Water: Pricing the Priceless

by

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SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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ABSTRACT

Unilever, a large multi-national Consumer Packaged Goods (CPG) company, uses water as an essential ingredient in its products and as a critical component in its manufacturing processes. In many instances, the price of water does not reflect market dynamics insofar as water is cheaper where there is low availability and vice versa. Business continuity costs due to poor water quality or water shortages may far outweigh the direct costs that Unilever incurs in purchasing water. Hence, by performing a literature review, numerous interviews with experts and stakeholders and an extensive review of existing water valuation tools, we created a framework that is capable of calculating a comprehensive value of water for any of Unilever's 250+ manufacturing sites based on site-specific conditions. We identified and developed the three core components of our framework, namely: purchase price, processing and handling cost and business disruption cost. Our main contribution is the estimation of a business disruption cost that takes into consideration mitigation options available and a scenario analysis of different water-related events to yield the total value-at-risk. A risk-adjusted value of water would enable Unilever to optimize water use and build resilience within its manufacturing operations by incentivizing water efficiency and catchment-based water stewardship initiatives where they are needed most. As the evaluation of a comprehensive price of water is a complex challenge, this project is a first step towards building a more robust framework. We have listed several recommendations that would strengthen the framework.

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1. INTRODUCTION

Water is starting to take center stage in industry, and companies are acknowledging the importance of managing risks pertaining to poor water quality and supply. According to the World Economic Forum, water crisis has been one of the top 5 global risks in terms of impact since 2012, and in January 2015, the World Economic Forum cited water crisis as the most critical global risk based on impact to society as a measure of devastation (Cann, 2015). Unilever, a large multi-national Consumer Packaged Goods (CPG) company, uses water as an essential ingredient in its products and as a critical component in the manufacturing processes of its more than 250 worldwide site locations. Through the Unilever Sustainable Living Plan (USLP) on manufacturing, Unilever focuses predominantly on water efficiency, seeing water as a potential risk to business continuity within an increasingly volatile, uncertain, complex and ambiguous (VUCA) world. Unilever, like many other companies, is facing increasing water stress or depleting water quality, the risk of production disruption is increasing. Recent droughts in Brazil, Taiwan, and Poland, pose a potential threat to business continuity within Unilever's operations.

In many instances, the price of water does not reflect market dynamics insofar as water is cheaper where there is low availability and vice versa. Business continuity costs due to poor water quality or water shortages have the potential to far outweigh the direct costs Unilever incurs in purchasing water. As such, in order to optimize water use and build resilience within Unilever's manufacturing operations, the objective of this project is to create a framework that calculates the true value of water that encompasses Unilever's business disruption costs resulting from adverse water-related events across manufacturing sites around the world. By developing a more holistic understanding of the cost of water to the business, Unilever could employ this value in its business decision-making to motivate water efficiency and catchment-based water stewardship initiatives where they are needed most.

Our project was performed in a phased manner – first, by capturing the various risks associated with water scarcity and water quality, among other risks, and then by translating those factors into a monetary value. Our scope includes quantifying the value of water to take into account the business disruption losses stemming from water related events.

We created this framework as an objective, practical and user-friendly tool. We expect it to be meaningful to end users, which include various supply chain functions such as Sustainability, Finance and Engineering.

2. LITERATURE REVIEW

To inform the creation of a robust water valuation model and to better understand the challenges faced in the past, this literature review focuses on gaining insights into six key areas, which are discussed in sections 2.1 through 2.6. We begin with a review of the numerous solutions that have been used and are available to ensure sustainable quantities of water for water users worldwide. Next, we evaluate water pricing through an economic lens to better grasp the existing practices employed in water economic valuation. Unlike traditional commodities such as corn and sugar, which are traded in open markets with a price based on their supply and demand, water is a non-traditional commodity. As such, water is compared to and contrasted with another non-traditional commodity, carbon, to inform our water pricing methodology. Then, we review the variety of risks that affect water scarcity and subsequently examine numerous approaches and tools available to evaluate water resources. Lastly, we review conventional inventory management principles and a few approaches to quantify business disruption events.

2.1. The Problem, Past Solutions and Future Strategies

Though water is abundant on earth, the supply of clean water is geographically limited. Only about 0.5% of the world's water is unfrozen freshwater available to support human subsistence (World Business Council for Sustainable Development, 2006) and growing urban populations and agricultural demands exacerbate the problem of water shortages due to mismanagement of water resources. Water management is a challenge for industries that are heavily reliant on uninterrupted supplies of water. Businesses face an uncertain future with regard to their water use, as strained water resources are expected to worsen due to population growth (Gleick, 2003). It is estimated that by 2025:

- Water withdrawals are expected to rise by 50% in developing nations and 18% in developed nations (United Nations, 2014)
- Approximately 1.8 billion people will be living in countries or regions with absolute water scarcity (FAO, 2015)
- Roughly two-thirds of the world's population could experience water stress conditions caused by water scarcity (United Nations, 2014)

Until now the conventional approach employed in alleviating the challenge of water scarcity has been the installation of greater water input infrastructure, such as dams, aqueducts, and treatment plants. This approach is referred to as a "hard-path" solution. Gleick (2003) argues that "hard-path" solutions are an unsustainable strategy for meeting future water demands due to the sheer scale and speed of investments needed to match the needs of water users. Instead, Gleick (2003) promotes water conservation as the most effective and efficient forward-looking strategy in ensuring sustainable supplies for all water users.

2.2. Water as an Economic Good

Economics is "the science which studies the relationship between ends and scarce means which have alternative uses" (Perry, Rock, & Seckler, 1997). Given that water has multiple uses and is becoming scarce, it is appropriate to classify water as an economic good to promote water conservation.

A clear definition of cost, value and price is required to understand water through an economic perspective. The concepts of price, cost and value of water are often mistakenly used interchangeably. Value has two different meanings, as Adam Smith once stated using the paradox of water and diamonds. Value in use is determined by what the item is used for while value in exchange relates to what can be purchased with the item (Hanemann, 2005). Cost, on the other hand, is any expenditure required to produce a certain good in the most economical manner (Doyle, 2015). Finally, price is the rate at which someone can exchange money for a good (Doyle, 2015). Market price reflects the interaction between what is produced, according to costs (supply) and what it is worth to people, related to value (demand).

However, the price of water normally only reflects supply costs, capital costs and operating costs, and does not include what Hanemann calls the scarcity value (2005). Because governments usually provide water supply and water is seen as a public good, water is subsidized and cheap where maintaining water infrastructure is inexpensive (Hanemann, 2005). Rogers, Bhatia & Huber (2001) identified the various cost components that are normally not considered. In addition to the supply cost, Rogers, Bhatia & Huber argue that the full cost of water should include opportunity cost, economic externalities and environmental externalities (Figure 1).

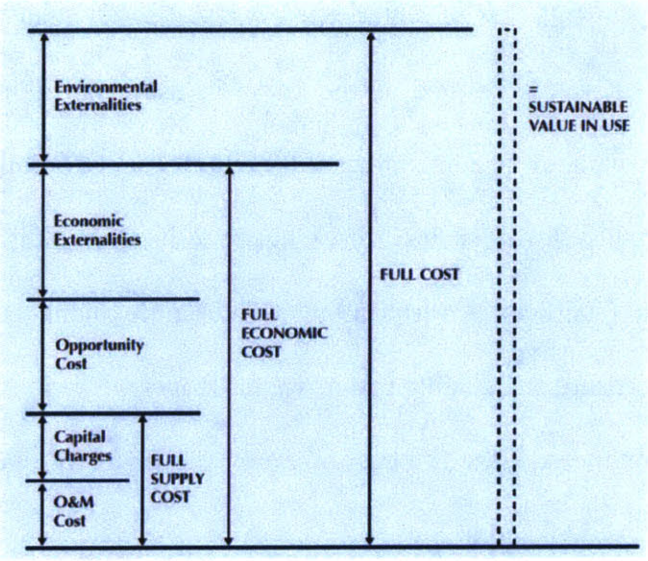


Figure 1. Different Levels of Cost

Note: Reprinted from *Water as a Social and Economic Good: How to Put the Principle into Practice*, by Rogers, Bhatia, & Huber, 2001.

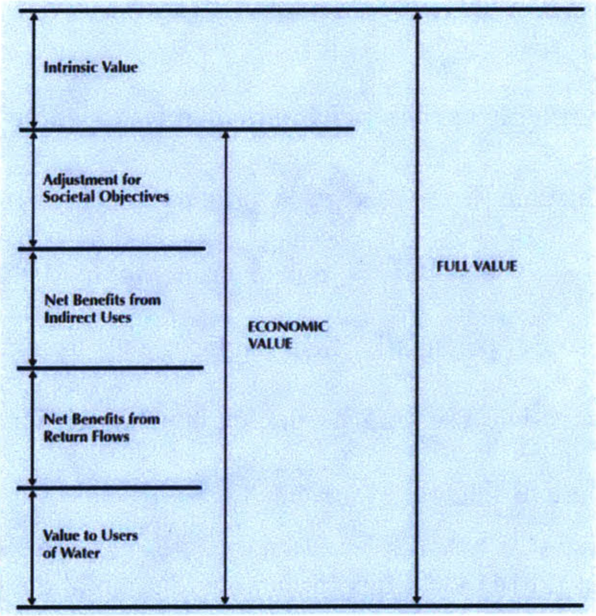


Figure 2. Different Levels of Value

Note: Reprinted from *Water as a Social and Economic Good: How to Put the Principle into Practice*, by Rogers, Bhatia, & Huber, 2001.

As opposed to the full cost of water, Rogers, Bhatia & Huber (2001) determined that the full value of water was defined as the value in use (one of Smith's definitions). As shown in Figure 2, value in use encompassed value to users of water (willingness to pay), net benefits from return flows (or direct use), net benefits from indirect use, adjustments for societal objectives (such as poverty alleviation, employment and food security) and intrinsic value. To ensure sustainable use of water, Rogers, Bhatia & Huber (2001) suggest that in any valuation method, the full cost of water, portrayed in Figure 1, should match the full value of water, as depicted in Figure 2.

Once the full cost and the full value are identified, a comprehensive price of water becomes a powerful tool to create awareness and effectively reduce water consumption for users (Harou et al., 2014).

2.3. Limitations in applying carbon pricing principles to water pricing

Commodity pricing has been used as a primary mechanism to regulate and curtail carbon emissions. In early discussions, our sponsor proposed that insights gleaned from carbon's valuation could potentially help support the formation of water valuation methodologies. This is because, much like carbon, water is also a commodity with monetary values that are difficult to evaluate.

However, Mandel (2014) identifies limitations that highlight key differences between water and carbon – because of these limitations, the approach employed for pricing water should differ from the one used in pricing carbon.

A context-based approach specifies minimum and maximum impacts a company can have on social and environmental conditions based on the actual status of local social and ecological conditions. Unlike the broad, global impacts of carbon, the impacts of water are local and context specific. Due to water's context specific nature, water stress in a particular region is a significant risk factor affecting company operations at that location. A business' reliance on water at a specific location can heavily influence the risk that water poses to its operation. For instance, if the location where a company operates has scarce water supplies, the company may face dire risks despite any number of water efficiency initiatives implemented. This is why cutting water use like cutting carbon emissions will not necessarily solve the problem. Such factors need to be considered in evaluating water risks (Mandel, K., 2014).

2.4. Water Risks

In order to value water, we needed to understand the numerous risk factors that affect water supply and subsequently translate them into monetary figures. The causes for water shortage and water quality that can potentially lead to business disruption can be broadly grouped into physical risks, reputational risks and regulatory risks (Larson, 2012) – these are further explored next.

2.4.1. Physical Risk

According to Larson (2012), physical risk is the threat posed by the physical scarcity of clean water at a given location. For instance, a facility located in an arid region may face high physical risk due to the reduced total availability of water.

A mechanism to account for and allocate water based on its physical risk at a location was proposed by McElroy, M. (2012) for the Cabot Creamery Cooperative. This mechanism calculates the total amount of water in the watershed that supplies a particular operation. Next, it allocates portions of water to neighboring ecosystems and households being served by the watershed. Lastly, the remaining volume of water is apportioned to various organizations, including businesses, according to their relative contribution to the GDP in the watershed. This approach will provide input into our model as a mechanism to capture infrastructure related physical water risks.

2.4.2. Reputational Risk

Reputational Risk is water risk due to social impacts. Often termed a company’s “social license to operate,” it generally refers to a local community's acceptance or approval of a company's presence in an area. For example, water withdrawal in less-developed regions, where many people survive on less than the recommended daily allowance of clean water may pose a slightly higher risk to the company. Due to water’s context-specific nature, Mandel (2014) claims that for each water basin a company operates in, the company must consider the water needs of local communities and other businesses alongside its own. These water users may impose additional risks, termed social risks, on the business’s operation.

2.4.3. Regulation Risk

The final element in water risk evaluation is the risk posed by regulation, which is water risk due to government intervention. Companies need to be aware of regulatory considerations, such as limits on water withdrawals and escalation in water prices. For example, if a company operates in a water-scarce region, it may face the risk of increasing water prices, sometimes drastically and without warning. This may be a result of government policies aimed at curtailing demand.

Regulatory bodies are often tasked with a challenging proposition – efficient and effective allocation of water among competing consumers. Furthermore, as governments are also the enforcers of the regulation, they can choose to be transparent and keep stakeholders informed or be less transparent and give stakeholders little notice. Another influencing factor is the fact that in some places the regulatory reaction is also strongly linked to elections and political interests. Grafton et al. (2004) argue that an optimal scheme for water allocation, implemented by governments in water stressed regions, would alleviate strains on the water infrastructure caused by its various end users including the public, agriculture and industry. Many schemes currently practiced produce inefficient outcomes as a result of improper and incomplete cost accounting, failure to weigh costs and benefits, and a reliance on command and control style quantitative regulations (Grafton et al., 2004). Therefore, employing government imposed water markets to allocate water can help to remedy these flaws and increase efficiency in the use of water resources (Grafton et al., 2004).

2.5. Existing Water Management Approaches and Tools

In order to avoid business disruption due to water-related challenges, a number of approaches have been developed to help decision-makers take action. These approaches include the use of financial services for risk management and risk mitigation. Larson (2012) has classified the benefits and limitations of these approaches into the following categories:

- Water use accounting tools
- Business risk assessment frameworks
- Reporting and disclosure protocols
- Standards and certification frameworks

Collectively, these approaches can be utilized, with varying levels of success, to assess water resources by identifying and evaluating water risks. The WWF Water Risk Filter, in particular, identifies a wide range of tools and compares their main aspects, which include user-friendliness, supporting disclosure of water information, industry coverage, geographical coverage and risk analysis (World Wildlife Fund, 2014). The various tools currently available to perform water risk assessments are listed in Figure 3. Morgan & Orr (2015) use this figure to demonstrate that few available tools aim to value water and that each of these tools cover a limited scope. These tools include WaterVar, FV Tool, TrueCost of Water Tool and Water Risk Monetizer.

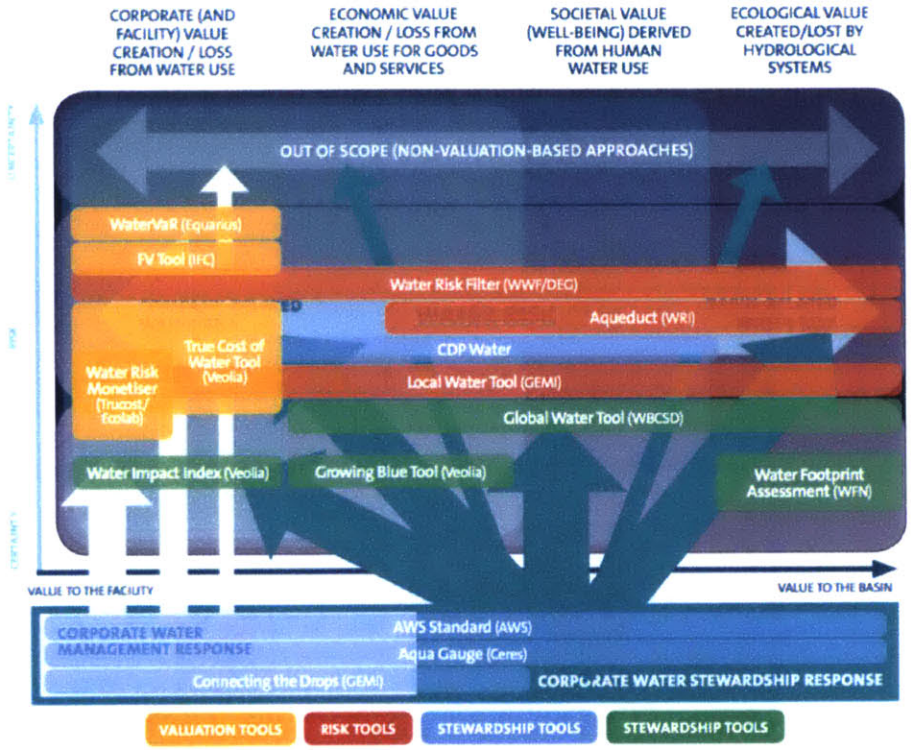


Figure 3. Water Tools placed into the water valuation framework

Note: Reprinted from *The Value of Water: A framework for understanding water valuation, risk and stewardship*, by Morgan & Orr, 2015.

Existing frameworks are progressively demonstrating awareness and providing insights about water use in a variety of sectors. For example, in the 2015 CDP Water Disclosure, 82% of the reporting companies in the Consumer Good sector declared that they have recognized water-risk and 75% declared that they have opportunities to improve water efficiency (CDP, 2015).

A study performed by Mueller et al. (2015) analyzed the results of water stress tools for 10 sites located in India, United States, Mexico, China, Brazil and Spain – the results are presented in Figure 4. As each tool uses different datasets, Mueller et al. (2015) conclude that the tools that they reviewed yield inconsistent results. For example, while the WRI

Global Water Tool and India Water Tool predicted that water was sufficient in the city of Lucknow in India, the UNH Global Water Tool, Aqueduct and Water Risk Filter predicted that water was scarce.

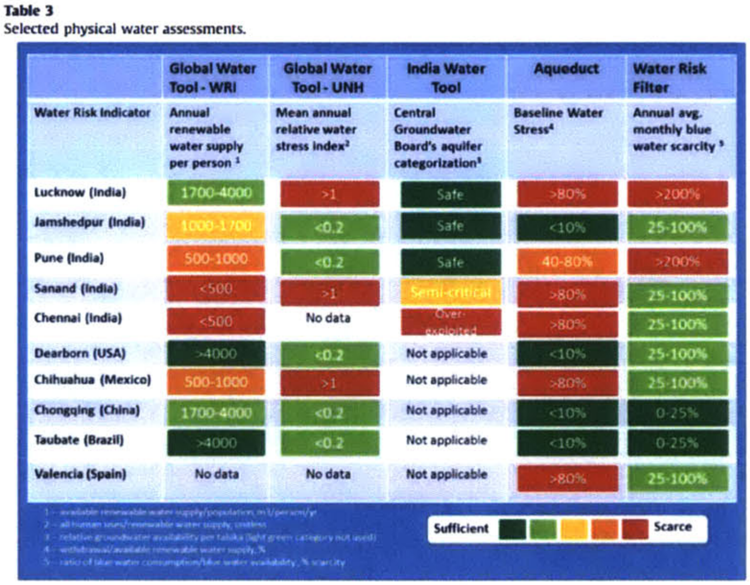


Table 3
Selected physical water assessments.

	Global Water Tool - WRI	Global Water Tool - UNH	India Water Tool	Aqueduct	Water Risk Filter
Water Risk Indicator	Annual renewable water supply per person [1]	Mean annual relative water stress index[2]	Central Groundwater Board's aquifer categorization[3]	Baseline Water Stress[4]	Annual avg. monthly blue water scarcity [5]
Lucknow (India)	1700-4000	>1	Safe	>80%	>200%
Jamshedpur (India)	1000-1700	<0.2	Safe	<10%	25-100%
Pune (India)	500-1000	<0.2	Safe	40-80%	>200%
Sanand (India)	<500	>1	Semi-critical	>80%	25-100%
Chennai (India)	<500	No data	Over-exploited	>80%	25-100%
Dearborn (USA)	>4000	<0.2	Not applicable	<10%	25-100%
Chihuahua (Mexico)	500-1000	>1	Not applicable	>80%	25-100%
Chongqing (China)	1700-4000	<0.2	Not applicable	<10%	0-25%
Taubate (Brazil)	>4000	<0.2	Not applicable	<10%	0-25%
Valencia (Spain)	No data	No data	Not applicable	>80%	25-100%

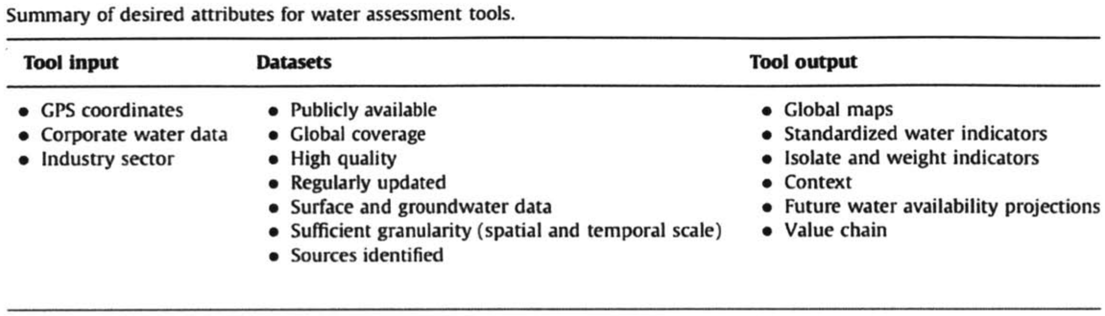
1 – available renewable water supply/population, m3/person/yr
2 – all human uses/renewable water supply, unitless
3 – relative groundwater availability per taluka (light green category not used)
4 – withdrawal/available renewable water supply, %
5 – ratio of blue water consumption/blue water availability, % scarcity

Sufficient 🟩 🟩 🟨 🟧 🟥 Scarce

Figure 4. Selected Physical Water Assessments

Note: Reprinted from *Requirements for water assessment tools: An automotive industry perspective*, by Mueller et al., 2015.

