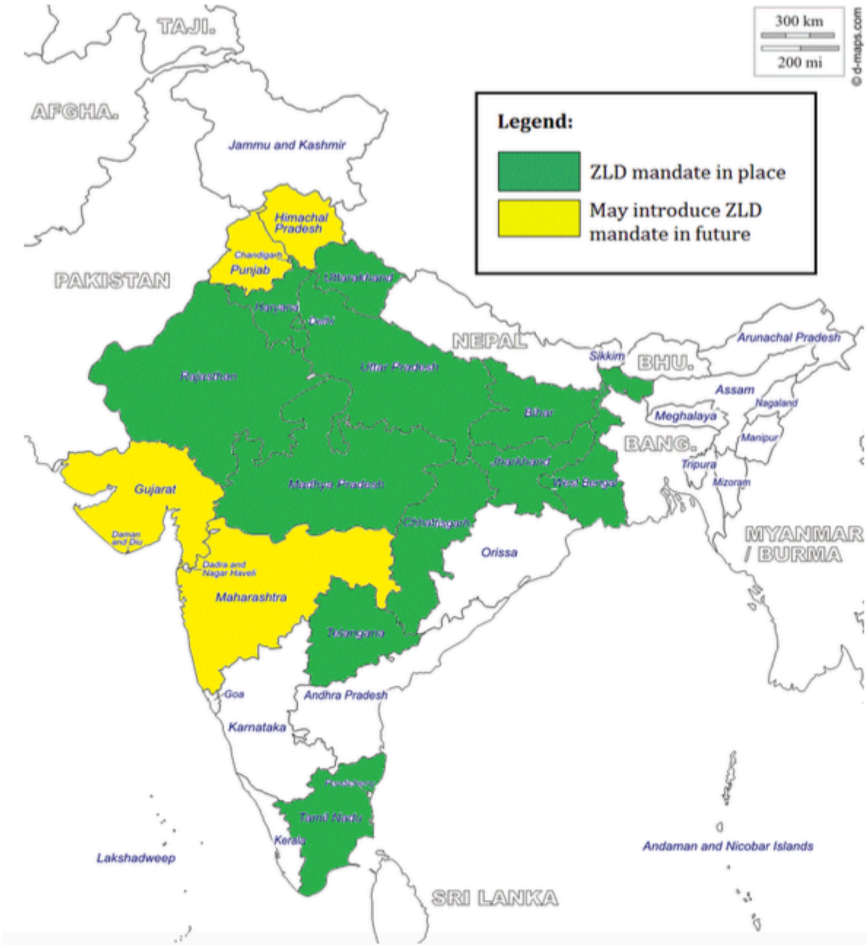

Fig. 13. Indian states who have, or soon likely will have ZLD legislation (Sustainability Outlook, 2015a, p. 5)

When ZLD legislation expands, water will be viewed differently in India, and its price may better represent its worth. A further result of the expansion of ZLD legislation is the increased need for ZLD technology that will boost companies offering water treatment technologies (ibid.).

2.6. Investment decisions

Investment decisions are important to consider for this study as they are a factor in the successful transition to a more sustainable production. As the theoretical review below reveals, investment decision-making is not as straight forward as one may think. According to Cooremans (2012), investment decisions should not be considered as a one-time event, but rather as a dynamic process being influenced by different factors over a period of time. Fig. 14 below shows this process, where the initial idea first goes through a diagnosis which either identifies the initial idea as a decision-event or not. The next step builds up solutions, which are then evaluated and undergo a choice. The next step is implementation, or not, as decided in the previous step.

Fig. 14. The investment decision-making model developed by Cooremans (2012, p. 499), and re-designed by this research paper.

Cooremans (2012) argues that the strategic nature of an investment decision has a large impact on whether the investment is taken or not. If an investment is considered strategic, or in other words, if it adds to the company's competitive advantage, it is more likely to be accepted. Cooremans (2012) has coined a term, *strategicity,* to signify this phenomenon.

Relating specifically to investments in energy efficiency, Nehler and Rasmussen (2015) argue that the gain in energy efficiency seldom is sufficient for a company to accept an energy efficiency investment (although energy efficiency is considered important). This makes non-energy benefits (or multiple benefits) significant. They also found that investments in energy-efficiency are seldom considered as a specific investment category, which tends to affect the investment decision-making process.

Qiu et al (2015) show in an empirical study that firms view investments in energy efficiency differently from other investments when considering acceptable discount rate and payback time. Their study showed that acceptable discount rates for energy efficiency investments range between 40-45%, which is much higher than acceptable discount rates for other investments. Likewise, whereas the normal payback period threshold for investments in industrial firms lies around two to three years, an investment in energy efficiency needs to give a payback in as short as 9 months. Naturally, this will vary between countries and firms. However, if firms start analysing the fuller picture of the investment, i.e. start accounting for the multiple benefits of the investment, perhaps using the Hall and Roth (2003) factor of 2.5, the payback time decreases significantly. This is significant for the study at hand because it implies that by accounting for multiple benefits, investments in resource efficiency may become more attractive. This research also argues that not only benefits, but all effects of a measure should be included in the decision-making process.

3. Method

Understanding the resource nexus and the multiple effects of changes in textile industries requires a relatively in-depth analysis of the factories at hand. For that reason, this research argues that case studies offer the most appropriate means of investigating effects. Seeing as all factories vary to some extent, and since different factories encounter various situations, five different factories have been chosen as multiple case study subjects in order to present a wider picture of possible effects and interdependencies of resources and processes. The aim of creating a multiple effect framework with wide applicability is further helped by analysing a range of changes and subsequent effects. Although a multiple case study does not allow for wide generalizations to all textile industries, it provides an indication of possible effects, and presents what may be experienced in other factories. This research uses qualitative methods with quantitative elements. It uses descriptive statistics to add to the qualitative analysis.

3.1. Multiple case study

Case studies of organisations such as firms allow for an investigation into, among other things, industrial relations, processes of change and adaptation, and management and organizational aspects (Robson, 2011). This case study attempts to understand the multiple effects of measures taken by textile factories in the Indian state of Tamil Nadu to lower the cost incurred by ZLD implementation.

Flexibility in the design structure of the case study depends on whether the study is exploratory (seeking new answers) or confirmatory (looking for evidence to support an already existing theory) (Robson, 2011). Due to the novelty of this particular research, the approach is more exploratory than confirmatory, allowing for more flexibility in the design.

A multiple case study is used to draw cross-case conclusions (Yin, 2009). This research uses a multiple case study to identify possible effects following measures taken by the relatively small population of Indian textile factories forced into ZLD implementation, in order to lower the increased costs that it entails. Since the analysed measures taken by the individual factories differ from each other, they collectively present a list of possible effects that may be experienced when factories take measures to lower the cost of ZLD. The multiple case study approach is further useful as it allows for the investigation of different resource nexus relationships. It adds to the notion that measures need to be analysed case by case, yet drawing knowledge from previous measures taken.

Following the claim that case studies are a strategy for conducting research (Yin, 2009), this paper views the case study approach as the overall perspective, and employs interviews, surveys and secondary data collection as methods within that strategy.

3.1.1. Case study subjects

The case-study subjects consist of one direct supplier to IKEA, and four of that direct supplier's suppliers, i.e. IKEA's sub-suppliers. In the paper, these case study subjects are named supplier D (IKEA's direct supplier), and suppliers 1, 2, 3 and 4 (IKEA's sub-suppliers). All factories are situated in the Indian state of Tamil Nadu, and are part of the textile producing supply-chain. Supplier D is the only factory which is vertically integrated, meaning that they have a large part of the production in-house. This includes spinning, fabric wet processing and garmenting cut-sew operation facilities. The other four case study factories in this study, i.e. Supplier D's suppliers, are purely wet processing factories. These factories differ somewhat in terms of dyeing types, for example yarn, fabric and towel dyeing. The differences between the factories are not considered a limitation in this study, since it's the effects of various projects which is of interest. The factories were chosen as case study subjects since they are all subjected to the Tamil Nadu mandate on ZLD (as described in the theory section), which puts them all in a similar situation regarding resource utilization.

3.1.2. Involved actors

3.1.2.1. Sweden Textile Water Initiative (STWI)

The Sweden Textile Water Initative (STWI) is a joint initiative between Swedish textile and leather brands and the Stockholm International Water Institute (SIWI). The aim of the STWI programme is to reduce energy, water and chemical use in textile supply chains. There are 29 participating companies, including IKEA, and clothing companies such as H&M and Indiska. It involves factories in five countries: India, Bangladesh, China, Turkey and Ethiopia (Sweden Textile Water Initiative, 2016). This research focuses on textile factories in India.

3.1.2.2. IKEA

The furniture retailer IKEA is, as mentioned above, part of the STWI programme. Being interested in the nexus-relationships between resources in their textile supply chain, they offered contact to their supplier and four sub-suppliers in India who they have earlier nominated for the STWI programme.

3.2. Data collection methods

As argued by Kvale and Brinkman (2014), the topic should determine the method in all research conducted. If the question to be answered is *how* something is being done, or *how* something is understood, it's best to use qualitative interviews. When, instead, the question is *how much,* it's better to conduct surveys to gather data. As mentioned above, this research is set up as a multiple case study, and has employed three different methods to collect information: semi-structured interviews, surveys and secondary data collection. By using interviews, surveys and secondary data collection, this research is able to get a deeper understanding of the problem at hand. This approach is supported by Nehler et al (2014), who argue that when researching a complex concept such as the non-energy benefits (or multiple benefits) of energy efficiency, a case study involving in-depth interviews and questionnaires is a good approach.

3.2.1. Secondary data collection

As stated by Robson (2011), secondary data is useful in the sense that it takes advantage of the fact that others have already gathered the data, and it allows the researcher to focus on the interpretation and analysis of data. Secondary data was gathered from STWI's final reports on measures taken by the nominated factories in order to lower the cost of operating with ZLD. This data was analysed and categorized before being used as a foundation for the multiple effects framework.

3.2.2. Surveys

Surveys allow for an extensive quantity of data to be collected quickly (Robson, 2011). Surveys in the shape of online questionnaires were used in this research in order to gather data from the textile factories to be used as a foundation for the multiple effects framework. It acts as a complementary data collection method to the secondary data collection, where knowledge gaps have been filled in through asking specific complementary questions. The surveys were distributed to the five factories through IKEA. The survey was directed to factory managers, who were asked to answer all questions with reference to a specified project undertaken.

3.2.2.1. Questions asked in the survey

The survey questions were divided into categories such as water, energy, chemicals, productivity and working environment. Each section searched for answers regarding any change experienced within that category, and if it was possible to express a financial difference due to that change. The survey was written in English, and answered by all five factories who received it.

3.2.3. Semi-structured interviews

Semi-structured interviews were conducted in order to collect qualitative information from IKEA co-workers and a cKinetics sustainability consultant who are all connected to the case studies in different ways. As Kvale and Brinkman (2014) recommend, a researcher should interview as many persons as necessary in order to gather all the information needed for the research. By interviewing staff from the consultancy firm cKinetics, it was possible to understand details related to the improvement measures taken at the factories. By interviewing staff from IKEA, it was possible to understand the customer's expectations and concerns in relation to ZLD and the resource nexus.

Rubin and Rubin (2005) argue that although there should be a plan for which questions to ask in an interview, this should be flexible in order to follow any changes that emerge. The questions should adapt to changing circumstances and aim to always be relevant. Seeing as the topic being studied in this research is not covered to any great extent in existing literature, the interviews serve as knowledge gathering on the topic. After each interview, questions planned for the next interviewee were revised, thus improving the relevancy of the questions. One interview was held in Swedish, while the other four were held in English. The interviews were recorded and transcribed, but will for ethical reasons not be published with this research.

3.2.3.1. Interviewees

For this research it was decided to interview one consultant who has been involved directly with the measures being taken at the textile factories (Anshul Chawla, cKinetics); one person representing the business case in the customer company (Varun Chawla, Business Developer IKEA); one person representing the sustainability case at the customer company (Sandesh Waje, Sustainability Developer, IKEA); and one person representing the global work on water sustainability within the customer company (Margareta Björkander, IKEA).

3.2.3.2. Questions asked in interviews

The questions differed between the interviewees as they have different areas of expertise. There were some questions which were asked to all, and these were related to their thoughts on the future competitiveness of the Indian textile factories which are mandated to use ZLD.

