Sustainability Outlook

Value Added Water

An approach to create business case for water sustainability in industry

Methodology Approach co-written along with cKinetics

Image courtesy: Allen Qiao's flickr stream

Water is at the heart of all production, but quantifying its business case has been elusive… until now

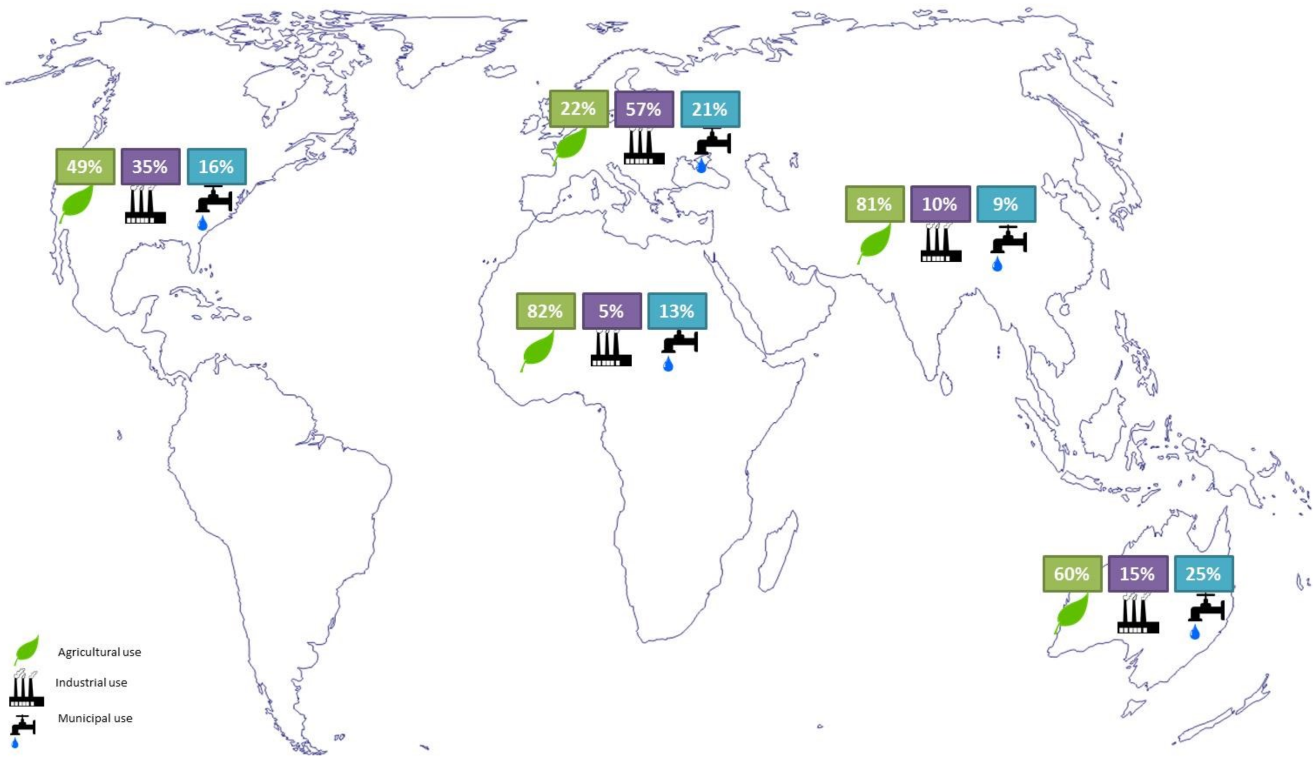
Water is often perceived as a 'public good' or 'gift of nature', abundantly available for use and as a result also becoming one of the most neglected natural resources. **Value Added Water (VAW)** is an attempt to rethink the way water is viewed and valued, especially by water-intensive Industries. It helps build the business case on working with projects that are related to saving water in its various forms. This document outlines the **VAW** approach to understand value "hidden" in various forms of water during use. It is especially useful in the following industries:

Paper and pulp	Pharmaceutical	Textile
Food and Beverages	Fertilizer	Chemicals
Power plants	Steel	

Risks arising from non-availability of water

Fresh water has competing uses across agriculture, industry and domestic use. Though agriculture is the primary consumer of fresh water (for irrigation), the proportion varies across regions, depending on the levels of economic development of countries.

