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Applicability of Flexible Water Bag Technology in Redistributing Surplus Water to Dry Zone of Sri Lanka

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Abstract

Two third of total land area of Sri Lanka is defined as Dry Climatic Zone (DCZ) due to its seasonal drought. As a country, attention has given to increase water availability even during the dry period and for long-term drought periods. Sri Lanka had a hydraulic civilization since fourth century BC, as a result, DCZ dwellers have adopted to paddy cultivation and other high water consumed crops. Currently, DCZ suffers from shifting climate change impacts. This paper has carefully examined the applicability of flexible water bag technology as an alternative strategy to distribute surplus water to DCZ. However, Sri Lanka receives 130 billion cubic meter of rainwater, yearly but in the same time natural river basins annually discharge 50 billion cubic meters of water to the Sea. Using a flexible water bag as a method of bulk water transportation has developed over the last few decades. These bags have evolved largely and at present, it also has capability to transport 2500 m^3 of water. This method has been tested and proven a viable solution. The main objective of the study is to determine whether, underutilized surplus water resource can be redistributed to the DCZ by using flexible water bag technology. Secondary data were used to examine the feasibility of the main objective. This study has depended on secondary data from Department of Meteorology and Department of Irrigation on rainwater density; discharging quantities of water from river basins. Analytical methodology is followed to find out the conceptual feasibility in an inductive way. The conclusion of the study confirms that the flexible water bag technology can be used to redistribute surplus water to the DCZ of Sri Lanka.

Keywords: Bulk Water Transporting, Flexible Water Bag Technology, Sri Lanka, Dry Zone, Hydraulic Civilization.

INTRODUCTION

Background of the study

Existence of mankind mainly rely on water, air and food. Life cannot exist without these three basic components. Air is freely available while water and food are not. However, food also depends on water. Therefore, it is clear that water is unarguably one of the main basic component to operate a human life.

According to Al Fry 70% of World fresh water recorded every year are being used by the farmers. While industries and domestic use are at 22% and 8% respectively (***The United Nations world water development report, 2003***). Also UNDP 2006 and OECD 2012 reports says apart from its role of being a basic necessity, water also contains an economic value as well ***(The united Nations world water development report2016).***

A larger portion of the world's workforce depends on 8 major water dependent industries. They are: agriculture, Transportation, Forestry, Fisheries, Recycling, Energy, Building and Resource Insensitive Manufacturing. Among these eight categories over a billion people comes under Fisheries, Agriculture and Forestry. This itself prove how vital the role of water when it comes to economic context is.

There is another major factor that has managed to increase the importance of water is the rapid growth of population. Along with the evolving of human civilization the population grew drastically. As a result, at preset the world population stands at 7.5 billion. The correlation between the increasing population and the amount of resources need has triggered major concerns for the scientists and lawmakers across the globe.

Beginning of the 21st century marked one such occasion where the world identified that skyrocketing population and their demands have wearied the fresh water resource, thus the living is becoming more complex and a challenging for the generations to come.

It is evident that the staggering 7 billion people is burdening the nature heavily and Water being a limited resource, it has come to a point where immediate steps are needed to find ways and methods to manage the increasing demand for water.

Therefore, Water Management and Development plans have become a central topic in the present context of the world.

Attempts to safeguard the water resource are being made through several policy frameworks such as Sustainable Development concepts and also through concepts like Green Economies. Further prominent legal frameworks have also been drawn under human rights to safeguard the rights of people to safe drinking water and sanitation. (**The united Nations world water development report2016).** However, the problem still remains at large as world is yet to find a cement solution for water scarcity.

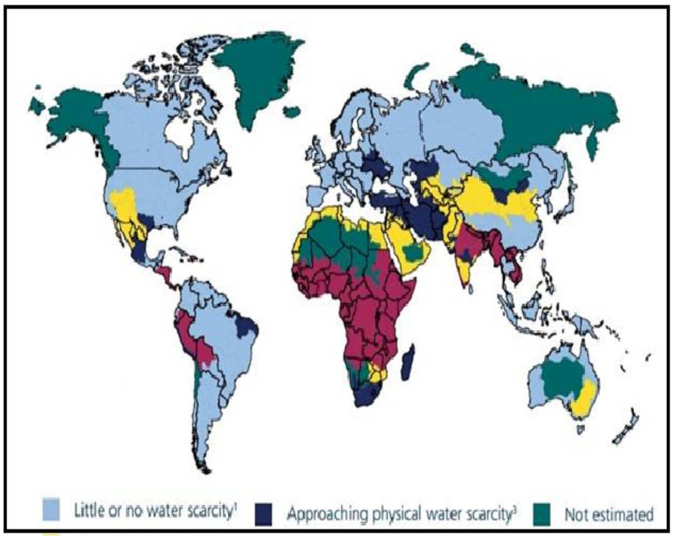
Problem Statement

In early stages, mankind selected water bodies to erect their civilizations. However, with the increasing numbers of population this system could not sustain and people had to establish their civilizations away from the water bodies. Some countries naturally inhabited easy access to water and some could not, thus create the necessity for the distribution of water.