Mueller et al. (2015) explain that the discrepancies between the outputs yielded by each tool are due to variations in scope and the definition of indicators. Although every tool has a water stress indicator, the methodology for calculating this indicator is not consistent. Another issue is the input data. While Aqueduct solely uses GPS location, Water Risk Filter uses a questionnaire with multiple choices answers that assess the facility's vulnerability to water shortages. Mueller et al (2015) concluded their study summarizing the desirable attributes for an effective water assessment tool, classifying them into input, datasets, and outputs, as shown in Figure 5.



Summary of desired attributes for water assessment tools.

Tool input	Datasets	Tool output
• GPS coordinates • Corporate water data • Industry sector	• Publicly available • Global coverage • High quality • Regularly updated • Surface and groundwater data • Sufficient granularity (spatial and temporal scale) • Sources identified	• Global maps • Standardized water indicators • Isolate and weight indicators • Context • Future water availability projections • Value chain

Figure 5. Desired Attributes for Water Assessment Tools

Note: Reprinted from *Requirements for water assessment tools: An automotive industry perspective*, by Mueller et al., 2015.

Adding to Mueller et al. contribution, the WWF (2014) claims in another tool comparison that there is a challenge posed by the underlying data used by each tool as most tools use either incomplete or obsolete datasets or non-water related data. The existing water tools are a good start for companies to create awareness of water-related-risks and assume a more responsible water stewardship strategy. Today, companies are able to measure water use and understand social and environmental impacts related to water use and water disposal. However, the connection between quantitative measures of water performance and the existing qualitative water risk indicators has not yet been successfully established (Pacific Institute, 2016).

2.6. Inventory Management Approach

An alternative approach to consider is treating water as an input raw material with high uncertainty in its supply. The uncertainty is primarily caused by location-based water scarcity or water stress. For traditional commodities, the total cost formula, shown in Equation 1, is used to identify the optimal inventory management policy for a commodity that results in the lowest total cost of inventory (Silver, Pyke, & Peterson, 1998). The total cost results from summing up Purchase cost (cD), Ordering cost (c_tD/Q), Holding cost ($c_eQ/2$) and Shortage cost (c_sE[Units Short]).

$$TC(Q) = cD + c_t\left(\frac{D}{Q}\right) + c_e\left(\frac{Q}{2}\right) + c_sE[Units\ Short] \tag{1}$$

Usually, the classical inventory methods associate uncertainty with customer demand (D), but there is also uncertainty in the supply of raw materials. Designing a simulation tool, Petrovic (2001) aimed to include uncertainties across the supply chain. Normally, inventory policies consider variability in customer demand and lead times (right side of Figure 6); however, Petrovic pointed out that uncertainties result from suppliers as well. If historical data is available, a probability distribution can be used to model such uncertainties, but this data is currently not readily available centrally. In cases where data is unavailable, Petrovic (2001) proposes a judgment call and the use of managerial experience. If the amount of water needed for every facility were to be calculated like any other raw material, Petrovic's approach would help incorporate all of the uncertainties and risks related to water.

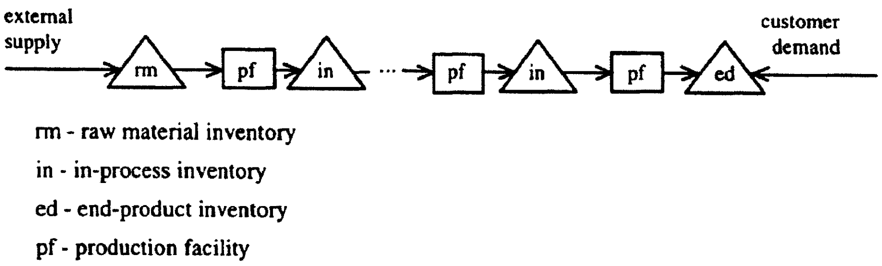


Figure 6. Supply Chain schematic

Note: Reprinted from *Simulation of supply chain behavior and performance in an uncertain environment*, by Petrovic, 2001.

2.7. Supply Chain Risks and Business Disruption

There are multiple scenarios that can lead to business disruptions, affecting companies unexpectedly (Sheffi, 2005). Most of those disruptions lead to a decline in available capacity, which leads to unmet demand and lost sales (Simchi-Levi et al., 2014). In order to manage supply chain risks, companies regularly rely on historical data to estimate, for every possible event, the likelihood of occurrence and the financial consequences. Traditionally the expected cost of a disruption, shown in Equation 2, is calculated by adding the cost of mitigation (y) and the expected value of loss, given by the probability of a disruption (P(y)) and the amount of loss (L(y)) (Kleindorfer & Saad, 2005).

$$Expected\ Cost = y + P(y)L(y) \tag{2}$$

Traditional methods fail to provide guidance required to prepare for rare and unpredictable events, such as climate change, population increase and industrial growth, due to the lack of centrally available historical data. Simchi-Levi et al. (2014) designed a model in which historical data was not necessary. Simchi-Levi et al. (2014) focused on assessing the impact of different disruption scenarios and chose to focus on the worst-case scenarios. The variables considered for each scenario included suppliers' information, information about the parts and end products produced on each site, lead times from suppliers to site, time to recovery (TTR), cost of loss, supplier risk assessment and mitigation strategies, such as alternate suppliers and excess inventory.

2.8. Key Lessons

This literature review provided a better understanding of the mechanisms and role of the different existing water risk assessments and risk mitigation strategies as they apply to water valuation. The insights gained assisted us in shaping our model – our aim was to select the best aspects of existing tools and mold them into a broadly applicable water valuation tool. We learned that a true value of water should include more than the purchase price (supply costs). Also, we understood that unlike carbon pricing, water valuation should be a context-specific approach. Another valuable insight is that existing tools rely on incomplete and / or old data sets or non-water related data, which yield inconsistent results. These tools still fail to assess costs associated with business disruption and in the absence of historical data, operational experience should be used.

3. METHODOLOGY

In order to create a framework that estimates a comprehensive value of water, we began with a site visit to a Unilever operated manufacturing facility to better understand water's contextual challenges and opportunities. Next, we performed interviews with relevant stakeholders to gain insights that would support our water-pricing framework. Then, we examined current tools employed in the industry to learn from established techniques used to capture the value of water. Lastly, we created our framework by using the evolutionary prototyping life cycle model.

3.1. Site Visit

We visited the Jefferson City site, a Unilever manufacturing facility that produces hair care products, in order to better understand contextual elements as they relate to the use of water in Unilever's operations. The visit helped us get sufficient background knowledge about the issue of operational water use including the criticality of water supply to operations and the motivations for effective water risk management.

A walkthrough tour of the facility illustrated the various plant processes using water in the safe, efficient production of hair care products. A questionnaire was created in preparation for the visit, with wide-ranging queries as they related to production – the complete questionnaire is included in Appendix 1. Subsequently, interviews with key plant personnel, including the Safety, Health, and Environmental (SHE) Manager and SHE Supervisor, comprehensively examined the following plant practices, as outlined within the questionnaire:

- Analysis of water shortage scenarios
- Characterization of plant water demand
- Current condition of water sources
- Identification of disposal areas
- Risks assessments, mitigation measures, challenges and Key Performance Indicators (KPIs) as they pertain to water

Water abstraction is a key metric for all sites centrally and has been reported since 1995. Each site has annual targets to drive water efficiency across the site. Other teams across Unilever also have targets to drive reductions across the value chain. Alternative sources of water were not readily identified and water shortages were not seen as a current or near future threat. Additionally, several projects to improve water efficiency and reduce water use had been identified, however the payback period for the investment did not meet internal investment requirements. The ability to better represent the value of water would reduce the investment payback period for water conservation projects making such projects more appealing from a financial standpoint.

3.2. Interviews

Numerous interviews were conducted with a diverse range of subject matter experts to further complement our literature review and assist us in creating the framework. Interviews were a mix of phone calls and face-to-face interviews. We started each interview by recreating the purpose of our project and the main challenges that we were facing, which provided the interviewers with enough context to contribute significant insights. We split the people we interviewed between Unilever employees and expert stakeholders external to Unilever's operations. Through the interviews with Unilever personnel, which were phone calls, we aimed to better understand the global perspectives on water use within Unilever's operations. Experts from academia and industry were approached to gain subject matter expertise within the realms of sustainability, water risk and commodity pricing.

3.3. Current Industry practices

To supplement our literature review comparing existing tools (section 2.5), we found it valuable to perform a more in-depth exploration of the most relevant existing tools to better comprehend their mechanics and methodology. A review of the methodologies of these tools improved our understanding of currently available methods for identifying and evaluating water risks and converting these risks into scores or prices. The various ways in which different tool inputs were utilized to calculate meaningful water risk scores or prices provided us with effective options that we could potentially employ in developing our price valuation framework.

3.4. Lifecycle model used

In developing our framework, we used the evolutionary prototyping lifecycle methodology (McConnell, 1996). We began with an initial concept, which was a broad idea of what our client needed. We designed a first prototype and iterated the model through weekly meetings and regular communications with our client. We refined the prototype as we improved our understanding of the existing tools and resources preferred by our sponsor, the profile of our tool's end-user and the scope and limitations of our model.

4. RESULTS AND DISCUSSION

As we progressed towards creating the framework, we use our findings from interviews, insights from the current practices review, and key points learned from our literature review to generate the pricing framework. Subsequently, we create our framework and test its functionality with a few case studies.

4.1. Findings from our interviews

As mentioned in our methodology (Section 3.2) we interviewed people within Unilever and experts within MIT and Industry. Our findings are detailed in the following subsections.

4.1.1. Unilever Personnel

We interviewed the Safety, Health and Environment (SHE) Directors of Latin America (Jorge Acosta, Regional Environment Manager, LATAM) and Africa (Paul Muigai, SHE Director Africa). Additionally, interviews with representatives from Unilever's Advocacy group (Laura Barneby, Global Advocacy Manager) and its Sustainable Finance team (Roger Seabrook, Finance VP) broadened our understanding of water issues and carbon pricing within Unilever. Findings from our interviews are summarized in Table 1.

Table 1. Findings from Interviews with key Unilever personnel

Role / Title	Findings
SHE Director, Latin America	➢ Water shortages are already affecting operations in the region ➢ Mix of water sources vary for each plant ➢ They use KPIs to better monitor water use
SHE Director, Africa	➢ Water shortages have not significantly affected operations

Role / Title	Findings
	in the region to date ➢ They are aware of alternative supplies, but only in extreme cases and many sites have onsite storage
Advocacy Representative	➢ Advocacy works at both local and global levels. Global sets the strategy and local implements and tailors it to the local context
Vice-President, Sustainable Finance	➢ Suggested a 'Supply-Demand' case-based approach, where the shortage level is gradually increased and societal response is evaluated for each case ➢ Carbon approach is based on a desk study of business and governmental responses, which is being tested internally to better understand price point. It is still not confirmed whether the current processes are right, or how they will be used - that work is currently being performed

4.1.2. External experts

Table 2 contains our findings from the external experts that we interviewed, including MIT faculty, professionals working with NGOs and a sustainability executive from an industry competitor.

Table 2. Findings from Interviews with experts within industry, academia and NGOs

Expert Information	Findings
Paul Reig **Organization:** WRI **Role:** Associate, Water Program **Expertise:** Water risk assessments	➢ Reputational and regulation risk are difficult to estimate in terms of likelihood ➢ Only use quantifiable components in the pricing ➢ An approach to measure and reflect regulation risk is to define the uncertainty in regulatory changes and identify their key drivers. The greater the uncertainty in adverse legislation, the higher the risk and vice versa. Therefore, highly regulated localities have lower risk as regulatory actions can be planned for

Expert Information	Findings
Sameer Kamal **Organization:** Asian Development Bank **Role:** Urban Development Specialist **Expertise:** Water assessments	➢ Recommended to consider using GWI Water Tariff Survey data to gauge regulation risk. This survey is a comprehensive database covering water utilities prices worldwide ➢ Provided general guidance on how international financial institutions look at water investment decision-making ➢ Recommended to consider using the IBnet database to gauge regulation risk
Christopher R. Knittel **Organization**: MIT Sloan School of Management **Role:** Professor of Energy Economics **Area of Expertise:** Economics and (Carbon) Pricing	➢ Recommended to compare risks with no investment and the risks with investment and see if the expected value change is smaller than the investment cost. For example, compare profits in 2 different scenarios and measure the difference. One in an ideal world without droughts and one with droughts - consider using a decision tree ➢ Supported use of the economic value-at-risk framework that our model incorporates ➢ Mentioned the use of third party measures of political risk and government security used by companies in evaluating foreign investment – these can be used to gauge regulation risk
Jason Jay **Organization:** MIT Sloan School of Management **Role:** Director Sustainability Initiative **Expertise:** Water resource sustainability	➢ Suggested a context-based approach, i.e. ecosystem approach (Flow balance methodology). The approach suggested using the measuring the health of the watershed (serving a site) as the best indicator of water risk at a site ➢ Referred us to Vance Merola who led the creation of the True Cost of Water tool at Colgate-Palmolive
Name: Vance Merola **Organization:** Colgate-Palmolive **Role:** Director of Sustainability Group **Expertise:** Water resource accounting	➢ The True Cost tool developed by Colgate was focused on finding "hidden costs" related to water. Hidden costs include costs related to water pumping, water treatment, etc. Business costs incurred due to water shortage were not included in their tool ➢ Model simplicity is essential ➢ Explore existing tools, such as WRI-Aqueduct and Water Risk Monetizer to capture risks and evaluate their methodology

Expert Information	Findings
Name: James B. Rice, Jr. **Organization:** MIT Center of Logistics and Transportation **Role:** Director of the MIT Integrated Supply Chain Management (ISCM) Program **Expertise:** Risk assessments	➢ Review water utilities reporting, financial indicators and other KPIs, to try to find a probability distribution of business disruption events. Search for locations in the U.S. as a starting point, especially in places where water supply disruption has taken place (e.g. New York after Hurricane Sandy, California during recent droughts) ➢ Probabilities are prone to multiple factors that could vary from one place to another. So build high-level "archetypes" according to factors (or attributes) that apply to those locations. Define the factors that affect the probability distribution: maturity of water authorities, major users of water authorities, etc. ➢ Focus on understanding the costs, such as alternative water supply options, consider inventory and distribution policy, changes in production rate, etc.

We summarized our findings from these interviews as follows:

- Exclude subjective indicators from the model to the greatest extent possible to prevent introduction of biases into the model.
- Aim to create a practicable, user-friendly and simple framework with a defendable basis in order to promote stakeholder and end-user engagement.
- Consider evaluating reputational and regulation risk as qualitative measures separate from the model rather than incorporating them as quantitative parameters. Reputation and regulation risk can possibly be evaluated using qualitative metrics indicating risk severity. For example: high, medium, low etc.

4.2. Review of current industry practices

We chose to review the four most popular methods publicly available reported through 2014 CDP industry water surveys, as listed in Table 3. As the Water Risk Monetizer was launched in November 2014, it was not reported in the CDP survey data. However, we found it useful to evaluate because the Water Risk Monetizer attempts to monetize water risks and yields a business disruption cost, a critical goal of our thesis framework.

Table 3. Methods used to assess water risks,

Method	Number of User Companies
WRI Aqueduct	150
WBCSD Global Water Tool	124
Regional government databases	65
Life Cycle Assessment	36
WWF-DEG Water Risk Filter	26
GEMI Local Water Tool	20
FAO/AQUASTAT	19
Water Footprint Network	19
Combination of Tools	14
UNEP Vital Water Graphics	13
IPIECA Global Water Tool for Oil & Gas	8
Maplecroft Global Water Security Risk Index	8
ISO 14001/ISO31000/ ISO 14046	6
Pfister index (Water Stress index)	4
Business Continuity Planning process	3
PwC ESCHER tool	3
Ceres Aqua Gauge	2
European Water Stewardship Standard	2
Internal company knowledge	199
Other	129

Note: Adapted from CDP Water 2014_ Open dataset, by CDP, 2014.

Table 4 summarizes the tools reviewed. A common theme among the tools reviewed was the use of location as the primary input and the use of qualitative color scales as the output format.

Table 4. Review of the most popular tools

Tool	Description	Inputs & Outputs
WRI Aqueduct Water Risk Atlas	Online interactive Atlas, which shows overall water risk in a color scale.	**Required Inputs:** Location **Outputs:** Overall Water Risk, which is calculated using weighted averages and a normalization of 12 different indicators
WBCSD Global Water Tool	Includes an excel spreadsheet to input site-specific data. The "Dashboard" tab has a table with graphs of the input data. Also according to the location of the sites, several FAO AQUASTAT, WHO/UNICEF, UN, WRI Aqueduct indicators are shown. GRI, Bloomberg, CDP and Dow Jones Metrics are included as well.	**Required Inputs:** Water Withdrawals, Water Discharge, Location, Sales, Number of site workers **Outputs:** This tool displays qualitative scores of indicators obtained from other tools
WWF-DEG Water Risk Filter	Interactive website with a user-friendly interface showing risk results on a color scale.	**Required Inputs:** Location, Industry **Optional Inputs:** Company Related Questionnaire **Outputs**: Basin related risk, which is a weighted average of 20 parameters. Company related risk, according to the answers of 30 questions.
GEMI Local Water Tool	Excel spreadsheet divided into 6 modules: Site Data, Local External Conditions, External Impact Assessment, Risk Assessment, Management Plan and Reporting. The tool had some macros that did not work. Therefore, we were unable to confirm the required inputs and outputs.	These are the features we considered most relevant: Reporting Internal Metrics Module Water Withdrawals, Water Discharge, Water Consumption, Internal Recycled/Reused, Production/year, Revenue,

		Total Water Consumed/unit of production/year, Total Water Consumed/$ Revenue
Water Risk Monetizer Powered by Ecolab and TrueCost	Online interactive website, user-friendly interface with most of the input fields limited to dropdown lists. Results are shown using a color scale and bar charts that allow comparison of different facilities.	**Required Inputs:** Location, Industry Classification, Water Use Time Period, Amount of Water Use, Unit Price of water **Optional Inputs:** Projected price increase per year, Projected water use over 3 years, Revenue Data, Total Facility Output, Water Questionnaire (addressing reputation and regulatory aspects) **Outputs:** Water Risk Premium, Risk Adjusted Price, Water Scarcity, Reputational and Regulatory Risk Score, Revenue at Risk Likelihood Score

Besides the four most popular tools, we reviewed tools that generate descriptive assessments used by organizations to disclose their most relevant water-related issues for the benefit of institutional investors and to share critical information and best practices to support industry initiatives in managing and mitigating water risks.

Among these descriptive assessments, the most comprehensive are CDP Water Disclosure, CERES Aqua Gauge, CEO Water Mandate Corporate Water Disclosure Guideline and GEMI Connecting the Drops.

The review showed that the general trend is to reflect an overall water risk through a weighted average created using a combination of different indicators. However, the use of weighted averages introduces subjectivity into the model. For instance, the WRI Aqueduct Water Risk Atlas employs twelve different indicators (see Figure 7) that collectively form an overall water risk. Each indicator has a different weighting that is either based on the company's industry or is customized by the tool-user.

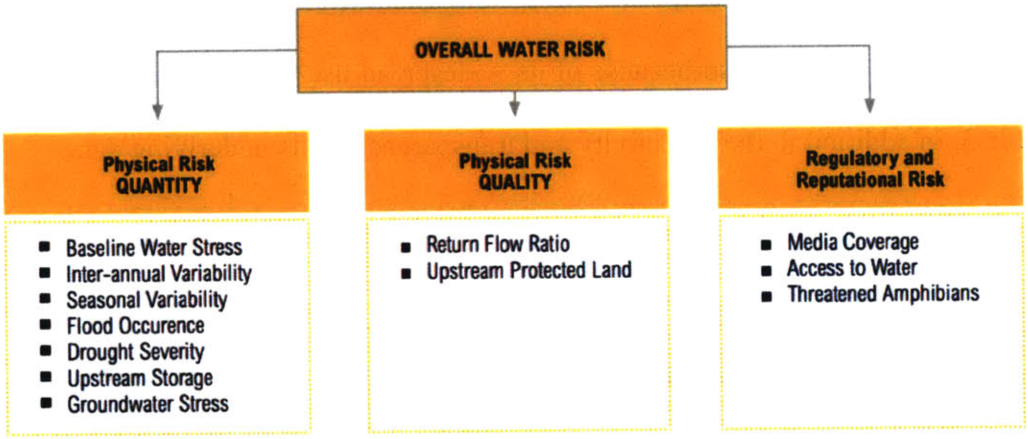


Figure 7. WRI Water Risk Atlas Risk Indicators

Note: Reprinted from *Aqueduct Water Risk Framework*, by Reig, Shiao, & Gassert, 2013.