3.2.4. Reliability and validity

Reliability refers to the consistency and accuracy of the research results (Kvale and Brinkmann, 2014). The secondary data is considered reliable since it has been gathered as part of an extensive efficiency programme (STWI) in which the factories were active participants. Regarding the surveys, naturally it must be acknowledged that factories are likely to be reluctant to reveal negative circumstances which may harm their attractiveness towards their customer, as they understand that their responses will be seen by them. However, having taken part in the STWI programme, they are all by now accustomed to reporting data and being transparent, so there is no immediate concern regarding reliability. The interview results can be considered reliable due to the extensive knowledge held by the interview subjects in their respective expertise. There were some differences in answers to certain questions, however that is only to be expected when interviewing professionals with diverging expertise. Having interviewed professionals with diverging expertise, the reliability of the interview results is augmented since different perspectives of the same situation are accounted for.

Validity refers to the correctness and strength of the statement made. It asks whether the method used in the research is actually investigating what it intends to (Kvale and Brinkmann, 2014). The secondary data is considered valid as all the data gathered relates to resource use and financial consequences. The validity of the survey was supported by the cKinetics team who work with these factories on resource efficiency, and by the STWI programme organisation. In order to check whether or not the respondents were able to see a direct correlation between the measure taken and the change experienced and reported, for some sections there was a question where respondents could grade on a scale from 1 to 10 how confident they were that this change was actually related to the measure at hand. However, there is always a risk that the survey questions are misunderstood by the respondents and answered incorrectly. The validity of the interview results was ensured through constantly updating the questions based on answers received. That way, invalid questions were kept to a minimum.

3.3. Ethics

All three data collection methods were designed with ethical considerations. For the secondary data collection, the data from project reports is presented anonymously in the research. In the surveys, companies were asked to give their factory name in order for the researcher to draw connections with other data, however the names of the responding factories have not been included in the paper. Likewise, when conducting semi-structured interviews, it's important to respect confidentiality and be aware of possible consequences faced by the interview subjects. The interview subjects should give their informed consent, and confidentiality should be ensured where applicable (Kvale and Brinkmann, 2014). In the interviews conducted in this study, the most important thing was to make sure that the trust that factories place in the interview subjects for confidentiality, regardless of whether it is as a purchaser or as a consultant, was respected. By breaking this confidentiality, there could be consequences in terms of competitiveness for the factories analysed. Again, in order to avoid any negative consequences for the factories involved, no factory names are mentioned in the paper. Interviewees gave their informed consent to publishing their answers.

3.4. Limitations

A multiple case study research would benefit from field-work; however, this was not possible for this research due to traveling constraints. It would likewise have been favourable to interview the factory managers and other staff, however this was also not possible due to traveling constraints. A further limit of the study is its generalizability to other factories. This paper assumes however that the Multiple Effects Framework (MEF) will be used dynamically and changed case-by-case.

Some limitations of the survey results are that some questions seem to have been misunderstood, perhaps as a result of the language barrier. The factories have been approached regarding ambiguous answers, and most of these have been clarified. There is also a risk that the survey was not clear enough regarding what it meant by the different answering options, for example that "positive", "neutral", "negative" meant a positive, neutral or negative change, instead of "positive" meaning affirmative, and "negative" meaning a negative answer. Attempts at correcting this have been made to the best ability of what the time frame allowed. Some respondents also answered the likelihood-scale relating to an effect they responded that they had not experienced. However, this is not considered a major limitation since this research is only concerned with whether or not an effect was experienced.

3.5. Delimitations

The choice of case study subjects is a result of recommendations from SIWI and IKEA in terms of applicability and accessibility. The paper has chosen to investigate firms which have all been subjected to ZLD, since this creates a neutral platform to investigate effects.

4. Results

This section will present the results from the three data collection methods. First, it will account for the secondary data. Secondly, it will handle the survey results, and finally the interview results.

4.1. Secondary data collection results

The secondary data collection results are taken from STWI's confidential final reports for the individual projects analysed in this paper. The below table (Fig. 15) shows the anonymised suppliers with their respective projects. The below projects were chosen due to their impact on several resources.

Supplier D	Implementation of bio scouring for dark/medium shades
Supplier 1	Yarn Waste Minimization
Supplier 2	Reducing one bath by continuing with pre-wash bath in yarn dyeing machine
Supplier 3	Reducing Material to Liquor Ratio (MLR) from 1:10 to 1:7
Supplier 4	Control of boiler feed water Total Dissolved Solids (TDS) to optimize blowdown

Fig. 15. Case study subjects with respective project (STWI, 2015)

Supplier D's project involved changing the scouring process (i.e. pre-treatment in cotton processing) from conventional to bio scouring, which is a more environmentally friendly process. Supplier 1 minimized the material waste of yarn through improved process control of dyed yarn stripes, and thereby saved resources used in dyeing the yarn. Supplier 2 optimized the production process through reducing it by one bath and instead conducting pre-washing baths in the yarn dyeing machine. Supplier 3 reduced the Material to Liquor Ratio (MLR) (i.e. the relationship between the volume of textile and the total volume of the dye bath) from 1:10 to 1:7. Supplier 4 improved their control of Total Dissolved Solids (TDS) in their boiler feed water in order to optimize blowdown, which is the emptying of boiler water to reduce the level of TDS in the boiler which causes inefficiencies. It was the only project which required an investment. What all these projects have in common is that they impact water use which in turn generates a variety of savings. The most important factor for this research is the multiple effects of these measures.

Company	Project	Investment cost (INR)	Lowered fresh water use (kL)	Savings from change in fresh water use (INR)	Lowered factory process water use (kL/year)	Savings from change in water treatment (INR)	Lowered electricity use (kWh)	Savings from change in electricity use (INR)	Lowered coal fuel use (tons /year)	Lowered wood fuel use (tons /year)	Savings from change in fuel use/year (INR)	Lowered chemical use (tons /year)	Savings from change in chemical use (INR)	Lowered material use (tons /year)	Savings from change in material use (INR)	Change in productivity	Total financial savings
Supplier D	Implementation of bio scouring for dark/medium shades	0	186 (kL/year)	8,370		180,000 (excl. chemicals and electricity)	36,765	294,120	32.7			19.5	Minus 1,771,200 (cost, not saving)				**No financial saving**
Supplier 1	Yarn Waste Minimization	0	10 (one-time saving)	13,600 /year			17,500		95		396000	26.5	1,060,000	45	9000000		**INR 10,982,500** (USD 165,150)
Supplier 2	Reducing one bath by continuing with pre-wash bath in yarn dyeing machine	0	20 (one-time saving)	1,171800			37,758	339,822		81,6		10.4	187,488				**INR 1,171,800** (USD 17,621)
Supplier 3	Reducing MLR from 1:10 to 1:7	0	5,250	393,750	21,000	2,362,500 (total incl. cost of electricity, wood and chemicals in CETP)	78,800	709,000 (included in total savings at CETP)		262,5 (CETP) + 250 (factory)	945,000 (included in total savings at CETP) + 900,000 (factory)	19.7	354,400 (included in total saving at CETP)			20% increase in production: 600 tons/year	**INR 3,650,000** (USD 54,887)
Supplier 4	Control of boiler feed water TDS to optimize blowdown	400,000	83.7	2,100						14.7	66,150						**INR 68,250** (USD 1,026)

Fig. 16. Resource and financial savings experienced by case study subjects as found in secondary data, i.e. the STWI confidential final reports for the individual projects.

Fig. 16 shows the details on resource and financial savings experienced as a result of the projects presented above. They have been extracted from the confidential STWI final reports presenting all projects undertaken to lower the cost of ZLD by the suppliers. The data has been added to a table to facilitate analysis. This table does not however intend to present exact figures leading to an exact saving, as some savings were not quantified in the final reports due to a lack of baseline data. The intention is rather to present the figures as reported in the final reports, and subsequently show an indication as to how relevant the specific factors are for a factory undertaking projects to lower the manufacturing cost of ZLD. There is therefore no mathematical analysis of the figures, nor a comparison between them. As the projects differ from each other, not all factors are applicable for all, thus leaving some empty cells in the table. All savings are in Indian Rupees (INR). For reference, USD 1 equals approximately INR 66.5 in June 2016.

4.2. Survey results

Below follows an account of the additional effects experienced by the case study subjects as a result of specific measures taken by the factories to lower the cost of ZLD. As mentioned above, the measures differ between the different factories. The intention is not to compare or aggregate the experienced effects between the different measures taken by the factories, but rather to look at their likelihood and generate a list of possible effects. Since it is whether or not an effect is applicable that is being investigated, whether the effect is positive or negative is less important. What is important is if the effect is worth analysing when making these types of measures to lower the costs of ZLD. All costs and savings are given in INR, Indian Rupees.

4.2.1. Additional effects on water use

Supplier	Has the project led to a **change in water chemistry**, thus affecting the products somehow?	Can this be translated to financial terms?	What cost/saving?	On a scale from 1 to 10, 10 being the most likely, how sure are you that these water-related changes can be attributed solely to this project?
Supplier D	Neutral	-	-	1
Supplier 1	Neutral	-	-	1
Supplier 2	Neutral	-	-	7
Supplier 3	Positive	Yes	Saving: Approx. INR 3,650,000/year	10
Supplier 4	Neutral	-	-	1

Fig. 17. Additional effects on water use

Supplier 3 answered that the project led to a change in water chemistry, thus affecting the products somehow. They were also able to quantify the saving by giving it a financial value. They were certain that the change could be attributed to the project at hand, and stated a likelihood of 10/10.

4.2.2. Additional effects on energy use

Supplier	Has **energy use** increased at all, for any energy type in any part of the production (even if it has decreased elsewhere)?	Can this be translated to financial terms?	What cost/saving?	On a scale from 1 to 10, 10 being the most likely, how sure are you that these water-related changes can be attributed solely to this project?
Supplier D	No	-	-	1
Supplier 1	No	-	-	1
Supplier 2	No	-	-	9
Supplier 3	No	-	-	1
Supplier 4	No	-	-	9

Fig. 18. Additional effects on energy use

None of the suppliers experienced an increase in energy use for any part of the production even if energy use decreased elsewhere. Since there was no increase experienced, the likelihood of the changes being attributed solely to the project is irrelevant in this case.

4.2.3. Additional effects on chemical use

Supplier	Have you experienced an increase in any **chemical use** since the project, even if it decreased elsewhere in the production?	Can this be translated to financial terms?	What cost/saving?	On a scale from 1 to 10, 10 being the most likely, how sure are you that these chemistry-related changes can be attributed solely to this project?
Supplier D	No	-	-	10
Supplier 1	No	-	-	1
Supplier 2	No	-	-	10
Supplier 3	No	-	-	10
Supplier 4	No	-	-	1

Fig. 19. Additional effects on chemical use

None of the respondents experienced an increase in chemical use in one part of production even if they experienced a decrease elsewhere. Since there was no increase experienced, the likelihood of the changes being attributed solely to the project is irrelevant in this case.

4.2.4. Effects on the facility

Supplier	Have you experienced a change in the need for **maintenance work** after your project?	Has there been a change in the need for **engineering controls**?	Has the project led to a change in **cooling/ heating requirements** either in the process or building?	Has the project led to a change in **wear and tear on equipment/ machinery**?	On a scale from 1 to 10, 10 being the most likely, how sure are you that these maintenance-related changes can be attributed solely to this project?
Supplier D	Neutral	Neutral	No	No	1
Supplier 1	Neutral	Positive	No	No	5
Supplier 2	Neutral	Neutral	Yes, less heating. Saving: Approx. INR 227,000 /year	No	10
Supplier 3	Neutral	Neutral	Yes Saving: Approx. INR 193,000/year	No	10
Supplier 4	Neutral	Neutral	No	Yes	8

Fig. 20. Effects on the facility

None of the suppliers experienced an increase in the need for maintenance work after the project. Supplier 1 experienced a positive change in the need for engineering controls, while the others saw no change. 2/5 respondents answered that there was an effect on heating or cooling in the process or in the building, and were able to provide the financial saving. Both of these were entirely sure (the likelihood was 10/10) that these changes could be attributed solely to the project at hand. Supplier 3 was the only one to experience an effect on the wear and tear of equipment, and was rather certain that this change was related to the project (the likelihood was 8/10).

