WATER FOOT PRINT AND CONCEPT – A TOOL TO REDUCE WATER CONSUMPTION

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ABSTRACT

Water is required directly or indirectly for any job/ activities or process. Water required for commercial, domestic, agricultural & industrial activities is derived from underground & surface water. Depending on requirement water is used as such or after treatment. Water demand is being measured as actual water consumption, e.g. as per National Building Code the water consumption in urban area is 135 LPCD & 1 Kg of paper manufactured by Kraft process requires 350 lit/ kg of paper produced. This is actual water consumption during the process, activities or job being carried out. However there are direct/ indirect water consumptions at various stages before the process begins or the products manufactured. The summation of the water consumption before, during & after the process gives the correct figure of the water consumption. This is called as Virtual Water Footprint. This helps for calculation of total water demand for the given geographical boundary or defined set of activities. Water Footprint is further divided into three types as Green (direct use of rain water), Blue (use of naturally & manmade stored water) & Grey (water required to counteract the impact of pollutant in receiving water body) water footprint. Importance of Water Footprint, frame work to calculate Water Footprint & methods for reducing Water Footprint are discussed in this paper.

Key words: Green, Blue & Gray Water Footprint, manufacturing process, direct & indirect water consumption.

Introduction

Water is used for agriculture, domestic & industrial activity. Total water requirement is defined as Water Footprint. It is categorized as Green, Blue & Gray Water footprint. Green water represents direct consumption of precipitated water. Blue water is the consumption of water from manmade & natural water storage. Traditionally resources are filled by precipitated water (fresh water) in the form of rain & ice. The amount of Blue water required for dilution to bring down the concentration of pollutant in waste water (generated during activity) to its acceptable level in the receiving water body is called as Grey Water. The total Water Footprint is the summation of Green, Blue & Grey water.

After independence the Indian economy has gone through revolutionary changes. From 1990 onward many products (food, cosmetics, electronics & automobiles etc.) are available on the shelf. The product which earlier confined to homemade or cottage industry has taken the form of medium & large scale industry e.g. Food processing industries. Majority of products are being manufactured under the different brand names. Increasing demand coupled with excellent marketing & easy access to finance is inspiring the Indian consumers to acquire more than the basic

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needs. Obviously each product comes along with actual & virtual water consumption thus making the total Water Footprint of Indian larger.

❖ Water Balance of Catchment Area Conventionally in calculating water balance moisture in agriculture, soil vegetation, biotic life, & loss of water by Evapo-transpiration is not considered. The water demand is considered only for agriculture, domestic & industrial activities. The water is also lost from the catchment area by evaporation. A critical evaluation of Blue, Green & Grey Water Footprint of given catchment area can help to assess the total water demand for present & future. The Green, Blue & Grey Water Footprint in relation to water balance in catchment area is given in Figure - 1.