Figure: Water withdrawals by sector



Source: United Nations World Water Development Report 2014

Globally, industry accounts for 19% of all water withdrawals, though with significant regional variations depending on the level of economic activity and level of maturity of the economy[1]. It is estimated that industrial sector accounts for only 5% of freshwater withdrawals in low income countries but the number increases to over 57% in some high income countries[2]

With growing population, increasing demand of goods and changing consumption patterns, demand for fresh water by all segments – agriculture, industry and domestic is expected to significantly increase over the next few decades.

[1] United Nations World Water Development Report 2014
[2] UN Water Report, Managing water under uncertainty and risk

Growing demands from manufacturing (400%), thermal electricity generation (140%) and domestic use (130%) are expected to lead to a 55% increase in global water demand (in terms of water withdrawals) by 2050[3].

On the other hand, the existing ground water resources are experiencing a rapid decline due to over-exploitation (withdrawal rate > replenishment rate) of these sources. It is estimated that around 20% of the world's aquifers are overexploited and the rate of groundwater abstraction is increasing by 1% to 2% per year[4]. As a result of these over-withdrawals, freshwater availability across the world is increasingly under threat. The challenges of non-availability of water of the desired quality are likely to be more acute in countries experiencing rapid economic growth.
Water can be a serious business risk to the industry which can manifest itself in either operational risk, reputational risk or regulatory risk. Water needs to be available in the right quantity, of right quality, at the right place, at the right time and at the right cost for sustainable and viable Industrial operations.[5]

Underpricing of water - primary cause of unsustainable use

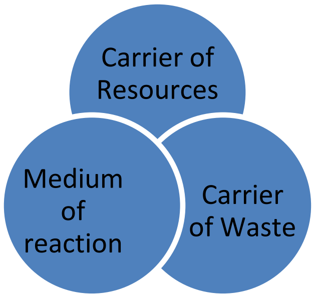
Despite the impending challenge to its availability (both in terms of quantity and quality), water is an underpriced resource. Subsidization of water for industry prevents its true cost from being reflected and promotes its indiscriminate and inefficient use. Since water is so underpriced, industry does not have an incentive to conserve it. Since industry is focused on maximizing production and profit, it is more focused on procuring water at the lowest cost rather than in the most efficient manner.

Water used in Industry for product and process

Within the fence, water can have two purposes in industries – (a) for product (as an input raw material) and (b) for processing. Water is an essential component in many industrial processes and is used for washing, cooling, heating, cleaning, transportation of material, as a solvent etc. During production, water can be viewed as:

- Carrier of resources (energy or chemicals)
- Medium of reaction
- Carrier of waste

Figure: Purpose of water in industrial processing



However, if we go beyond the fence and consider the entire value chain of manufactured products, water is an essential resource both upstream (in supply chain of raw materials) as well as downstream (use and disposal by end customer). Our focus in the paper is use of water 'within the fence' of industrial manufacturing.

Industries with intensive water use (within the fence) include: thermal power plants, textiles, paper and pulp, steel etc. Cooling towers in thermal power plants are the largest consumers of fresh water amongst all industries. As per estimates, power plant cooling is responsible for 43% of total freshwater withdrawals in Europe and a significant proportion in other countries too.[6]

[3] United Nations World Water Development Report 2014
[4] United Nations World Water Development Report 2014
[5] UN Water Report, Managing water under uncertainty and risk
[6] United Nations World Water Development Report 2014

Mapping the journey of water in Industry

In a typical industrial process, a product is manufactured by employing multiple resources that flow over a mechanized line. These lines are like the veins and arteries within a human body. As described earlier, process water in an industry typically has three uses: as a carrier of energy, as a medium of reaction and as a carrier of waste. Thus, water in a water intensive industry serves the same purpose as that of blood in a human body. Right from the time water is pumped from its source, various steps are performed on it which lead to changes in its form and content. Water travels through a factory and at every stage some resource is added or removed from it. Water carries these resources to their intended destination and enables their utilization.