4.2.5. Effect on emissions

This question asked whether the factory was aware of how the below emissions were affected as a result of the project.

Supplier	CO	CO2	NOx	SOx	Dust	Cost/saving?
Supplier D	No	No	No	No	No	-
Supplier 1	No	No	No	No	No	-
Supplier 2	No	No	No	No	No	-
Supplier 3	No	No	No	No	No	-
Supplier 4	No	No	No	No	No	-

Fig. 21. Effect on emissions

None of the suppliers were aware of how the above emissions have been affected by the project.

4.2.6. Effect on work environment

Supplier	Have your employees mentioned any changes in their **work environment** since the project implementation?	Is it possible to express these changes in monetary terms through change in productivity, change in sick days, change in staff turnover etc.?	Have you noticed a change in **worker morale?**	Is there a changed need for **personal protective equipment?**	Was there any **staff training** connected to the project?	Any change in **lighting**?	Any change in **noise levels**?	Is there a change in **temperature control**?	Is there a change in **indoor air quality**?	On a scale from 1 to 10, 10 being the most likely, how sure are you that these work-environment-related changes can be attributed solely to this project?
Supplier D	Yes	No	Positive	No	Yes	No	Neutral	Neutral	No	10
Supplier 1	Yes	No	Positive	No	Yes	No	Neutral	Neutral	No	5
Supplier 2	No	No	Neutral	No	Yes	No	Neutral	Neutral	No	5
Supplier 3	No	No	Neutral	No	Yes	No	Neutral	Neutral	No	5
Supplier 4	No	No	Positive	Yes, Saving: INR 2,000/ month	Yes	No	Neutral	Positive	No	6

Fig. 22. Effect on work environment

2/5 respondents experienced that employees mentioned a change in their work environment. However, none were able to express those changes in monetary terms. 3/5 saw a positive change in worker morale. Only Supplier 4 saw a changed need for personal protective equipment, and noted a saving of INR 2,000/month. All suppliers had staff trainings connected to the project. None of the suppliers saw a change in lighting, nor a change in noise levels. Supplier 4 saw a positive change in temperature control, while none of the respondents experienced a change in indoor air quality. The likelihood that these changes can be attributed solely to the projects at hand ranges from 5 to10/10 on the likelihood-scale.

4.2.7. Effect on productivity

Supplier	Any increased **output/yield**?	Any change in **equipment performance**?	Any change in process cycle times leading to a change in **production time**?	Any change in **product quality**?	Any change in **reliability of production**?	Any change in **labour requirements**?	Has the project changed your **ability to expand** your production?	If so, how?	Any change in **production interruptions**?
Supplier D	No change	Neutral	No change	Neutral	Neutral	No change	No	-	Neutral
Supplier 1	More	Neutral	No change	Positive	Positive	Positive change	No	-	Neutral
Supplier 2	More	Neutral	Shorter	Neutral	Positive	No change	Yes	The project has reduced the process time by 20 minutes/batch	Neutral
Supplier 3	No change	Neutral	No change	Neutral	Positive	No change	Yes	The water savings have led to an increase in production	Neutral
Supplier 4	No change	Positive	No change	Neutral	Neutral	No change	No	-	Neutral

Fig. 23. Effect on productivity

2/5 respondents encountered an increased output/yield. Only Supplier 4 saw a positive change in equipment performance. Supplier 2 saw shorter process cycle times leading to a change in production time, while Supplier 1 saw a positive change in product quality. 3/5 experienced a positive change in reliability of production. Only Supplier 1 saw a positive change in labour requirements. 2/5 reported a changed ability to expand production. The reason given for this change by Supplier 2 was that the process time was reduced by 20 minutes. None experienced a change in production interruptions.

4.2.8. Additional effects

Supplier	Any change in **product waste**?	Any change in **hazardous waste**?	Do you feel that your ability to live up to any other local or national **regulations** has changed?	Any change in **brand image**?	Any change in **use of space**?	Have you experienced any further **negative effects** from this investment?	Have you experienced any further **positive effects** from this investment?
Supplier D	No change	No change	No change	Positive	No change	No	Yes
Supplier 1	Positive change	No change	No change	Positive	No change	No	Yes
Supplier 2	No change	No change	No change	Neutral	No change	No	Yes
Supplier 3	No change	No change	No change	Neutral	No change	No	Yes, leakages have stopped
Supplier 4	No change	No change	No change	Neutral	No change	No	Yes

Fig. 24. Additional effects

Only Supplier 1 experienced a change in product waste. None saw a change in hazardous waste, nor the ability to live up to local or national regulations. 2/5 experienced a positive change in brand image. None experienced a change in use of space. There were also no further negative effects from the project reported, while all five experienced further positive effects, of which one was that leakages had stopped.

4.2.9. Effect on behaviour

Supplier	Has the investment or change made you more or less prone to invest in resource efficiency?	Will you consider investments/projects in resource efficiency differently after this project?
Supplier D	Positive	Positive
Supplier 1	Positive	Positive
Supplier 2	Positive	Positive
Supplier 3	Positive	Positive
Supplier 4	Positive	Positive

Fig. 25. Effect on behaviour

All suppliers answered that they are more prone to invest in resource efficiency after the project at hand. They also all answered that they will consider investments or projects in resource efficiency differently after this project.

4.2.10. Effect on finances

Supplier	Were there any financial savings incurred due to this project that hasn't been accounted for?	Were there any financial costs incurred due to this investment that hasn't been accounted for?	Were you expecting all the savings and improvements that came out of the investment?	Which was the most beneficial outcome for you after this investment?	Was this the outcome you thought would be the most beneficial for you, or was it a surprise?	Any change in capital expenditures?	Overall, from all cost-saving projects that you have undertaken since ZLD implementation, how much of the cost that implementation of ZLD has entailed has been offset?
Supplier D	No	No	Yes	Steam condensate reused, boiler efficiency improved by 3%	Expected	Delaying	>5%
Supplier 1	Yes	No	Yes	Steam savings by changing faulty steam traps	Yes	Increase	>20%
Supplier 2	No	No	Yes	Energy and water savings	"Most beneficial for us"	Reduction	>5%
Supplier 3	No	No	Yes	Water Ratio from 10 to 7	"Water Savings"	Increase	>5%
Supplier 4	Yes, INR 10,000/month. Compressor running time minimized. Boiler blowdown frequency monitored and set right (unnecessary blowdown avoided)	Yes, INR 30,000 for moisture meter	Yes	Moisture measurement in output yarn regularised, unnecessary blow-down avoided, running time of compressor reduced	"Surprise"	Increase	>5%

Fig. 26. Effect on finances

2/3 respondents answered that there were financial savings incurred due to this project that hadn't been accounted for. Supplier 4 described this saving of INR 10,000/month in the above table. Supplier 4 also experienced a financial cost which has not been accounted for; INR 30,000 for a moisture meter. They all expected the savings and improvements in water, energy and chemicals from the project. They all noted their most beneficial outcome in the table above, and all but one expected that this would be the most beneficial outcome. The change in capital expenditures varied between them, where Supplier D experienced a delaying, Supplier 2 a reduction, and the other three an increase. When considering all the cost-saving projects undertaken since ZLD implementation, Supplier 1 answered that less than 20% of the cost had been offset, whereas the others answered less than 5%.

4.3. Interview results

The below section presents the results from the interviews made. The interviews were conducted in order to give a better understanding of the resource nexus in the textile industry, as well as to understand the wider perspectives of the mandate on ZLD, and what future prospects may be. It gives an insight into what other factories and purchasing brands may be expecting in the future, and how factories can be supported by purchasing brands and policy-makers in the successful transition to a more sustainable production. The four interviews are presented independently, and have been categorized in topic areas.

4.3.1. Anshul Chawla, Sustainability consultant at cKinetics, Delhi, Telephone interview, March 21st 2016

4.3.1.1. Holistic business case

Mr Anshul Chawla (A.C.) highlighted the importance of considering a holistic business case when investing in water efficiency. He believes that when considering an investment in water efficiency, there may not be a real business case since the water resource is inexpensive. However, when you look at the investment holistically, there may be a business case.

He gives an example from supplier D, which conducted a bio scouring project. Bio scouring is a replacement chemical. When conducting trials for using this replacement chemical, they found that the process cost increased. This is because the bio scouring chemical is more expensive than the one that was used before. However, at a system-level, this change led to net savings. Although the chemical is expensive, it was possible to combine at least two different process steps into one. As presented above, the project saved water, energy, and generated savings on the treatment side. Thus, on a local level the change may look more expensive, but on a system-level it might generate savings.

Regarding the value of water, A.C. stressed that when discussing this, there needs to be a certain understanding regarding the use of water in the textile industry. He clarified that water is only a carrier for energy, chemicals and waste and is not an ingredient in textile production at this supply chain level. When looking at water not as a resource but as a carrier; whenever you add a chemical to that, there is an additional value associated with the water. A.C.'s explanation of this relationship between water and cost is presented in Fig. 27 below.

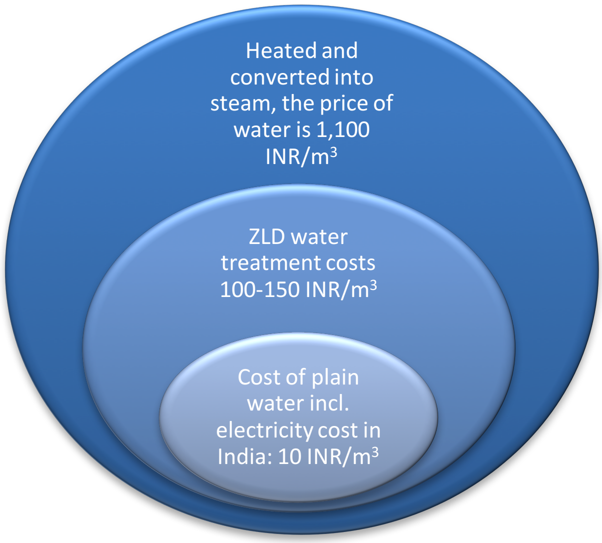

Fig. 27. The actual cost of water in textile production in India

In other words, the cost of water can increase by 10 to 100 times depending on how the factory uses the water; i.e., how it carries energy and chemicals. The cost of water can increase to as much as 3000-5000 INR/m^3 if it carries dyes or certain chemicals as part of the production process. This is where the connection between the resources comes into the picture, and where a business case for water efficiency can be made. The business case is created through connecting water use to a more expensive resource. In India, process chemicals give the best business case for water efficiency, and secondly thermal energy. This differs between countries since the price of fuel varies between countries. Therefore, the resource that gives water the best business case should be regarded locally. In Tirupur, in the Indian State of Tamil Nadu where these factories are located, it's process chemicals and thermal energy which give the best business case. Electrical energy doesn't provide as good of a business case in this region.

4.3.1.2. Unexpected effects of measures

When asked regarding any unexpected effects of the measures taken by these textile factories, A.C. made a special mention of the project by supplier 3, which was the reduction of MLR from 1:10 to 1:7. Apart from the expected resource savings of chemicals and energy, there were two benefits which they had not accounted for. Firstly, it led to a process time reduction of 30% which lead to a direct productivity increase. The second unexpected benefit was related to the fact that Supplier 3 is connected to a Central Emission Treatment Plant (CETP), and thus they do not operate their own ZLD, but outsource it. A certain amount of companies come together to put up a CETP, and all factories connected to the CETP have a certain quota for amount of water to be treated. Since Supplier 3 experiences a water reduction of 30%, this meant that they had a 30% spare quota. With this spare quota, they could increase their production. The actual production expansion was 15% due to the increased volume capacity. This meant that they were able to add more machines. This was an effect beyond the factory fence which was not originally accounted for. A.C. stated that this was a learning process for cKinetics and that they will apply this possible effect to other projects as well when they have similar projects. They will from now on assess how the measure affects the factory's production capacities.

When asked whether there are any energy-use regulations which are difficult to comply to due to the implementation of ZLD, A.C. answered that this wasn't really the case. Generally, factories forced into using ZLD don't face problems with other regulations. On the contrary, by complying with ZLD, these factories automatically comply with waste water discharge and chemical regulations. According to A.C., there are only positive effects of ZLD, and no negative effects in terms of ability to live up to regulations.