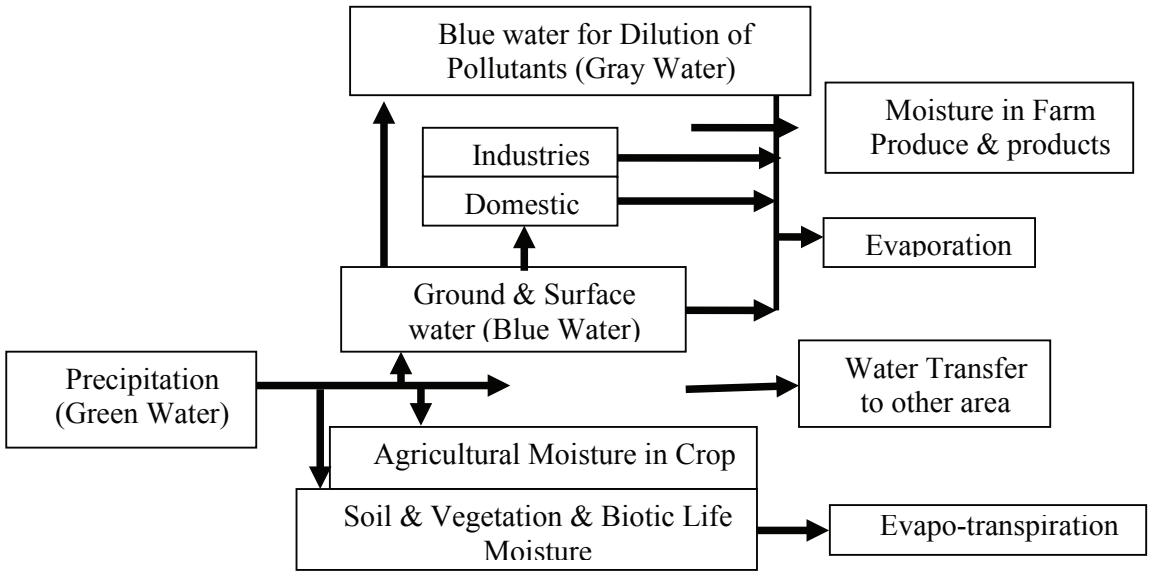

Figure- 1.Green, Blue & Grey Water Footprint in relation to water balance in catchment area

❖ **Input Output Analysis**

Input Output Analysis for defined geographical boundary is given in Figure – 2. Three possibilities are a. system is comfortable when Input>output, b. manageable when Input = Output & c. fragile or water deficient when Output> Input

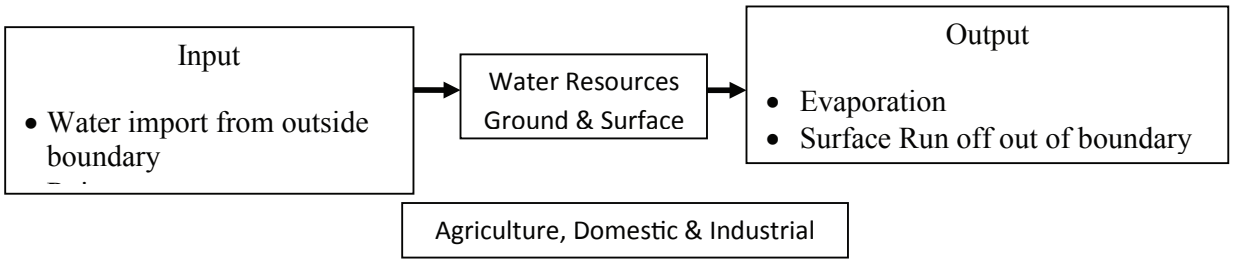

Figure - 2. Input output analysis

The water required is drawn from available resources. Conventionally water consumption is measured as the metered volume of water received for the job activity or process. The conventional water consumption is also followed by waste water generation. This Waste water generated shall be treated before disposal to bring down the level of pollutant to natural level in receiving water body.

❖Direct Water Consumption in Manufacturing

The typical water input output analysis of manufacturing process is shown in Figure – 3. All the values of water volume Q either can be calculated or measured. This gives direct water consumption of process.

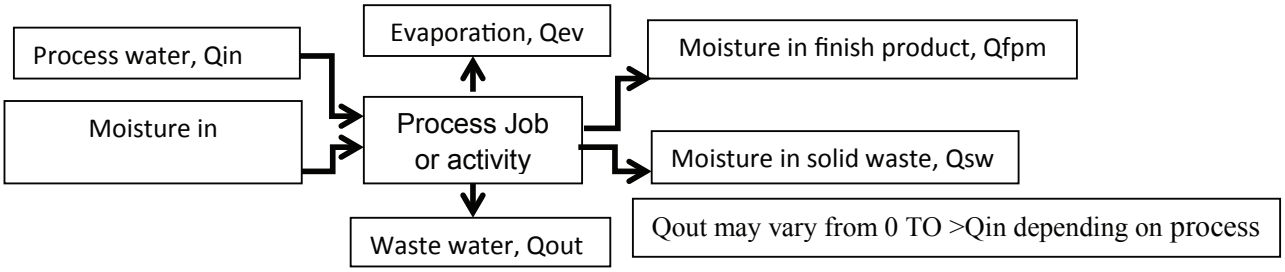

Figure - 3. Water input output analysis for manufacturing process

❖ Indirect Water Consumption

The raw materials are received at site, processed to make products & products reach the consumer through supply chain. The water is required at various stages in the chain. This is illustrated with typical example of Ketchup – a product from tomatoes in Figure 4.