At present it is evident that some countries like Norway, Canada, Alaska and Greenland have ample amount of water while countries in the Middle East for an example experience a water scarcity. Therefore, it is clear that the Water has not been equally distributed among the abundant life forms of the world.

However, this disparity of water distribution is not only evident among countries but also within the countries as well. Countries like Australia, Sri Lanka and United States of America are perfect examples to depict this disparity in water distribution within a territory.

Map 01: Global Physical and Economic Water Scarcity



Source: The united Nations world water development report2016

Note: Little or no water scarcity: Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purpose.

Physical water scarcity: (water resources development is approaching or has exceeded sustainable limits): More than 75% of river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition – relating water availability to water demand – implies that dry areas are not necessarily water scarce.

Approaching physical water scarcity: More than 60% of river are withdrawn. These basins will experience physical water scarcity in the near future

Economic water scarcity: (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists. *Source: CAWMA (2007, Map 2.1, p. 63), reproduced with permission from the International Water Management Institute (IWMI).(The United Nations, 2016)*

Therefore, the world needs to develop criteria to transport its water surplus, to water scarce lands across the globe. It is clear that the traditional methods like irrigational canals are not sustainable anymore as the land resource have been taken over by the growing population.Consequently, the need has arisen to find an essential solution to develop criteria to transport water in large amounts.

Research Objectives

Key Objective :

To ascertain whether the surplus water discharged by natural river basins in the country can be transported using flexible water bag technology to the dry zone of Sri Lanka.

Specific Objective:

To determine whether the underutilized surplus water resource in the island can be utilized?

To Determine the flexible water bag technology which is being used for bulk water transportation, be implemented to redistribute surplus water to the dry zone of the country?

Significance of the Study

It is now evident that some countries experience a water surplus while some are forced to experience a water scarcity and as explained above. These disparities are evident not only among countries but within territories as well.

Sri Lanka is one such example to show disparities in water distribution within a country or a territory. According to country profile, Sri Lanka receives an Annual Rainfall (Avg.) (2015) – 2,131 mm of rain annually, amounting to about 130 billion cubic meters of water(Central Bank of Sri Lanka, 2016).

There are four rainfall seasons during the year,

1. The South - West monsoon period (May to September)
2. Intermonsoon period following the South-West monsoon (October to November)
3. The North - East monsoon period (December to February)
4. The Intermonsoon period following the North- east monsoon (March to April)

Rainfall water is captured and stored in tanks and distributed through canals. This network is called the Cascade system. Surface water that remains, after evapotranspiration and seepage, drains in to sea through 103 natural river basins. Though Sri Lanka experience a 130 billion cubic meter of water every year, ¾ of its land area, 6 out of 9 provinces and 14 out of 25 administrative districts is climatically defined as the dry zone. Dry zone has always been an agro culturally difficult area due to its relatively low rainfall and prolonged dry season sometimes spreading over 6 to 7 months *(Plan Sri Lanka, 2010).*

This clearly indicates that there is an unequal distribution of water within the country. Due to this phenomenon, inhabitants of the dry zone have less access to water. This situation has expanded the density of the issues faced by the people when attempting to full fill their basic needs related to water. Such as drinking, Cooking, Sanitary and other industrial and commercial purposes. The people who are worst affected are the ones who have less access even to pipe born water.According to the data given by Department of Censes & Statistics only 40% of Sri Lankan population has organized water supply facilities and 59.4% is depending on other sources such as wells, tube wells, streams and rivers etc., including 10% on unprotected sources *(Gamini, n.d.).*

However, in the present setting as the land resource have also become scarce due to the high population growth rate, allocation of large portion of land space required to erect a traditional water redistribution mechanism is also challenging. Therefore, it is inevitable that the country cannot no longer depend either on cascade system or any other surface water distribution or storing systems. This situation is forcing the lawmakers to find an innovational alternative to redistribute the surplus water to the dry zone of the country.