The positive effect on behaviour change was a surprise to A.C. After having conducted these measures to lower the costs of operating with ZLD, the factory managers were much more receptive and open to the other projects and ideas that cKinetics brought forth. This behaviour change was also very important for the factory management. For them it meant action on the ground. They now plan more carefully in terms of resource efficiency. cKinetics sees this behaviour change as a catalyst.

4.3.1.3. How to increase systems thinking

When asked what he believes will motivate factory management to invest with systems thinking in mind, A.C. answered that there is nothing better than case studies. Case studies demonstrate a certain outcome, with which the factories can establish correlations to their own production. This way, they can realize and visualise that this is something they could actually expect in their own process since it's the same or similar process.

He also added that another good motivator for investing with systems thinking in mind would be training and capacity building programs which make them think about these issues. The training doesn't necessarily have to give them any answers, just simply make them think about these issues. In fact, cKinetics has developed a tool, called the "Value Added Water" tool, as described in the theoretical framework. When using this tool, and when starting to compile data, users are faced with their use of all resources. Seeing their own resource use makes them wonder how they can decrease or optimise it. It's beneficial if they themselves plug in all the data in order to realize the opportunities and themselves make the correlations. This approach is much more effective in the long-term than simply approaching individuals and telling them about possible savings. When asked whether the tool acts as a type of therapist, where the therapist simply asks questions and the patient reaches an understanding independently, A.C. answered that yes, if they start collecting the data for themselves, they will start making the correlations. There is in fact no need to tell them about the correlations. It's all about collecting the right information and filling it into the right format.

4.3.1.4. Future competitiveness

When asked whether he believes that Indian factories which are forced into ZLD will be competitive in the future, A.C. gave his personal view. First, he finds it important to distinguish between regional and national competitiveness. Some Tamil Nadu factories are surviving after 5 years of regulation, and thus it's possible to survive this forced regulation. However, there needs to be a more uniform levelled playing field. It's difficult when factories in a certain region are subjected to a certain law while others aren't. A global mandate would create a more levelled playing-field, but he says himself that this is more of an idealistic idea. A more practical view would be if there is a national draft for ZLD legislation, which is already being discussed.

In the short run a national legislation for ZLD may keep Indian competitiveness behind, but eventually brands would choose Indian production as it offers a more sustainable and responsible production, even if it's costlier. Regions which offer much better water management than others could be more competitive. That makes a big case for purchasing brands to shift their purchasing to more responsible production even if marginally costlier.

Another aspect which A.C. finds important in terms of future competitiveness of factories mandated under ZLD is the fact that mass-implementation of ZLD from a national mandate means newer and cheaper technologies, since it increases the market demand for ZLD technologies. The question of how to reduce the cost of treatment to a level where it becomes a levelled playing field also plays a role.

In summary, A.C. believes that there are three factors to be taken into account regarding future competitiveness. These are policy-making, purchasing brands dealing with increased costs, and technical development from mass implementation. If these factors develop in the right direction, Indian companies will definitely be more competitive than factories in other countries. However, as A.C. said, "If they fall on the wrong side, we can only hope…"

When asked whether ZLD will be an advantage to these companies, or if it will be difficult to compete in a global market, A.C. answered that immediately, it will be difficult. He said that this is a thought which needs to mature with all of us. Brands then need to decide if they would move to other places which are cheaper. Immediately these factories will be on the losing side, but eventually brands will need to purchase responsibly.

Regarding future costs of ZLD, A.C. said that the expense of ZLD will reduce, but it will always be costlier than conventional production. Compared to a factory in Bangladesh where there is no ZLD mandate, the cost is higher in India. It may reduce over time, but it will always be higher. When asked whether factories will be able to reach non-ZLD production costs by conducting efficiency projects such as the ones in this study, A.C. says that this is their wishful thinking. They try to make it comparable to other systems by lowering energy costs, chemical costs etc.

When asked whether the Indian government understands the effect on industry, A.C. answered that industry representatives have been telling the government that ZLD legislation is making India less competitive globally. They have been saying that many small factories may not be able to implement this and may have to shut down.

4.3.1.5. Offsetting the cost

An important question remains: How much can efficiency projects offset the increase in cost because of ZLD? A.C. answered that they have not done an offset evaluation for the projects, i.e. how well the cost is offset, but it's important to understand that the dyeing process is only a part of the whole supply-chain. Raw cotton, spinning, weaving, wet processing, etc., together make up a whole supply chain. We cannot make an assessment of the cost only based on this part of the process, we have to look at the whole supply chain. For a typical dyeing factory, ZLD increases the cost by 15-20%. That does not however change the raw material price. Cotton is still at the same cost, so when you make the garment, it only has a 4-5% impact on the garment exported. At the brand selling price, it has less than 1% price impact. You have to look at the price of the supply chain. It may have a very local impact as the process becomes costlier, but that cost is distributed across the supply chain.

Regarding the actual offset for the factories at hand, A.C. had no numbers to share, but states that the situation is better than before. It's on a project-to-project basis, so they can't say how much they are able to offset it. It can impact either a small process part or a larger system, so it's difficult to generalise.

4.3.1.6. The role of brands and authorities

When asked what brands and authorities can do to help these factories comply with ZLD and remain competitive, A.C. said that brands should be investing in capacity building. He already sees this change happening. For far too long there has been a focus on audits. Audits are checklists, and they give factories a score which they should have improved by the next audit. All factories want to improve, but often they don't know what to do. If someone can help them with what to do and give them technical assistance on how to do it, that makes a much stronger impact. They want to improve, but they want someone to tell them how to do it. They wonder what the next step is, and wonder if what they're planning is technically correct and if it will work or not.

As a follow-up question, A.C. was asked whether he believes that factories will be open and transparent to share measurements. He believes that financial numbers will not be shared easily, as the factories might think that the business teams at the purchasing company will try to lower the costs. However, they will most probably be comfortable sharing other resource numbers. This is of course at the condition that they feel that the purchasing company will help them, and not pressure them. So it's also about building confidence. To quote A.C.: "If they see you as a friend who will help you in improving, they will share their data. If they see you as a policing person, then they will be reluctant, because they don't know what wrong you will find in the data and then give them trouble." It also depends on the brand, and how dependent the factory is on the brand at hand. If there is a higher dependence, then they will be more willing to share. If the brand has less than 1% of the overall volume, then they don't have enough leverage to put pressure on the factory to share details. Collaboration is important, and if both small and large brands come together and ask for the same thing, more can be done. That's essentially what the STWI program is doing.

4.3.1.7. Advancing the understanding of the resource nexus

When asked how the understanding of the resource nexus could be advanced, A.C. answered that it would be helpful if more factories kept data. According to A.C., large factories already keep data, but smaller factories would need to do it too. That would make it easier for consultants to draw resource nexus connections and propose appropriate actions. Essentially, it helps to diagnose. It would also be helpful if they could share their data more openly. This will happen when they start seeing the consultants and the purchasing brands as trustworthy, and when a good relationship has been established. Thus, Small and Medium-sized Enterprises (SMEs) would need to set up more data collection systems. However, that should not be forced, as it's better to first convince them why its important to collect certain data. Advancing the collection of data should be the first approach before enforcing anything. Also, knowledge sharing from a familiar factory, as well as global expertise, is appreciated by the factories.

4.3.2. Varun Chawla, IKEA Purchaser, Delhi office, Telephone interview, April 28th 2016

4.3.2.1. Business team approach

Being an IKEA purchaser working with Supplier D (and indirectly with Suppliers 1, 2, 3 and 4), Mr Varun Chawla (V.C.) mentioned that he does discuss the effects of the projects undertaken to lower the cost of ZLD with Supplier D. These discussions are mostly related to business issues, such as Return on Investment (RoI), pay-back period etc.

As regards the difference in approach towards these projects between the business team and the sustainability team, V.C. says that the approach is the same because they all speak the same language, and the only difference is that the sustainability team is more ethically founded. That means that they talk more about the facts, the benchmarking etc. while the business team has an approach which is more from the overall business level.

4.3.2.2. Prioritizing effects

Regarding the business team's approach to other possible effects of investments or changes that they propose to their suppliers, V.C. said that they have a very clear discussion of what the positive aspects are and what is probably not in favour at that certain point in time. They discuss which things would actually benefit the management in making them more competitive and more aligned with the IKEA business model. He said that they also evaluate negative impacts and how they can find better solutions and the right balance between the positives and the negatives.

4.3.2.3. Brand attitude towards ZLD

V.C. believes that it's helpful for IKEA when the local enforcement for suppliers, in this case the ZLD legislation, is very strong. That makes it easier for IKEA to comply to the standards they have set for themselves.

4.3.2.4. Future competitiveness

V.C. says that Supplier D has become more attractive to IKEA since the implementation of ZLD and the consequential projects to lower the costs of ZLD. Supplier D is now considered an appreciated supplier in the textile category, partly because of the sustainability initiatives. Thus, Supplier D has become a preferred choice for discussing new products and initiatives since they know that Supplier D has the right mind-set, the right value fit and they are aligned with the IKEA business model.

He further stated that purchasing prices from Supplier D have not changed. In some areas they are even able to save some extra money, for example through the fact that salt now can be reused.

V.C. believes that ZLD factories definitely will be more competitive in the future. In 5-7 years, other factories will also be facing these demands, so the companies who now take the lead will be more competitive. By that time, they will have recovered their investments as well, so it will definitely be cheaper. He also thinks that the way in which ZLD protects communal resources is very important for a business to survive. If the utilization of water and other resources remains unchanged, it will become a challenge. Therefore, in a way, V.C. believes that ZLD could actually help these suppliers to survive and become more competitive and effective.

According to V.C., IKEA is leading these initiatives today, but 5-10 years down the line, other customers will also be asking for suppliers who work with these issues. Sooner or later everyone will have to take a step towards it. If a factory makes this transition already now, it will be very beneficiary for them.

4.3.2.5. Additional effects of projects

V.C. has not seen any changes in product quality or reliability in delivery from Supplier D due to the projects at hand. With regards to the sub-suppliers, i.e. Suppliers 1, 2, 3 and 4, one of them was not able to deliver to Supplier D on time due to the changes related to their projects. However, there does not seem to have been any major problems with product quality or reliability in delivery overall.

4.3.2.6. The role of local authorities

V.C. believes that local authorities could help through supporting the suppliers with some kind of softer loan with a lower interest rate. Since ZLD implementation involves a lot of costs, and since not all factories are able to take these costs, that sort of loan would be helpful. V.C. goes on to say that the second thing could be to subsidize land where factories can place the ZLD plant since ZLD uses a lot of land. Thirdly, authorities could set up a communal water treatment plant which suppliers collectively could send their water to. Thus, they should either subsidize the operations or give some more subsidies related to this.

4.3.2.7. The role of IKEA

V.C. believes that IKEA can support this transition to ZLD through interacting with the factory management. The transition requires a mind-shift, so it's more interaction with factory management that is needed. This means more meetings, the sharing of good examples, and appreciating suppliers who are improving and taking initiatives. Furthermore, the suppliers should be backed by a business commitment, since that makes it easier for suppliers to decide for an investment. IKEA has not yet set any business commitment with Supplier D, but it is being discussed.

4.3.2.8. National legislation

Regarding the effect of a national legislation on ZLD, V.C. said that demand for ZLD technology will be higher, which should bring down the prices. When only a few do it, it's more expensive. Regarding the effect on product prices, V.C. answers: "We'll have to see if suppliers will want to pass on this cost to their customers. That's something which IKEA needs to look into."

V.C. said that being a purchaser in India, he supports a national ZLD legislation. However, the implementation time should be divided into phases. A road map should be prepared, and it should be discussed with the different suppliers' associations. He believes that they should move towards a national legislation, but that it should not be done in a rush. A phase, step-by-step approach would be preferable.

Faced with the question of whether IKEA would leave India in case there is a national ZLD legislation, V.C. proclaimed that there are more factors to consider than just that legislation for whether IKEA would stay or not, for example transportation costs from other countries.

4.3.2.9. Sharing of costs

V.C. says that IKEA should not be passing on the costs of ZLD to its final customers. Instead, IKEA and suppliers can discuss a value-sharing agreement if the cost of ZLD is too high for the supplier. V.C. said that if he were a factory owner, he would not pass on the increased product cost to his customers, but rather ask for a business commitment. Another option would be to support by offering a loan. To quote V.C.: "…but for sure not pass on this cost to the customers."