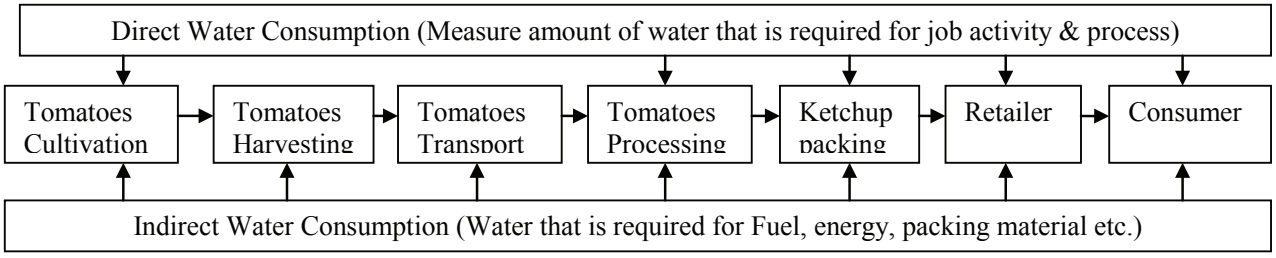

Figure- 4. Direct & Indirect Water Consumption in Ketchup

Water requirement in raw material to consumption chain for Ketchup is given in Table – 1

Table – 1 Water Requirement from Offsite to Consumer site for Ketch up

Site	Activity	Water requirement	Site	Activity	Water requirement
Off	Cultivation	Growing Tomatoes	Production	Processing	Washing, heating, cleaning
Off	Harvesting	Drinking, washing	Consumption	Retailer	Drinking, Transportation
Off	Transport	Packing & transport	Consumption	Consumer	Washing & cleaning

Conventionally water consumption at production site is only considered. Summation of offsite,

❖ Water Footprint

Water Footprint is the term that is similar to well established term like Energy & Carbon Footprint. Water Footprint concept gained interest after it was introduced in 2002 by Hockstra. Water Footprint is consisting of Green, Blue and Grey Water Footprint & details are given in Table - 2.

Table – 2 Green Blue & Gray water Foot print

Water Foot Print	Resource & Usage	Example
Green	Precipitated water available for direct use before it gets stored or recharged.	Indian Rain Fed- Farming, Animal grazing, Forest produce
Blue	Surface & Ground water Resources available round the year	Irrigation, Domestic, Industrial, Commercial
Gray	Blue water required for dilution to prevalent river water quality standards	Waste residue from Agricultural, Domestic & Industries. Scope for Treatment, reuse & recycle

❖ Water Footprint of Manufacturing Process

Raw material(s) is passed through unit processes to get the finished product. This may be either a straight chain from raw material to finished product or branching may take place at any of the unit process. Besides water electricity, labor & other semi finished or finished products (e.g. packaging material) are required at various unit processes.

◆ Water Foot Print of Unit Process

◆Water is required for cleaning, washing, heating, cooling, cooking etc. It can be directly measured by the flow meter. It is given as Water Foot Print per unit output of the process. Summation of water Footprint of all unit processes gives Water Foot Print of Product.

◆ Water Footprint of Energy

Water Footprint of energy can be calculated on the basis of Energy Footprint of a product

WFep = EFp X WFe

WFep= Water Footprint of energy (e) required per unit of product (p), l/unit

EFp= Energy footprint of product, kwh/unit of product

WFe=Water Footprint of energy, l/unit of energy

◆ Water Footprint of manpower

Water consumption for drinking, washing, WC flush etc. shall be considered as Water Footprint of manpower. . Besides, to counteract the sewage generation, Grey water Foot print is to be added.