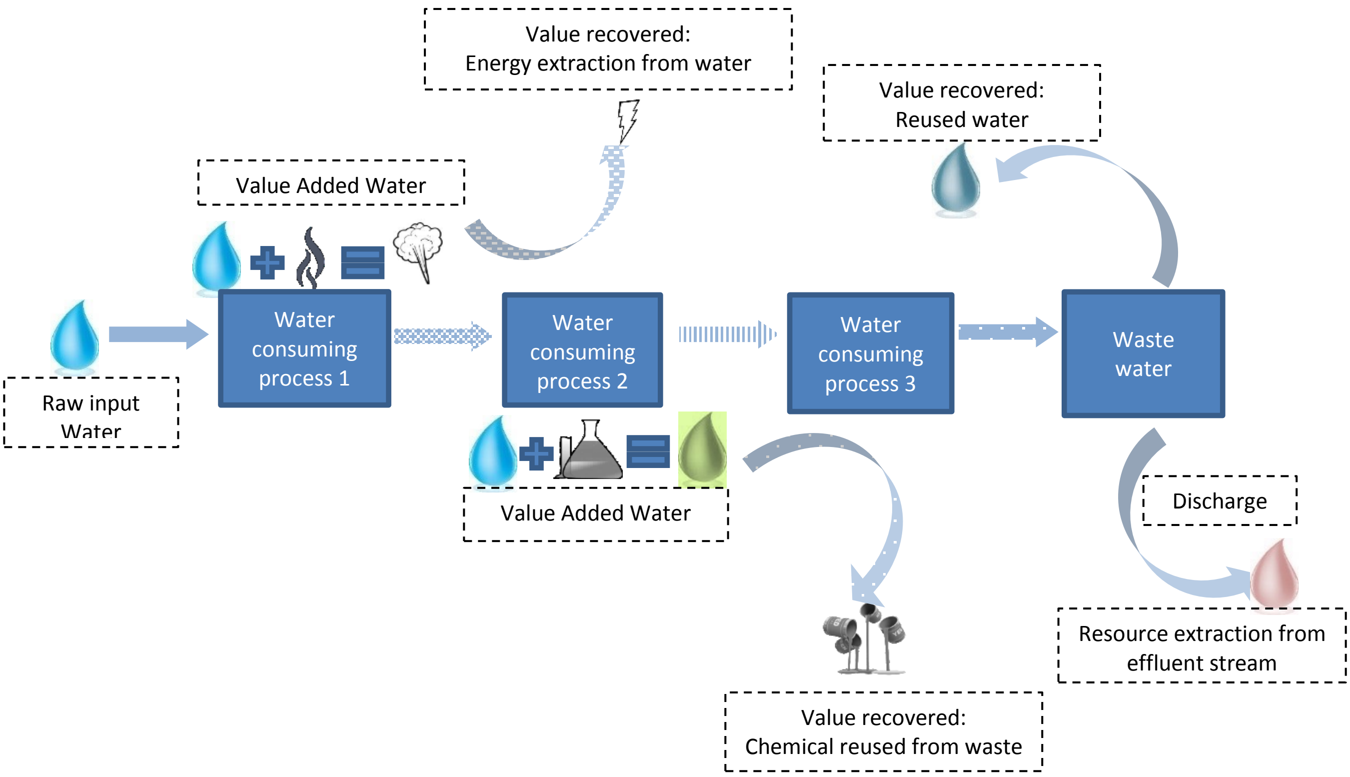
Value addition occurs, each time resources are added to water at different stages of processing. This would be in the form of energy or chemicals. Some examples of such value addition are:

1. Energy and chemical addition during water treatment
2. Energy while pumping water
3. Energy for conversion of water in to steam
4. Process chemicals

Since energy and chemicals are both highly priced resources, 'cheap water' when pumped from the source, becomes a valuable resource on entering the industrial process due to the addition of other valuable resources.

This in a nutshell is the concept of ***Value Added Water*** is one which helps businesses view water more holistically as a *carrier* of conventionally valuable resources within the fence of a factory rather than just as a single resource. It involves taking a *systems approach* towards water as opposed to the *conventional commodity approach*.

Figure: The Value Added Water Approach



Significance of VAW

Using the value added water approach helps develop a holistic outlook for resources used in industrial production and thus uncover multiple benefits. Such an approach helps in developing a better understanding of the overall flow of resources within a factory.