Likewise, the Water Risk Filter yields two overall risk scores. The first score measures the water risk based on the condition of the water basin that supports an operation and is calculated using a customizable weighted average that includes 20 different indicators. The second score, which is optional, identifies the water risk for company's operation based on its reliance on water and the impact of its water use on external stakeholders. This score results from a customizable weighted average of the Company Related Risk Questionnaire, which includes 30 queries.

Although the Water Risk Monetizer includes an additional calculation for a "Water Risk Premium," which shows the operational value-at-risk, it is similar to other tools in that it uses a combination of indicators in its overall risk calculation.

The WRI Aqueduct was deemed the optimal basis for objectively identifying and evaluating water risks to incorporate within our framework. This was in part due to our sponsor's preference, but also because of its widespread use within industry, as highlighted in Table 3, in addition to the objectivity and transparency of its underlying data.

Paul Reig (from the WRI) advised our team to select a single indicator as the basis of our model in order to maintain model objectivity. Of the outputs available through Aqueduct, baseline water stress is the best indicator as it is based on quantifiable data from reliable sources. Baseline water stress ranges from 0 to 5, and is derived through a normalization of Equation 3.

$$Baseline\ water\ strees = \frac{Total\ water\ withdrawals}{Mean\ available\ blue\ water} \tag{3}$$

4.3. Components of our Framework

In developing a framework to comprehensively and accurately monetize the value of water, we decided to employ the Inventory Management Approach as noted in Section 2.6. We related the various constituents of the Inventory Management Approach - Purchase Costs, Ordering & Holding costs and Shortage costs - to a corresponding water-related cost component, as depicted in Figure 8.

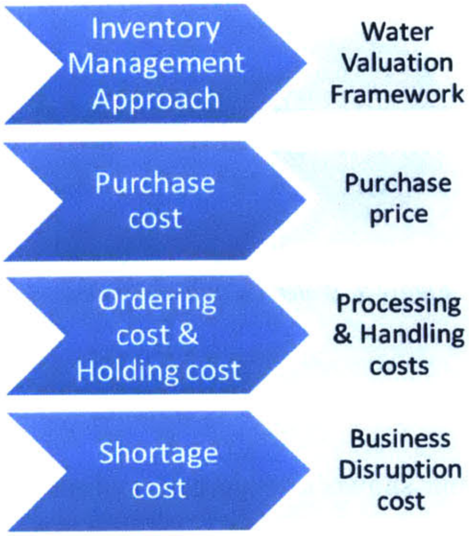


Figure 8. Comparison of components of Water Valuation Framework and Total

"Purchase cost" is the price paid in order to acquire water at the given location. The Purchase price offers a baseline value supplemented by value additives such as the "Processing and Handling Cost" and the "Business Disruption" cost. Processing and Holding costs include all costs associated with having water in the condition required for operation – these costs include water handling and processing costs incurred in activities such as pre-treatment and wastewater treatment, which Colgate's TrueCost Tool refers to as additional costs. Lastly, Business Disruption costs represent the financial value-at-risk resulting from disruptions in water supply, which is similar to what the Water Risk Monetizer terms the "Water Risk Premium."

The resulting water valuation framework is outlined in Equation 1 and the components of the framework are graphically portrayed in Figure 9.

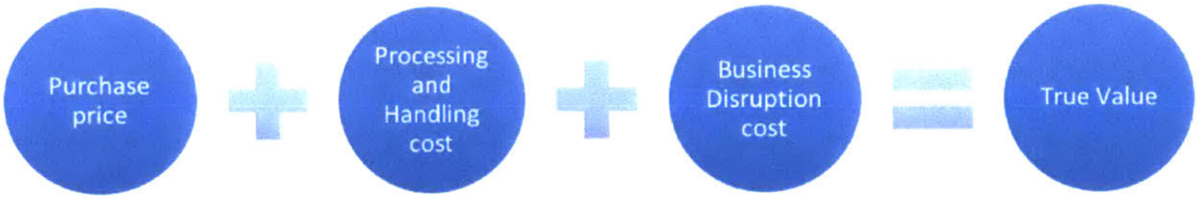
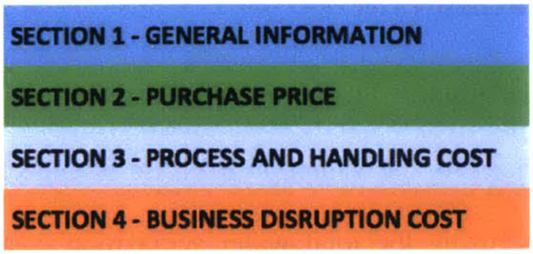


Figure 9. Water Valuation Framework

4.4. Water Valuation Framework

As defined in Section 4.3 and shown in Figure 9, to find the True Value of water, our framework includes three components: Purchase price, Processing and Handling cost and Business Disruption cost. This framework is a result of multiple iterations and continuous feedback from our client (Section 3.4). Because water-related events at Unilever sites across the world have not been recorded centrally, information on historical cases was not readily available to clearly evaluate the Business Disruption cost, which corresponds to the financial implications of operational disruptions resulting from events associated with location specific water stress. Additionally, the Purchase price and Processing and Handling cost of water vary considerably throughout Unilever's facilities worldwide. Our framework was designed to assist Unilever in compiling the minimum data requirements and to use that data in estimating the true value of water for a given facility. As shown in Figure 10, the framework is divided into four sections. A screenshot of the complete framework has been included in Appendix 2.



SECTION 1 - GENERAL INFORMATION
SECTION 2 - PURCHASE PRICE
SECTION 3 - PROCESS AND HANDLING COST
SECTION 4 - BUSINESS DISRUPTION COST

Figure 10. Sections of the Framework

In order to ensure unbiased and accurate results, we envision the data collection exercise to be performed as a multidisciplinary effort between the Environment (or HES), Finance, Operations and Engineering functions. We suggest that this exercise be performed at least on an annual basis to ensure model accuracy.

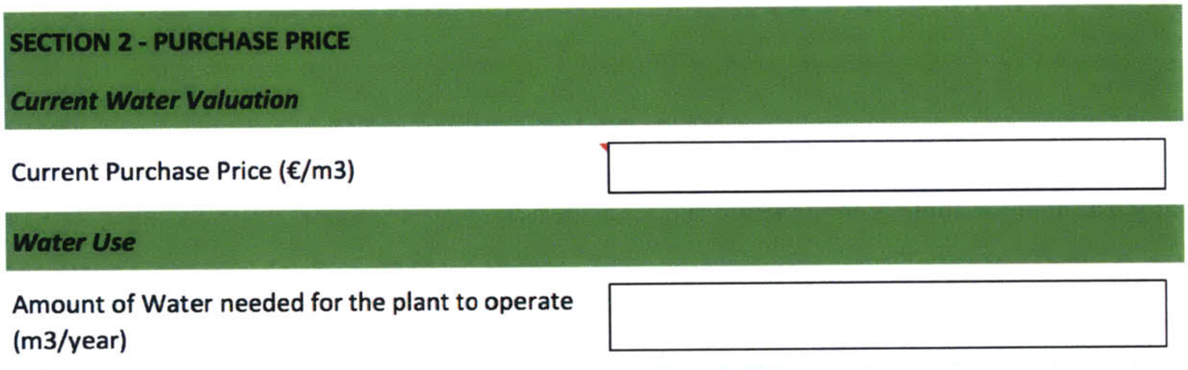
4.4.1. Section 1 - General Information

The first section comprises two sub-sections with information about the template user and the facility. Including the identity of the template users will facilitate traceability of the information.

In terms of the site information, the Facility Name (FN) is the name of the site - a pre-populated dropdown list comprising all current Unilever manufacturing sites in operation worldwide was included. The Total Production (TP) represents the total annual site production. Finally, the Total Revenue (TR) is the total annual site revenue. The total production and revenues serve as the basis for calculating the Business Disruption cost. For future consideration, annual site profits could be used as an alternative basis for calculating the Business Disruption cost - this would result in a lower value for the Business Disruption cost.

4.4.2. Section 2 – Purchase price

Section 2, shown in Figure 11, is used to estimate the first component of our framework, Purchase price. As the valuation exercise is expected to be performed on an annual basis, we suggest using the total water acquisition cost from the previous year's 'Monthly Site Level Cost Report' in estimating the Purchase price.



SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)	

Water Use

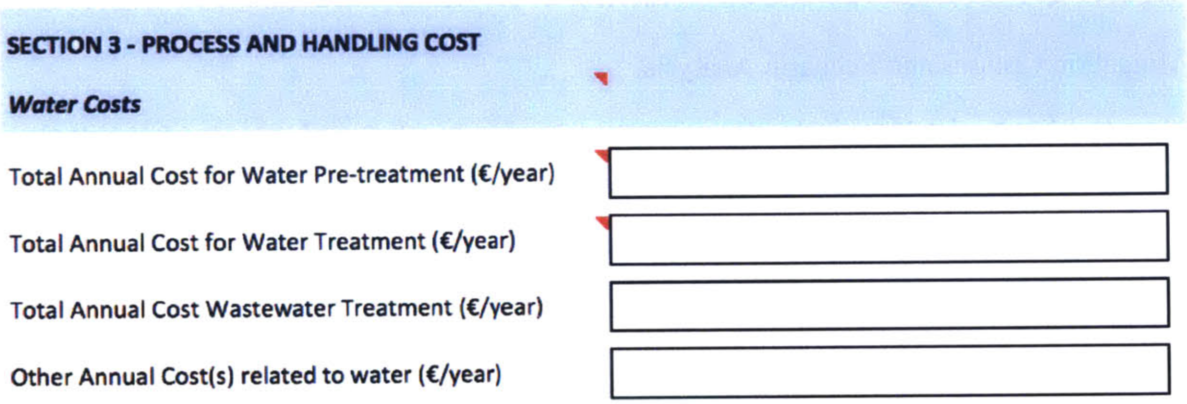
Amount of Water needed for the plant to operate (m3/year)	

Figure 11. Section 2 - Purchase Price

4.4.3. Section 3 – Process and Handling cost

Section 3 estimates the Processing and Handling cost by identifying the operational and maintenance costs associated with water treatment and handling processes, such as the energy costs of pumping water, heating water or disposing wastewater. Two methods for collecting this data are either through available water mass-balance data and the accounting system or by using the Beverage Industry Environmental Roundtable (BIER) tool. The BIER tool, a publicly available tool from the True Cost of Water toolkit, performs a comprehensive, spreadsheet-based calculation of the processing and handling cost based on a set of process related inputs (see Appendix 3).

The BIER tool has been identified as a good approach to estimate the additional costs associated with water handling. We suggest using this tool to populate Section 3 of the framework, as presented in Figure 12. Additionally, we included the 'Other Annual' cost field to gather supplemental costs related to water not captured within the other fields.



SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)

Total Annual Cost for Water Treatment (€/year)

Total Annual Cost Wastewater Treatment (€/year)

Other Annual Cost(s) related to water (€/year)

Figure 12. Section 3 - Process and Handling cost

4.4.4. Section 4 - Business Disruption cost

Business disruption costs correspond to the financial implications of operational disruptions resulting from events associated with location-specific water stress. The cost, also known as value-at-risk, is a function of the likelihood of the various undesirable water scenarios multiplied by the corresponding financial costs incurred by Unilever, as shown in Equation 4.

$$Business\ Disruption\ Cost = \sum_{k=1}^{n} \sum_{i=1}^{m} \frac{f_k(c_{ik} + \cdots + c_{mk})}{w} \tag{4}$$

n - number of scenarios
m - number of cost types
f_k - frequency of scenario k (per year)
c_{ik} – financial cost type i for scenario k

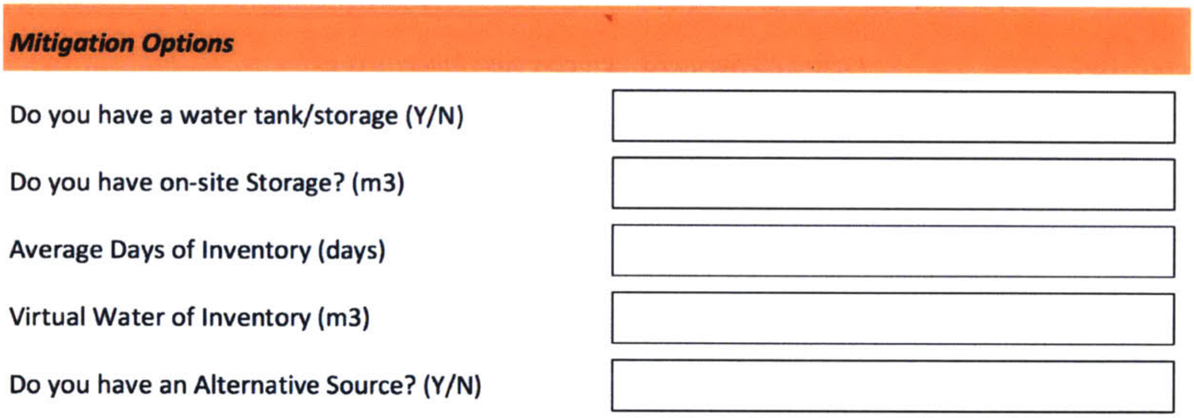
W – water abstracted (per year)

The financial cost of events is directly influenced by the availability of mitigation measures such as additional capacity in terms of on-site water storage or inventory safety stock.

The Business Disruption cost section was further divided into two subsections: Mitigation Options and Scenario Analysis.

4.4.4.1. Mitigation Options

Mitigation Options represent the site's flexibility in responding to water shortage events. We assume that three mitigation options can be available at a site (Figure 13).



Mitigation Options

Do you have a water tank/storage (Y/N)	
Do you have on-site Storage? (m3)	
Average Days of Inventory (days)	
Virtual Water of Inventory (m3)	
Do you have an Alternative Source? (Y/N)	

Figure 13. Mitigation Options

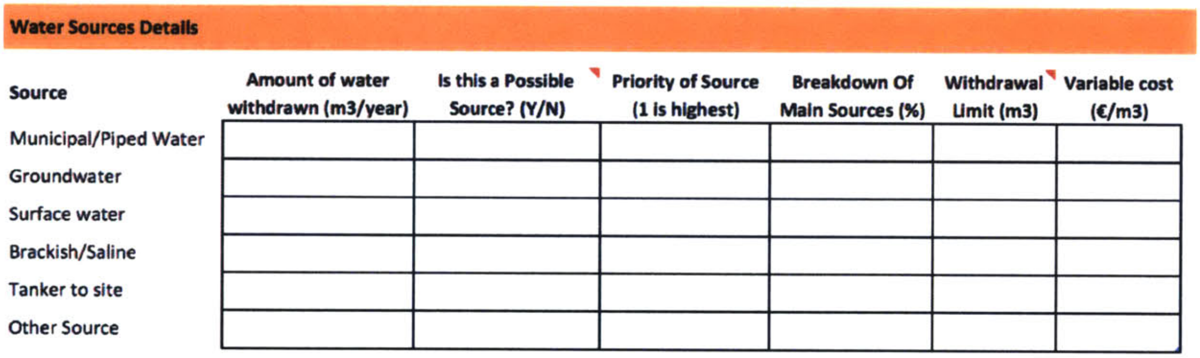
The first mitigation option is on-site water storage, which includes tanks or other storage infrastructure that enable a site to temporarily continue operations in case of supply disruptions.

The second mitigation option corresponds to the inventory of finished goods available onsite, which we refer to as the Average Days of Inventory (DI) - it is expressed in terms of days of production. The Inventory Water (IW) represents the amount of water used to manufacture the safety stock inventory available (m^3) and is defined in Equation 5.

$$IW = \frac{DIxW}{365} \tag{5}$$

W – annual amount of facility water consumption (m3/year)

The third mitigation option includes the alternative sources of water available for on-site use. Figure 14 shows the information considered relevant as it relates to water sources. The "Monthly Site Level Report" was used in determining the various sources available including: municipal / piped water, groundwater, surface water, brackish / saline, tanker to site, and other sources, in case a different water source is available.



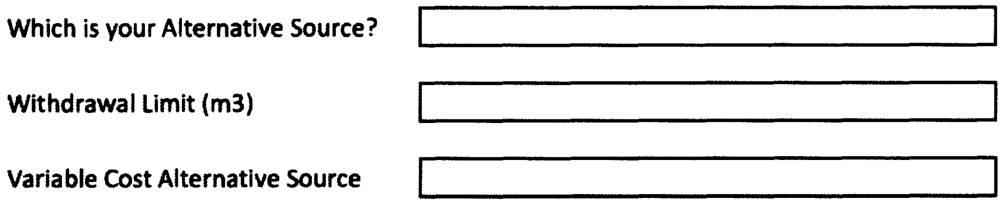
Water Sources Details

Source	Amount of water withdrawn (m3/year)	Is this a Possible Source? (Y/N)	Priority of Source (1 is highest)	Breakdown Of Main Sources (%)	Withdrawal Limit (m3)	Variable cost (€/m3)
Municipal/Piped Water						
Groundwater						
Surface water						
Brackish/Saline						
Tanker to site						
Other Source						

Figure 14. Water Sources Details

The current revision of the framework lacks withdrawal limits for the main source. However, auxiliary sources of water were assumed to have associated limits of withdrawal. Finally, the variable cost represents the cost of an incremental volume of water from a particular water source.

Information displayed in Figure 14 is used to fill in the "Alternative Source Details" section, shown in Figure 15. The framework has been designed to automatically prepopulate the "Alternative Source Details" section with the information pertaining to the source listed with "Priority of Source" value of 2; if there is only one source of water available, the "Alternative Source Details" field will be not applicable. We included an additional assumption in the variable cost; in cases where the variable cost of the alternative source was zero, the field will have the maximum variable cost of all water sources.



Which is your Alternative Source?

Withdrawal Limit (m3)

Variable Cost Alternative Source

Figure 15. Alternative Source Details

4.4.4.2. Scenario Analysis

In estimating the Business Disruption cost we needed to identify pertinent water-related production disruption scenarios that could potentially impact site operations and monetize their associated risk. We calculated scenario risks by multiplying the probability of the various scenarios with their corresponding financial consequences and aggregating the individual scenario risks, to achieve a total value-at-risk cost.

Initially, we expected to calculate the Business Disruption cost by defining water-shortage event scenarios according to the duration of a water shortage event and the percentage of water loss for each of these events (see Appendix 4). We hoped to tie the probability of these shortage events to the Aqueduct baseline water stress value of the location that the factory operated in – ideally, we wanted to create a probability distribution for each of Aqueduct's baseline water stress score that could be extrapolated to sites worldwide. As

Unilever did not collect data regarding historical water-related factory outages, other sources of water-loss frequency data were needed to make this approach viable.

An alternative method for estimating event likelihood was suggested to us during our interview with Dr. James Rice (see Section 4.1.2.). He recommended exploring the public domain for information indicating the historical frequency of municipality outages, which were often tied to the location water stress and as a result could be used to generate event scenario probabilities. He suggested that this data might be obtained through annual reports, press releases and other public notices published by local municipalities. Outage frequency data for municipalities could subsequently be tied to the Aqueduct baseline water stress value for the location that the municipality operated in. Upon performing this exercise for a small subset of locations and gathering event likelihood profiles for a range of different Aqueduct baseline water stress values, these probabilities could be extrapolated to sites worldwide. Unfortunately, we were unable to successfully locate such data through a cursory review of publicly available data sources.

In the absence of a tenable basis for evaluating event probabilities, we decided to pursue an alternative strategy for evaluating scenario value-at-risk. Recognizing that the best available site-specific operational information resided with experts on the ground, we decided to initially rely primarily on the best judgment of operations personnel, with support from the corporate sustainability group, in monetizing water risks.

The design of the scenario analysis section of our new framework was based on a pre-populated compilation of historical water-loss scenarios. These scenarios were derived from disclosures reported by companies operating in the same industry as Unilever

(Consumer Staples) on CDP Water Reports for the years 2013, 2014 and 2015. The data was summarized and filtered in CDP's Water Disclosure Summary and is included in Appendix 5. The compiled scenarios were classified under four distinct impact categories and are detailed in Table 5.

Table 5. Business Disruption Scenarios

Impact Category	Loss Type	Scenario Root Cause
Drought / Water Scarcity	Power outages	Municipal / private utility water demand is not met
	Switching water source	Disruption in municipal water supply / infrastructure
	% Restricted water (municipal)	Disruption in municipal water supply / infrastructure
	% Restricted water (municipal)	Government enforced water rationing
	% Restricted water (borehole)	Groundwater depletion
	% Restricted water (river)	Low river levels
	Full restriction on water abstraction	Loss of Social License to Operate
	Higher Price of Water	Incremental cost increase (inflation / in line with other utilities)
	Higher Price of Water	Government enforced emergency water charges
Flooding	Flooding	Tropical Storm
Water Pollution (Quality below standards)	Water Pollution	
Inadequate Infrastructure	Pipe Burst	
	Other Water Utility Related Disruption	

Unlike physical risk, which is directly proportional to the measure of water stress in a region, reputation and regulation risks are a function of the complex interplay of a variety of factors including political stability and socio-economic conditions. Initially, because of the uncertainty inherent in the measure of reputation and regulation risks, we considered excluding them from our model. However, as the new framework relied on operational experience, we included scenarios associated with regulation and reputation risk on the grounds that the factory personnel would be sufficiently informed about regional social and governmental issues to estimate event likelihoods.