Research Problem

How to design criterion for water redistribution in Sri Lanka to address drinking water scarcity in areas without access to pipe born water in Hambantota District Secretariat Division.

Research Question

1. Can underutilized surplus water resource be utilized in Sri Lanka?
2. Can underutilized surplus water resource be utilized to solve the drinking water scarcity in Hambantota District Secretariat Division?
3. Can the flexible water bag technology which is being used for bulk water transportation, be implemented to redistribute surplus water to the dry zone of the country?

LITERATURE REVIEW

Water Resource

This study highlights the importance of water redistribution. One of the main academic disciplines to be discussed is, Fresh Water Resource. according to UN World Water Development report less than 3% of the world's water is fresh and the rest is seawater which is undrinkable.Of this 3% over 2.5% is frozen, locked up in Antarctica, the Arctic and glaciers, and not available to man. Thus humanity must rely on this 0.5% for all of man's and ecosystem's fresh water needs *(The United Nations, 2016)(The United Nations, 2003)(Fry, 2006).*

Since 1950 there has been a rapid expansion of groundwater exploitation providing: 50% of all drinking water 40% of industrial water 20% of irrigation water. 119,000 km3 net of rainfall falling on land after accounting for evaporation. 91,000 km^3 in natural lakes. Over 5,000 km^3 in man-made storage facilities –reservoirs. There has been a 7-fold increase in global storage capacity since 1950. 2,120 km3 in rivers – constantly replaced from rainfall and melting snow and ice ***(The United Nations world water development report, 2003)*** ***(The United Nations world water development report, 2016)*** *(Fry, 2006).*

Population and Demand

Population:

Between 2011 and 2050, the world population is expected to increase by 33%, growing from seven billion to 9.3 billion *(United Nations Department of Economic and Social Affairs,2011),* and food demand will rise by 60% in the same period *(Alexandratos and Bruinsma, 2012).* Furthermore, it is projected that populations living in urban areas will almost double, from 3.6 billion in 2011 to 6.3 billion in 2050 *(United Nations Department of Economic and Social Affairs,2011).*

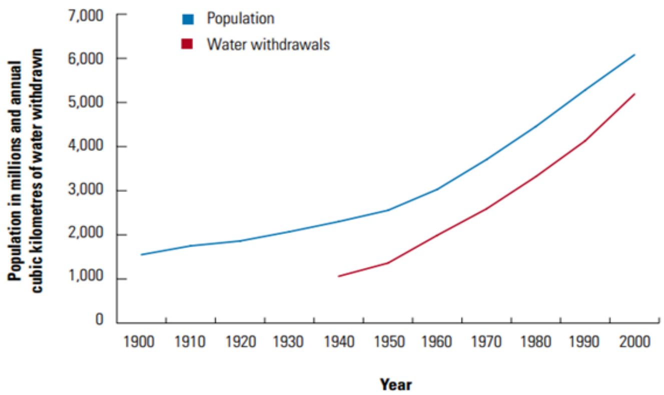


Figure 01: World Population and Freshwater Demand

Source:(The United Nations World Water Development Report,2003)

As population increases, freshwater demand increases and supplies per person inevitably decline. Per capita water supplies decreased by a third between 1970 and 1990 and there is little doubt that population growth has been and will continue to be one of the main drivers of changes to patterns of water resource use *(United Nations Fund for Population Activities Report 2002).* Future projections of worldwide population growth have been revised downward in recent years, primarily as a result of significant declines in birth rates. Although there are differences of opinion, most projections expect this slow- down of growth rates to continue and for the world's population to stabilize at about 9.3 billion people (still over 50 percent higher than the 2001 population of 6.1 billion) somewhere in the middle of the twenty-first century *(United Nations Fund for Population Activities Report 2002).* Nearly 7 billion people in sixty countries will live water-scarce lives by 2050. Even under the lowest projection, just under 2 billion people in forty-eight countries will struggle against water scarcity in 2050 *(Gardner-Outlaw and Engelman, 1997)(The United Nations, 2003).*

Demand

Among the major consumers of water, Agriculture accounts for roughly 70% of total freshwater withdrawals globally and for over 90% in the majority of Least Developed Countries (LDCs) *(Food and Agriculture Organization, 2011).* Developed countries generally withdraw less for agriculture and more for energy. Production and large industry, which account for 15% and 5% of global withdrawals, respectively. Fulfilling the water-related needs of households (for drinking water, sanitation, hygiene, cleaning, etc.), institutions (e.g. schools and hospitals) and most small- and medium-sized industries, municipal systems account for the remaining 10% of global freshwater withdrawals *(World Water Assessment Programme,2012).*