◆ Water Foot Print of straight Chain & branch chain Manufacturing process

It is respectively given in Figure – 4 & 5

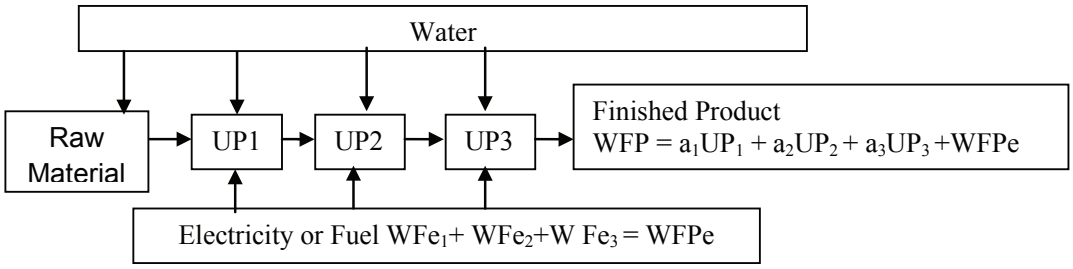

Figure – 4 Straight Chain Process

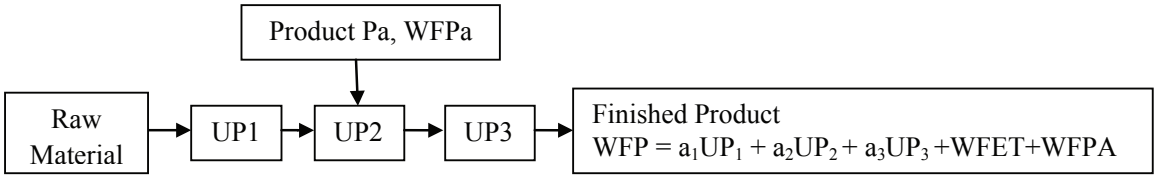

Figure – 5 Branch Chain Process

Up = Unit Process (1 to n)	WF = Water Foot Print
a_n = WF / unit output of unit process	e_n = Energy Foot Print / Unit (1 to n) Product
WFe = WF of energy,/unit product	WFPa = WF of Product a
WFPe = WF energy /unit product	WFP = WF of Finished Product

Value of an & en can vary from 0 to +0. Zero value is to be assigned for the input which doesn't require any water e.g. Sun drying. The influencing factors in deciding the values in Water Footprint are climate, geographical conditions, human behavior, attitude & understanding, water stress & awareness of water conservation. However the value can be assigned for the given geographical boundary & the efforts are to be made for its acceptance in larger boundary.

❖ **Water Footprint of Water**

The water is pumped from the source to the Water Treatment Plant (WTP). From WTP it goes to the tap at consumer end through water distribution system. The water is lost in pipeline leakages, as drain out from sedimentation tank & backwash & rinse water from the filter. Leakages are also to be accounted in distribution system. The leakage varies from +0 to +20 % depending on the location. This is shown in Figure– 6. 1000 lit of water accounts to 1250 lit of Blue water.

