Sustainable Water Resources Development in Tamil Nadu, India Through Water Security Pathways

Dr. P.M.Natarajan*, Dr. M. Ponnavaiko** Shambhu Kalloikar*** Dr. G. Rangaraju**** and S.Ganesh*****

* Member - Working Group, Planning Commission, Government of Tamil Nadu, 155, 8TH Cross Street, Arulanandanagar, Thanjavur 613 007, Tamil Nadu, India; E-Mail: natarajan_pm@yahoo.com
**Vice Chancellor, Bharat University, Chennai, Tamil Nadu, India: E-mail: ponnav@gmail.com
***Commissioner, Horticulture, Government of Tamil Nadu, Chennai, 600005, Tamil Nadu India E-Mail: shambuias@yahoo.com
**** Former Director, Soil and Water Management Institute, Thanjavur E-Mail: gr_tnau@yahoo.co.in
***** Collector, Pudukottai District, Government of Tamil Nadu E-Mail: ganeshas@rediffmail.com

Abstract

India is one of the wettest nations. However, few states including Tamil Nadu are reeling under water miseries due to lack of effective water security pathways. However, it is possible to additionally generate or, save 28.32km^3/1,000TMC of water and enhance to 74.84km^3/2,643TMC from the 46.52km^3/1,643TMC in Tamil Nadu by water management. Even then, the per capita per annum water deficit will be 684m^3(59.76%) in 2050 comparing the Falkenmark Water Stress Indicator at 1700m^3. Therefore, the main option for permanent water security to this state is sharing the unutilised 1,728km^3/61,023TMC of water let into the sea in India.

Key words: Water scarcity, Water security pathways, Action Plan, Sustainable water resources development

1. Introduction

Tamil Nadu is the southernmost state of India, delimited with Indian Ocean on the south, Bay of Bengal in the east and on the west, north and east by Kerala, Karnataka and Andhra Pradesh states respectively-Figure 1. With the geographical area of 130,058km^2, this state covers 4% of the total area of India, 7% of population and 3% of water resources.

Figure 1

Total water resource of Tamil Nadu is 46.52km^3/1,643TMC including 23.05km^3/814TMC groundwater potential. Due to the poor water resources coupled with changes in the hydrologic cycle, pollution of water etc., this state is facing severe water stress in many years.

The per capita annual water availability of this state is 590m^3 against the Falkenmark Water Stress Indicator, (Falkenmark, 1989 and Amber Brown Marty D. Matlock, p-2) [a country or region is said to experience "water stress" when annual water supplies drop below 1,700m^3 per person per year] and the

XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico. 29 May- 3 June, 2017

deficit befalls 1,110m^3(65.29%) now. ***If the water resource of this state is not improved, the per capita water resource in 2050 will drop to 416m^3 with a deficit of 1,284m^3(75.53%), facilitating to provide only one meal in a day to the people of this state.*** Therefore, only by effective water security pathways, mainly by sharing the excess water let into the sea in India, the water miseries of this state could be arrested permanently. Hence, the objective this paper is to bring Tamil Nadu without water misery by water management.

2. Methodology

In the present context of water stress, both the water rich and the water deficient nations have started to adapt more than 30 water management strategies to sustain water resources development (Natarajan, P.M, Ph.D and Shambhu Kallolikar, 2004, p-13 and 14). Since Tamil Nadu is reeling almost in absolute water scarcity, the authors are suggesting water security pathways to sustain water resources development.

3. Favorable Water security pathways to Tamil Nadu

The ideal pathways to attain water security to Tamil Nadu are 1.Flood and rainwater harvesting 2.Artificial groundwater recharge 3.Wastewater management 4.Offseason tillage 5. Saving water in agriculture 6. Desalination 7. Enhancing irrigation efficiency 8. Rejuvenation of water bodies and 9. Water sharing.