4.4.4.3. Likelihood

Although we were able to generate a baseline water stress rating using Aqueduct for locations where Unilever operates, a direct connection to the probability of the scenarios identified in Table 5 was not discernible because of the absence of historical data. Consequently, we decided to rely on operational insight and experience in estimating the probability of such events, as suggested by Petrovic (2001) and Simchi-Levi (2014) in their methodologies. At locations worldwide, Unilever operations personnel would be surveyed using the data-gathering template included in Appendix 2 to determine the frequency of the scenarios outlined in Table 5.

Upon gathering a representative set of site data regarding the frequency of water shortage events, we suggest building several scenario likelihood profiles to correlate event frequencies with an objective risk indicator, such as the risk rating provided by Aqueduct and aligned with climate models. Established scenario likelihood profiles can then be applied universally based on location-specific Aqueduct risk ratings.

4.4.4.4. Financial Consequences

In appraising the financial implications of adverse water-related scenarios, the framework again relies upon operational insight and experience. At locations worldwide, Unilever operations personnel would be surveyed using the data-gathering template included in Appendix 2 to estimate the financial ramifications of the scenarios outlined in Table 5.

Broadly speaking, financial consequences were divided into the following categories:

- Lost production and revenue
- Additional cost of alternative sources
- Infrastructure investment and increased operational expenditures
- Other costs

The cost of lost production and revenue was integrated into the framework as described by the decision-tree diagram presented in Figure 16. To keep the framework simple, we assumed that the time to set up the alternative source is insignificant. The estimated cost of lost production takes into account all three mitigation measures specified in Section 4.4.4.1.

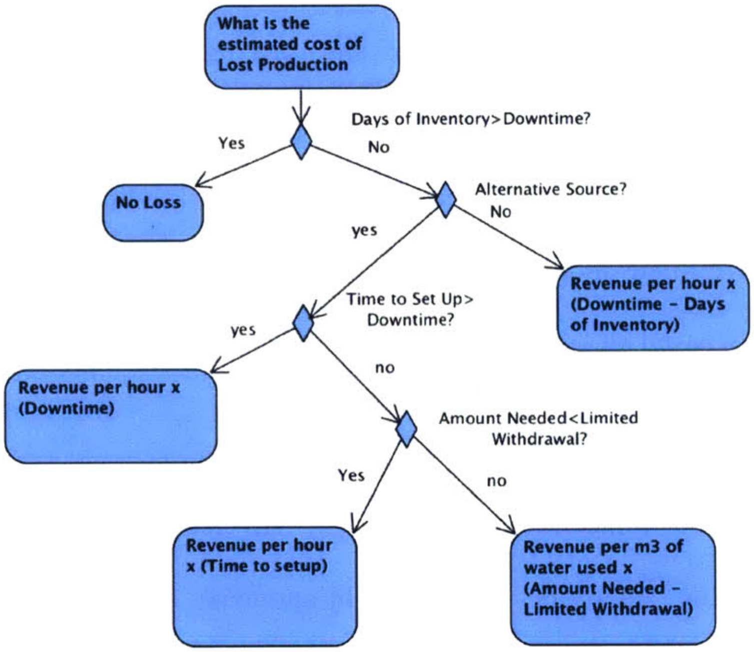


Figure 16. Estimated Cost of Lost of Production Flowchart

Events such as water rationing by government-operated municipalities or sundry causes leading to water supply curtailment of the primary water source can force operations to switch to emergency sources of water, where available, often at a higher premium. Additional costs incurred in using secondary sources of water have been incorporated in the framework in the manner described in Figure 17.

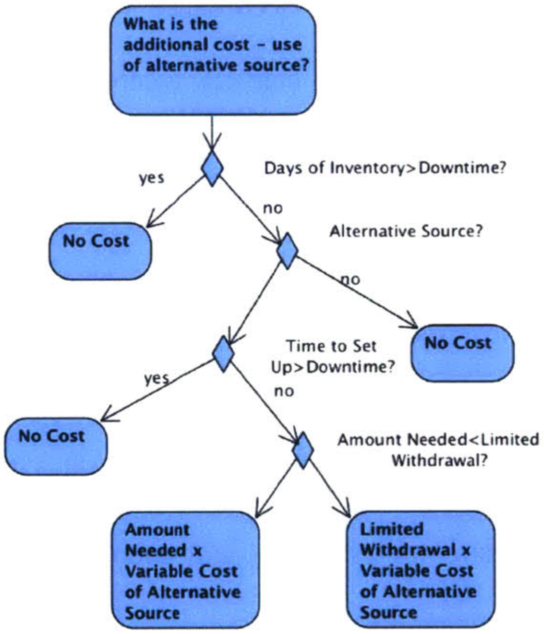


Figure 17. Additional Cost (Alternative Sources) Flowchart

Events such as poor quality water supply or regulatory mandates requiring higher quality water discharge specifications may prompt the installation of additional water processing infrastructure leading to capital expenditures and increased operational costs. The framework includes the capability to include these ad-hoc investments and costs.

Additional water-related costs such as government imposed tariffs, taxes, and penalties resulting from regional water stress concerns can be captured within the “Other costs” section of the framework.

4.4.4.5. Value-at-Risk

The Value-at-Risk for each scenario is calculated using the likelihood and financial consequence attributed to each event, in accordance with Equation 4. The aggregated Value-at-Risk for all event scenarios collectively comprise the site’s Value-at-Risk, or Business Disruption cost.

4.5. Model Limitations

As previously noted, we aimed to create a simple framework that was universally deployable at sites across the globe. However, based on an extensive review of available literature and numerous stakeholder interviews, we decided to introduce scope restrictions into our framework to ensure an objective and reliable analysis while maximizing transparency within business functions.

The current revision of the framework excludes numerous factors that could impact the price of water at a given location, for a number of reasons including lack of available data, an absence of objective quantifiable approaches or a preference on the part of our sponsor. Such factors include political instability, the country’s dependence on hydropower, cultural or religious value of water, effects of climate change, population growth and ecosystem susceptibility. These factors can be built-in at a later date with greater understanding.

Our framework exclusively considers water-related events within the context of manufacturing operations, excluding events affecting the wider supply chain continuity such as agricultural disruptions. Water provides multiple benefits to communities and is vital for the ecosystem. We did not include the valuation of ecosystem services because the scope of this project was limited to manufacturing.

From a financial impact perspective, we only included quantifiable impacts. No consideration was given to market share loss or negative effects on Unilever's brand. Furthermore, indirect and tangential water-related costs such as public relations expenses or legal fees due to water disputes were not included.

Potential changes in hydrological conditions due to climate change were not included. Although Aqueduct has estimations of water stress for 2020, 2030 and 2040, we decided to base our model on historical conditions, in accordance with advice received during our expert interviews. Changes in demographics that could potentially change the future dynamics of water use and affect the evolution of water-basins were also excluded from the framework. These can be built in through future efforts as needed.

We expect the model to generate base case values for water that can be supplemented by running sensitivity cases. Sensitivity cases can explore the change in water valuation associated with alternative scenarios such as UNFCCC climate change scenarios and population growth. Our sponsor expects to use the framework to perform multiple sensitivity analysis to measure the change in value resulting from varying water-related impact scenarios such as frequent power outages, high population growth and longer droughts. These sensitivity cases will in turn generate values of water commensurate with the risks faced by a site based on future projections.

4.6. Model Testing

To demonstrate framework functionality, we decided to find the value of water generated by the framework using a few test cases. The primary purpose of this section is to illustrate how our framework yields different results with varying inputs. Given factors in place during this research project, we used our best judgment in testing the framework, using data provided by Unilever, CDP disclosures and publicly available information. The cases used were hypothetical sites with data that was generated using publicly available information for the sole purpose of testing model functionality.

We performed a case study on four sites with the following characteristics:

- High level of production and one mitigation option (inventory)
- High water stress and no mitigation option and purchase price of €0/m3
- Two mitigation options and lower water stress
- One mitigation option and lower water stress

To focus this exercise on analyzing the effects of the Business Disruption cost, for the purpose of this exercise, we assumed that the Processing and Handling costs were equal for every facility. However, we recognize that there are significant variations in energy and recycling costs globally. We used the unit cost of water treatment in San Diego, CA (The City of San Diego, 2013) and a unit wastewater treatment cost derived from an estimation of the cost for different wastewater treatment facilities in Spain (Hernández-Sancho, Lamizana-Diallo, Mateo-Sagasta, & Qadir, 2015) as values to estimate the Processing and

Handling cost. With regard to these test cases, we assumed that the amount of wastewater treated was equivalent to the amount of water abstracted. In reality, over 30% of the water abstracted goes into the product and therefore does not need to be treated as wastewater.

Also, to narrow the number of mitigation options available, we assumed that there was no buffer capacity available in any of the cases evaluated. We include a screenshot of the inputs used and the results tab of each of the cases evaluated in Appendices 6, 7, 8 and 9.

4.6.1. Case 1

We evaluated a hypothetical case of a Laundry manufacturing site that has a high production output and a relatively high baseline water stress score. This facility has only one source of water supply and in testing our mitigation options feature, we assumed that the location had 7 days of inventory on-site (DI = 7 days). The facility is located in a region of high water-stress – hence, we chose higher frequencies for the drought scenarios. However, as reflected in the Business Disruption cost (Appendix 6), the inventory available offsets any cost of lost production caused by drought scenarios as none of the events lasted longer than 7 days. The Business Disruption cost of € 0.70/m^3, as shown in Appendix 6, corresponds to the increase in risk-based operational costs resulting from water disruption scenarios.

4.6.2. Case 2

Case 2 assumed a manufacturing site dedicated to making Laundry products as well. This facility has a baseline water stress of 5 and a current water price of € 0/m^3. It has only one source of water supply and we assumed that it had no other mitigation option available.

Because this facility is situated in a location experiencing high water-stress, we increased the frequency of water disruption scenarios. As expected, the Business Disruption Cost climbed to € 8.08/m^3, due to the estimated value of production susceptible to losses (Appendix 7).

4.6.3. Case 3

Our third case is a facility that produces Beverages. It has a baseline water stress of zero and an assumed water price of € 0.13/m^3. This facility has two sources of water supply and we supposed that it also had on average 2 days of inventory available as a mitigation option. The Business Disruption cost amounts to € 1.89/m^3, as shown in Appendix 8. Despite its two mitigation options, there is some lost production because the average days of inventory available is lower than the amount available in Case 1.

4.6.4. Case 4

Lastly, we chose a case with a manufacturing site that produces Hair products. It has a baseline water stress of zero and a current water price of € 0.56/m^3 (Appendix 9). We assumed that the facility had only one source of water supply and that it had on average 1 day of inventory available as a mitigation option. The Business Disruption cost corresponds to € 1.47/m^3. Though this site has a low water-stress score, the presence of only one mitigation option represents some value at risk.

4.6.5. Comparison of cases

Table 6 summarizes the results of the four cases tested. We expected sites with a lower baseline water stress score to have a lower Business Disruption cost. However, the

Business Disruption cost in Case 1 was the lowest (€ 0.70) because it had 7 days of inventory of finished goods to mitigate the impact of water-disruption events – we assumed that in most cases, the different water-related scenarios lasted less than 7 days. Case 2 had the lowest Purchase price of water. However, in the absence of mitigation options, we expected that any water-disruption event would severely impact business continuity – as a result, the Business Disruption cost of Case 2 exceeded those of all other cases evaluated.

Table 6. Comparison of cases

	Case 1	**Case 2**	**Case 3**	**Case 4**
Lead Category	Laundry	Laundry	Beverages	Hair
Production Level (tonnes)	502,000	62,000	138,000	333,000
Total Revenue per year	€ 662,000,000	€ 82,000,000	€ 467,000,000	€ 988,000,000
Total Water Abstraction per year (m^3)	476,000	127,000	322,000	593,000
Days of inventory	7	0	2	1
Baseline Water Stress	3.61	5	0	0
Purchase Price	€ 2.13	€ -	€ 0.13	€ 0.56
Process and Handling cost	€ 0.56	€ 0.56	€ 0.56	€ 0.56
Business Disruption cost	€ 0.70	€ 8.08	€ 1.89	€ 1.47
True Value	€ 3.39	€ 8.64	€ 2.58	€ 2.59

From this exercise, we could infer that the addition of the Business Disruption cost, which captures both water risks and existing mitigation options at the site, provides a better representation of the true value of water than just the current purchase price alone. However, we recommend that the team that is responsible for filling out the inputs to this framework be circumspect in performing the exercise. In particular, the appropriate days of inventory and the frequency and impact of scenarios should be carefully deliberated and selected to ensure model accuracy.

5. RECOMMENDATIONS

In the following paragraphs we summarize several recommendations for future research to improve performance and functionality of the model.

The framework currently assumes a linear relationship between the quantity of water lost and the volume of production curtailed. In reality, water criticality and the required base load, or the minimum amount of water needed for a site to be in operation, varies from site to site depending on a number of factors. We recommend a deeper exploration of the criticality of water as it relates to the volume of production. A more comprehensive review of this relationship may result in a more precise estimation of the cost of lost production, thereby generating a more accurate value of water.

In order to keep the framework simple, in terms of water sources supplying water to the site, the framework is restricted to two sources of water – the main source and one alternative option for abstraction. There will be facilities with multiple alternative sources of water available, adding to the list of the mitigation options in case of a water loss event. As such, additional functionality incorporating more than two sources of water within the frame should be pursued through future efforts.

Upon the loss of the main source of water supply, our framework assumes a negligible time delay and cost of switching water sources, which may not be the case in every instance. For instance, bringing water in tankers from an area of water abundance may incur significant costs or result in production cutbacks, which are not reflected in the current version of the framework. Future framework revisions should consider including these features.

In terms of loss mitigation measures, the framework currently includes excess inventory, which can also act as buffer capacity to offset production shortfalls resulting from water related events. Further development of the framework should consider additional mitigation options such as shifting production to neighboring sites, using excess inventory at neighboring sites and ramping up site production after a water loss event as a means of recovering from those significant events.

The preliminary set of scenarios included within the framework represents a general list of commonly experienced water-related events that have been historically experienced by industry. However, the list of scenarios is not exhaustive. Envisioning the addition of new scenarios, we designed this framework to enable the seamless addition of site-specific scenarios, as deemed appropriate.

A key recommendation is to begin the collection of site data such as available mitigation options, alternative water sources and average days of inventory in addition to the other framework-related inputs. The occurrence of water-related events, such as droughts, floods and water pollution, is generally considered frequent and widespread. Therefore, we recommend Unilever to capture and record event details such as frequency, recovery time, mitigation costs and other framework-related inputs resulting from such crises.

As mentioned in Section 4.4.4.2., we hoped to tie the probability of different water-loss scenarios to Aqueduct baseline water stress values. Upon collecting a sufficient level of historical data, we recommend creating a probability distribution corresponding to

Aqueduct baseline water stress scores for the various operating locations. This relationship can then potentially be used to extrapolate water-loss event statistics to sites worldwide, based solely on Aqueduct baseline water stress scores.

In the context of this project, the model was tested using a set of assumptions, which yielded reasonable values. However, in practice, if model-generated values exceed acceptable ranges, then Unilever should consider removing the Processing and Handling cost component as a means of curtailing value estimates.

Additionally, the framework assumes that additional investments to improve plant water efficiency would reduce Business Disruption cost as well as Process and Handling costs, as depicted in Figure 18. However, in practice, we understand that adding water efficiency infrastructure could potentially increase costs associated with operating and maintaining the new infrastructure, which would be reflected by an increase in the Processing and Handling costs. If this increase is countered by a reduction in the Business Disruption costs, the true value of water will decrease. On the other hand, if the increase in the Processing and Handling costs exceed the associated reduction in Business Disruption costs, the true value of water will increase, further incentivizing additional water-efficiency infrastructure. As such, we advise Unilever to closely monitor the relationship and interplay between the Processing and Handling cost and the Business Disruption cost while using the model.

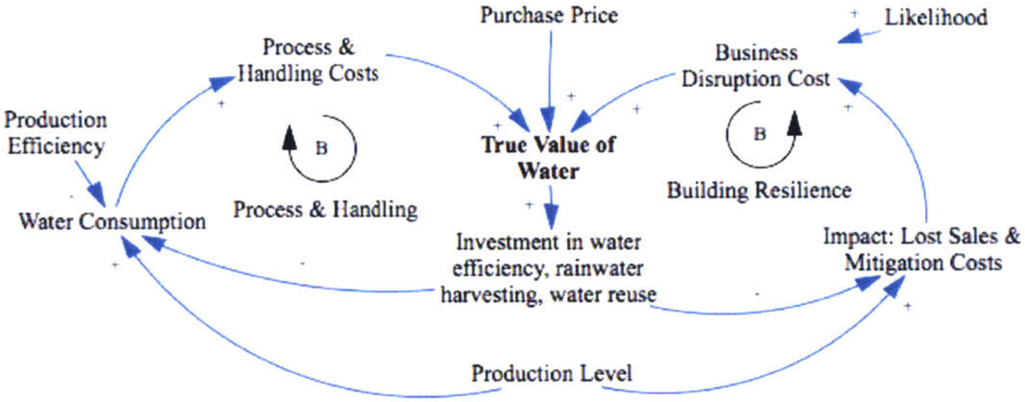


Figure 18. How True Value of Water drives Investments

Finally, future research should explore the use of Monte-Carlo simulations of water loss events in estimating Business Disruption costs. Simulations would produce a statistical range of values rather than a single-point estimate and thereby produce more accurate results. Additionally, iterative simulations in performing a lifecycle assessment of water-loss scenarios would enable a more accurate accounting of mitigation options than the current model design.

6. CONCLUSION

The main objective of this thesis was to create a water valuation framework for Unilever that could be universally deployable at any of its manufacturing sites worldwide. From literature review and expert interviews, we learned that water valuation entailed two parts. First, major risks that threatened the water supply or water quality at a location had to be identified and evaluated. Next, these location-specific water risks had to be translated into a monetary value of water and would yield a value across Unilever's manufacturing sites.

In building our framework, we relied heavily on a core supply chain management principle, namely, the Inventory Management Equation, which led to the incorporation of three components: the Purchase price, the Processing and Handling cost and the Business Disruption cost. A principal component in our framework is the Business Disruption cost, which monetizes a site's water risk based on the site's operational footprint and its vulnerability to adverse water-related events.

We leveraged publicly available data and tools wherever possible. To that end, our sponsor recommended integrating the approach described within the BIER tool in our framework as a means to quantify processing and handling costs, rather than creating a parallel accounting system. We also included Aqueduct risk indicators to contextualize the location of the site evaluated in terms of water stress. We tested the functionality of our model with four different cases and the results of such cases confirmed that our framework is highly sensitive to the data inputs used.

We had to narrow our scope in working towards a simple, user-friendly and pragmatic framework. Given the myriad risk factors that affect water valuation, we acknowledged a number of factors that were excluded from this project (Section 4.5). Along with these factors, we propose several key recommendations (Section 5) for expanding model functionality and for improving model accuracy.

Our main contribution is a methodology to calculate the Business Disruption cost. With no data available pertaining to the frequency and impacts of water disruption events, our framework relies on operational experience to perform water-related scenario analysis and risk valuation in computing a site's Business Disruption cost.

Although the results presented in this thesis are still preliminary, we are confident that our framework represents a valuable first step in setting a precedent towards developing a robust water valuation tool. This framework will enable Unilever and other similar companies prone to water-related business disruption to generate water valuations that are commensurate to their risk exposure, with the aim of improving operational resiliency.

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8. APPENDIX

Appendix 1 - Site Visit Questionnaire

Scenario Analysis

1. If the mains failed due to burst pipe – what would you do? What controls do you have in place?
2. There's a drought in the region, the government are placing restrictions on water abstraction, how would this impact you and what would you do?
3. The drought has also restricted the dilution capacity of the river and therefore significantly increased costs, how would you react?
4. You need to increase the number and length of CIPs due to quality requirements, this results in increased burden on your effluent treatment plant (ETP), beyond design capacity, what could you do to ensure that you are still in compliance?
5. How sensitive is the business to fluctuations in the price of water related to this use? i.e. what would the business impact be if the price of water doubled, or increased ten-fold?
6. Are other water sources available? How long would it take and what are the costs to get other sources on line? What changes would be needed to production processes or services to accommodate the new source?

Water use

1. Are there seasonal or other fluctuations in water use and if so, please define the seasonality and describe the associated demand fluctuations?
2. How is the calculation of source freshwater performed?
3. In order to assess the importance of sufficient amounts of clean freshwater available for the production, please characterize the allocation of water within each process and the respective criticality of each utility (ex. safety critical, Immediately / delayed production critical, production non-critical)?

Definitions are as follows:

- **Safety or Immediately Production Critical:** Water use is imperative to safe and/or efficient operation and production will shutdown in case of disruption to water supply. Ex. Firewater, Process-cooling water etc.
- **Delayed Production Critical:** An interruption in water supply will result in localized process downtime, but will not disrupt system-wide plant operations.
- **Production Non-Critical:** Water use is neither production nor safety critical and loss of water will not impact plant production. Ex. Utility water, potable water etc.