4.3.3. Sandesh Waje, IKEA Sustainability Developer, Delhi office, Telephone interview, March 31st 2016

4.3.3.1. Background

When asked what the most important resource efficiency is in India, Mr Sandesh Waje (S.W.) answered that this is definitely energy. Today there is a significant cost in terms of how much the factories pay for the generation of energy at utilities. The second most important resource efficiency in India is water. Water is also becoming costlier day by day, but still today energy is more important than water. For that reason, he believes that it might have been a mistake from a business perspective by the state Tamil Nadu to prioritize water instead of energy. He maintained that they need to acknowledge what costs the most, which in this case is energy. Factories will always prioritize energy savings rather than water savings because of the cost.

When asked if Tamil Nadu is facing water scarcity and whether this might have led to this prioritization of water, S.W. answered that water scarcity is not the case in all of Tamil Nadu, but in the industrial areas such as Tirupur. Factories in Tirupur are not allowed to take out water from the ground. They have to purchase water from an authorized party. That's one of the reasons why water has become costlier in this area. However, in other parts of Tamil Nadu, that may not be the case. In fact, water scarcity is not the main reason for the ZLD legislation. The major reason for the ZLD legislation is the pollution emitted by the textile industries in that region. When water resources are controlled this way, water becomes scarce. There is in fact a strong link between water pollution and water scarcity.

4.3.3.2. Future competitiveness

S.W. believes that ZLD will soon be applicable throughout India, and that very soon it will also be mandated in Pakistan and Bangladesh. Those who have already changed into ZLD will have a competitive advantage at that point.

He continued to say that there are mixed views from factories regarding if they appreciate ZLD or not. Today many see it as a cost due to the energy, but most appreciate that it will be an advantage for them in the future.

Asked about how suppliers with ZLD are graded in terms of sustainability by IKEA after the projects, S.W. responded that in India some IKEA suppliers have ZLD, while others don't depending on the local regulations where suppliers are situated. IKEA doesn't compare these suppliers to each other, but rather compare suppliers to their own performance in the last years compared to the current year.

4.3.3.3. The role of authorities

S.W. argues that authorities in India are heavily into inspection and auditing, and not so much into supporting. The successes of the factories in Tamil Nadu are all thanks to the efforts and hard work of the factories themselves. They are not getting substantial help from authorities. He adds however that there has been some financial support: “Wherever it was not possible for industry to change to ZLD in 2011, the government offered some soft loans, and they formed some groups where some of the money was funded by the government and some by international banks.” This is still offered, even at the national level.

4.3.3.4. The role of IKEA

According to S.W., IKEA help improve the competitiveness of suppliers faced with ZLD through two main approaches. First, IKEA takes the initiative for efficiency projects, where they expose suppliers to new technologies and new projects for sustainable production with focus on water, energy and chemicals. Secondly, there is the implementation of IWAY (The IKEA Way on Purchasing Products, Materials and Services), IKEA’s social and environmental purchasing standard. During IWAY auditing they make sure that the suppliers are doing well, and where there is room for improvement they share knowledge with them.

He continued to argue that IKEA is leading the efficiency agenda in South Asia. He gave the example of Bangladesh, where IKEA was the first company to do a water project in the country. This was appreciated by other customers of that supplier. The water control authority also appreciated it, and created a guideline for water use in industry based on that project.

4.3.3.5. Nexus relationships

When asked how IKEA considers the nexus relationships of resources in these projects, S.W. provided an example. In 2013 they conducted a pilot at one of the suppliers in Bangladesh. At first they started focusing on water use and the water processes. However, throughout the process they realized that they can’t work exclusively on the water aspect. If they want to work with water use, then they need to consider the chemicals and the energy consumption of the suppliers. Thus, they worked simultaneously on all these aspects, which proved advantageous both in terms of resource and cost savings. IKEA clearly see the nexus relationships between resources. He continued to say that the suppliers also understand this very well.

4.3.3.6. National legislation

When asked about what will happen to Indian textile industry’s competitiveness if there was a national legislation on ZLD, S.W. made an important comment. India is not just a big manufacturing country; it is also a big market for these brands. For that reason, he doesn’t think that the brands will leave the country. They will stick with responsible Indian suppliers as the same thing will happen in other countries in a few years. If they would leave India because of ZLD, they would move in vain. IKEA will probably not move since they believe in long-term partnerships and need the IWAY standard to be implemented. It would be difficult for a company such as IKEA to move to other countries and face the same challenges as they have faced already in India.

As a sustainability developer at IKEA, he would appreciate a national legislation on ZLD. He commented that the water shortage is getting more serious day by day, and therefore they need to have efficient operations at the factories.

When asked about the prioritization between water and energy, he argued that its difficult to weigh these two resources against each other as different regions have specific shortages. In certain regions they have droughts and in others they don't. It's a case by case, region by region issue when it comes to the importance of energy and water.

This answer was followed up with a question of whether or not there would be a problem in terms of energy use if ZLD was made a national obligation. He answered that only implementing ZLD will not cause any acute problems for the industry or for the government in providing energy. This is because the government and many industries, including IKEA, are asking suppliers to start investing in renewable energy such as wind and solar. Luckily, there isn't really a trade-off in energy use between factories and communities.

4.3.3.7. Advancing systems thinking

S.W. was asked how to get suppliers to invest with systems thinking in mind. His response was that IKEA conducts water risk mapping and share that information with the supplier. Whenever they have to take a decision on a particular project, they can imagine what the needs are. IKEA offers training, support and analysis to the suppliers. They tell them about future potential compliances with which they will have to comply in a specific region. They have for example learnt that by 2018, the Indian government is planning to have ZLD implemented across the nation. When they got this information, they openly shared this information with the suppliers and with the business teams. That way, they can be better prepared to comply by 2018.

4.3.4. Margareta Björkander, Global Water Sustainability Responsible at IKEA, Älmhult office, Telephone interview, April 6th 2016

4.3.4.1. IKEA's water strategy

Ms Margareta Björkander (M.B.) was asked to describe IKEA's water strategy. Her response was that IKEA's general approach is that they will be water positive by 2020. This regards all purchasing and all of IKEA, and it affects their approach in the textile industry. When it comes to the textile industry, they have two approaches. Firstly, they have decided to be part of the STWI projects, where they have included a number of suppliers and sub-suppliers. Secondly, they have made many energy projects internally, which look rather similar to those done through STWI. Where water has been a component for the industry conducting energy projects, they have included water in the project and not only focused on energy. Energy and water are very closely related at the textile industries. It's not always the case that both water and energy are saved at the same time, but these are highly interlinked. However, most often, when doing an efficiency measure, you can see an efficiency improvement on both resources. STWI's projects tend to touch water, energy and chemicals in a holistic approach.

M.B. continued with the specific case of India, saying that the more legal structures there will be, such as ZLD, the greater the effect and the awareness around that. When Tamil Nadu mandated ZLD, IKEA had already come to the point where they asked the suppliers to have the relevant water treatment in place. Therefore, they welcome that sort of legislation because it helps in achieving the standards that IKEA asks for.

4.3.4.2. The resource nexus

When asked to what extent they isolate resources in projects, M.B responded that they very early on gave up the idea that they could work with water separately in the textile industry. This is mostly because they need to create an incentive for suppliers to work with water, since for water there is not as strong a business case as there is for energy. Among the textile suppliers, it very rarely happens that they only focus on energy in projects. They also include water and chemicals. All those who work with textiles in IKEA have the opinion that if you have wet processes and water use, then energy and chemicals should be investigated simultaneously.

She continued to say that they have pushed energy and water projects as business development projects, and that naturally means that the cost is the most interesting aspect. Energy has been rather easy to work on from an efficiency perspective since when you save energy, you automatically also save money. Water use management is something which Margareta finds still more driven by the sustainability organisation than the business organisation. This is partly due to the fact that water is not priced in the same way as energy, and because the awareness about water is more complex, and the connection between water and energy is not widely understood. Reports say that the water crisis seems to be the next big climate issue. But she doesn't feel that this has yet been internalized in business operations. The reasons for wanting to work on water are numerous; starting from the fact that we can't live without water to the fact that it is a valuable resource. IKEA wants to see water as a valuable resource; however they've seen that in terms of efficiency, it's easier to connect water to energy as it gives a clearer cost picture, and because there is already a method in place. The interest in water is more from a sustainability perspective, and not so much from a cost perspective. She says that they are just at the beginning of illustrating the cost of water. The discussion on the fact that water is under-priced has been going on for a long time, but there hasn't really been a clear development in the right direction.

One example of the trade-off between resource uses which M.B. mentions is often discussed within IKEA is the trade-off between water and energy use when focusing on not discharging any water from the factories. This means that production can be costlier due to increased energy use. This example shows that water and energy might not always be connected in a logical way. However, she believes that in most cases of saving water, there is also an energy saving.

When asked whether there is any prioritization between the efficiency of certain resources within IKEA, she answered that they haven't faced any sharp decisions where they had to choose one resource over the other. However, if there is ZLD legislation, then it's a legal requirement which cannot be ignored. That gives a stronger case for water efficiency.

4.3.4.3. Added costs

M.B. sees the issue with added costs because of ZLD in terms of the necessity to widen the understanding among both business and sustainability teams within IKEA about the cost of water treatment at different dimensions. Suppliers are sometimes ahead of IKEA when it comes to development in sustainability. They may have already started to work on a specific issue when IKEA comes along with its' demands and standards. They may find it odd if a customer doesn't accept a higher price due to better sustainability. However, those who work with the textile industry know that better water treatment costs money.

4.3.4.4. Multiple effects

She stated that there are often benefits of changes which cannot be quantified, but which they are aware of. For example, with ZLD legislation follows other positive side effects, such as the advancement of technology developments. With legal enforcement and a strong follow-up, there are good chances that the entire industry will move to the better.

When asked about whether IKEA works with the multiple benefits of water efficiency in the same way as they do with energy efficiency, and the answer was no. She continued to say that there are often effects which are not easily connected to a project, and there are also monetary benefits or effects (negative and positive) which are very difficult to illustrate. M.B. continues to say that in the end, the projects that they undertake under a water or energy umbrella end up looking very much alike.

The interviewer commented that companies make investments which are usually not about resource efficiency, but rather about production. For that reason, it might be advisable for those interested in resource efficiency to integrate it into general investments, rather than isolating resource efficiency. M.B agreed, and to quote her: "If you say that 'this investment has been done, and it stemmed from certain improvement potentials, but we made an analysis which showed that a lot of water, energy, chemicals etc. could be saved, and for that reason we decided to do this investment.' Then drop the prioritization order and say that this investment led to these effects, in terms of money, resource efficiency and other effects." She added that perhaps it's better to list 'Best Available Investments' rather than 'Best Available Techniques'.

4.3.4.5. Future developments

M.B. said that legislation such as ZLD drives research and development forward. She said it might be visionary, but in 20 years from now the textile industry might not be using water to dye fabrics anymore. There are already some technologies which colour polyester etc. without using water.

4.3.4.6. National legislation

M.B doesn't think that IKEA would leave India if ZLD became a national legislation, partly because they are establishing themselves there in terms of retail, and they want to work with local sourcing. In general IKEA has the philosophy of not leaving a country when there are complexities that arise. IKEA has a very stable supplier base, as the average duration for being an IKEA supplier is 11 years. In this case the mentioned increased complexity relates to the development of a country, and that is something that they would welcome. In case ZLD spreads in the region, it would be a good thing. When the interviewer commented that IKEA has a policy of implementing the strictest rules which nations set in all other purchasing regions, M.B. affirmed this comment and added that for that reason, it would be beneficial for IKEA if ZLD was mandated in other countries in the region, such as Bangladesh and Pakistan.

4.3.4.7. Business integration

Asked about business integration in sustainability issues, M.B answered that the general business developer is today up to date with sustainability and they are requiring more and more from the sustainability team in terms of more flexibility and more knowledge. This is so that they are able to keep good dialogues and understand complex situations. Before, they used to speak about resources in isolation, such as waste, water, energy and whatever they found important. Nowadays it's a more complex discussion about how these different parameters connect.