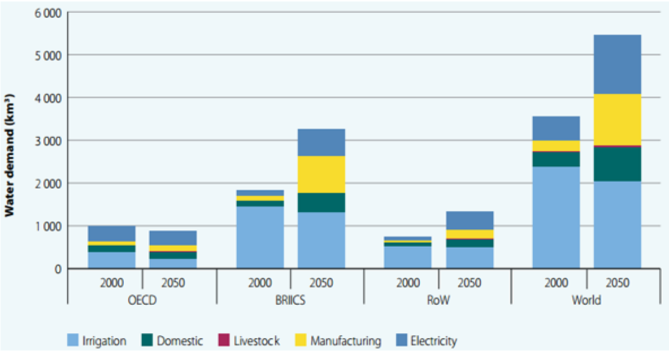


Figure 02: Global Water Demand (Freshwater Withdrawals): Baseline Scenario, 2000 And 2050

Source: OECD (2012, Fig. 5.4, p. 217). (The United Nations World Water Development Report,2016) (This figure only measures 'blue water' demand and does not consider rain fed agriculture).

BRIICS - Brazil, Russia, India, Indonesia, China, South Africa

OECD - Organization for Economic Co-operation and Development

RoW - Rest of world.

Sri Lankan problem

Study focuses on redistributing surplus water in Sri Lanka to areas that are not accessible even to pipe born water in Hambantota district. It is difficult to provide pipe borne water supply coverage to the entire Island. Capital investment to produce one cubic meter of water is around Rs. 300,000 to 400,000. In order to recover the capital cost and O&M cost, it is required to sell a cubic meter of water at the rate of Rs. 125 to Rs. 150. Therefore, it is essential to introduce demand management measures such as;

i) Reducing water leakages; one of the main losses. It is mainly due to poor quality of water fittings, and substandard plumbing systems. Regulatory measures are required in order to procure quality water fittings and installation services.

ii) Rain Water Harvesting is to be promoted as an alternative source of supply, and a special subsidy may be provided to identify areas where the population densities are very low, and distribution investments are very high.

iii) Water saving equipment is to be available for the consumers at subsidized rates; and such technologies should be popularized.

iv) Water conservation measures are to be introduced to the school curriculum in order to promote a water saving culture in our country*(Gamini, n.d.).*

Therefore, innovative methodologies are required to identify the cost of providing water supply facilities and to implement a cost recovery system in order to meet the challenges in the water sector.

Bulk Water Transportation

Flexible water bags as a method of bulk water transportation

Intentional movement of water through human intervention over as large distance is called water transportation. Water transportation occurs in both large and small quantities and methods used for this exchange falls under three categories.

1. Aqueducts - which include pipelines, canals, and tunnels.
2. Container shipment - which includes transport by tank truck, tank car, and tank ship.
3. Towing - Where a tugboat is used to pull an iceberg or a large water bag along behind it. (Malagnoux, 2008).

Figure 03: Example Flexible water bags

Source: http://static.euronews.com/articles/322071/1000x563_322071.jpg.

Flexible Water Bag Technology

Spragg Bag

The bags that used in Spragg technology can vary in sizes. One bag would average approximately 43 feet in diameter and 500 feet in length with the capacity of 4,500,000 gallons of water (17,000 m3). But the size of the water bag depends on the loading and off-loading requirements.

CH2M-Hill, an engineering firm produced five special studies for Water bag loading and off loading facilities under the contract with Spragg and Associates and their findings on water delivery system have given in the list below.

1. Shore side facilities to handle water from the source (i.e., pump stations, water storage structures, etc.) and ocean pipelines to the offshore water-loading platforms.
2. Water-loading platforms to fill the bags
3. Bag assembly facility to prepare and deliver empty bags to the water-loading facility
4. Transport system to tow full bags to a marshaling facility
5. Marshaling facility to assemble bags into towing strings for transport to delivery sites
6. Off-loading facility to remove water from the bags
7. Empty bag handling and transport system to rig empty bags for the return trip to the loading facility.
8. Mooring and bag handling facilities in the vicinity of the off-loading facility
9. Ancillary facilities, such as water filtration plants, booster-pump stations, pipelines to municipal reservoirs or wells, and ocean pipelines from the off-loading facilities *(http://www.waterbag.com/).*

Moreover, a specially designed system of coated fabric and a fiber connection has also been used to meet the required strength of over 1000 pounds per inch for both bags and interconnection skirts. According to Laborde Marine, a 4,300 horsepower tug with a bollard pull of 110,000 pounds can pull a string of fifty bags (500-foot long) weighing 1,300,000 tons, at a speed of 3 knots.