Water Disposal

1. Is there any treatment to disposal specifications prior to disposal?
2. What is the total amount of wastewater discharged / recycled? (m^3/ year)

a) What are the water disposal sinks? Sinks include:

Ocean

Surface (e.g. River/ Lake)

Subsurface/ Well

Off-Site Water Treatment

Risk Assessments / Mitigations / Metrics

1. Have there been risk assessments, quantitative or qualitative, performed for the facility in the context of water? If so, can you share those with us?
2. Plant flexibility to vary its water source and volumetric supply to cope with peak seasonal demands, or supply disruptions. Contingency planning to respond to water risks, such as price increases and more stringent regulations?
3. What are water-related actions taken at the production site in regard to improving its own operations, including significant short-term or long-term investments planned that are related to water issues (e.g. water treatment plant, water recovery, water efficiency)?

4. What water-related metrics / KPIs (Key Performance Indicators), standards and procedures do you employ at the site?

Status of Source

1. What is the ability of the source to meet current average and peak water demands associated with agricultural, industrial, residential, and ecosystem needs?
2. What has been the reliability of available water quantity and / or water quality over the past 10 years?
3. What is the susceptibility of the source to significant fluctuations in availability of water due to weather events, such as drought, weather patterns and trends, or other catastrophic events over the past 5, 10, and 50 years?
4. What is the condition of infrastructure, such as storage, treatment plants, and transmission pipelines?
5. What is the financial status of the municipal water supplier?
6. What are the points of vulnerability to accidental or intentional contamination?
7. What is the likely ability of the source to meet projected future water demands associated with agricultural, industrial, residential, and ecosystem needs?
8. To what degree does the business affect this source through its water use or impacts?

Challenges

1. What current / anticipated problems has / had the company withdrawing / obtaining the required amount of water for its operations?
2. What, if any, challenges do the company face in transporting or storing water used in its operations?
3. What physical challenges, regulatory challenges, "social license" issues or ecological constraints of water disposal do you have in your operations? i.e. concerns may include eco toxic, eutrophication, acidification, water specification, regulatory limits etc.?
4. What is the potential for disruption due to jurisdictional, political, social, or cultural disputes?
5. What are the current / anticipated challenges to meet legal wastewater quality standards? Has the company paid any penalties or fines for significant breaches of discharge regulations within the last 5 years? Is there a strong enforcement of water related regulations in the area of operation?
6. Disposal - What, if any, challenges exist in meeting discharge quality requirements? Please explain which elements do not comply, if applicable (e.g. Nutrients / COD/ Biological oxygen demand (BOD)/ TSS / Chemicals / Temperature/ Metals / etc.)?
7. Stakeholders - Who are the other key stakeholders (e.g. communities, other industries, agriculture etc.) dependent on the water supply and quality within the water basin the plant operates in and how is their relationship with Unilever in the context of water?
8. Engagement - How deep is the operation engagement with other local basin stakeholders like municipalities, governments, companies, farmers and NGOs to solve water-related conflicts and to manage local water resources?
9. Has there been any involvement in any water-related disputes with other stakeholders in the basin within the last 5 years? If so, please describe the dispute in more detail including the origin and current status of the dispute.

Appendix 2 – Template for Data Collection

SECTION 1 - GENERAL INFORMATION

Personal Information

Name(s)

Department(s)

Site Information

Facility Name

Total Production (ton)

Total Revenue (€/year)

SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)

Water Use

Amount of Water needed for the plant to operate (m3/year)

SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)

Total Annual Cost for Water Treatment (€/year)

Total Annual Cost Wastewater Treatment (€/year)

Other Annual Cost(s) related to water (€/year)

SECTION 4 - BUSINESS DISRUPTION COST

Mitigation Options

Do you have a water tank/storage (Y/N)

Do you have on-site Storage? (m3)

Average Days of Inventory (days)

Virtual Water of Inventory (m3)

Do you have an Alternative Source? (Y/N)

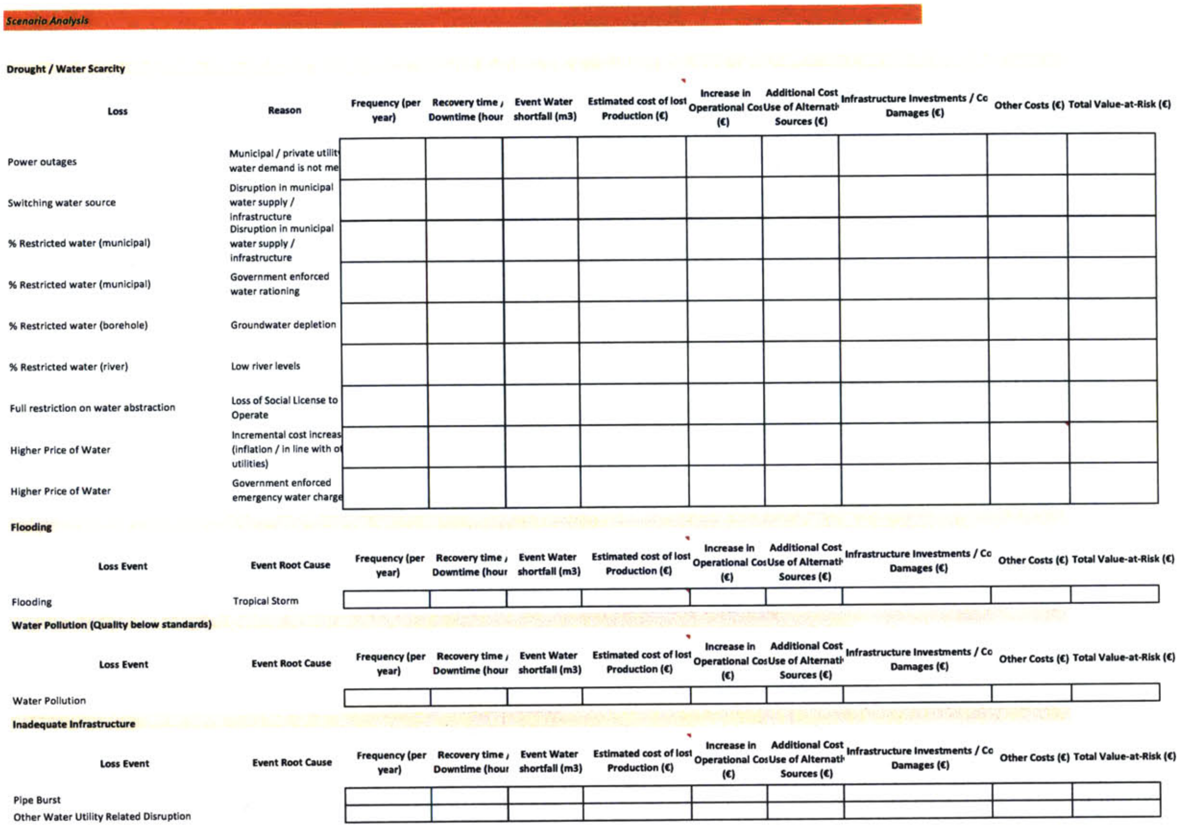
Water Sources Details

Source	**Amount of water withdraw (m3/year)**	**Is this a Possible Source? (Y/N)**	**Priority of Source (1 is highest)**	**Breakdown Of Main Sources (%)**	**Withdrawal Limit (m3)**	**Variable cost (€/m3)**
Municipal/Piped Water						
Groundwater						
Surface water						
Brackish/Saline						
Tanker to site						
Other Source						

Which is your Alternative Source?

Withdrawal Limit (m3)

Variable Cost Alternative Source



Scenario Analysis

Drought / Water Scarcity

Loss	Reason	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Power outages	Municipal / private utilit water demand is not me									
Switching water source	Disruption in municipal water supply / infrastructure									
% Restricted water (municipal)	Disruption in municipal water supply / infrastructure									
% Restricted water (municipal)	Government enforced water rationing									
% Restricted water (borehole)	Groundwater depletion									
% Restricted water (river)	Low river levels									
Full restriction on water abstraction	Loss of Social License to Operate									
Higher Price of Water	Incremental cost increas (inflation / in line with o utilities)									
Higher Price of Water	Government enforced emergency water charge									

Flooding

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Flooding	Tropical Storm									

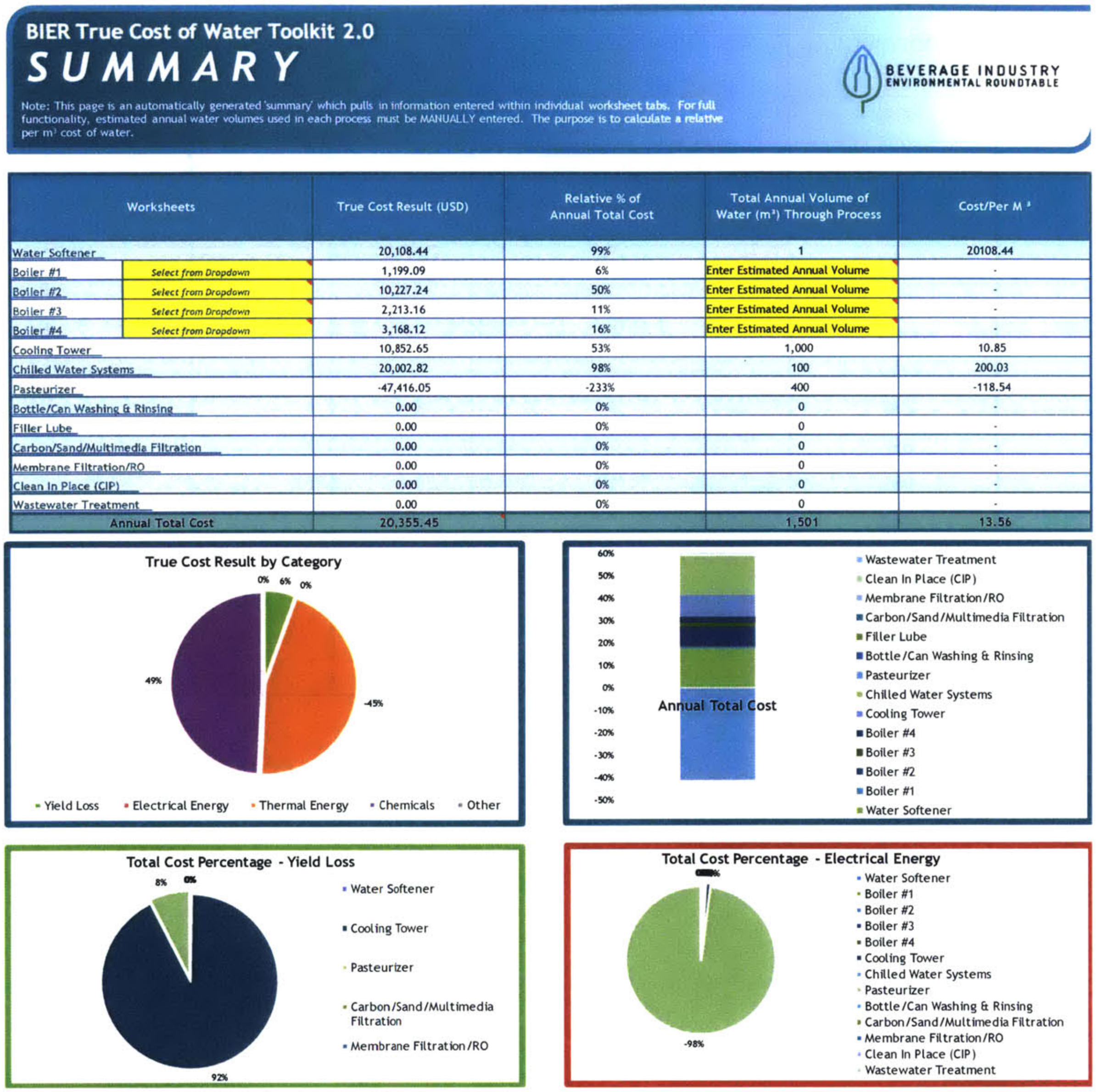
Water Pollution (Quality below standards)

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Water Pollution										

Inadequate Infrastructure

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Pipe Burst										
Other Water Utility Related Disruption										

Appendix 3 – BIER True Cost of Water Toolkit 2.0 Summary



BIER True Cost of Water Toolkit 2.0

SUMMARY

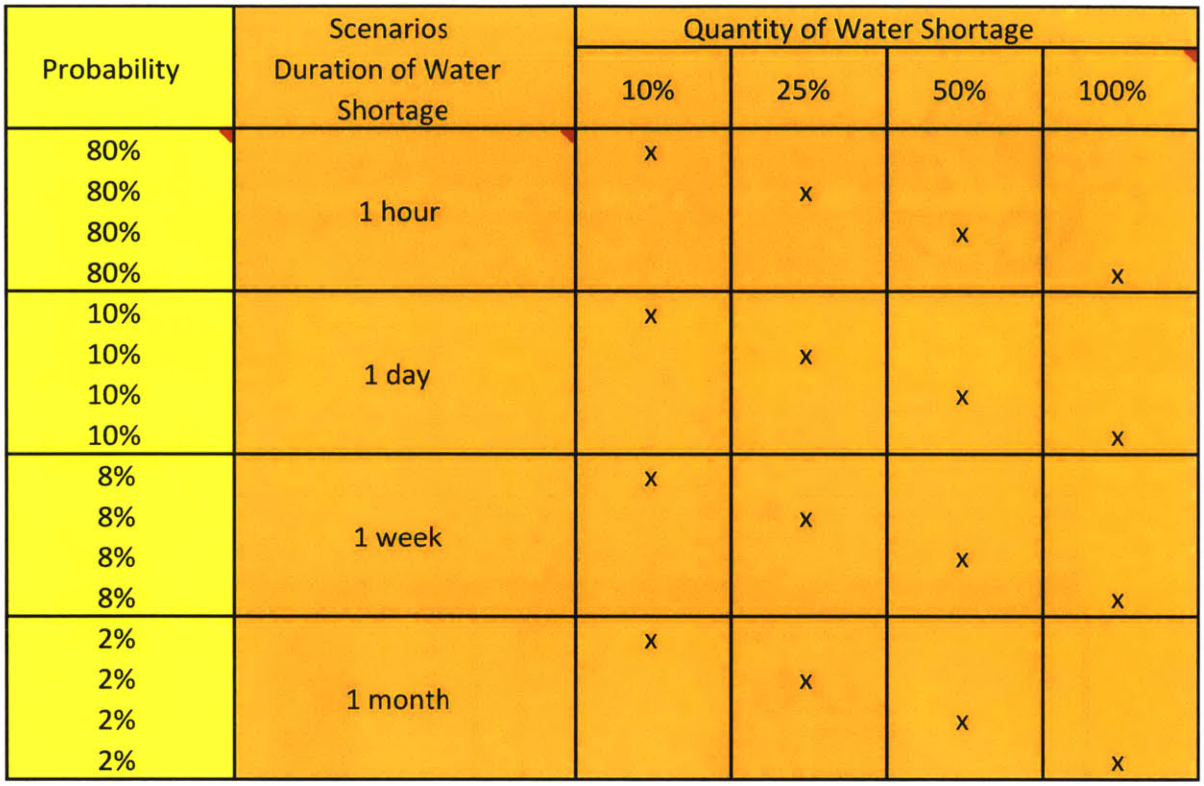
BEVERAGE INDUSTRY
ENVIRONMENTAL ROUNDTABLE

Note: This page is an automatically generated 'summary' which pulls in information entered within individual worksheet tabs. For full functionality, estimated annual water volumes used in each process must be MANUALLY entered. The purpose is to calculate a relative per m³ cost of water.

Worksheets		True Cost Result (USD)	Relative % of Annual Total Cost	Total Annual Volume of Water (m³) Through Process	Cost/Per M ³
Water Softener		20,108.44	99%	1	20108.44
Boiler #1	Select from Dropdown	1,199.09	6%	Enter Estimated Annual Volume	-
Boiler #2	Select from Dropdown	10,227.24	50%	Enter Estimated Annual Volume	-
Boiler #3	Select from Dropdown	2,213.16	11%	Enter Estimated Annual Volume	-
Boiler #4	Select from Dropdown	3,168.12	16%	Enter Estimated Annual Volume	-
Cooling Tower		10,852.65	53%	1,000	10.85
Chilled Water Systems		20,002.82	98%	100	200.03
Pasteurizer		-47,416.05	-233%	400	-118.54
Bottle/Can Washing & Rinsing		0.00	0%	0	-
Filler Lube		0.00	0%	0	-
Carbon/Sand/Multimedia Filtration		0.00	0%	0	-
Membrane Filtration/RO		0.00	0%	0	-
Clean In Place (CIP)		0.00	0%	0	-
Wastewater Treatment		0.00	0%	0	-
Annual Total Cost		20,355.45		1,501	13.56

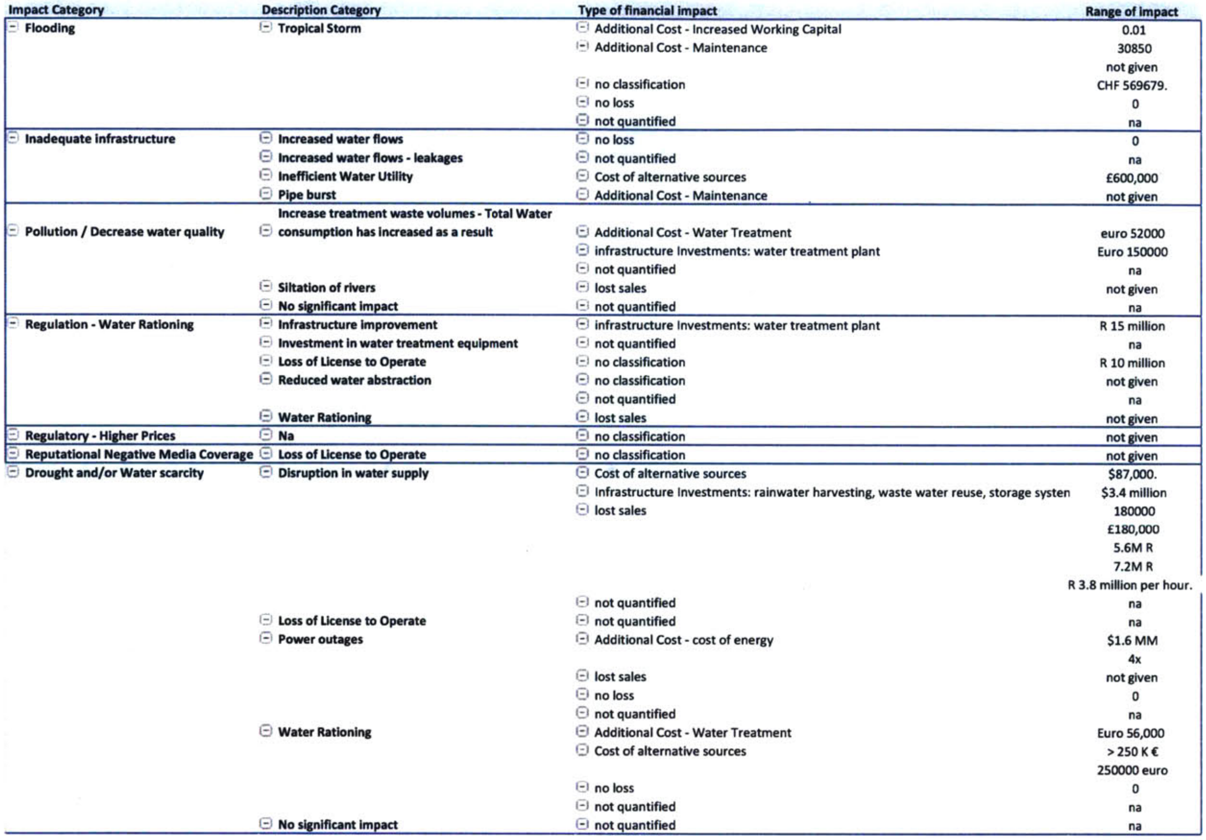
Note: Retrieved from *BIER True Cost of Water Toolkit 2.0 Summary*, by Beverage Industry Environmental Roundtable, 2015.