5. Analysis and Discussion

Below follows the analysis and discussion section, where the data will be analysed and discussed. To recap, there are three research questions for this study. The first two are: “What financially quantifiable and non-quantifiable effects have resulted from measures taken to lower the increased costs incurred due to ZLD regulation on the chosen five textile factories in Tamil Nadu, India?” and “How can the findings from the above question be concretized into a framework for application by industry?” These two will be answered through analysing and integrating the secondary data and the survey data with the theoretical review, and consequently creating a multiple effects framework. The third research question reads: “What lessons learned are there for Indian textile factories who are about to face ZLD regulation, policy-makers who are about to impose it, and the factories’ customers?” This question will be answered through analysing the interview results in light of the theoretical review presented earlier. This section is divided as follows; first a mention about the analytical methods used. Following that, the multiple effects framework will be developed and discussed. Finally, the interview results will be analysed and lessons learned will be presented in a discussion.

5.1. Analytical methods

The analysis looks somewhat different for the different parts of the results gathered. The secondary data and survey data will first be categorized in terms of the reported effects. It will then be analysed in light of the Multiple Benefits of Energy Efficiency Improvements Framework (MBEEIF) and the Value Added Water (VAW) concept. Based on this, a framework listing the multiple effects of investments in ZLD will be created. It will be referred to as the Multiple Effects Framework (MEF). The interview results will be analysed by dividing them into categories, and subsequently analysing them against the theoretical background.

Regarding the actual analytical methods used, the results of this study have been analysed in a combination of using induction and abduction. Induction is where a number of cases are observed in order to make a general statement about those cases. Abduction is where reason is used to draw conclusions, finally leading to a statement. This is used when there is a lack of knowledge about the topic studied, and where there is a need to explain and understand something. More specifically, this analysis is using bricolage analysis, where various analytical methods are being employed (Kvale and Brinkmann, 2014).

This research assumes the ability to generalize the results to other factories facing similar situations, as well as to a wider application of the MEF. However, the ability to generalize from case studies is debated. Instead of asking whether the results from the case study should be generalized, it is instead possible to ask whether or not the knowledge generated in a specific interview can be translated to other relevant situations. One approach of generalizing from case studies is through naturalistic generalisation, where the personal experience of the researcher develops into a framework of expectations (Kvale and Brinkmann, 2014). This is the approach to generalising that this study will employ.

5.2. Multiple Effects Framework (MEF)

The Multiple Effects Framework (MEF) is a contribution of this research to the understanding of the resource nexus and the multiple effects of resource efficiency in industries. It integrates the important findings from the secondary data collection and the survey results. It includes those factors which were seen to be significant for the case studies, and which may therefore act as guidance for other factories facing similar regulations with ZLD. The MEF for projects following ZLD focuses on water, energy and chemicals, but other resources such as land could be added to the framework for other cases. By assigning the MEF to a specific project, the risk of double-counting effects decreases, as argued by Nehler and Rasmussen (2015). Likewise, their argument on considering the time perspective due to the variability in timeframe of indirect effects is accounted for through suggesting that the MEF is used dynamically over time, and that effects can be added as they are discovered. The MEF should therefore not be used as a one-time event, but rather be a living tool amended and analysed over time.

The ambition to create the MEF stems out of the need for a more integrated resource management in industry. It provides a better foundation for decision-making, both in terms of business as it identifies hidden costs and benefits, and in terms of resource use, as it acknowledges the interconnections between these. Relating to Qiu et al (2015)'s finding that firms view investments in energy efficiency differently from other investments in terms of acceptable discount rates and payback time, this framework helps firms understand the interconnectedness between resource efficiency measures and business operations.

Moreover, the MEF places its focus on the costs and benefits of the factories rather than the community as a whole. This way, the framework becomes more easily used and more applicable for companies. What sets the MEF apart from the VAW and the MBEEIF frameworks, is that it does not stem out of the analysis of a specific resource. VAW focuses on water, and the MBEEIF uses energy as its entry point. The MEF is a framework which does not place any specific significance to a certain resource, but sees to all effects that may result from any sort of project. This means that not only benefits are accounted for as in the MBEEIF, but costs and rebound effects are also considered for a better decision-making foundation. In certain cases, an approach focusing more on an individual resource may be preferable, for example related to a regulation on a specific resource use. However, the MEF could be considered even in such as case, as changing the use of one resource often affects the use of another resource.

The MEF could be used as a frame for different kinds of projects, where the effects measured varies between these. The MEF presented in this study is therefore the MEF developed for Indian textile factories facing ZLD regulation (Fig. 28 below). Naturally however, this is only a small case study and the MEF can be amended once new data is available. This is in line with Semertzidis

(2015) comment about the importance of being aware that the resource nexus, that is, the interconnections between resources, changes over time along with prices, technologies, behaviours etc. This study proposes that a MEF approach can be used dynamically and be changed to apply to different situations. The importance lies in considering the relationships between these factors and effects, and acknowledges benefits, costs and rebound effects.

5.2.1. Application of effects reported in secondary data

The data presented in the results section from the secondary data is all applicable to the framework since these are changes which have been experienced by the factories and reported in detail. The MEF will therefore include change in water use, water treatment costs, electricity use, thermal energy (coal or wood) use, chemical use, material use, and productivity. The effects represented in the secondary data collection can be measured if appropriate resource measurement technologies are available. According to Mr Anshul Chawla in an interview conducted for this study however, this may not be the case in smaller factories. This is further supported by Nehler et al (2014) who found through empirical research that one of the reasons for why firms don't quantify and monetize experienced multiple benefits is because of a lack of metering. The availability and use of measurement equipment should therefore be a priority for policy-makers and purchasing brands to support the factories with. Measurements give knowledge which offers a better foundation for decision-making.

5.2.2. Application of effects reported in survey

Below follows a discussion of the survey results and any implications that they may have for the development of the MEF. The changes which proved significant for the factories were numerous. Only a few of the effects (including some derived from the MBEEIF) which were asked for in the survey can be excluded from the framework designed for Indian textile factories responding to the increased cost resulting from ZLD. For this study, it is of less importance whether values increased or decreased as a result of the project. The most important factor is whether or not there was a change in the specific area. If there was a change, this should be included in the framework.

The results on additional resource use are an extension of the data gathered in the secondary data collection as it asks for any further effects on these resources. It thus investigates whether a resource has been affected, or if its use has increased or decreased, in some part of production even if the opposite was seen elsewhere. An effect was reported in terms of water chemistry, but not for energy and chemical use. Although only showing an additional effect on water, these results illustrate the need to consider the resource nexus in decision-making. The sum of all increases and decreases should therefore be considered.

The answers regarding effects on the facility indicate that these need to be considered, as the financial effects reported are significant, both in terms of costs and savings. The only effect which did not seem applicable for this particular MEF was a changed need for maintenance.

None of the factories were aware of how various emissions were affected as a result of the projects they undertook. This of course requires that they have easy access to measurement tools, which purchasing brands and authorities can support them with.

The answers given on the effect on work environment show that most of these should in fact be considered. The effects which do not seem applicable to this specific case are lighting, noise, and effect on indoor air quality.

An effect on productivity was likewise reported, which is supported by Seneviratne (2007) who argues that improved water efficiency also improves production efficiency for industrial firms. The only effect which did not seem significant for these particular projects was a change in production interruptions. The reported effect on the ability to expand production is likewise supported by Seneviratne (2007) who argued that improved water efficiency reduces the need to invest in infrastructure when increasing production, as well as ensuring adequate water availability for the expanded production. Thus, as argued by this paper, by reducing water use in-house, the limited ability to expand production because of ZLD can be rectified.

The questions on additional effects showed that for these particular projects, a change in brand image should be considered. All respondents also experienced further positive effects which have not been accounted for, such as the cessation of leakages. This suggests that the MEF should allow for additional non-specified effects to be named and quantified by firms. Hazardous waste and change in available space will not be used for MEF in this specific case.

The questions on effect on behaviour were asked not in order to integrate these effects into the MEF, but in order to investigate the behaviour effect when firms conduct projects which account for a variety of effects. As the results indicate, the investigated projects did in fact cause a behaviour change in all respondents, suggesting that if firms are guided in systems thinking, they are likely to continue working in that direction.

As for the effect on behaviour, the questions related to finance were not asked in order to be integrated into the MEF, but rather to investigate the financial implications of the projects at hand. There were both costs and savings incurred due to the projects which had not been accounted for. This suggests that applying the MEF is crucial for obtaining an adequate foundation for project decision-making. Further, the firms seem to have anticipated the effects obtained. However, for Supplier 4, it was a surprise that certain effects turned out to be the most beneficial outcome. In terms of capital expenditures, there were a variety of effects as one experienced a delay, one a reduction, and the other three an increase. This indicated that purchasing brands could support their suppliers in case capital expenditures temporarily place firms in a difficult financial situation. It was also judged significant enough to be added to the MEF. With regards to how much of the cost of implementing ZLD that has been offset due to all cost-cutting projects, it did not offer a positive picture. Only one factory was able to offset the cost by less than 20%, whereas the other four had only offset the cost by less than 5%. This result suggests that ZLD continues to cause a heavy financial burden for textile factories in India, and authorities as well as purchasing brands are encouraged to support factories in their strife to improve competitiveness while developing in a sustainable manner. The application of the MEF could perhaps show a somewhat different cost offset-level for factories.

All results indicate that it is difficult for the factories to monetize the effects experienced. This brings up an important question: how do we consider the factors (benefits or costs) that can't be easily quantified or monetized? As stated in the theory section, the ability to monetize the multiple benefits (or non-energy benefits) of an investment is crucial in order to make them part of an investment decision (Finman and Laitner, 2001). As seen in Fig. 6 of the theory section, far from all multiple benefits can easily be quantifiable in the short term (Rasmussen, 2014, p. 738). This study therefore suggests that factories facing time restrictions pay extra attention to measuring those factors which are easily quantifiable in the short term. They can be found in the top left corner of Fig. 6 in the theory section. These have also been added to the MEF. If time allows, factories may also attempt at monetizing seemingly unquantifiable effects using the methods proposed by Nehler and Rasmussen (2015, p. 9). For that reason, those have also been added to the MEF. In an attempt to facilitate for factories who do not have measurement tools available, the framework builds on Nehler and Rasmussen's (2015, p. 9) quantification guide by offering quantification guidance for all effects in the MEF. Moreover, as found by Nehler (2014), even those multiple benefits which can not be monetized can be mentioned in the investment decision as an important factor to consider.

5.2.3. Application of the Multiple Benefits for Energy Efficiency Improvements Framework (MBEEIF)

Seeing as the non-energy benefits, or multiple benefits, of energy efficiency improvements (as shown in Fig. 5 in the theory section) relate to general changes that occur in a factory after any type of change, these could also apply to the projects presented in this study. Some of the multiple benefits noted in Fig. 5 were however not experienced by the case study subjects in this study. Those effects have therefore been coloured in grey (as seen in Fig. 28 below) in this specific MEF designed for textile factories in India facing ZLD-implementation. However, they could very well be applicable in other cases, and should be considered in future studies. Therefore, they remain in the framework, coloured in grey.

The guideline to quantifying seemingly unquantifiable multiple benefits as presented in Fig. 7 (Nehler and Rasmussen, 2015, p. 9) in the theory section has been applied to the MEF by providing a quantification guide in connection to those effects which are more difficult to quantify and monetise. These suggestions have been modified to fit both positive and negative effects. Naturally, indicators used to quantify effects are approximations and do not fully represent the effects experienced in a project. They do however give an indication of reality.

5.2.4. Application of the Value Added Water (VAW) concept

The VAW approach is supported by Nehler and Rasmussen's (2015) argument that those multiple benefits which are not easily quantifiable can be measured through other more measurable benefits. It feeds into the creation of the Multiple Effects Framework (MEF), as it places a lot of emphasis on the nexus between resources. The VAW has been integrated in the MEF by acknowledging the value of discharged sludge leaving the factory. The VAW concept also provides a helpful method of pinpointing which projects that should be undertaken by seeing the full value of water at a given point in the process. The VAW can therefore act as a method employed before using the MEF, where the value of water at specific process steps is identified, and subsequently specific improvement projects are identified. This way, projects undertaken are prioritized based on a better foundation for decision-making, making the projects less risky and more prone for a successful return on investment. Once the VAW has offered a better understanding of the production process and identified an improvement project, the MEF comes in as a decision-making tool and a post-project evaluation tool.

5.2.5. Application of the rebound effect

As discussed in the theory section, improved energy efficiency can lead to an increased demand for energy which can to certain degrees offset the resource saving that has been made. This is the essence of the rebound effect, as described by Broberg (2015). The MEF has applied the rebound effect to include not just the offset saving of one specific resource, but of the increased use of several resources. The MEF asks for an overall change in resource use such as energy, water and chemicals. As were seen in the case studies, some factories experienced increased capacity and production, which might mean more resource use.