Identifying and minimizing wastages/leakages

Ascertaining the value of water at different stages of processing helps uncover the stages at which water (along with other resources added to it) is the most valuable. This highlights those stages in the product processing at which wastages in the form of leakage; excessive use etc. should be avoided even more and where efficiency improvements need to be carried out.

Identifying opportunities for input optimization and output maximization

Once value of water has been uncovered for a given stage, we can look to optimize the output of that stage without increasing the input variables; i.e. VAW can be used as a tool for resource optimization "within the fence" in water intensive industries.

VAW could also be used for obtaining indicators for benchmarking amongst companies. VAW could be employed as a tool formulating policies regarding benchmarking of resource consumption in various production processes in water intensive industries. Thus VAW approach can be useful in streamlining operations by enabling setting up of standards and benchmarks for use of resources including water across various industrial processes.

Identifying the value of water in waste streams

Multiple tools for manufacturing management focus on reduction of waste. The use of VAW approach can also enable efficient waste water management. As discussed above, by adopting the VAW approach, the value of water can be estimated at both, the input and output stage of each process. Application of VAW on the output side of a process helps to uncover the value of waste water that is typically discharged and discarded. Valuing waste water can help in developing a business case for resource recovery or water recycling. If the cost of extraction of a resource from the waste water is lesser than the VAW value of that waste water, the case for recovery/recycling becomes valid.

Industrial symbiosis

Another avenue to explore for waste is the case for industrial symbiosis by material flow. If the value of waste stream is sufficiently high, a factory could look for other industries that would be interested in purchasing this stream. Such an exchange would also reduce the load induced by water on the subsequent stages within the facility. It helps in optimizing the resource requirement downstream such as energy for water pumping and chemicals for effluent treatment. Thus, VAW approach can be an enabling tool to gauge the attractiveness of waste water streams

Applicability of VAW

Employing VAW as a tool, the analysis throws up alternative ways of developing the business case around water-related projects. Some illustrations are as follows:

1. Reusing chemicals is not just about reducing the chemical cost but also about reducing the amount of water to pumped around and reducing the load on the ETP (and associated costs).
2. Thermal efficiency is not just about focusing on the boiler but also about asking why hot water is needed in the first place and if it can be met from other low cost means (such as waste heat).
3. Expenditure on an Effluent Treatment Plant (ETP) is not an expense if the cost of treating the water for reuse within the factory is less than that of value added water at the discharge point.

Thus VAW paves the way for creating monitoring methods that help in uncovering savings and new key performance indicators for resource efficiency.

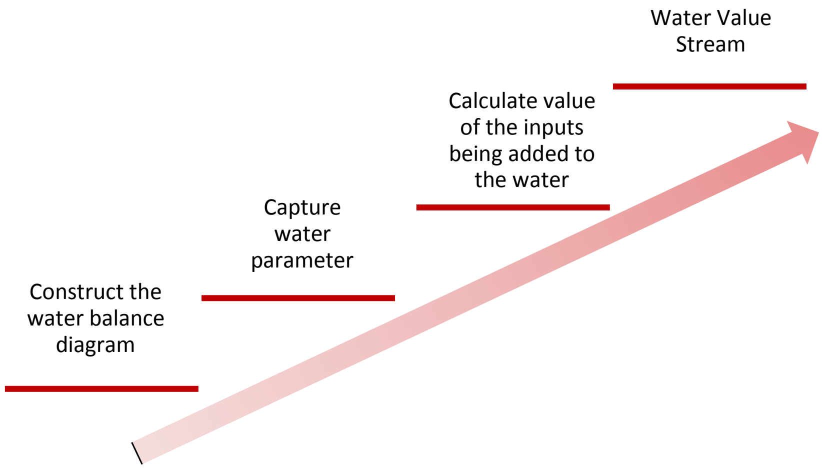
Methodology on applying VAW

In order to employ the VAW tool in a given factory, we need to create a *Water Value Stream*. The water value stream illustrates the journey of water within the factory with the value of water highlighted at every stage. It also illustrates the quality of water at each of these stages.