3.1 Flood and rainwater harvesting

T.S.VijayaRaghavan Committee, estimated that in 7 river basins (Figure 2) of Tamil Nadu State, about 76.94TMC (thousand million cubic feet) of floodwater is let into the sea in the normal monsoon years 1.Palar 12.50TMC 2.Pennaiyar 9.09TMC 3.Vellar 21.47TMC 4. Vaigai 3.26TMC 5. Vaippar 4.73TMC 6. Tamiraparani 11.39TMC and 7. Kodaiyar 14.50TMC (The Hindu, June 23, 2014). In addition to this about, 50TMC of floodwater per annum in the Coleroon River of Cauvery Delta is let into the sea as and when there is sudden floodwater release from Karnataka, which could not be harvested there. Therefore, in Tamil Nadu about 100TMC of floodwater is let into the sea in every normal monsoon year.

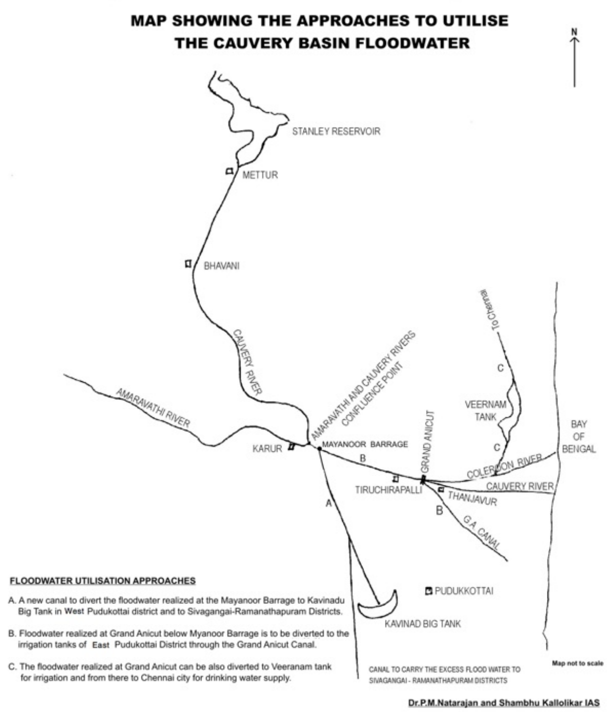
Figure 2

The floodwater can be harvested in the existing storages after rejuvenation. The floodwater in the Mayanoor Barrage and Grand Anicut can be diverted to 1. Kavinadu Big Tank in Pudukottai district to supply water for irrigation to the western region 2. Sivagangai and Ramanathapuram drought prone districts 3. Veeranam tank for irrigation and 4. Chennai city from this tank for drinking. ***The immediate action to use the floodwater in Grand Anicut is to bring it to the east Pudukkottai tanks through the rejuvenated Grand Anicut Canal (this can be done with less spending by minor earthwork)-Figure 3.***

In the Cauvery delta about 55TMC rainwater can be harvested. This water can be harvested in the new farm ponds of the farmers' land at 1500m^3 in each pond.

In certain monsoon years (1970, 2005, 2015) about 500TMC-1000TMC floodwater is generated. To store the floodwater including Chennai, new storages are to be created.

Figure 3



3.2 Artificial groundwater recharge

Since groundwater is the '***democratic resource***' of people, there is heavy extraction over and above the recharge. Hence, there is depletion and seawater ingress in the coastal aquifers in many nations including in Tamil Nadu. By adapting spot specific artificial groundwater recharge techniques continuously for more than a decade in Tamil Nadu, it is possible to recharge 3metre and 4metre thick sedimentary and hard rock terrains' aquifers respectively and additionally recharge about 375TMC of groundwater.

3.3 Wastewater management

In Tamil Nadu about 126TMC of water is used per annum for domestic use at about 135litres per capita per day. In this water about 101TMC is generated as wastewater and let into the water bodies and open space mostly without treatment.

By treating and recycling the wastewater for non-domestic purposes like toilet flushing, cooling, washing, gardening, irrigation etc., about 100TMC of fresh water can be conserved. By industrial effluent management, the state can conserve about 20% water.

Through advanced stage of treatment, the treated sewage can be used even for drinking. Now Singapore, Australia, Namibia and states such as California, Virginia and New Mexico are already drinking recycled water, demonstrating that purified wastewater by a sewage treatment plant can be safe and clean, and help to ease fresh water shortages (Renee Cho, April 4, 2011). To preserve the freshwater in the hydrologic cycle wastewater management is necessary.

3.4 Water saving in agriculture

Cultivation practices like Off-season tillage, System of Rice Intensification (SRI), Sustainable sugarcane initiative, Crop substitution, Micro irrigation techniques, could bring water saving, besides other benefits.