5.2.6. Introducing the Multiple Effects Framework (MEF)

The MEF is presented below (Fig. 28). In the MEF, all figures should be the sum of all increases and decreases for factors mentioned in each section. The final sum at the end of the framework (combining all the totals from the different sections) gives a final cost or saving incurred due to the project. The framework can be used either as an estimation for a project pre-implementation, or as an evaluation of a project which has already been undertaken. If used as an estimation, the framework can be re-visited after project implementation to account for any mistakes in the estimation, and follow-up on the effects over time. Learnings from the evaluation of implemented projects could furthermore be applied to future projects, providing a continuously improving understanding of the multiple effects of projects.

The Multiple Effects Framework (MEF)

All figures should be the sum of all increases and decreases.

Project description	
Investment cost	

Overall resource use	**Quantification guide**	**Effect**	**Sum of financial costs and savings/year**
∆ fresh water use (kl/year)	Found on water utility bill. Install measurement equipment.		
∆ water treatment cost excl. chemicals and electricity	CETP or IETP charge/kL		
∆ VAW value of sludge discharged from factory	Quantity of added resources in sludge (e.g. salts/chemicals/energy) multiplied by price of these resources and quantity of sludge		
∆ electricity use (kWh)	Found on electricity utility bill. Install measurement equipment.		
∆ coal fuel use (tons/year)	Found on coal bill. Install measurement equipment.		
∆ wood fuel use (tons/year)	Found on wood bill. Install measurement equipment.		
∆ chemical use (tons/year)	Found on chemical bill. Install measurement equipment.		
∆ material use (tons/year)	Found on material bill. Quantity of scrap. Install measurement equipment.		
			TOTAL:

Facility changes		**Effect**	**Sum of financial costs and savings/year**
∆ maintenance	Maintenance costs		
∆ need for engineering controls	Change in staff productivity, sick days, staff turnover, or rehabilitation costs? KPI: labour hours/production output		
∆ cooling and heating requirements	Change in energy cost, space used?		
∆ wear and tear on equipment or machinery	Change in maintenance costs? Change in need for new equipment purchases?		
			TOTAL:

Change in emissions	**Quantification guide**	**Effect**	**Sum of financial costs and savings/year**
Δ CO2	Change in the cost of emission allowances? Change in cost of changing filters?		
Δ CO			
Δ NOx			
Δ SOx			
Δ dust			
			TOTAL:

Work environment	**Quantification guide**	**Effect** (description)	**Sum of financial costs and savings/year**
Δ work environment and safety	Change in staff productivity, sick days, staff turnover, rehabilitation costs? KPI: labour hours/production output		
Δ worker morale			
Δ lighting	Change in cost of lighting and lighting maintenance? Change in staff productivity, sick days, staff turn-over? KPI: labour hours/production output		
Δ noise levels	Change in cost of using silencers and noise insulation? Change in productivity, sick days, staff turnover?		
Δ indoor air quality	Change in production failures? Change in product quality? Change in staff productivity, sick days, staff turnover? KPI: labour hours/production output		
Δ temperature control			
Δ need for protective equipment	Change in frequency and costs of equipment purchases? Change in sick days?		
			TOTAL:

Productivity	**Quantification guide**	**Effect**	**Sum of financial costs and savings/year**
∆ output/yield	Change in production capacity? KPI: ton output/day		
∆ equipment performance	Change in labour requirements for maintenance (KPI: labour hours/production output)? Change in electricity use (KPI: kWh/output)? LCC analysis		
∆ process cycle times leading to a change in production times	KPI: output/day		
∆ product quality	Change in material cost due to change in scrap (KPI: INR/ton material)? Change in number of complaints?		
∆ reliability of production	Change in production disruptions (KPI: disruption cost/year)?		
∆ production interruptions	Change in output/day and maintenance costs		
∆ labour requirements	Change in salary costs		
∆ ability to expand production	Potential increased revenues from expansion		
∆ product waste	Change in disposal cost?		
∆ hazardous waste	Change in disposal cost? Change in regulatory fees?		
			TOTAL:

Additional effects	**Quantification guide**	**Effect**	**Sum of financial costs and savings/year**
∆ ability to live up to local/national regulations	Change in cost of regulatory fees?		
∆ brand image	Change in customer classification of factory (KPI: sales/year)?		
∆ use of space	Change in revenue due to changed use of space and productivity rate?		
∆ further negative effects	Anything which has not been mentioned but which can be observed in the factory		
∆ further positive effects			
∆ capital expenditures	Change in available funds for other investments		
Any additional effect experienced in the specific project	E.g. cessation of leakages etc.		
			TOTAL:

Overall cost or saving (all totals)	

Fig. 28. The Multiple Effects Framework applied to the textile industry in India responding to ZLD implementation through cost-cutting projects. Grey-shaded effects are effects which were not shown to be significant for the case study subjects, but which could be applied when using the MEF in other situations. KPI is an abbreviation of Key Performance Indicator.

5.3. Lessons learned

This section will account for the lessons which can be learned from the experiences of a consultant used by the factories, and by IKEA regarding ZLD implementation and the resource nexus. As seen in the map (Fig. 11) in the theory section, ZLD is likely to spread to many more factories around India (Sustainability Outlook, 2015a). For that reason, it makes sense to prepare these factories for the challenges that are likely to arise, and help them lower the costs while being aware of overall resource use. Likewise, it makes sense to guide policy-makers and purchasing brands in how to support this transition to a more sustainable production.

This section will handle the third and final research question: “What lessons learned are there for Indian textile factories who are about to face ZLD regulation, policy-makers who are about to impose it, and the factories’ customers?” The interview results provide the basis for answering this question. Attempts are made at drawing conclusions from IKEA’s experience of this change to how other purchasing brands can act as well.

The interview results have been analysed by first grouping them into thematic areas, and then discussed with reference to answers given by the different respondents and concepts explained in the theoretical section.

5.3.1. Resource nexus and systems thinking

The understanding of the resource nexus is an important factor of this research. The interviews showed that there seems to be a trend towards a better understanding of the resource nexus in industry, at least among sustainability consultants and the company IKEA. According to Sandesh Waje (S.W.) and Margareta Björkander (M.B.), IKEA has clearly understood the correlation between water use and the use of energy and chemicals. They no longer conduct water projects exclusively focusing on water, but instead also integrate energy and chemicals in these projects. This has proved to be a successful approach for them. M.B. has also seen a development where the business teams are more involved in, and have more knowledge about, sustainability issues. According to M.B., the efficiency gain from an efficiency project can be disappointing. However, it’s important to understand the interconnectedness of the many different factors, and how changing one use affects the use of other resources.

According to S.W., systems thinking in factories is improved amongst their suppliers through IKEA offering information, training and support. For example, they share water risk mapping to which suppliers can adapt accordingly. This is an area where other purchasing brands can help their suppliers recognize the resource nexus.

If a more overall resource nexus approach would be taken, extending the analysis outside of the factory fence, the overall resource use would most likely look different. When operating ZLD, energy increases in the treatment phase. However, perhaps energy use decreases overall due to less energy needed in producing the clean water outside of the facility. Authorities might be interested in making an evaluation of the overall resource use, not just considering the effect within the factory fence.

A.C. stressed the importance of case studies in order to increase systems thinking among factories. When they see that a factory similar to theirs has received a certain outcome from a project, they are more prone to take the risk of conducting a project, and more aware of the multiple effects that may arise. It may be advisable for authorities and purchasing brands to collect case studies which they share with other factories. However, that always brings up the question of competitiveness, and whether factories will actually be willing to share their progress and ideas with other factories.

A.C. stressed a further method of improving systems thinking among factory management. By asking them to measure and compile their data, they themselves start realizing these connections between effects and act accordingly. There is no need to tell them about the connections. It’s better that they realize these themselves. Unfortunately, few companies have all the measurement equipment needed for this. This is supported by Nehler et al (2014) who argue that lack of metering is a key reason for multiple benefits not being monetized and added to investment decisions. An implication for purchasing brands may therefore be to help factories acquire measurement equipment.

5.3.2. Multiple effects

Through analysing secondary data, surveys and interviews, this research finds that it’s too simplistic to only consider the multiple benefits of a project when in fact a given project leads to a range of both positive and negative effects. Likewise, the rebound effect can be seen as either a positive or negative effect depending on from which perspective it is seen. A factory may consider the rebound effect as a benefit, while those concerned with sustainable development might consider it a negative effect. By considering both positive and negative outcomes, the attractiveness of the project at hand might be seen in a different light. By only considering the multiple benefits of a project, the factory may be deciding for an investment which in the end turns out to give a low return on investment. That would lower the attractiveness of efficiency projects in the future, and that money could instead be invested in more efficient projects. In short, this research proposes that the term multiple effects is used instead of multiple benefits, as it gives a more well-rounded understanding of the investment or project at hand.

The existence of multiple effects in the case study projects was visible in the survey data. However, the interviews also provided information on this point. For example, A.C. commented on the fact that Supplier 3 experienced some unexpected effects as a result of their project. These were outside of the factory fence, and this shows the importance of also considering the effects outside of the immediate operation and how that affects the company. Perhaps there should be an open database or cooperation database on effects experienced by companies facing ZLD. These could then be added to the MEF for application.

V.C. stated that he had not experienced any changes in product quality or reliability from Supplier D as a result of the project they undertook. However, there had been some difficulties with deliveries from one of the sub-suppliers to Supplier D due to a cost-cutting project at that supplier, but this was not a major problem. Furthermore, as shown in the results, Supplier 1 experienced improved product quality due to the project. Thus, the multiple effects of projects may end up affecting business operations to a certain extent.

On a more general note, as mentioned by M.B., ZLD legislation can bring the multiple effect of advancing technology developments, which might move the entire industry in a positive direction. This is an example of where the effect is applicable both to the factory itself and to industry in general.

5.3.3. National ZLD legislation

All respondents seem to welcome a national ZLD legislation. However, while welcoming it, V.C. argues that it needs to be implemented in a step-by-step approach to cause the least stress possible on industry.

Regarding whether or not purchasing brands would stay in India or not due to ZLD legislation, V.C. answered that there are more factors than just ZLD legislation that would affect that decision. M.B. likewise did not believe that IKEA would leave a country for such a reason. This may mean that nations should not refrain from ZLD legislation in fear of brands leaving the country. Naturally however, this situation varies between different brands.

5.3.4. Future competitiveness

The interviews gave the impression that ZLD legislation will in the short term place factories on the losing end, however in the long term, if matters move in the right direction, they will instead be more competitive in the future. A.C. believed that Indian companies with ZLD could become more competitive in the future if policies, purchasing brands and technological improvements all move in the right direction. Regardless, he believes that immediately, it will be more difficult for these companies to compete on a global market, but that in the long term they might be more attractive to purchasing brands. V.C. and S.W. also believe that they will be more competitive in the future when other factories are exposed to this regulation.

What needs to be asked here however is if the factories will survive that initial drawback. Perhaps by the time they are competitive due to brands being more willing to purchase responsibly, they will no longer exist. That threshold needs to be accounted for, and policy-makers and purchasing brands need to think of what can be done to avoid that “valley of death”. As A.C. said, the Indian government has been approached by industry representatives regarding the lowered competitiveness, but it seems as though the government is willing to take that risk since they prioritize the availability of clean water. They could however help improve competitiveness through different support systems.

Another important factor which was mentioned by S.W. is the fact that India is not just a large manufacturing country, but also a large market for the purchasing companies. For that reason, it will be more attractive to stay in India since this is preferable in terms of transport. This point was also made by M.B. regarding IKEA's presence there, and their wish for local sourcing. This fact may therefore prove advantageous for India. The question is what would happen to factories facing ZLD in countries where the domestic market is not as strong. These results seem to suggest that there is a greater risk that purchasing brands leave manufacturing countries with a weak domestic market.