Spragg bag proved its viability when the engineers at the Massachusetts Institute of Technology conducted an extensive stress and vibration test on zipper, fabric and tow system. They applied over 1000 pounds per inch and it successfully survived. Therefore, a string of fifty bags have the capacity of delivering a 228 million gallons (850,000 m3) of water per trip *(http://www.waterbag.com/).*

Economic aspects of Water Bags

The cost to transport water 300 to 800 miles (1,300 km) through the ocean, based on deliveries of 5 million US gallons per day (19,000 m3/d) to 10 million US gallons per day (38,000 m3/d), is estimated to be between $350 to $450 per acre foot, depending on the length of the voyage and the amount of water delivered per trip. Increasing the amount of water delivered per day in each waterbag train will help to significantly reduce the cost of the water delivered. Once the reliability of the waterbag delivery system has proven its economics and reliability it will just be a matter of adding more water bags to the trains, and more trains to the system in order to increase the amount of water delivered to selected locations, while also reducing the cost of the water delivered. Based on the increasing reliability of the waterbag delivery system over time, it should be possible to be able to economically deliver 100,000's of acre feet per year to many coastal locations around the world.

According to the inventor of the Spragg bag, the total cost of delivering fresh water down the California coast by his waterbag technology for a distance of 800 miles (1,300 km) from British Columbia to Monterey would cost about $966 per acre-foot per year. Keith Spain in a study for a Master of Arts then shows in an analysis that it would save the residents of the Monterey Peninsula some $1,134 per-acre foot otherwise using a desalination plant. This is a savings of over $19 million per year for the Monterey taxpayers. This number assumes a usage of approximately 17,000 acre feet (21,000,000 m3) per year (17,000 X $1,134 = $19,278,000 savings) (Malagnoux, 2008).

RESEARCH METHODOLOGY

Research Design

The main focus of this study is to understand the possibilities of using bulk water transportation to redistribute the surplus water of Sri Lanka to the dry zone of the country.

Data Collection and Methods

Secondary Data

Department of Meteorology data was used to identify the Climatic zones and the average annual rainfall of Sri Lanka and to do a comparative study on the rainfall patterns to catchment areas of Kalu-ganga (which is the center attention of the study) and Kuda Wella South GND in Hambantota DSD. Records of Hydrology division of the Department of Irrigation was used to identify 103 natural river basins in Sri Lanka and also to identify the river with the largest run off.

Data from Hambantota Districts Secretariat division was gathered on the 582 Grama Niladari divisions to identify areas without pipe born water supply.

UN World Water Development Reports was cited to identify existing scenarios, trends, definitions, parameters, special characteristics, threats or challenges, facts and figures of the world fresh water resource. Secondary data from internet was used to gather information on bulk water transportation methods practiced in other countries. Apart from that internet, Journal articles and previous studies were referred to study about the concept, technological evolution and implementation of flexible water bags as an innovational method for bulk water transportation and to identify other methods used in rest of the world to address the water scarcity.

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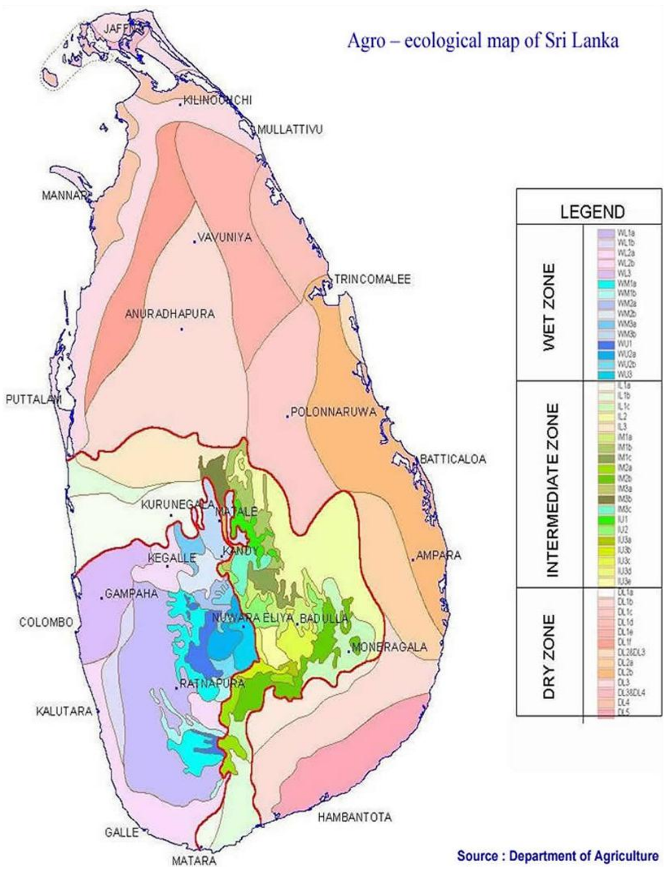
Sample