3.4.1 Soil moisture enhancing by summer ploughing

By summer ploughing, the February (21.5mm) and the subsequent rains (103mm) [March: 17mm; April: 34mm; May: 52mm] can be facilitated to absorb and retain in the soil. Otherwise, summer rain is lost as runoff, evaporation and transpiration. Hence, the Soil can be nearer to its field capacity at the start of cropping season-that varies from 5cm in fine textured soils and to 2cm for light soils in the root absorption zone. By retaining about 3.5cm of rainfall as soil moisture, the soil can be made to hold about 62TMC of water in the 50.62lakh.ha gross area sown in this state.

3.4.2 System of Rice Intensification

Based on the success of paddy cultivation by System Rice Intensification (SRI) in Madagascar, many countries, adapt this method now. Since, SRI method can produce significantly higher paddy yield with lower production costs (seeds, pesticides, laborers) than conventional practices, it is generating higher profits to farmers. Higher paddy yield obtained with SRI cultivation is the result of the combined effects of 1. SRI transplanting methods 2. Organic nutrients and 3. Intermittent irrigation with sufficient dry periods. Further, the considerable savings of water (during land preparation 530m^3/ha, during nursery preparation 375m^3/ha and during vegetative and reproductive stages 19,387m^3/ha: Total water saving 20,292m^3/ha) with SRI at field level results in substantial savings of electric energy at 3,028kWh per hectare. The reduced extraction of groundwater and increased water productivity in SRI would be an additional benefit, having long-term benefits of maintaining groundwater reserves that are declining faster due to over use, especially for the cultivation of summer paddy (Dhananjoy Dutta and Bishnu Charan Mahato, 2012, p-5).

Out of 19.3lakh ha under rice cultivation in Tamil Nadu, by bringing about 14.5lakh ha (75%) under SRI the state can gain about 150TMC of water at 300mm per ha. If the entire land under rice in Tamil Nadu is brought under SRI, a huge quantity of water can be saved.

3.4.3 Alternate cropping in wet land

Substituting dry cops like ragi, cambu, cholam, chillies, sunflower, pulses which require between 350mm and 600mm water to rice which needs 1200mm water in 1000,000Ha of wet land, it is possible to conserve 21.3TMC of water at 650mm per ha. Hence, there is scope to save more water if additional wet crop area is brought under dry crop cultivation.

3.4.4 Micro irrigation

Micro irrigation techniques are used for many crop types. Under this technique, irrigated dry crops and sugarcane are considered now for Tamil Nadu. At 150mm per ha about 50TMC of water can be conserved from 1,000,000ha of irrigated dry crops and at 650mm per ha about 69TMC of water can be saved from 300,000ha of sugarcane area.

Hence, feasibility exists for saving about 352.3TMC of water from agricultural sector alone.

3.5 Desalination of seawater

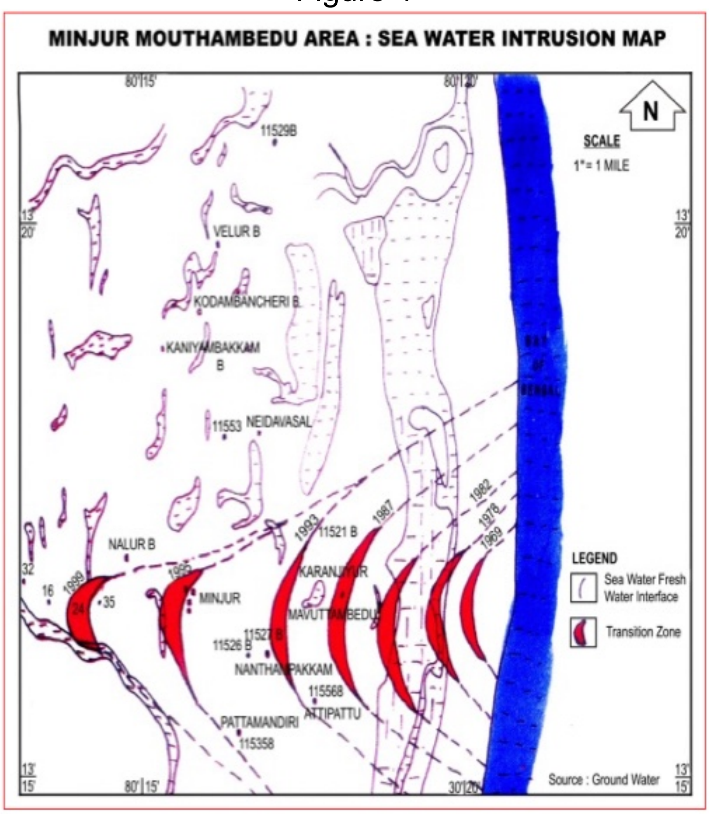
Currently there are more than 18,000 desalination plants in operation worldwide in 130 countries. About 90million m^3 of desalinated water per day is under production and used for various purposes and this quantity works out to 32.85km^3/1,160.08TMC per annum (Global Clean Water Desalination Alliance, 2015, p-2). So, more than 12 times the capacity of the Stanley Reservoir (93.45TMC), Tamil Nadu, India is desalinated.