Steps involved in Water Value Stream Mapping

Step 1: Water balance diagram
Water value stream mapping commences with the construction of a water balance diagram of the factory. The water balance diagram lists down the total water drawn from source and its volume utilization at various consumption centers within the factory. It is an accounting of quantity of water withdrawn and water utilized. This diagram also serves the purpose of a water circuit by illustrating the flow of the water within the factory

Figure: Steps for mapping Water Value Stream



Step 2: Record water parameters
For every consumption center and process listed in the water balance diagram, the quality of water at each of the stages should be listed down. Quality parameters include temperature, total dissolved solids (TDS) and pH should be recorded for every equipment / process.

Step 3: Calculate value of inputs added to water
For each consumption center, the resources added or removed should be enlisted along with the quantities. These could be electricity, fuel such as diesel or natural gas, and chemicals/concentrates. This helps in understanding total value of water in monetary terms at every stage within the production process.

The above steps will enable a factory to create and examine its *Water Value Stream Map.* Through this map, one can examine the value that water processes at every center during manufacturing.

Image courtesy: Tim Jone's flickr stream

A sample format for capturing data pertaining to the water value stream

After the construction of the water balance diagram, the following tabular format could be used for arriving at the water value stream of the factory

		Process 1	Process 2	Process 3	Process 4
	Process input				
	Material description				
	Qty (Kg or metres ideally in EWP)				
	Process output				
	Material description				
	Qty (Kg or metres ideally in EWP)				
input	**Input water**				
	Form of water used (liquid)				
	TDS				
	pH				
	Temp (oC)				
	Recoverable or active chemicals				
	Volume				
	Value				
Value added	**Thermal energy added**				
	Amount of heat (Kcal or MJ or kg steam)				
	Value				
	Electricity added				
	kWh consumed				
	Value				
	Chemicals added				
	Description				
	Qty				
	Value				
Ouptut	**Ouput water**				
	TDS				
	pH				
	Temp (oC)				
	Recoverable or active chemicals				
	Volume				
	Value (Rs)				

Analysis of the water value stream map

Some aspects that need to be particularly observed after Water Value Stream Mapping are:

- The parameters of water each stage
- Peak value of water per cu. m in process (i.e. input water value + value added on a per cu.m basis)
- Cu.m of water per unit output of final product from the process

The optimization of the Water Value Stream Map should be conducted by asking the following questions at every step:

- For Input
    - How can less water per unit output be used?
- For Value added:
    - Is the water-value being extracted optimally?
    - How can the process be accomplished with less value added?
- For Output
    - Can more value be extracted from the output water (even in some other process)?

It is imperative that the exercise of water value stream mapping and its analysis is carried out by a cross functional team consisting of people from design, production, utilities and chemical stores. Problem solving and analysis by a cross functional team is another added benefit of employing VAW.

Illustration of Creating a Water Value Stream for a textile dyeing process

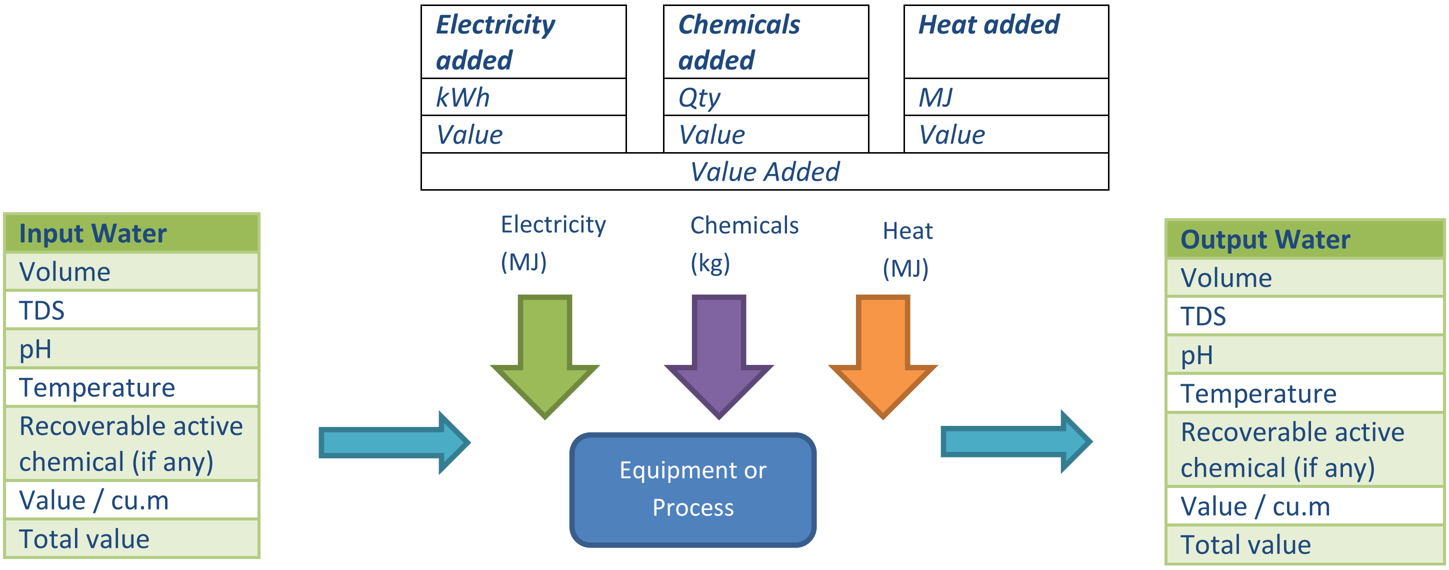
The textile industry is a guzzler of water, energy and chemicals. Energy is for operating machines and utilities and also for heating water in the factory. Chemicals are used for processes and also for water treatment. Water is primarily used as a carrier of other resources. In India, the textile industry constitutes 2% of the industrial fresh water consumption[7]. The industry is thus heavily reliant on water for its existence. The resource intensity of the textile industry coupled with the importance that it needs to place on water make it an ideal case for employing VAW as a diagnostic and optimization tool.