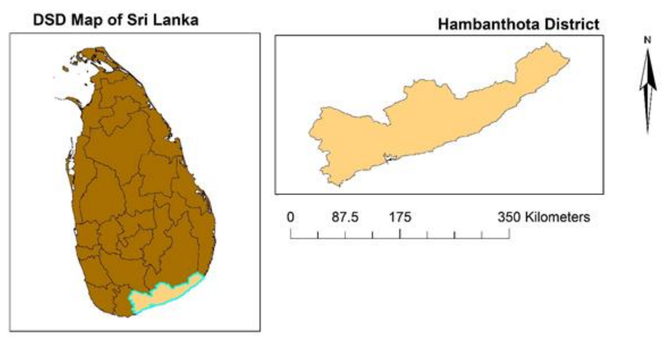
Climatic zones of Sri Lanka



Map 02: Agro Ecological map of Sri Lanka.

Source: Department of Meteorology (based on Department of Agriculture)

Hambantota district is the most affected district among other districts of the island from water scarcity.



Map 03: Geographical location of Hambanthota

Source: Constructed by Researcher

Kudawella South in Hambantota District was selected as the main study area. It is situated in close to the sea. This factor is critical when implementing bulk water transportation. Furthermore, Kudawella is also one of the worst affected from water scarcity and with a less coverage of pipe born water as well.

Map 04: Kudawella South GND

Source: Constructed by Researcher

Kalu-Ganga

Kalu Ganga belongs to the wet zone of the country and it also holds the largest run off in the country. Therefore, it was selected as the main resource source to implement a bulk water transportation method (Appendices 1)**.**

Even though this data set was presented in 1974 the latest data collected from the Putupaula one of the observation stations of the Irrigation Department (Hydrological Annual Report 2012/13), proves that Kalu-ganaga holds the largest runoff in Sri Lanka (Appendices 2).

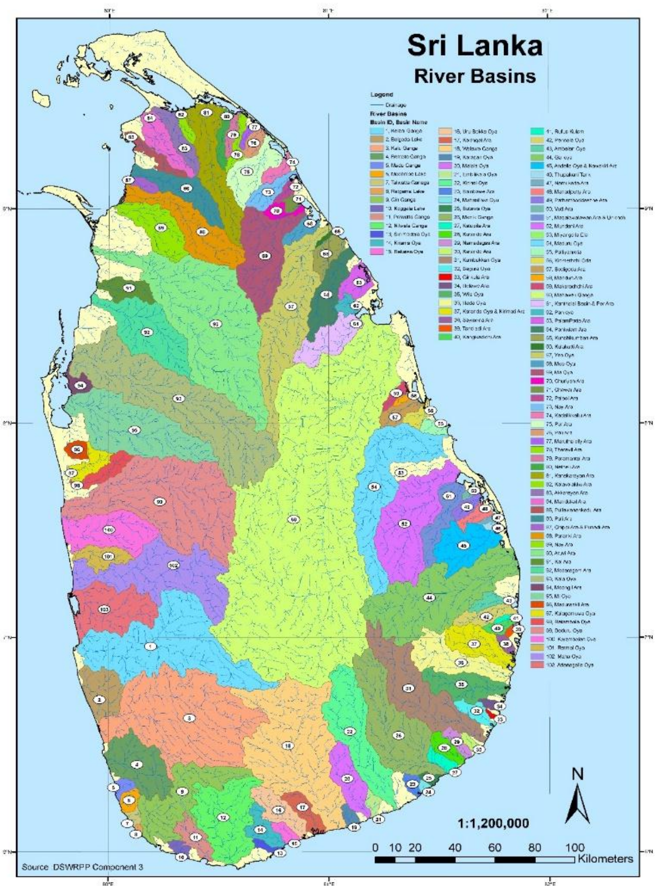
Limitations of the study

Bulk water transportation was not a method used in Sri Lanka for water distribution, therefore knowledge on theoretical and practical implication of this method in the Sri Lankan context was not available.