Since, desalinated water is easing the water stress in many countries. ***Perhaps this source is likely to stop the third world war, believed to arise because of water scarcity.*** For the present Tamil Nadu coastal population, about 30TMC of water at 135lpcd for domestic use is needed. This water can be supplied from desalinated seawater to the coastal districts first and subsequently to inland in Tamil Nadu in phases. By this approach, the freshwater of this state can be used for other purposes.

3.6 Arresting seawater intrusion

Due to heavy groundwater pumping in many coastal region countries, exceeding the replenishable capacity of the aquifers, there is huge depletion-seawater ingress and salinisation of aquifers. In Minjure and Mouthambedu well fields located north of Chennai City, Tamil Nadu, the fresh groundwater aquifer has been salinised to a length of about 20km from the coast with a seawater migration rate at 427m per annum-Figure 4 (Natarajan, P.M, Ph.D and Shambhu Kallolikar, 2004, p-196).

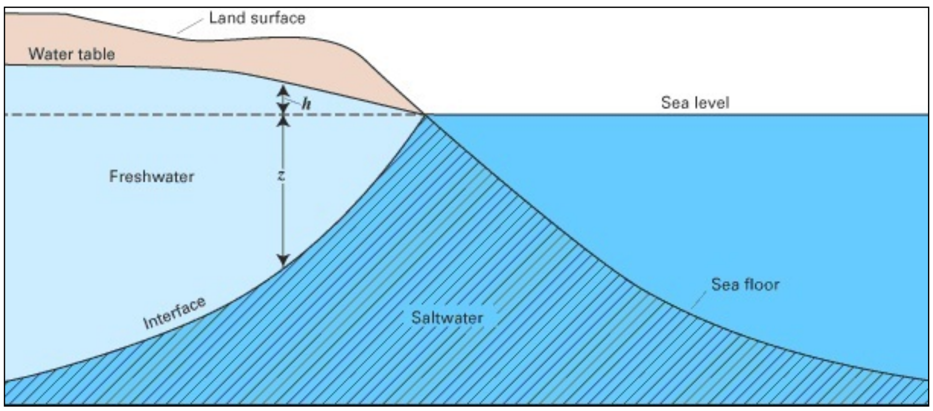
Figure 4



This scenario suggests that about 50% of the fresh groundwater available in the sedimentary aquifers of this state is likely to be salinised shortly if the salinisation trend is not stopped by recharge.

The two hydrologists Ghyben and Herzberg studied the groundwater in the coastal area of the Europe and found that the seawater is below 40 times of the fresh groundwater column/thickness of the coastal aquifer below mean sea level (Hilton H. Cooper, JR, et al, 1964). Due to the density variations of the sea and groundwater, the above hydrological situation occurs in the coastal area aquifers. This relationship is mathematically explained below with the help of a seawater and groundwater model–Figure 5.