Appendix 4 – First Iteration of Scenarios



Probability	Scenarios Duration of Water Shortage	Quantity of Water Shortage			
		10%	25%	50%	100%
80%	1 hour	x			
80%			x		
80%				x	
80%					x
10%	1 day	x			
10%			x		
10%				x	
10%					x
8%	1 week	x			
8%			x		
8%				x	
8%					x
2%	1 month	x			
2%			x		
2%				x	
2%					x

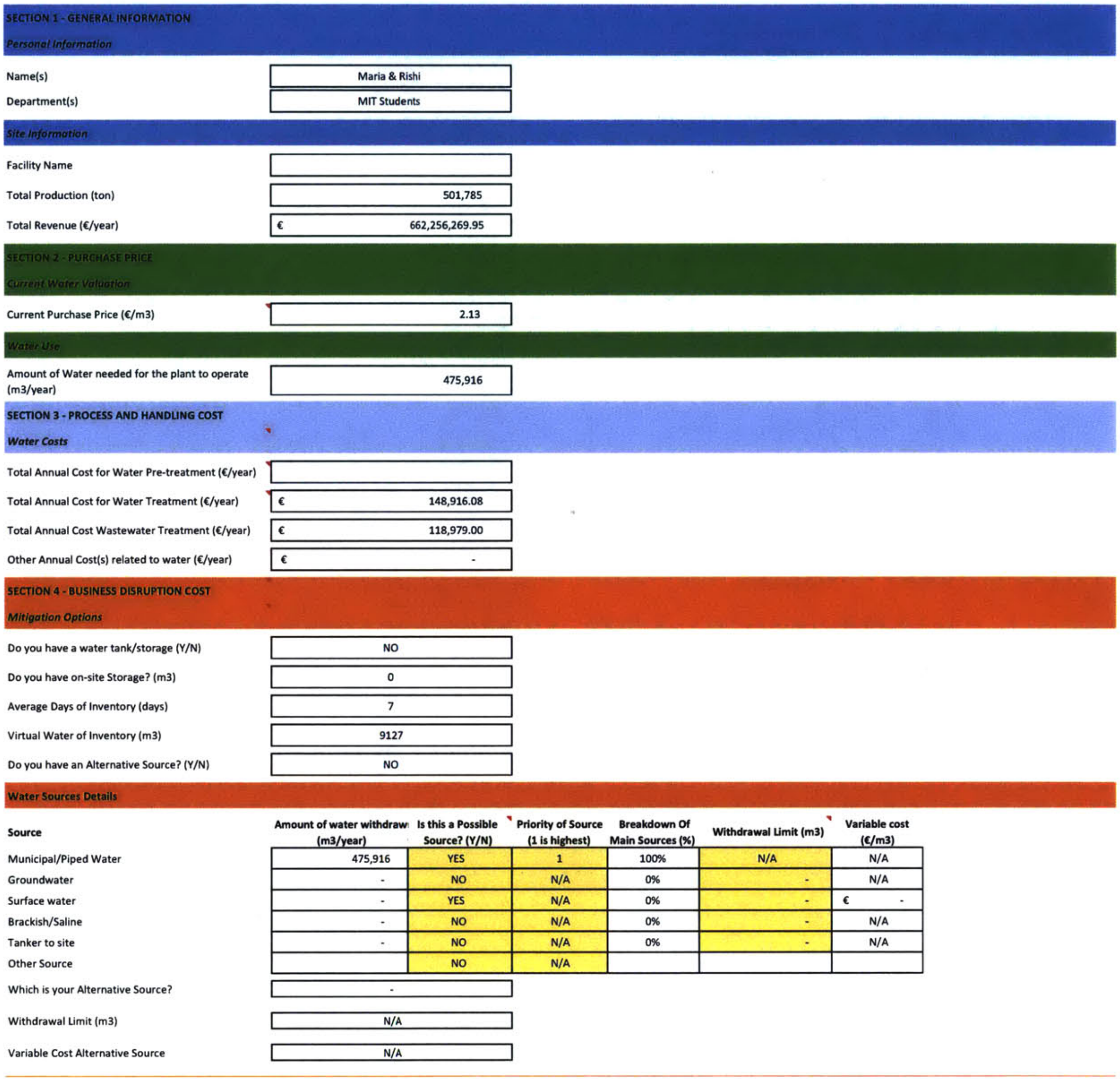
Appendix 5 – Pivot Table with Impact Categories



Impact Category	Description Category	Type of financial impact	Range of impact
⊟ Flooding	⊟ Tropical Storm	⊟ Additional Cost - Increased Working Capital	0.01
		⊟ Additional Cost - Maintenance	30850
			not given
		⊟ no classification	CHF 569679.
		⊟ no loss	0
		⊟ not quantified	na
⊟ Inadequate infrastructure	⊟ Increased water flows	⊟ no loss	0
	⊟ Increased water flows - leakages	⊟ not quantified	na
	⊟ Inefficient Water Utility	⊟ Cost of alternative sources	£600,000
	⊟ Pipe burst	⊟ Additional Cost - Maintenance	not given
⊟ Pollution / Decrease water quality	⊟ Increase treatment waste volumes - Total Water consumption has increased as a result	⊟ Additional Cost - Water Treatment	euro 52000
		⊟ infrastructure Investments: water treatment plant	Euro 150000
		⊟ not quantified	na
	⊟ Siltation of rivers	⊟ lost sales	not given
	⊟ No significant impact	⊟ not quantified	na
⊟ Regulation - Water Rationing	⊟ Infrastructure improvement	⊟ infrastructure Investments: water treatment plant	R 15 million
	⊟ Investment in water treatment equipment	⊟ not quantified	na
	⊟ Loss of License to Operate	⊟ no classification	R 10 million
	⊟ Reduced water abstraction	⊟ no classification	not given
		⊟ not quantified	na
	⊟ Water Rationing	⊟ lost sales	not given
⊟ Regulatory - Higher Prices	⊟ Na	⊟ no classification	not given
⊟ Reputational Negative Media Coverage	⊟ Loss of License to Operate	⊟ no classification	not given
⊟ Drought and/or Water scarcity	⊟ Disruption in water supply	⊟ Cost of alternative sources	$87,000.
		⊟ Infrastructure Investments: rainwater harvesting, waste water reuse, storage systen	$3.4 million
		⊟ lost sales	180000
			£180,000
			5.6M R
			7.2M R
			R 3.8 million per hour.
		⊟ not quantified	na
	⊟ Loss of License to Operate	⊟ not quantified	na
	⊟ Power outages	⊟ Additional Cost - cost of energy	$1.6 MM
			4x
		⊟ lost sales	not given
		⊟ no loss	0
		⊟ not quantified	na
	⊟ Water Rationing	⊟ Additional Cost - Water Treatment	Euro 56,000
		⊟ Cost of alternative sources	> 250 K €
			250000 euro
		⊟ no loss	0
		⊟ not quantified	na
	⊟ No significant impact	⊟ not quantified	na

Note: Adapted from *CDP Water Disclosure Summary*, by Unilever, 2015.

Appendix 6 – Case 1



SECTION 1 - GENERAL INFORMATION

Personal Information

Name(s)	Maria & Rishi
Department(s)	MIT Students

Site Information

Facility Name	
Total Production (ton)	501,785
Total Revenue (€/year)	€ 662,256,269.95

SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)	2.13

Water Use

Amount of Water needed for the plant to operate (m3/year)	475,916

SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)	
Total Annual Cost for Water Treatment (€/year)	€ 148,916.08
Total Annual Cost Wastewater Treatment (€/year)	€ 118,979.00
Other Annual Cost(s) related to water (€/year)	€ -

SECTION 4 - BUSINESS DISRUPTION COST

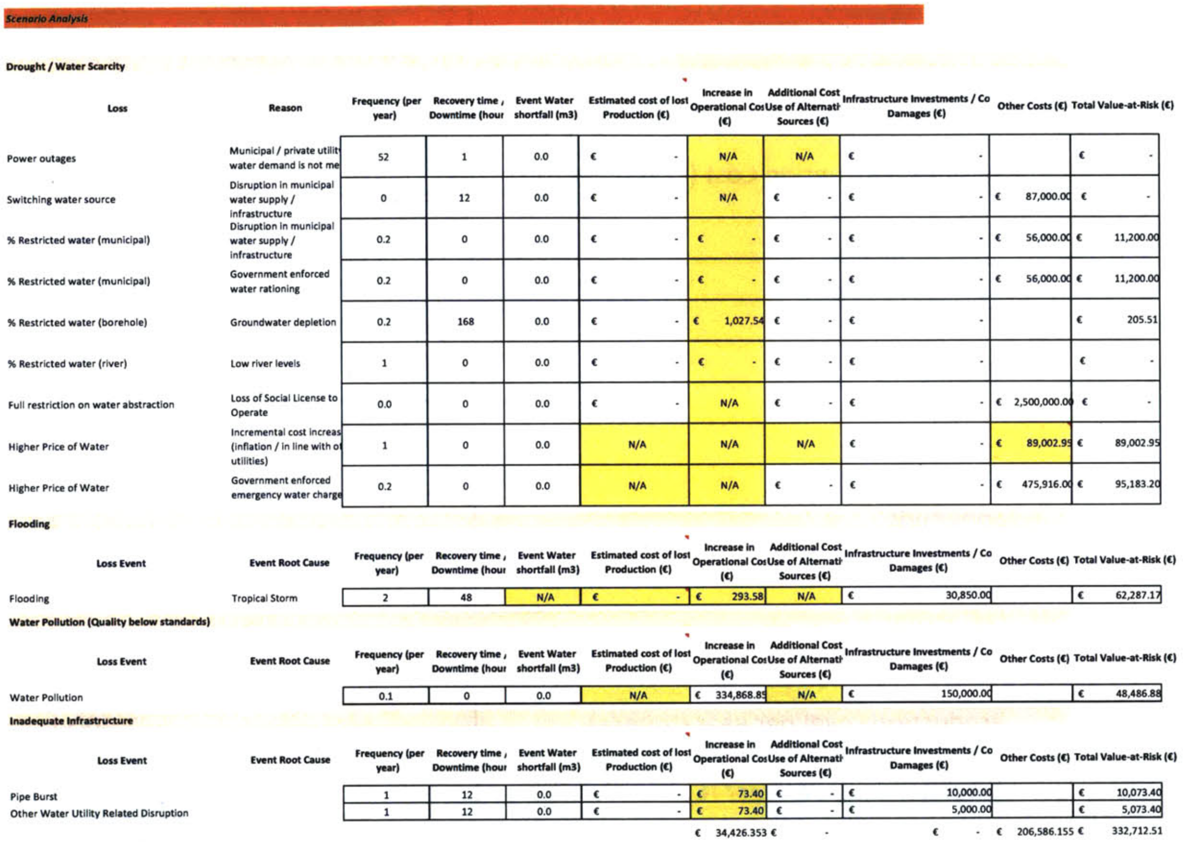
Mitigation Options

Do you have a water tank/storage (Y/N)	NO
Do you have on-site Storage? (m3)	0
Average Days of Inventory (days)	7
Virtual Water of Inventory (m3)	9127
Do you have an Alternative Source? (Y/N)	NO

Water Sources Details

Source	**Amount of water withdraw (m3/year)**	**Is this a Possible Source? (Y/N)**	**Priority of Source (1 is highest)**	**Breakdown Of Main Sources (%)**	**Withdrawal Limit (m3)**	**Variable cost (€/m3)**
Municipal/Piped Water	475,916	YES	1	100%	N/A	N/A
Groundwater	-	NO	N/A	0%	-	N/A
Surface water	-	YES	N/A	0%	-	€ -
Brackish/Saline	-	NO	N/A	0%	-	N/A
Tanker to site	-	NO	N/A	0%	-	N/A
Other Source		NO	N/A			

Which is your Alternative Source?	-
Withdrawal Limit (m3)	N/A
Variable Cost Alternative Source	N/A



Scenario Analysis

Drought / Water Scarcity

Loss	Reason	Frequency (per year)	Recovery time , Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Power outages	Municipal / private utilit water demand is not me	52	1	0.0	€ -	N/A	N/A	€ -		€ -
Switching water source	Disruption in municipal water supply / infrastructure	0	12	0.0	€ -	N/A	€ -	€ -	€ 87,000.00	€ -
% Restricted water (municipal)	Disruption in municipal water supply / infrastructure	0.2	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ 11,200.00
% Restricted water (municipal)	Government enforced water rationing	0.2	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ 11,200.00
% Restricted water (borehole)	Groundwater depletion	0.2	168	0.0	€ -	€ 1,027.54	€ -	€ -		€ 205.51
% Restricted water (river)	Low river levels	1	0	0.0	€ -	€ -	€ -	€ -		€ -
Full restriction on water abstraction	Loss of Social License to Operate	0.0	0	0.0	€ -	N/A	€ -	€ -	€ 2,500,000.00	€ -
Higher Price of Water	Incremental cost increas (inflation / in line with o utilities)	1	0	0.0	N/A	N/A	N/A	€ -	€ 89,002.95	€ 89,002.95
Higher Price of Water	Government enforced emergency water charge	0.2	0	0.0	N/A	N/A	€ -	€ -	€ 475,916.00	€ 95,183.20

Flooding

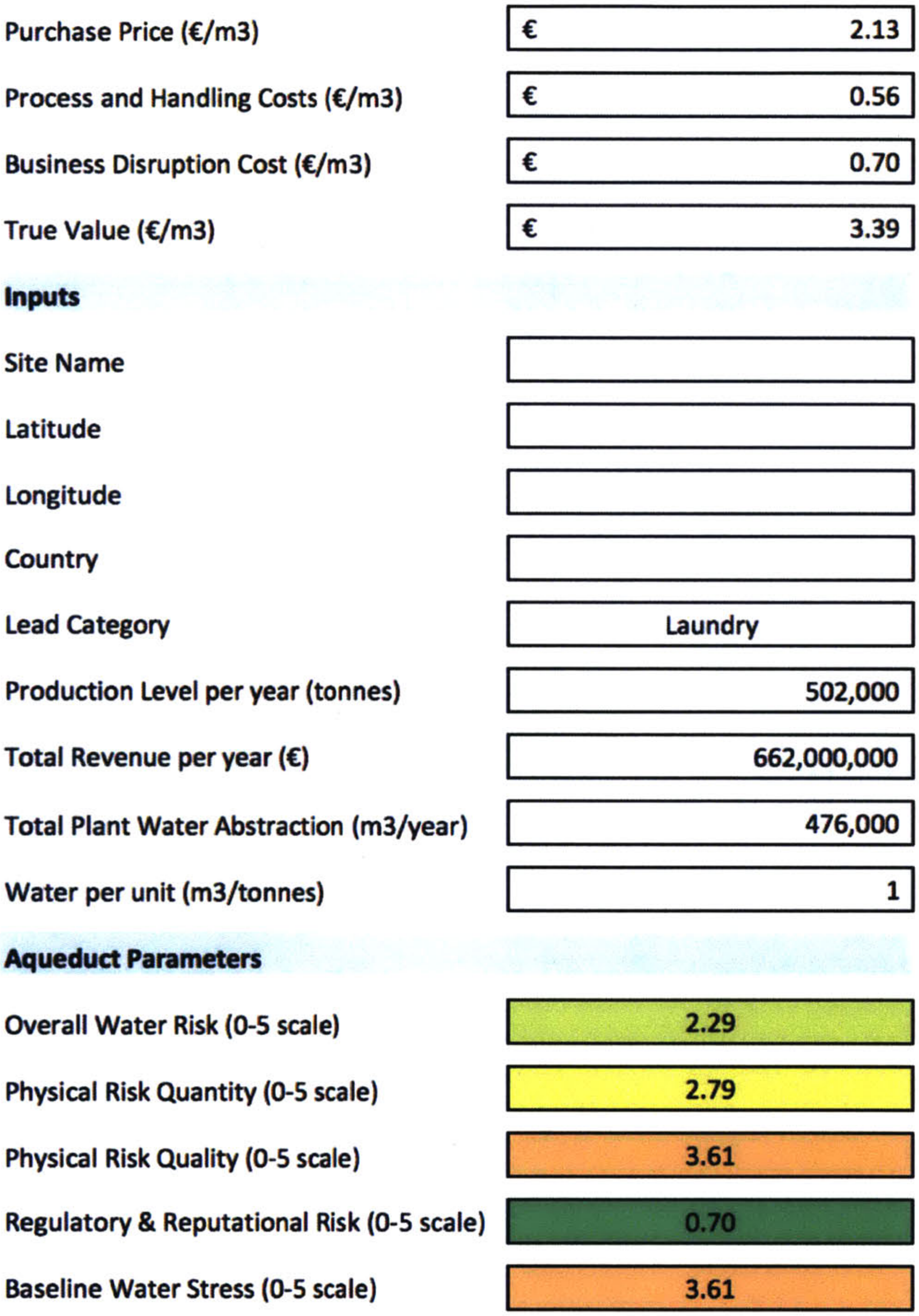
Loss Event	Event Root Cause	Frequency (per year)	Recovery time , Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Flooding	Tropical Storm	2	48	N/A	€ -	€ 293.58	N/A	€ 30,850.00		€ 62,287.17

Water Pollution (Quality below standards)

Loss Event	Event Root Cause	Frequency (per year)	Recovery time , Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Water Pollution		0.1	0	0.0	N/A	€ 334,868.85	N/A	€ 150,000.00		€ 48,486.88

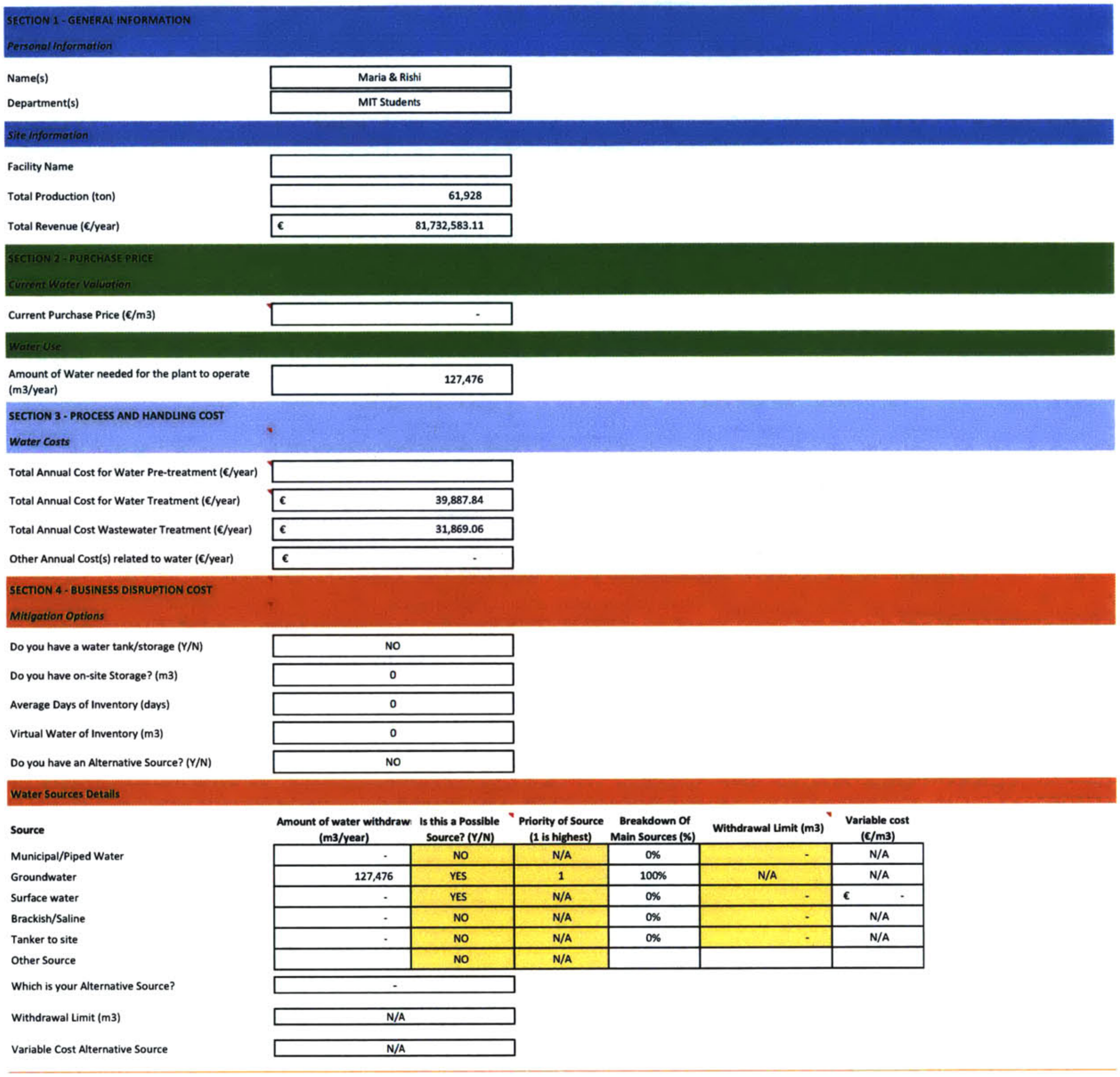
Inadequate Infrastructure

Loss Event	Event Root Cause	Frequency (per year)	Recovery time , Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Pipe Burst		1	12	0.0	€ -	€ 73.40	€ -	€ 10,000.00		€ 10,073.40
Other Water Utility Related Disruption		1	12	0.0	€ -	€ 73.40	€ -	€ 5,000.00		€ 5,073.40
						€ 34,426.353	€ -	€ -	€ 206,586.155	€ 332,712.51



Purchase Price (€/m3)	€ 2.13
Process and Handling Costs (€/m3)	€ 0.56
Business Disruption Cost (€/m3)	€ 0.70
True Value (€/m3)	€ 3.39
Inputs	
Site Name	
Latitude	
Longitude	
Country	
Lead Category	Laundry
Production Level per year (tonnes)	502,000
Total Revenue per year (€)	662,000,000
Total Plant Water Abstraction (m3/year)	476,000
Water per unit (m3/tonnes)	1
Aqueduct Parameters	
Overall Water Risk (0-5 scale)	2.29
Physical Risk Quantity (0-5 scale)	2.79
Physical Risk Quality (0-5 scale)	3.61
Regulatory & Reputational Risk (0-5 scale)	0.70
Baseline Water Stress (0-5 scale)	3.61

Appendix 7 – Case 2



SECTION 1 - GENERAL INFORMATION

Personal Information

Name(s)	Maria & Rishi
Department(s)	MIT Students

Site Information

Facility Name	
Total Production (ton)	61,928
Total Revenue (€/year)	€ 81,732,583.11

SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)	-

Water Use

Amount of Water needed for the plant to operate (m3/year)	127,476

SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)	
Total Annual Cost for Water Treatment (€/year)	€ 39,887.84
Total Annual Cost Wastewater Treatment (€/year)	€ 31,869.06
Other Annual Cost(s) related to water (€/year)	€ -