Countries that have already implemented bulk water transportation projects using flexible water bags have not fully disclosed the costing behind the entire project or the costing for the flexible bags. Therefore, estimating a proper cost for the study was challenging. Study focuses on finding possibilities of dragging a flexible bag filled with fresh water on the sea water from a small scale vessel or barge from one place to another. Therefore, it is important to finalize a cost for such an operation in order to identify the viability of such a project. But due to many natural variables affecting the costing of the journey it was difficult to finalize a price or a value for the project. The runoffs of the 103 natural river basins in Sri Lanka was not given in the annual Hydrology Report of the Irrigation Department. The only available data was presented separately and that was also not published. As a result, conducting a proper comparative analysis between the runoff's of these rivers was challenging. The researcher had to obtain all the unconnected data of the 103 river basins when selecting Kalu-Ganaga as the sample for the research to study possibilities of bulk water transportation. Among the available data only some river basins out of 103 had full data spanning for last 10 years (Ex: Records of Walawe ganga was not reported continuously during the last 10 years)

ANALYSING

Countries like Norway and Suriname use bulk water transportation to export their water resource to other countries. United States of America use bulk water transportation to redistribute their water resource to water scarce areas within their borders as well.These examples from the globe can be taken as a paradigm for Sri Lanka as well. Suriname and Norway are two countries that are open for sea and has a surplus water resource and they engage in water exporting commercially.With an annual Rainfall (Avg.) (2015) – 2,131 mm, amounting to about 130 billion cubic meters, Sri Lanka too comprise with a surplus water resource.



Map 05: Sri Lanka River Basins

Source: Department of Irrigation

Being strategically positioned in the Indian Ocean between countries like Australia and Middle East which has a high demand for fresh water Sri Lanka can take Norway and Suriname as perfect examples to engage in bulk water transportation for commercial purposes as well.

Meanwhile when compared with the US situation, where they use bulk water transportation to redistribute the ample amount of water available to the water scarce areas within their territory, Sri Lanka with 103 natural river basins and a rich annual rainfall also possess the capacity to practice the American method and address the water scarcity issues in the country.

Despite the rich water availability, 6 out of 9 provinces and 14 out of 25 administrative districts in Sri Lanka is climatically defined as the dry zone (Map 02: Agro Ecological Map of Sri Lanka). Island experience a surplus water resource and it overflows annually through natural river basins.

Flexible Water Bags

It is significant to examine the importance and the viability of the flexible water bag technology which is introduced in this study, when compared with the ancient surface irrigation system practiced in Sri Lanka up to date.

Cascade system comprise with irrigational canals was used to collect and distribute water to the dry zone in Sri Lanka in the old days, however the sustainability of this system was challenged after the independence in 1948 and as a result projects like Mahaweli and Gal Oya was launched to strengthen the supply of water to the dry zone in the country.

Nevertheless, such large scale projects required a large land area and allocating the required space for these projects became problematic in the last phases of these projects. And the result was underground tunnels like Uma Oya and Upper Kothmale.

But then in the present context the population of the country has increased and along with that demand for water has similarly increased. Unfortunately, the available land resource is declining thus allocating more time, money and space to develop a surface water distribution system is proving to be questionable.

However, compared with the surface water distribution method, transporting water via a flexible bag is an economically sound solution. The capital cost and the maintenance charges are minimal. The most highlighted fact is that a flexible water bag will not consume a large area of land compared to the surface water distribution system currently implemented in Sri Lanka.

It is clear that allocating more land for surface water distribution methods are not a sustainable answer for the problem at hand, land resource is fixed and cannot be propagated and at a situation like this Sri Lanka can easily test flexible water bags as a bulk water transportation method.

Kalu Ganga

Kalu Ganga which starts and ends its journey within the wet zone possesses the largest runoff in the country among the 103 natural river basins. However, Kalu Ganga records an annual

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discharge amount of 72.4% as a percentage of precipitation while river Mahaweli records only 30.9%.(Figure 09: 103 Rivers in Sri Lanka) Kalu Ganga also receives an annual precipitation volume of 11,302 (mcm) while Mahaweli records 26,368 (mcm)(Manchanayake & Madduma Bandara, 1999).

Comparison of these two river basins clearly shows that the water of Kalu Ganga is not being properly utilized and can be used to address the water scarcity in the dry zone of the country or in another country.