Ghyben-Herzberg relation-Figure 5



The figure shows the Ghyben-Herzberg relation. In the equation,

$$z = \frac{\rho_f}{(\rho_s - \rho_f)} h$$

the thickness of the freshwater zone above sea level is represented as h and that below sea level is represented as z. The two thicknesses h and z, are related by ρ_f and ρ_s where ρ_f is the density of freshwater and ρ_s is the density of saltwater. Freshwater has a density of about 1.000 grams per cubic centimeter (g/cm^3) at 20°C, whereas that of seawater is about 1.025 g/cm^3. The equation can be simplified to,

$$z = 40h.$$

Therefore, by developing the groundwater in such a way by keeping one-foot fresh groundwater above mean sea level, it is possible to arrest seawater intrusion in the coastal aquifers everywhere in the world.

Through appropriate artificial groundwater recharge techniques suitable to the existing hydrogeological/ geomorphological settings of Tamil Nadu, it is possible to arrest the groundwater depletion and seawater ingress completely-Table 1 (Natarajan, P.M, Ph.D and Shambhu Kallolikar, 2004, p-32). By regular recharge, it is possible to save about 2TMC of fresh groundwater every year from salinisation in Tamil Nadu.

Artificial groundwater recharge techniques-Table 1			
Sl. No	Technique	Sl. No	Technique
1	Spreading methods	10	Gravity head recharge well
	a. Basin	11	Connector well
	b. Ditch	12	Collector well
	c. Furrow	13	Infiltration
	d. Channel	14	Bore blast
	e. Flooding	15	Hydro fracturing
	f. Irrigation	16	Fracture sealing and cementation
2	Pit method	17	Contour trench
3	Induced recharge	18	Contour bund
4	Recharge well	19	Gully plug
5	Sub-surface dyke	20	Leveling
6	Percolation pond	21	Terracing
7	Check dam	22	Recharge shaft
8	Nala bunds	23	Injection well
9	Stream channel modification	24	Combination methods of artificial groundwater recharge
Natarajan, P.M, Ph.D and Shambhu Kallolikar, 2004			

3.7 Virtual water trade

Some nations are saving water by importing agricultural commodities, instead of cultivation. The total amount of water that would have been required in the importing countries if all imported agricultural products would have been produced domestically is 1,605km^3/year. These products are however being produced with only 1,253km^3/year in the exporting countries, saving global water resources by 352km^3/year. This saving is 28% of the international virtual water flows related to the trade of agricultural products and 6% of the global water use in agriculture. Egypt imports wheat and in doing so saves 3.6km^3/year of its national water resources. Similarly Japan saves 94km^3/year from its domestic water resources, Mexico 65km^3/year, Italy 59km^3/year, China 56km^3/year and Algeria 45km^3/year (Chapagain, A.K, Hoekstra, A.Y and Savenije H.H.G, 2006).

Global virtual water flows during the period 1997-2001 added up to 1,625km^3/year (compared to an estimated 400km^3/year in interbasin water transfers; Shiklomanov, 1999), with the major share (61%) of the virtual water flows between countries is related to international trade in crops and crop products, 17% is related to the trade in livestock products and the rest is related to the industrial products (Chapagain and Hoekstra, 2009). They calculated that 16% of the global water use is not meant for domestic consumption but for export. A recent study by WWF-UK shows that UK relies nearly 62% on external water resources for the goods and services consumed internally (Chapagain and Orr, 2008). A similar study by WWF-Germany shows that Germany is 50% dependent on external water resources to meet its water demands (WWF Germany, 2009).

By practicing virtual trade, Tamil Nadu can manage water scarcity**.** It is suggested to use the limited water to the industries or to dry crops cultivation in the water-starved districts of hard rock terrain, and import water-embedded products to these regions from the water rich areas of this state. By this approach, it could be possible to save about 20TMC of water now and more than 50TMC in future.

3.8 Improving irrigation efficiency

Increasing efficiency in surface-water and groundwater irrigation in Tamil Nadu is another way of meeting water needs of the nonagricultural sectors. At present, surface-water irrigation is estimated to operate at 35% efficiency, and meets 58% of the total irrigation demand. A modest increase in surface-water irrigation efficiency, say by 15%, could reduce total irrigation demand by about 8km^3/282.52TMC. This saving, which is significantly more than the combined demand of 6.3km^3/228.48TMC of the domestic and industrial sectors at present can meet the projected additional demand of 7.2km^3/254.26TMC of these sectors by 2050.