SECTION 4 - BUSINESS DISRUPTION COST

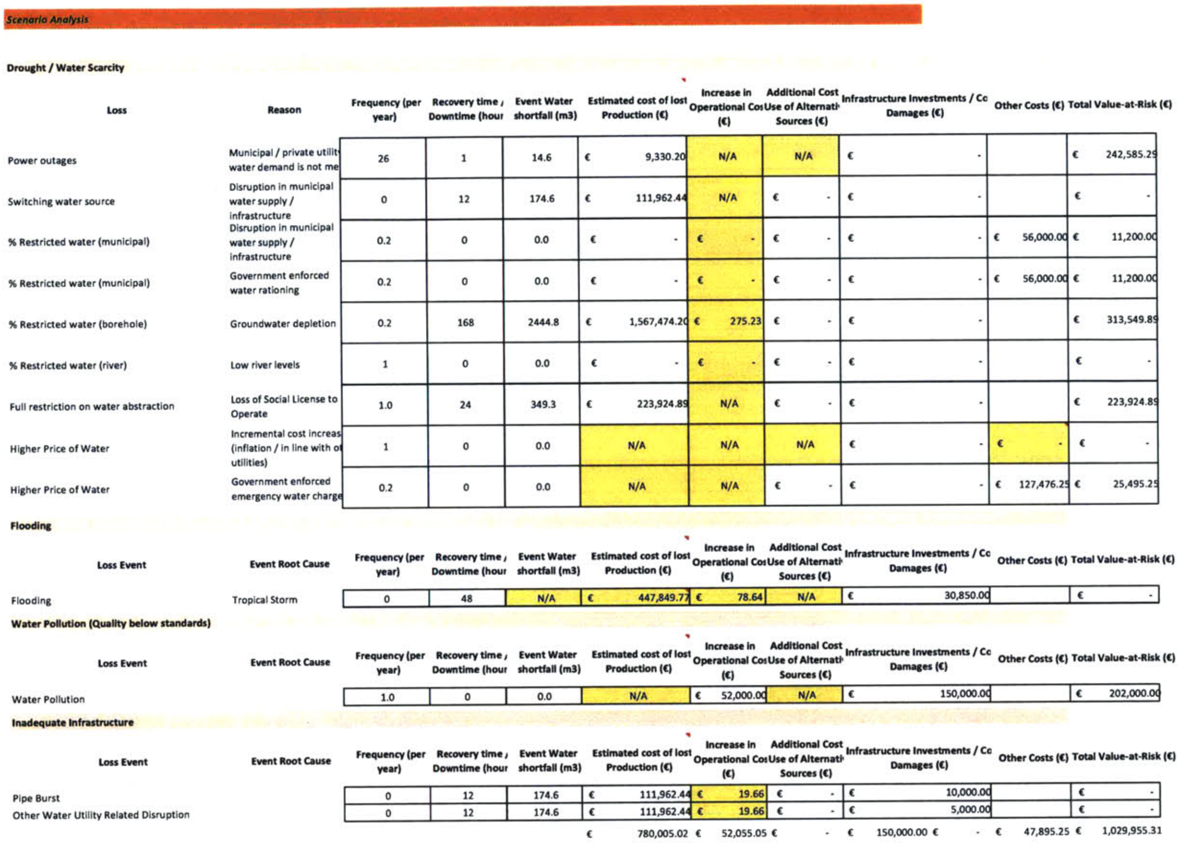
Mitigation Options

Do you have a water tank/storage (Y/N)	NO
Do you have on-site Storage? (m3)	0
Average Days of Inventory (days)	0
Virtual Water of Inventory (m3)	0
Do you have an Alternative Source? (Y/N)	NO

Water Sources Details

Source	Amount of water withdraw (m3/year)	Is this a Possible Source? (Y/N)	Priority of Source (1 is highest)	Breakdown Of Main Sources (%)	Withdrawal Limit (m3)	Variable cost (€/m3)
Municipal/Piped Water	-	NO	N/A	0%	-	N/A
Groundwater	127,476	YES	1	100%	N/A	N/A
Surface water	-	YES	N/A	0%	-	€ -
Brackish/Saline	-	NO	N/A	0%	-	N/A
Tanker to site	-	NO	N/A	0%	-	N/A
Other Source		NO	N/A			

Which is your Alternative Source?	-
Withdrawal Limit (m3)	N/A
Variable Cost Alternative Source	N/A



Scenario Analysis

Drought / Water Scarcity

Loss	Reason	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Power outages	Municipal / private utilit water demand is not me	26	1	14.6	€ 9,330.20	N/A	N/A	€ -		€ 242,585.29
Switching water source	Disruption in municipal water supply / infrastructure	0	12	174.6	€ 111,962.44	N/A	€ -	€ -		€ -
% Restricted water (municipal)	Disruption in municipal water supply / infrastructure	0.2	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ 11,200.00
% Restricted water (municipal)	Government enforced water rationing	0.2	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ 11,200.00
% Restricted water (borehole)	Groundwater depletion	0.2	168	2444.8	€ 1,567,474.20	€ 275.23	€ -	€ -		€ 313,549.89
% Restricted water (river)	Low river levels	1	0	0.0	€ -	€ -	€ -	€ -		€ -
Full restriction on water abstraction	Loss of Social License to Operate	1.0	24	349.3	€ 223,924.89	N/A	€ -	€ -		€ 223,924.89
Higher Price of Water	Incremental cost increas (inflation / in line with ot utilities)	1	0	0.0	N/A	N/A	N/A	€ -	€ -	€ -
Higher Price of Water	Government enforced emergency water charge	0.2	0	0.0	N/A	N/A	€ -	€ -	€ 127,476.25	€ 25,495.25

Flooding

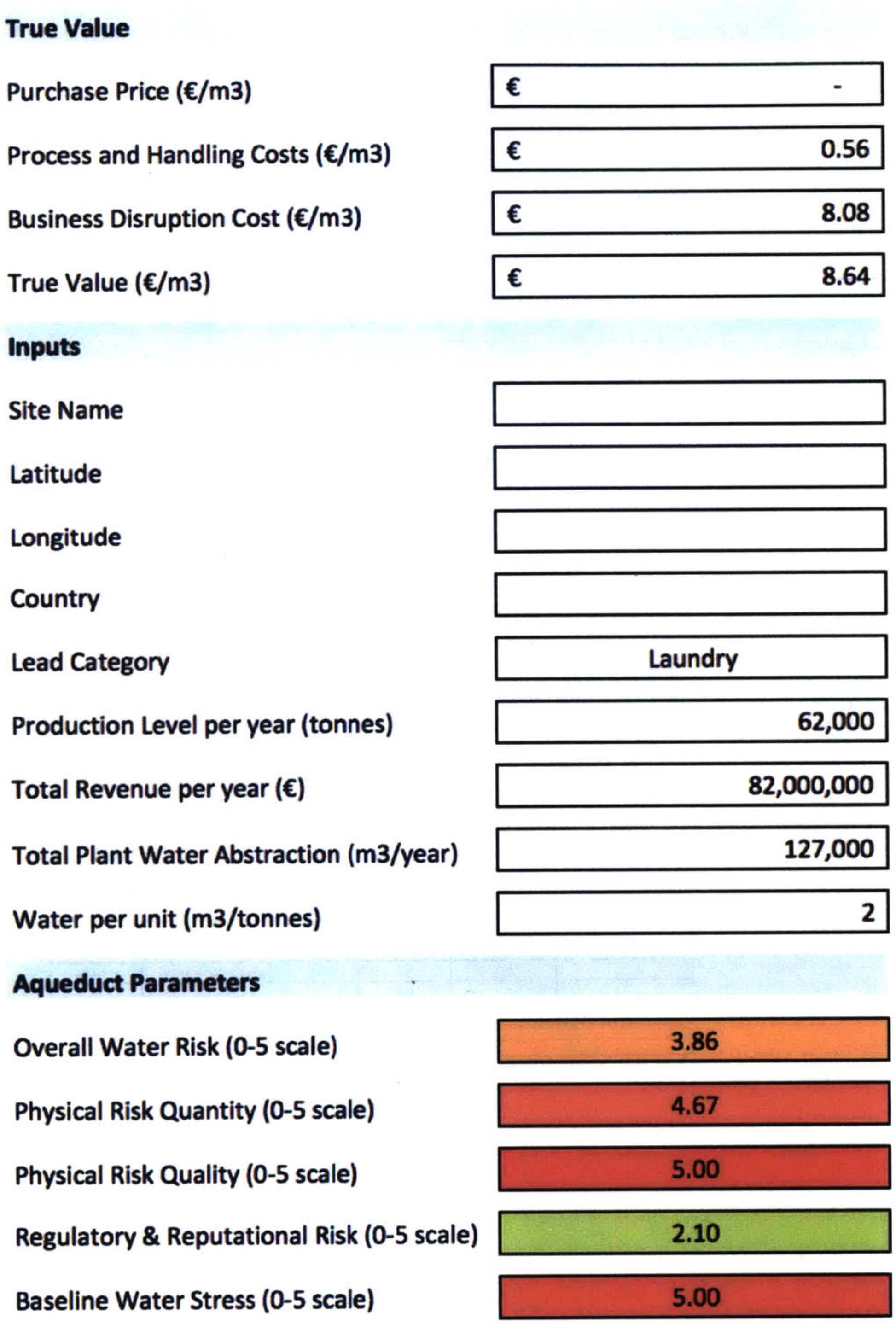
Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Flooding	Tropical Storm	0	48	N/A	€ 447,849.77	€ 78.64	N/A	€ 30,850.00		€ -

Water Pollution (Quality below standards)

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Water Pollution		1.0	0	0.0	N/A	€ 52,000.00	N/A	€ 150,000.00		€ 202,000.00

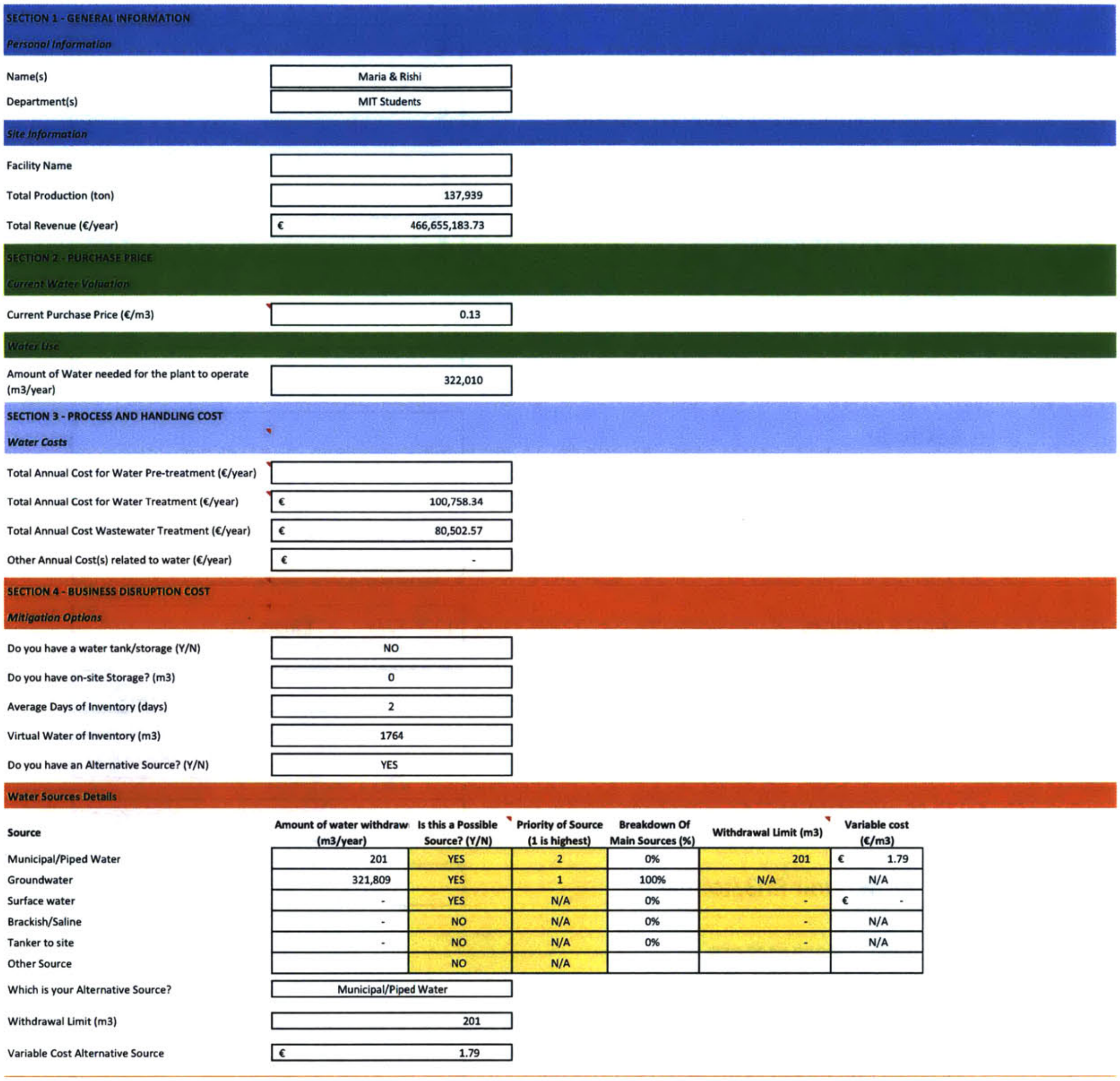
Inadequate Infrastructure

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Pipe Burst		0	12	174.6	€ 111,962.44	€ 19.66	€ -	€ 10,000.00		€ -
Other Water Utility Related Disruption		0	12	174.6	€ 111,962.44	€ 19.66	€ -	€ 5,000.00		€ -
					€ 780,005.02	€ 52,055.05	€ -	€ 150,000.00	€ -	€ 47,895.25	€ 1,029,955.31



True Value	
Purchase Price (€/m3)	€ -
Process and Handling Costs (€/m3)	€ 0.56
Business Disruption Cost (€/m3)	€ 8.08
True Value (€/m3)	€ 8.64
Inputs	
Site Name	
Latitude	
Longitude	
Country	
Lead Category	Laundry
Production Level per year (tonnes)	62,000
Total Revenue per year (€)	82,000,000
Total Plant Water Abstraction (m3/year)	127,000
Water per unit (m3/tonnes)	2
Aqueduct Parameters	
Overall Water Risk (0-5 scale)	3.86
Physical Risk Quantity (0-5 scale)	4.67
Physical Risk Quality (0-5 scale)	5.00
Regulatory & Reputational Risk (0-5 scale)	2.10
Baseline Water Stress (0-5 scale)	5.00

Appendix 8 – Case 3



SECTION 1 - GENERAL INFORMATION

Personal Information

Name(s)	Maria & Rishi
Department(s)	MIT Students

Site Information

Facility Name	
Total Production (ton)	137,939
Total Revenue (€/year)	€ 466,655,183.73

SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)	0.13

Water Use

Amount of Water needed for the plant to operate (m3/year)	322,010

SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)	
Total Annual Cost for Water Treatment (€/year)	€ 100,758.34
Total Annual Cost Wastewater Treatment (€/year)	€ 80,502.57
Other Annual Cost(s) related to water (€/year)	€ -

SECTION 4 - BUSINESS DISRUPTION COST

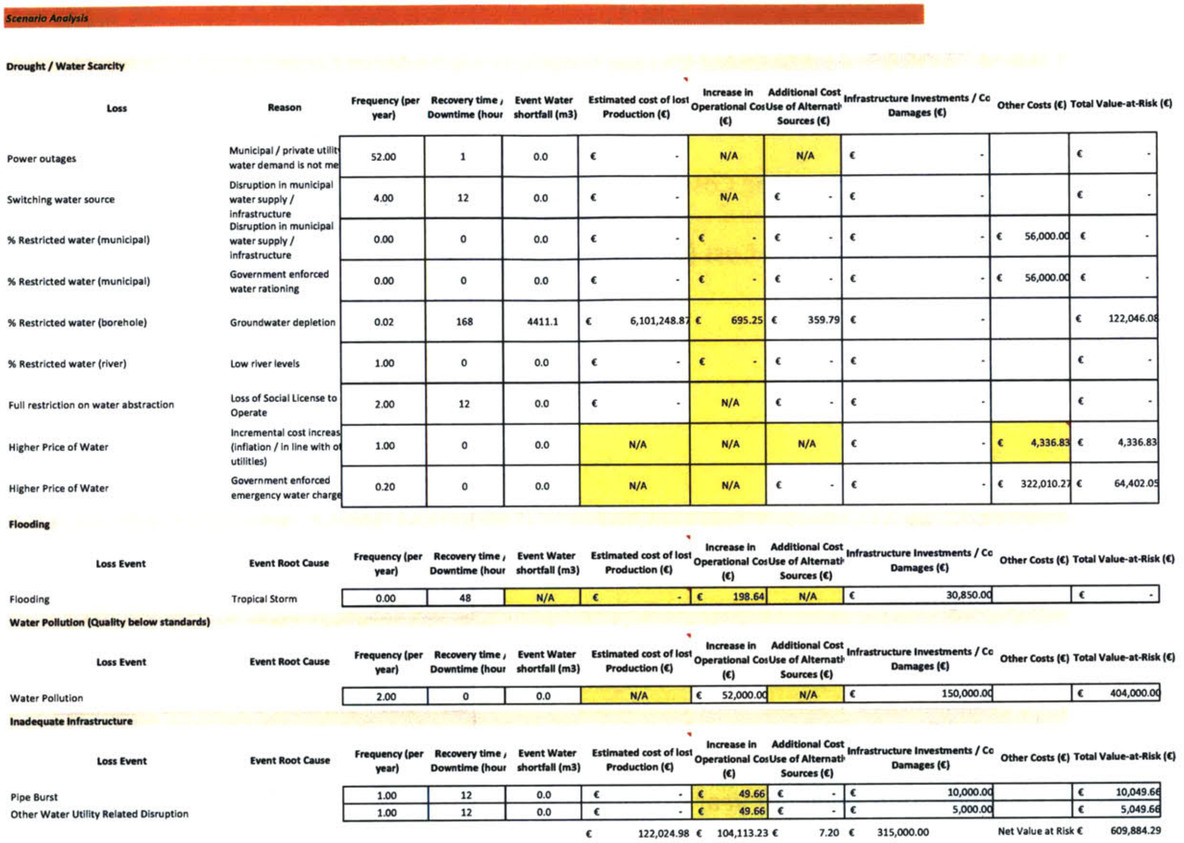
Mitigation Options

Do you have a water tank/storage (Y/N)	NO
Do you have on-site Storage? (m3)	0
Average Days of Inventory (days)	2
Virtual Water of Inventory (m3)	1764
Do you have an Alternative Source? (Y/N)	YES

Water Sources Details

Source	Amount of water withdraw (m3/year)	Is this a Possible Source? (Y/N)	Priority of Source (1 is highest)	Breakdown Of Main Sources (%)	Withdrawal Limit (m3)	Variable cost (€/m3)
Municipal/Piped Water	201	YES	2	0%	201	€ 1.79
Groundwater	321,809	YES	1	100%	N/A	N/A
Surface water	-	YES	N/A	0%	-	€ -
Brackish/Saline	-	NO	N/A	0%	-	N/A
Tanker to site	-	NO	N/A	0%	-	N/A
Other Source		NO	N/A			

Which is your Alternative Source?	Municipal/Piped Water
Withdrawal Limit (m3)	201
Variable Cost Alternative Source	€ 1.79



Scenario Analysis

Drought / Water Scarcity

Loss	Reason	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Power outages	Municipal / private utilit water demand is not me	52.00	1	0.0	€ -	N/A	N/A	€ -		€ -
Switching water source	Disruption in municipal water supply / infrastructure	4.00	12	0.0	€ -	N/A	€ -	€ -		€ -
% Restricted water (municipal)	Disruption in municipal water supply / infrastructure	0.00	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ -
% Restricted water (municipal)	Government enforced water rationing	0.00	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ -
% Restricted water (borehole)	Groundwater depletion	0.02	168	4411.1	€ 6,101,248.87	€ 695.25	€ 359.79	€ -		€ 122,046.08
% Restricted water (river)	Low river levels	1.00	0	0.0	€ -	€ -	€ -	€ -		€ -
Full restriction on water abstraction	Loss of Social License to Operate	2.00	12	0.0	€ -	N/A	€ -	€ -		€ -
Higher Price of Water	Incremental cost increas (inflation / in line with ot utilities)	1.00	0	0.0	N/A	N/A	N/A	€ -	€ 4,336.83	€ 4,336.83
Higher Price of Water	Government enforced emergency water charge	0.20	0	0.0	N/A	N/A	€ -	€ -	€ 322,010.27	€ 64,402.05