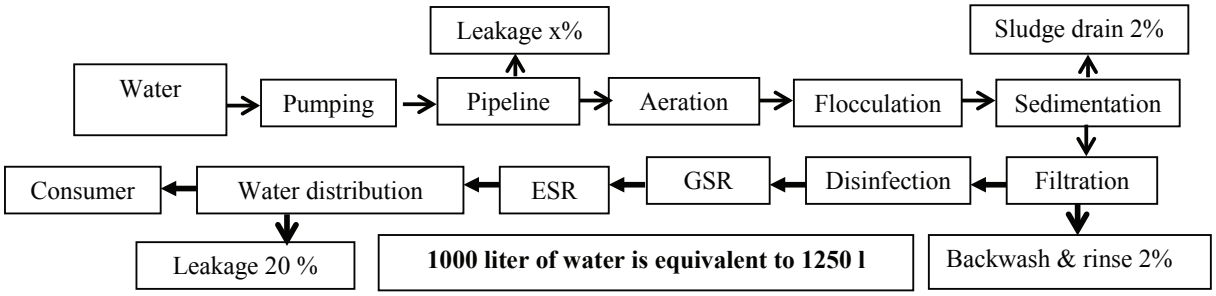

Figure – 6 Water Footprint of Water

❖ **Water Footprint of Agriculture Produce**

Traditionally Indian farming is rain-fed. However dams & ground water exploitation have brought more area under irrigation. This has increased the crop yield & has given adequate food in the bowl to have self-dependence. However it has disadvantages of increase in salinity, dependence on power supply & the bigger footprint of Blue Water of agricultural produce. Water is used for the plant growth & it gets incorporated in produce as moisture. There is loss of water by natural evaporation & evapo-transpiration. Water Footprint of produce is calculated as below.

$$WF_{Green} = GW_{Evaporation} + GW_{incorporated}$$

It can be assessed by using the crop model for evapo-transpiration based on input data of climate, soil & crop characteristics. Global average of Water Foot Print of some of Agricultural produce is given in Table - 3

Table – 3 Global Average Water Footprint of Agricultural Produce

Item	Water Footprint , l	Item	Water Footprint , l
Rice, 1 kg	3400	Banana, 1 kg	790
Wheat, 1kg	1300	Cabbage, 1 kg	237
Tomato	180	Potatoes, 1 Kg	287

❖ Water Footprint of urban dweller:-

• Water Consumption Only Calculations are given in Table - 4

Details	Value
Green Water Foot print, LPCD (Direct rain water is not used)	0
Water supply as per National Building Code, LPCD	135
Water Footprint of Water, l / l of water	1.25
Blue Water Footprint, LPCD (Drawn from natural/ manmade water source)	168.75
Sewage Generated, % of water supply	85
Water (Gray) Required to Dilute BOD raw sewage 200 to 5 mg/l, LPCD	4475.25
Total Water Footprint, LPCD	4644

◆ **Water Foot print of Food & Beverages.**

It is very difficult to arrive at the correct figure for Water Foot Print of Food consumed by Indian. This is due to varying diet & habits throughout the country. Table – 4 gives the example of some of the food & beverages we take daily. This gives an idea that our Water foot print is above 5000 l/day

Table – 3 Global Average Water Footprint of Agricultural Produce

Item	Water Footprint , l	Item	Water Footprint , l
Coffee 1 cup	140	Coca-Cola 1 l	55
Chicken, 1kg	3900	One Slice of bread	40
Potato Chips, 100 g	185	Groundnut oil refined, 1 Kg	7529
Egg one	135	Chicken 1 kg	3900

❖**Problems in Water Footprint calculation**

◆ Adequate data are not available both for agricultural & industrial sector.

◆ The values can widely differ because of different types of the process used for same product.

◆ Exclusively Blue water consumption for agriculture produce is very difficult to assess because different types of irrigation practices are followed.

◆ Water Consumption depends on availability of water & water conservation awareness.

◆ Water supply is not yet metered in all sectors of agriculture, domestic & industrial.

◆ The characteristics of receiving water body changes geographically. A few rivers in

in India are perennial. Some of rivers virtually carry waste water during the summer. Therefore the calculation of dilution water required to bring down the pollutant level to the natural level in the water body after considering its self-purification capacity is very difficult in India.

- A mathematical model is to be developed to assess Grey & Blue Water Footprint where reuse & recycle are being practiced.
- In case of reuse of waste water from one industry in other industry, the detailed calculations are required to compensate the reuse of waste water value against the Blue water.
- Lots of efforts are being made in European countries to find out the global average value. However the application in India cannot be considered as it is. We have to consider three tier values for Water Footprint.
- Small catchment or field specific
- Local, regional, national or catchment specific
- Global average
- Because of the observed water stress in all segments, efforts are being made to minimize the water consumption by adopting conservation measured, reuse & recycling of waste water. These efforts are ongoing. Therefore the values of today may differ tomorrow.

❖ Water Footprint Response Option

✓ Water Footprint of a product, consumer, community, business & nation shall be determined to get gross water consumption & check it with total water availability.