Although the competitiveness situation of ZLD factories in India might change in the future, there is a further possibility that should be acknowledged. M.B. discussed the possibility of the textile industry in the future not using water at all in production. This means that perhaps in the future, water will not be an issue for the textile industry. But the question is then what other resource it will be dependent on? Perhaps it would be energy since it seems to be one of the only substitutes to water. The question is then if there would instead be an energy crisis, and whether energy or water should be prioritized in that case. The answer probably depends entirely on the current status and the geographical circumstances. However, that leads to even further questions; will there ever be production which is not resource-intensive? Would that mean moving the production to other areas, such as Europe? Will labour instead be the deciding factor? What happens if labour costs in traditional producing countries rise and there is no longer an incentive to produce only in these countries? Will the global production map be levelled and changed? Many questions remain to be answered.

5.3.5. Dealing with the increased cost of manufacturing with ZLD

As mentioned by A.C., the cost of the final product increases by less than 1% due to ZLD. The full cost of ZLD is absorbed elsewhere in the supply chain. This corresponds to Fig. 12 in the theory section showing the cost of ZLD in a shirt diagram. The question of who should bear the cost of ZLD remains unanswered, but the results from the interviews in this study implies that it should be a combined cost-sharing between the factories, the authorities and the purchasing brands. The final customers seem to be exempted from this increased cost, as said by V.C and M.B.

5.3.6. Prioritization

As discussed in this research, the improved efficiency of one resource use does not necessarily mean a lowered use for other resources as well. This is especially clear in the case of implementing ZLD, where water use decreases but energy use increases. This leads to the question of how to prioritize between the positive and negative outcomes of a proposed change. A prioritization needs to be made whenever there is a trade-off between resource uses. As mentioned above, the Indian state of Tamil Nadu prioritized the availability of clean water over the increased use of energy, and consequently the cost of textile manufacturing. S.W. argued that it might have been a mistake from a business perspective by the Indian state of Tamil Nadu to prioritize water over energy, as energy is the costliest resource in that area of India, and will always be the first resource that industries will attempt to decrease the use of due to the cost. Then again, S.W. argued that the resource need and scarcity differs in different parts of India and should therefore be considered case-by-case. This paper argues that perhaps this means that a national legislation should allow for regional autonomy in resource prioritization. It also argues that perhaps the fact that efficient water use doesn't have the same attractiveness as efficient energy use speaks for the need of legislation to push for sustainable water use. It should however be done with respect for, and with consideration of, firms' ability to remain competitive.

Also regarding prioritization, V.C. said that IKEA has very clear discussions with their suppliers regarding the prioritization between multiple effects from proposed changes. They help their suppliers make decisions which improve their competitiveness as an IKEA supplier. This might imply that purchasing brands should be involved in the analysis of the MEF, where they inform the supplier of which effects that would be most strategic, and offer the highest competitive advantage, as discussed in the theory section. This is supported by A.C.'s comments on the fact that suppliers are wishing for guidance.

Sometimes prioritization is very straight-forward. As stated by M.B., whenever there is legislation in place mandating the use of a specific resource, then that resource becomes a priority even though it might not be the most cost efficient resource saving. In the case of ZLD legislation, the priority placed on water adds to the business case of water efficiency.

5.3.7. Lowering the cost of ZLD

The STWI programme attempts at helping factories reduce the increased cost of production that ZLD entails. As shown by Fig. 11 on the CAPEX and OPEX of ZLD in the theory section (Sustainability Outlook, 2015a, p. 10), it is evident that it is the operating cost that needs to be lowered in order for factories to lower the financial burden of ZLD. Measures reducing the operating cost are therefore more important than the reduced price of ZLD technology (albeit also being important). Below follows a discussion about what purchasing brands and authorities can do to lower the cost of ZLD.

5.3.7.1. The role of purchasing brands

A.C. believes that brands should help by investing in capacity building. This means that they help factories improve through technical assistance, rather than simply expecting it through audits. This however requires a good relationship between the supplier and the brand, and it helps if brands come together and ask for similar improvements, as they do in STWI.

V.C. likewise sees IKEA's role as supporting the factory management through sharing good examples and creating a value-sharing agreement if the cost of ZLD becomes too burdensome for the supplier. Another effective tool would be to offer business commitments to their supplier. This research believes that offering business commitments could be a powerful tool to help absorb the costs of ZLD in the supply chains. By committing to a certain production volume, the supplier can feel secure in investing in efficiency improvements. Business commitments might be what will bring this forward, and thus it might be those big purchasing brands such as IKEA who can make this transition smooth.

S.W. states that IKEA helps their suppliers improve their competitiveness through initiating efficiency projects and following up on their environmental and social standard for purchasing, IWAY, which keeps suppliers improving their sustainability and consequently their competitiveness. As stated by V.C., a mandate for ZLD helps IKEA to impose the high standards of sustainability that they have set for their suppliers. However, one should not forget that IKEA is a very progressive company in terms of sustainability, and this may not be the case for other purchasing brands.

5.3.7.2. The role of local authorities

V.C. believes that authorities could help by offering soft loans, subsidizing land for ZLD operations, or setting up communal water treatment plants so factories don't have to invest in their own. S.W. believes that authorities have taken on an approach which is focused on inspection and auditing, and less on supporting. He argues that the successes of factories in Tamil Nadu have not been thanks to the authorities, but to their own efforts. This may suggest that authorities can increase their support substantially. As argued by Semertzidis (2015), there is a need for tools and knowledge of the resource nexus to guide political discussions. This research therefore argues that in the same way as a tool for industry is being developed in this research, a tool for authorities should be developed to guide optimal legislation and support to industry for a sustainable change both financially and environmentally.

5.3.8. Investment decision-making

Understanding investment decision-making is another important factor when discussing lessons learned with regards to ZLD implementation. Returning to Cooremans' (2012, p. 499) model of investment decision-making as seen in Fig. 29 below, it shows that the initial idea for an investment leads to a diagnosis of that idea.

Fig. 29. The investment decision-making model developed by Cooremans (2012, p. 499); re-designed for this research.

If the idea is not diagnosed correctly, in other words, if the multiple effects of that investment are not fully understood, the subsequent steps, if conducted at all, are heavily influenced by the incorrect diagnosis. This research therefore suggests that multiple effects, where time allows, are always considered in connection to an investment. Due to time restraints for manufacturing firms, it might be advisable for purchasing brands to support factories with this, perhaps by applying the MEF.

V.C. said that they discuss the projects analysed in this research with their supplier in terms of business consequences, such as pay-back period and return on investment. Connecting this to the MEF, it would make sense for factories and brands to bring in the multiple effects of projects when discussing their success. That way, the projects may show a more well-founded business reality.

Referring to Cooremans (2012) concept of strategicity, this implies that the more a project aimed at lowering the costs of ZLD adds to the competitive advantage of the company, the more likely it will be implemented. By considering the multiple effects of that investment therefore, the company gains a better understanding of the full strategicity of the project at hand. Chances are that by considering the multiple effects, the project is viewed as more strategic by the factory.

The results of this study also suggests a different approach to investment categorization. M.B. agreed with the interviewer in the observation that most companies do not invest in resource efficiency, but rather invest in process efficiency since that is the more strategic focus for factories. This means that it might be more advisable for those interested in resource efficiency to approach the investment from a process optimization perspective. As M.B. suggested, it might be better to refer to 'Best Available Investments' instead of 'Best Available Techniques'. Essentially, this paper argues that the resources are each others' multiple benefits. As M.B. stated, their energy and water projects ended up looking very much alike. For that reason, it's better to consider them collectively in an investment. The projects presented in this research tend to have as their main motive to decrease resource use in order to decrease costs. However, if there are no regulations in place to cause this need, those interested in pushing for investments in resource efficiency can take a process optimization approach to reach this goal.

As argued by Nehler and Rasmussen (2015), energy efficiency investments are seldom considered as a specific investment category which affects the decision-making process. This research assumes that the same situation occurs for investments in water efficiency since water is undervalued and the incentive to invest is limited. It might therefore be advisable to connect the investment in water efficiency to other types of investments, such as process optimization. Perhaps it may even be helpful to speak of 'Improvement Investments' rather than investments in certain areas, such as process optimization, water or energy efficiency. Those 'Improvement Investments' could incorporate all multiple effects of an investment. The investment may originate from the need to solve one particular issue, but then be extended to incorporate general improvements as analysed in a MEF. This way, the investment might become more attractive to different members of the management group, such as the maintenance manager, the operations manager, and the financial manager.

A.C. stressed the importance of considering a holistic business case when investing in water efficiency, and he gave the example of supplier D where a more holistic approach showed more savings than a local approach. A.C. also gave an explanation of the fact that water changes in value depending on which resources that are added to it. This has also been explained in the theoretical section as the Value Added Water concept. As A.C. stated in the interview, the business case for water efficiency can be made by connecting it to other more expensive resources. M.B. also made this claim by saying that they connect water to energy in order to create a business case for their suppliers to focus on water efficiency. Since in Tamil Nadu it's process chemicals and thermal energy which give the best business case for water efficiency, these should receive extra attention by textile factories in this region.

5.3.9. Social effects

The set-up of this research did not allow for a satisfactory analysis of the social effects of the projects analysed. The social effects are crucial for a sustainable change, and the most important recommendation for future research is to include these in the analysis. Social implications which should be accounted for are for example what the investment or project means in terms of job opportunities. The labour cost is a real cost for industries but job opportunities is also an important factor for the community. Another factor which should be analysed is the effect on the local environment (which affects the surrounding communities). This research took on a primarily business-oriented approach to the projects analysed in order to ameliorate the business case for better resource efficiency. However, for future research, it would be useful to create a way of accounting for how social effects can be included in the MEF in terms of economic implications for the factory. Examples would be how the decreased discharge of untreated water impacts the health of the surrounding communities, which in certain cases also means the health of the factory workers. This change could be analysed through the KPI of less sick leave and higher productivity per worker.

Taken from a less business-oriented perspective, local authorities are most likely interested in analysing the social implications of certain industrial changes. For example, they would be interested in seeing the social effect that less discharge of untreated water entails as a result of ZLD. If authorities share that analysis with the factories who have implemented ZLD, they could incorporate that effect into their MEF and produce an even better understanding of the change. Further effects which would be interesting for authorities could be amount of water left unused by factories which could instead be used by communities. Likewise, the decreased CO^2 emissions from the savings of both thermal and electrical energy could be of interest to the authorities. It is therefore suggested that factories and authorities share data in order to reach a better understanding of effects of changes. Understandably however, factories might be reluctant to share their data with authorities. Authorities would need to convince factories of their willingness to support factories and use the data for mutual success.

6. Conclusion

The main aim of this research is to make a contribution towards breaking the silos which different resource sectors work within. It attempts to draw knowledge from particularly the water and energy sectors in order to create a more efficient approach to overall resource efficiency, while respecting the interests of firms. This paper clearly shows that one approach to assigning water a fairer price is through connecting it to energy and other resources which are more fairly valued. Perhaps we should move away from trying to make water costlier (i.e., setting a higher price of water) to making it costlier to use and pollute water. That's essentially what's being done in Tamil Nadu through setting a mandate for ZLD.

This research has attempted to further the understanding of the resource nexus particularly in industrial settings. By integrating the resource nexus into industrial decision-making, while acknowledging other multiple effects of projects, factories can better prioritize between proposed changes. Likewise, by acknowledging the resource nexus, authorities and purchasing brands can better support a sustainable industrial transition.

Further, this paper has contributed to the study field theoretically by creating the Multiple Effects Framework (MEF), which is a decision-making and evaluation tool for industries. By using this tool, industries consider the benefits, costs, resource nexus and rebound effects of their measure taken. The MEF accounts for an important finding in this research; that there should be a focus on both benefits and costs of measures taken, thus analysing the multiple effects rather than just the multiple benefits. Preferably, the MEF is to be used over an extended time period, allowing for long-term effects to be accounted for. It is further suggested that the MEF is seen as a dynamic framework which can be adapted to various industries and situations.

There are many questions related to this research that are recommended for future study. First, it is suggested to further develop the MEF in order to integrate even more effect areas which are significant for various industrial sectors. It is also recommended that further research evaluates the societal effects in terms of considering the multiple social effects of projects related to lowering the cost of operating with ZLD. Such research could focus both on factory savings, as well as on authorities' ambitions to sustain healthy communities.

Analysing multiple effects and the resource nexus of industrial projects may help factories overcome difficult financial situations such as the one faced by textile factories in Tamil Nadu, India, as a result of ZLD regulation. In short, this research shows that it can make business sense to take the extra time needed to better understand the multitude of effects which have an impact on production.

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