Map 06: Geographical Location of Kalu Ganga River Basin

Source: Google Maps

Water Pumping and Unloading

Meanwhile in his study on Malwathu Oya river basin Nagamuthu Piratheeparajah of the university of Jaffna, department of Geography has identified that fresh water released from Malwathu Oya river in its maximum capacity (300 cubic meters per hour) is not contaminated by the salt water for about 1km space from Arippu delta and in to the sea (Piratheeparajah**.** N, 2016).

When using a flexible water bag for bulk water transportation, water pumping and discharging mechanism plays a major role but compared with the technology used to build the bag loading and unloading mechanism is simple.

Mechanism used by Spragg bag and REFRESH water bag to pump water and to unload water from the bag can be compared to a simple mechanism of water pumping and unloading techniques of a water bowser.

Therefore, with the findings of Nagamuthu Piratheeparajah it is clear that Malwathu Oya has a 1km stretch of fresh water into the sea and such a condition is a sound background to pump water into a flexible water bag. If the findings of Piratheeparajah can be generalized, such an environment can ease the process of obtaining water from the Kalu Ganga river basin as well.

Thus it is clear that Kalu Ganga holds a suitable environment to practice a bulk water transportation method.

Kudawella South

Despite the water surplus, Sri Lanka also have areas like Hambantota that comes under the dry zone which experienced a low rainfall and a prolonged dry season sometimes spreading over 6 to 7 months *(Map 02: Agro Ecological Map of Sri Lanka).*

Hambantota is a coastal district secretariat division which comprises with 582 Gramaniladari divisions, among them Kudawella South is the closest GND to the sea (Map 03: Geographical location of Hambanthota) (Map 04: GNDs with and without pipe Born Water Supply in Hambanthota) (Map 05: Kudawella South GND).

Geographical position

Map 07: Distance between Kalu Ganga Basin and Kudawella South.

Source: Google Maps

This locational information shows that bulk water transportation method can be easily implemented to address the water scarcity in the Kudawella South by using the surplus water of the Kalu Ganga. It is now clear that Sri Lanka possess the availability and the capability to use flexible water bag technology as a bulk water transportation method to address the inland water scarcity.

CONCLUTION

When developing a certain country, a land or an area the quantity of the resources available has to be increased or the technology that is being used to utilize the available resources have to be modified. This is a common statement which is applicable to Kudawella area in Hambantota as well. Study explains that along with Kudawella the entire Hambantota district is affected with water scarcity.

Solving the water scarcity faced by the people living in Hambantota by increasing a natural element is not possible, the ancient methods used for water storing and distributing in Sri Lanka is not anymore a valid practice to distribute water sufficiently to Hambantota district. Therefore, it is clear that the country need to adopt a new mechanism or develop a new technology to address the water scarcity issue in Kudawella Gramaniladari Division in Hambantota District Secretariat Division.

As explained in the study Sri Lanka holds a large amount of surplus water and a major portion of it flows directly to the sea through 103 natural river basins, leaving ¾ of the country in dry zone. Therefore, a need has ascended to develop a mechanism to redistribute the underutilized surplus water to the water scarce areas in the country. A sound solution to cater this demand is to use flexible water bag method which is one of the bulk water transportation methods used in the world. Consequently, Sri Lanka has come to a point where the policy makers have to lean towards developing a mechanism to redistribute its surplus water by using a bulk water transportation method such as flexible water bag method, rather than resorting to old methods like storing rain water in tanks or dispensing it through a surface distribution method.

Development issues related to water in Sri Lanka is not triggered due to the lack of water availability. The problem is clearly not with the quantity but with the technology that Sri Lanka use to utilize the available water resource.

APPENDICES

Appendices 1 – Top 5 Water Resources in Sri Lanka based on annual discharge

Basin No.	Name of Basin	No-of River Gauging Stations	Catchment Area Inn'	Mean Annual Precipitation volume (mcm)	Mean Annual Discharge Volume to sea (mcm)	Annual Discharge as a % of precipitation
1	Kelani Ganga	09	2292	8660	5579	64.4
2	Bolgoda Ganga		378	1061	485	45.7
3	Kalu Ganga	05	2720	11302	8183	72.4
4	Bentara Ganga		629	2153	1247	57.9
5	Madu Ganga		60	202	119	58.9

Note: Irrigation Department start counting a year from October and ends in September.
Source: Records maintained by Hydrology Division, Department of Irrigation Sri Lanka

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