✓ The responsibility of reduction in Water Footprint from product, consumer & finally to Nation shall be shared at all the levels.

✓ The product shall be assigned the value of its Water Footprint & consumer shall be motivated to buy product of least Water Footprint. The government & media have to play major role to do this.

✓ Company shall allot the fund & act to increase Green Water Footprint, reduce Blue Water Footprint & treat & reuse waste water to reduce GreyWater Footprint

✓ In agriculture, scientists & technocrats shall work together for efficient use of rain water to optimize Green Water Footprint & better Crop & water management practices to minimize Blue Water Footprint.

✓ Planner shall consider Embeded water Footprint for proposed development plan for national water policy making

✓ The financing authority shall give weightage to Water Footprint value of the said project.

❖ Further Exploration

- To develop Methodology for Water Footprint calculations with Indian context
- Application of Water Footprint to assess the sustainability for gross water consumption required for development.
- Incorporating the Water Footprint in environmental accounts and reports similar to Energy audit.
- Inter linking Water Footprint to ecological, energy and carbon footprint methods, to bring them all in one consistence.
- Linking of Water Foot Print to material flow analysis, input-output modeling and life cycle assessment.

❖ **Recommendations**

1. Increase water productivity in rain-fed Agricultural areas. Selection of crop pattern & optimization of the rain water use shall be practiced to increase Green Water Footprint.
2. Encourage organic farming and efficient system of irrigation to reduce Gray water foot print.
3. Depending on geographical location, rainy days vary from 30 to 90. Rain water can be collected, stored & used as such or after the treatment for domestic & industrial application. This will reduce the Blue water footprint.
4. Blue water is finite & totally depending on the rains. If the rainfall is less, then Blue water source becomes critical. Therefore all efforts are to be made to minimize the Blue water consumption wherever possible, e.g. swiping out the floor with brooms followed by wiping out with the wet cloth.
5. While selecting the process & product, Water footprint of each alternative shall be studied. Alternative with least Water Footprint shall be selected. Always cost becomes the dominating factor in selection of alternative, however Water Footprint shall be given due weightage.
6. Water conservation, treatment, reuse & recycle of waste water to reduce Blue & Gray Water Footprint in Domestic & Industrial sector shall be followed & encouraged.
7. Similar to energy footprint, Water Footprint values shall be assigned to consumables.
8. Similar to Star Rating (for energy consumption) product shall be rated on the basis of its Water Footprint.
9. The Grey Water Footprint shall be considered as the efforts of corporate and manufacturers to reduce waste water generation, efficient waste water treatment, optimum reuse & recycle.
10. Urbanized areas draw their water from natural or manmade water resources. Waste water generated shall be treated & made available for agriculture & industrial activities at downstream. This will reduce the Grey Water Footprint of urbanized area & will reduce BlueWater Footprint of agricultural produce & industrial product.
11. Single or multiple recycling of the packaging material shall be promoted to reduce the Water Footprint of an individual & community.
12. Unaccountable losses like leakages, spillages etc. shall be eliminated. For example leakage in water distribution system sometimes amount to 20%. It shall be preferably stopped or minimized to reduce the Water Footprint of water supplied.
13. Support or force businesses to make annual water footprint accounts and to implement water footprint reduction measures.
14. Cluster of industries using the waste from other industries can be established to reduce Gross Water Foot Print of Growth Center.

❖ **Conclusion**

Energy & Carbon footprint are well established terminology in product assessment. Water footprint an upcoming concept & it shall be taken seriously. Efforts are to be made to develop mathematical models to calculate the Water Footprint. Blue, Green & Grey Water Footprint can help to

reduce the use of declining surface & underground water resources (Blue Water) in India. Green Water Footprint can promote direct use of rainwater. Blue Water Footprint can assess the fresh water conservation measures. Grey Water Footprint serves as indicator of waste water reduction, treatment, reuse & recycle. There is urgent need of recognition of Water Footprint by government & similar authorities. Collective efforts are required to develop the methodology for the determination of Water Footprint in India. This will become a very useful tool to reduce water consumption.

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