In the textile industry, water is used for three main types of sub-processes within the factory; for carrying chemicals, carrying heat and for dissolving impurities. Water is used for generation of steam which is a process requirement. It is the primary medium for the liquor that is used for the actual dyeing process. Water is also the primary medium for pre-dyeing processes which are used for making the fabric *Ready For Dyeing*. The fabric that is dyed or printed is also rinsed in water before it is sent for finishing processes such as drying and shrinkage control. Depending on the quality of water at the output of these processes, water is either drained off through an effluent treatment plant or it is reused or recovered.

The journey of water in a textile industry starts off with its extraction from the source (aquifer, river or purchased water). Depending on the quality of the water, a part of or the entire water is treated by a water treatment plant. Part of the treated water flows to the boiler where it is converted in to steam and then used in various processes for heating purposes. The rest of the water is used for pre-dyeing and dyeing processes. Since steam is used in most processes, cooling water is also essential to normalize the temperature where necessary. The process water is eventually treated in an effluent treatment plant and then discharged in to a drain.

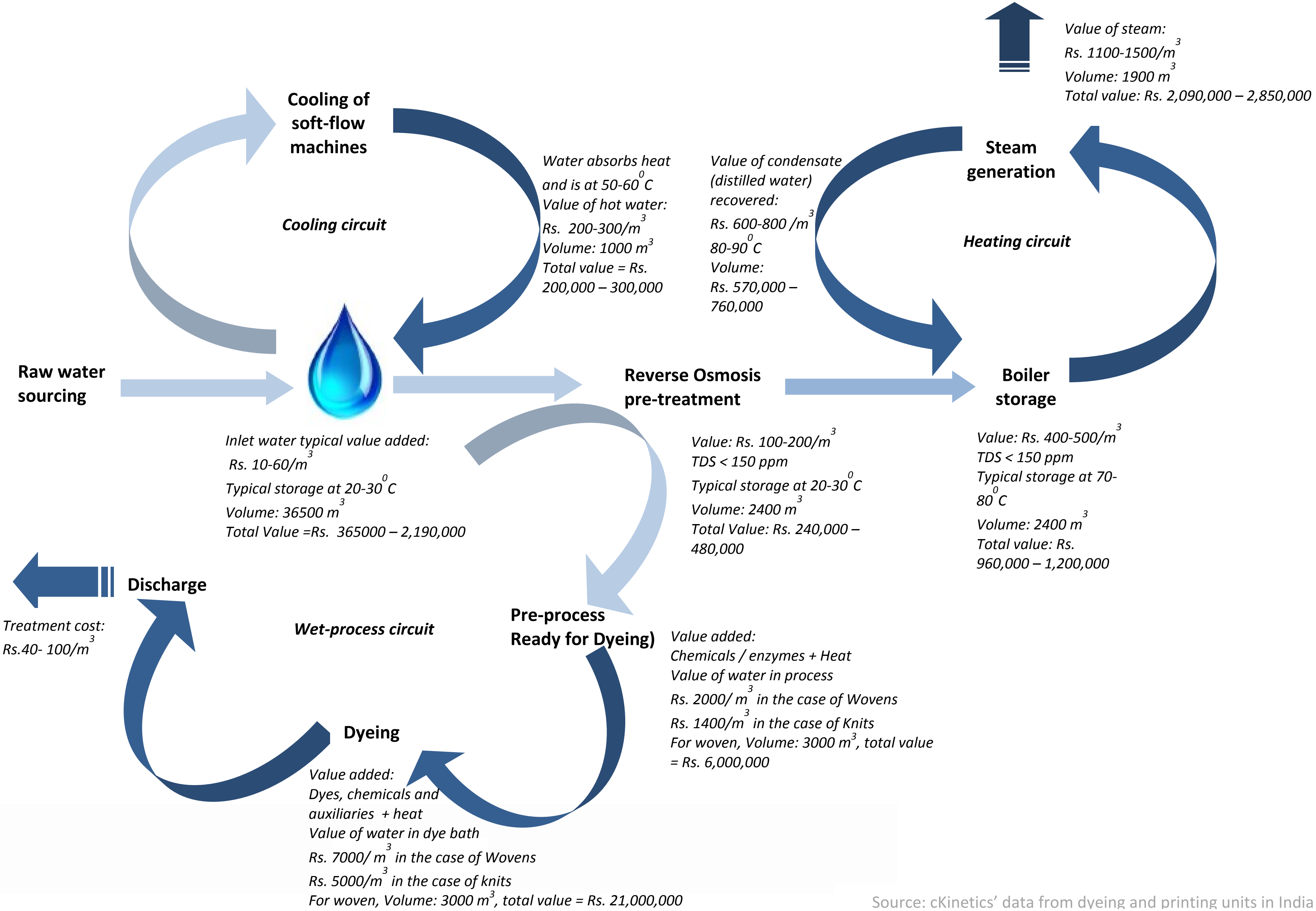
For creating the water value stream map, every consumption center / equipment in a textile factory was analyzed using the following concept

[7] Center for Science & Environment, “To use or misuse”, Downloaded from http://www.cseindia.org/dte-supplement/industry20040215/misuse.htm



*Note: Total Value = Value /cu.m * Volume of water*

Following is a water value stream map of a typical textile dyeing factory. It is evident that the though the cost of sourcing water is low, as it moves within the factory its value increases.



Source: cKinetics' data from dyeing and printing units in India

The Way Forward