Flooding

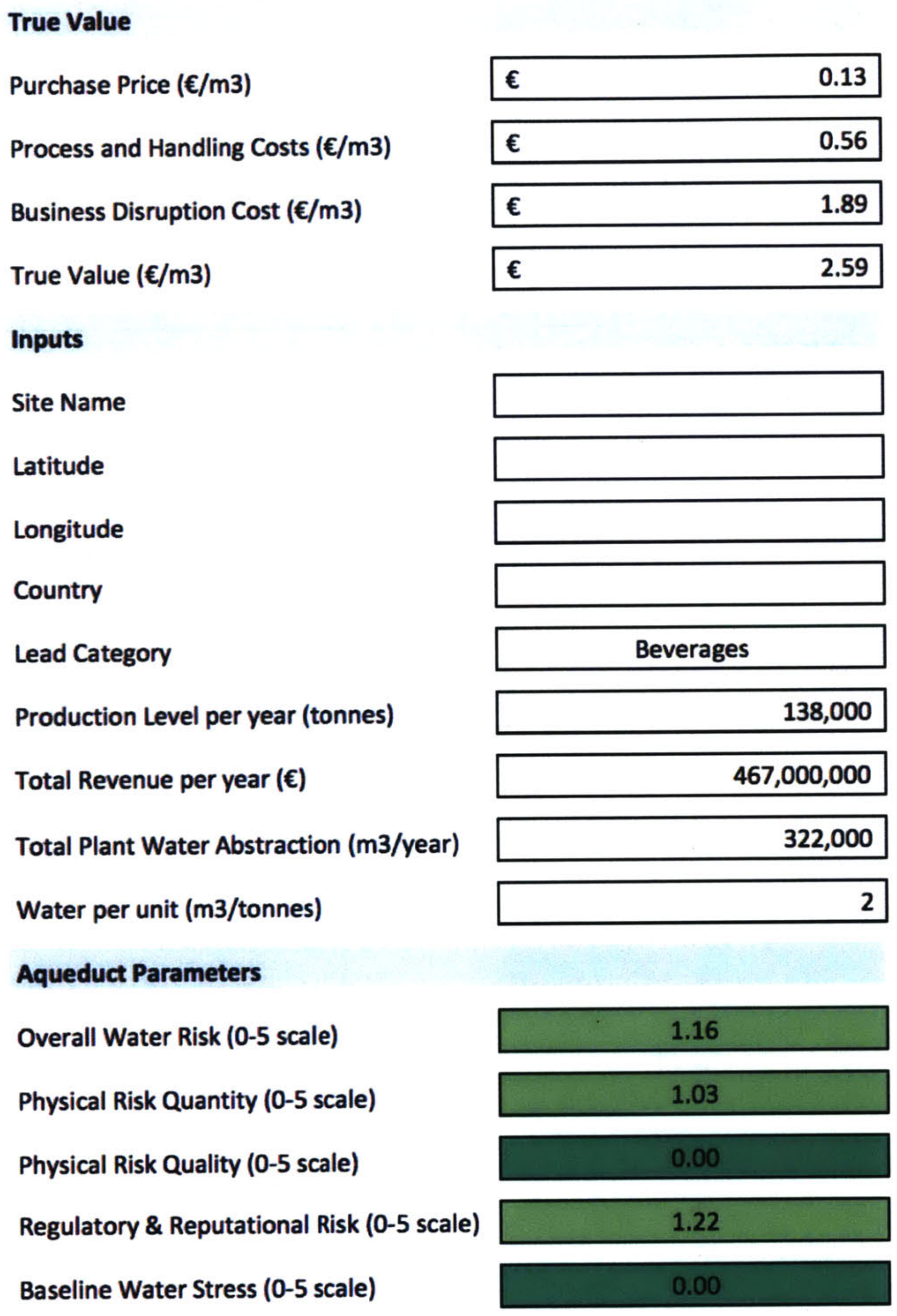
Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Flooding	Tropical Storm	0.00	48	N/A	€ -	€ 198.64	N/A	€ 30,850.00		€ -

Water Pollution (Quality below standards)

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Water Pollution		2.00	0	0.0	N/A	€ 52,000.00	N/A	€ 150,000.00		€ 404,000.00

Inadequate Infrastructure

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Pipe Burst		1.00	12	0.0	€ -	€ 49.66	€ -	€ 10,000.00		€ 10,049.66
Other Water Utility Related Disruption		1.00	12	0.0	€ -	€ 49.66	€ -	€ 5,000.00		€ 5,049.66
					€ 122,024.98	€ 104,113.23	€ 7.20	€ 315,000.00	Net Value at Risk €	609,884.29



True Value

Purchase Price (€/m3)	€ 0.13
Process and Handling Costs (€/m3)	€ 0.56
Business Disruption Cost (€/m3)	€ 1.89
True Value (€/m3)	€ 2.59

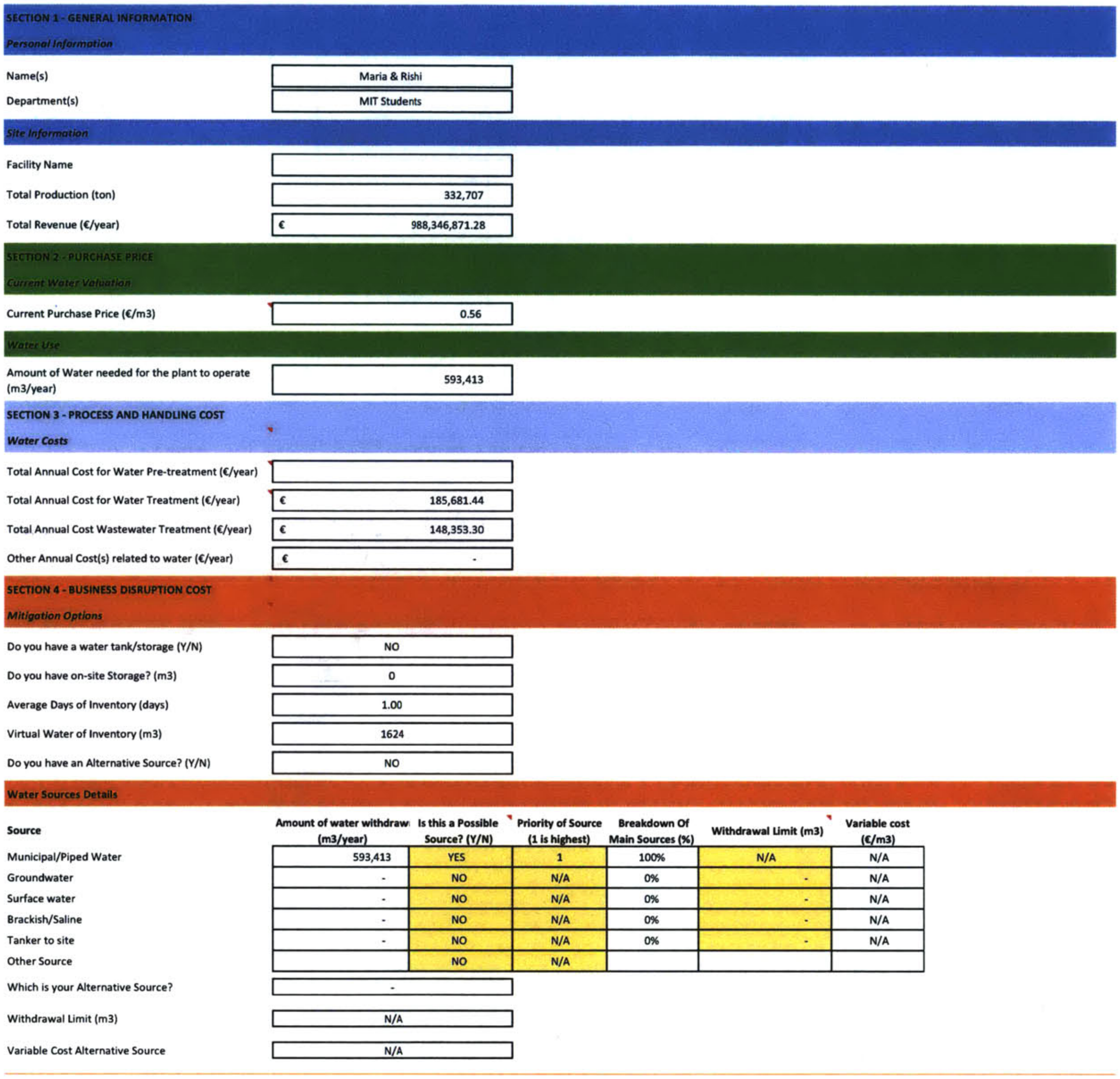
Inputs

Site Name	
Latitude	
Longitude	
Country	
Lead Category	Beverages
Production Level per year (tonnes)	138,000
Total Revenue per year (€)	467,000,000
Total Plant Water Abstraction (m3/year)	322,000
Water per unit (m3/tonnes)	2

Aqueduct Parameters

Overall Water Risk (0-5 scale)	1.16
Physical Risk Quantity (0-5 scale)	1.03
Physical Risk Quality (0-5 scale)	0.00
Regulatory & Reputational Risk (0-5 scale)	1.22
Baseline Water Stress (0-5 scale)	0.00

Appendix 9 – Case 4



SECTION 1 - GENERAL INFORMATION

Personal Information

Name(s)	Maria & Rishi
Department(s)	MIT Students

Site Information

Facility Name	
Total Production (ton)	332,707
Total Revenue (€/year)	€ 988,346,871.28

SECTION 2 - PURCHASE PRICE

Current Water Valuation

Current Purchase Price (€/m3)	0.56

Water Use

Amount of Water needed for the plant to operate (m3/year)	593,413

SECTION 3 - PROCESS AND HANDLING COST

Water Costs

Total Annual Cost for Water Pre-treatment (€/year)	
Total Annual Cost for Water Treatment (€/year)	€ 185,681.44
Total Annual Cost Wastewater Treatment (€/year)	€ 148,353.30
Other Annual Cost(s) related to water (€/year)	€ -

SECTION 4 - BUSINESS DISRUPTION COST

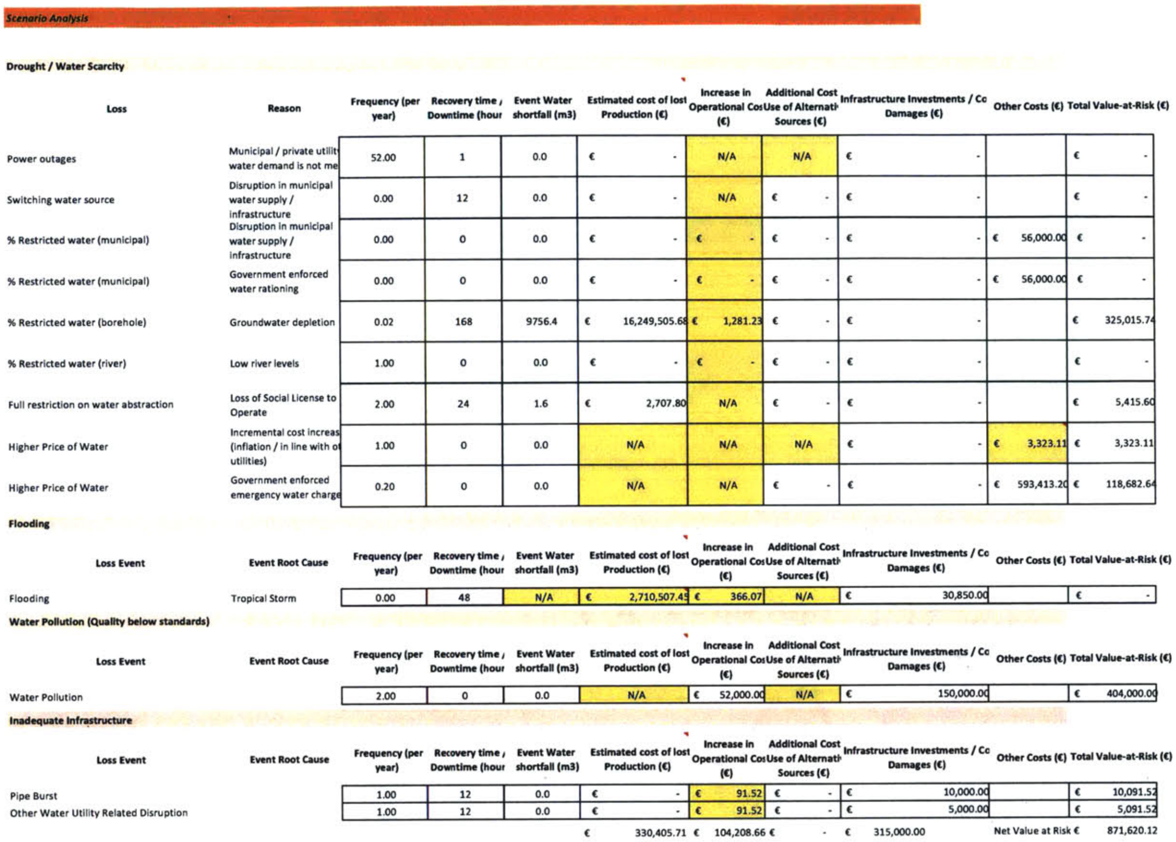
Mitigation Options

Do you have a water tank/storage (Y/N)	NO
Do you have on-site Storage? (m3)	0
Average Days of Inventory (days)	1.00
Virtual Water of Inventory (m3)	1624
Do you have an Alternative Source? (Y/N)	NO

Water Sources Details

Source	Amount of water withdraw (m3/year)	Is this a Possible Source? (Y/N)	Priority of Source (1 is highest)	Breakdown Of Main Sources (%)	Withdrawal Limit (m3)	Variable cost (€/m3)
Municipal/Piped Water	593,413	YES	1	100%	N/A	N/A
Groundwater	-	NO	N/A	0%	-	N/A
Surface water	-	NO	N/A	0%	-	N/A
Brackish/Saline	-	NO	N/A	0%	-	N/A
Tanker to site	-	NO	N/A	0%	-	N/A
Other Source		NO	N/A			

Which is your Alternative Source?	-
Withdrawal Limit (m3)	N/A
Variable Cost Alternative Source	N/A



Scenario Analysis

Drought / Water Scarcity

Loss	Reason	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Power outages	Municipal / private utilit water demand is not me	52.00	1	0.0	€ -	N/A	N/A	€ -		€ -
Switching water source	Disruption in municipal water supply / infrastructure	0.00	12	0.0	€ -	N/A	€ -	€ -		€ -
% Restricted water (municipal)	Disruption in municipal water supply / infrastructure	0.00	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ -
% Restricted water (municipal)	Government enforced water rationing	0.00	0	0.0	€ -	€ -	€ -	€ -	€ 56,000.00	€ -
% Restricted water (borehole)	Groundwater depletion	0.02	168	9756.4	€ 16,249,505.68	€ 1,281.23	€ -	€ -		€ 325,015.74
% Restricted water (river)	Low river levels	1.00	0	0.0	€ -	€ -	€ -	€ -		€ -
Full restriction on water abstraction	Loss of Social License to Operate	2.00	24	1.6	€ 2,707.80	N/A	€ -	€ -		€ 5,415.60
Higher Price of Water	Incremental cost increas (inflation / in line with o utilities)	1.00	0	0.0	N/A	N/A	N/A	€ -	€ 3,323.11	€ 3,323.11
Higher Price of Water	Government enforced emergency water charge	0.20	0	0.0	N/A	N/A	€ -	€ -	€ 593,413.20	€ 118,682.64

Flooding

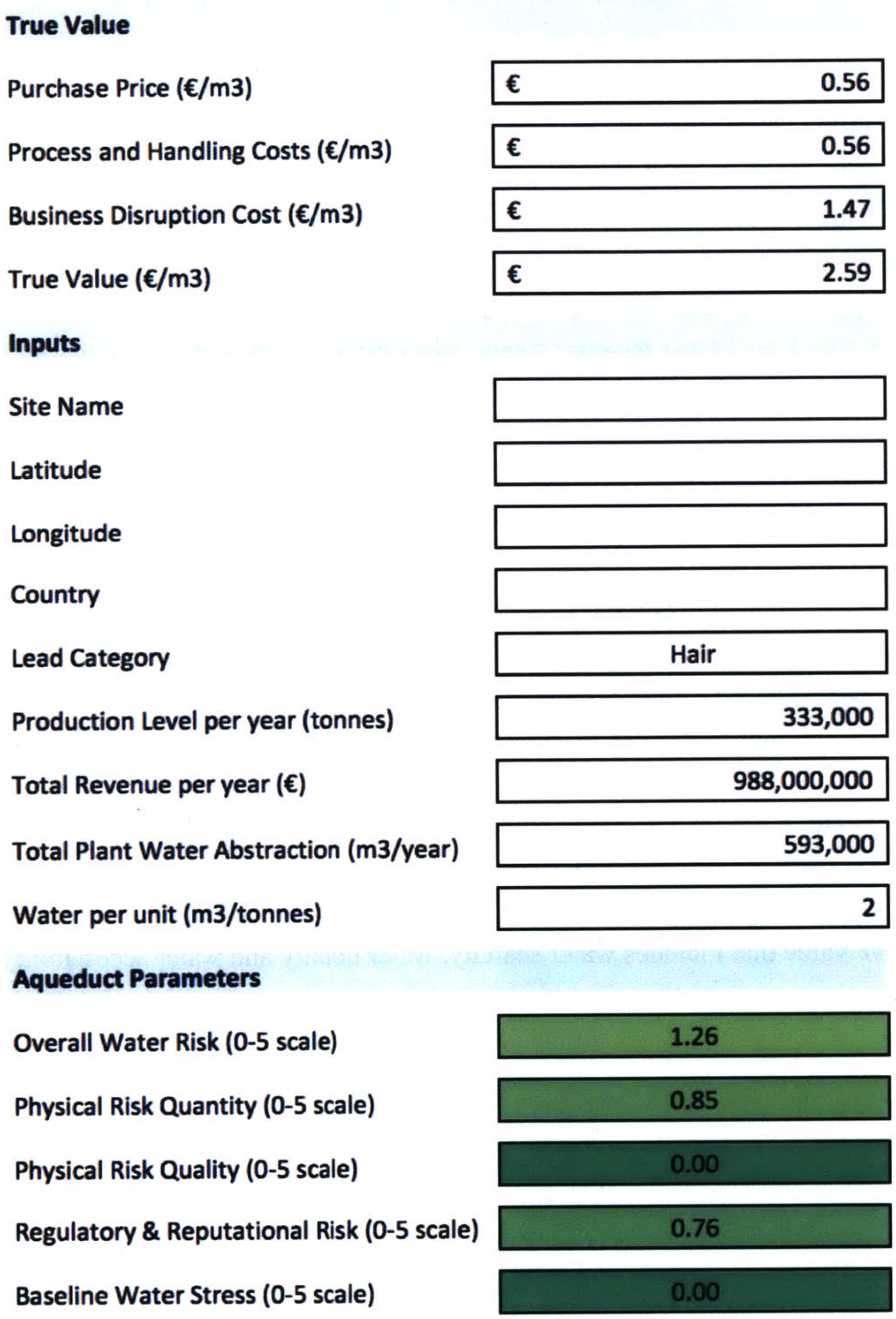
Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Flooding	Tropical Storm	0.00	48	N/A	€ 2,710,507.45	€ 366.07	N/A	€ 30,850.00		€ -

Water Pollution (Quality below standards)

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Water Pollution		2.00	0	0.0	N/A	€ 52,000.00	N/A	€ 150,000.00		€ 404,000.00

Inadequate Infrastructure

Loss Event	Event Root Cause	Frequency (per year)	Recovery time / Downtime (hour	Event Water shortfall (m3)	Estimated cost of lost Production (€)	Increase in Operational Cos (€)	Additional Cost Use of Alternati Sources (€)	Infrastructure Investments / Co Damages (€)	Other Costs (€)	Total Value-at-Risk (€)
Pipe Burst		1.00	12	0.0	€ -	€ 91.52	€ -	€ 10,000.00		€ 10,091.52
Other Water Utility Related Disruption		1.00	12	0.0	€ -	€ 91.52	€ -	€ 5,000.00		€ 5,091.52
					€ 330,405.71	€ 104,208.66	€ -	€ 315,000.00	Net Value at Risk €	871,620.12



True Value	
Purchase Price (€/m3)	€ 0.56
Process and Handling Costs (€/m3)	€ 0.56
Business Disruption Cost (€/m3)	€ 1.47
True Value (€/m3)	€ 2.59
Inputs	
Site Name	
Latitude	
Longitude	
Country	
Lead Category	Hair
Production Level per year (tonnes)	333,000
Total Revenue per year (€)	988,000,000
Total Plant Water Abstraction (m3/year)	593,000
Water per unit (m3/tonnes)	2
Aqueduct Parameters	
Overall Water Risk (0-5 scale)	1.26
Physical Risk Quantity (0-5 scale)	0.85
Physical Risk Quality (0-5 scale)	0.00
Regulatory & Reputational Risk (0-5 scale)	0.76
Baseline Water Stress (0-5 scale)	0.00

9. GLOSSARY OF TERMS AND ACRONYMS

AMIS: Alignment of Metrics Information System (AMIS)

CDP: Carbon Disclosure Project

CPG: Consumer Packaged Goods

Facility Name (FN): Name of the site being evaluated

Inventory Water (IW): Amount of water required to produce an equivalent amount of inventory of finished goods, expressed in m^3

Monthly Site Level Cost Report: Report that outlines water usage statistics and associated costs for each facility – including YTD production, amount of water abstraction per water source (m^3) and total cost of water per source (euro)

Purchase Price (PP): Purchase price expressed in €/m^3

Total Production (TP): Total production of the site in tones per year

Total Revenue (TR): Total revenue of the site per year (€/year)

UNFCC: United Nations Framework Convention on Climate Change

Unilever's "Site List": spreadsheet with site-specific information such as region, cluster, country, lead category, water scarce, production, latitude and longitude

Unilever Sustainable Plan (USLP): Master plan to guide Unilever's sales growth without increasing its environmental footprint.

VUCA world: Volatile, uncertain, complex and ambiguous world

Water Abstracted (W): Total amount of water abstracted at a site annually (m^3/year)

Water stress: According to the UN Global Compact (2014), water stress is a broad and subjective value that includes water scarcity, water quality and water accessibility.