In a world where both availability and quality of water are increasingly turning in to risks for businesses, water management is a necessity rather than a choice. This case is usually weakened when we look at water as a commodity since it continues to be underpriced. This can change if we develop a systems approach towards water and view water as a carrier of other resources within the fence of a water intensive industry. Value Added Water is one such diagnostic tool which industries can employ to understand not only the journey of water within their industry but also look at the monetary value that it processes in various consumption centers. The mapping of the water value stream necessitates the formation of a cross functional team which is a good way to approach issues that concern the whole factory. VAW could open up avenues for process optimization through identification of resource hotspots as well reveal opportunities for industrial symbiosis with regards to so-called waste streams. VAW also aids in making the water-energy-chemical nexus more tangible for industries that are most impacted by it. New key performance indicators arising from the VAW could be used for benchmarking by industries and also by policy makers.

Water intensive industries that recognize the threats arising from water availability could employ VAW and use it as a part of decision making. This could serve as a differentiator for products manufactured by the industry.

Image Courtesy: Pixabay

cKinetics (of which Sustainability Outlook is a division) conducts workshops for different water intensive industry segments on the applicability of VAW. To learn more about the workshops and participate in them please contact Susmita Kamath (skamath@ckinetics.com)

About Sustainability Outlook

Sustainability Outlook is a market access, insight and collaboration platform tracking actions related towards enhanced resource management in the Indian economy. Sustainability Outlook provides market analysis and data tracking services, news and intelligence updates, and creates momentum towards specialised sustainability interventions by facilitating a structured process for multi-party collaboration.

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