The current levels of surface water and groundwater irrigation efficiencies are 35% and 55%, respectively, and the total withdrawal at this level is estimated to be 46.3km^3/1,635.06TMC. Improvements of surface water and groundwater irrigation efficiencies to 50% and 65%, respectively, from the present levels, could reduce the irrigation demand by 24% (Upali Amarasinghe A. et al.).

It is possible to save about 50TMC of water in Tamil Nadu by enhancing the irrigation efficiency of both surface and groundwater by 15%.

3.9 Rejuvenation of water bodies

In Tamil Nadu, there are around 39,202 irrigation tanks (irrigating about 900,000hectares when they are filled), 85dams, and reservoirs. The results of the present status of the irrigation tanks' study had indicated that in less-tank-intensive regions, about 64% of Public Works Department (PWD) tanks and 76% of the Panchayat Union (PU), tanks are defunct and in tank-intensive regions, about 2.6% of PWD tanks and 1.2% of PU tanks are defunct (Palanisami, K et al, 2008).

By Global Positioning Survey, it is possible to know their present condition in the entire state. By rejuvenating them (desilting, removing encroachment, raising bunds, protecting supply channels without encroachments) it is possible to retain them to their original water holding capacity at $6km^3$/211.89TMC.

By rejuvenation of the water bodies in Tamil Nadu, the present capacity loss of 28.36TMC of water can be restored.

4. Per capita water improvement without inter-basin water transfer

By the above exercises, it is possible to generate/save about 1,113TMC or 1,000TMC of water in Tamil Nadu-Table 2. However, to achieve this target, continuous efforts for two decades with huge fund are necessary. Along with the additional water resources generated/saved it is possible to improve the per capita annual water resources to $956m^3$ from the present $590m^3$ and in 2050 to $684m^3$ from the $416m^3$. But, these exercises cannot improve the per capita annual water resources of this state to the Falkenmark Water Stress Indicator level at $1700m^3$ without inter-basin water transfer. However, these approaches are necessary to bridge the water supply and demand gap to the extent possible.

Quantity of water to be generated or saved by water security pathways –Table 2	
Water security pathways	Quantity of water in TMC
Flood and rainwater harvesting	155

XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico. 29 May- 3 June, 2017

Artificial groundwater recharge	375
Treating and recycling domestic wastewater	100
Water saving in agricultural sector	352
Desalination of seawater	30
Arresting seawater intrusion	2
Virtual water trade	20
Improving irrigation efficiency	50
Rejuvenation of water bodies	50
Total	1,113.2 or 1,000TMC/28.32km^3

5. Water supply demand gap in Tamil Nadu

Water demand for the existing Tamil Nadu 76.66million population at 1,700m^3 per capita per annum is 4,602TMC. At the above per capita, for the anticipated 104.75million population in 2050, this state needs 6,289TMC. Deducting the available water resources 1,643TMC, the present water supply demand gap is 2,959TMC and in 2050 the gap will be 4,646TMC. To bridge the demand, the sate needs to generate/save 133TMC water per annum up to 2050.

6. Arresting Tamil Nadu water miseries by sharing the excess water of the India Rivers

Present rainwater harvesting in Indian is 225km^3 against the total surface water resources of 1,953km^3 and hence the water let in to the sea is 1728km^3/ 61,023TMC. In 2050, only 450km^3 of surface water is going to be harvested in India and the water let into the sea will be 1503k^3/53,078TMC. (PLANNING COMMISSION GOVERNMENT OF NDIA, May 2009).

Therefore, in the Indian rivers, 21 times of the present and 11 times of the 2050 water supply demand gap of Tamil Nadu is let into the sea every year at 1700m^3 per capita.

In the east flowing south Indian rivers, Mahanadhi, Godavari, Krishna and Pennar there is a flow of 145.49 km^3/5,138TMC of water to the sea now and in 2050, there will be 121.79km^3/4,301TMC. Hence, about 2 times of the present and one time of the 2050 water supply demand of Tamil Nadu will flow to the sea from these rivers at the above per capita (Ashvani K. Gosain, 2014) and The Deccan Chronicle, February 11, 2016).

Hence, only by sharing the Indian excess water, Tamil Nadu would permanently arrest water scarcity. However, by sharing the nearby east flowing rivers- time, energy and money could be saved.

6.1 Benefits of Indian Inter-basin water diversion

Inter-basin transfer (IBT) of water schemes are not a new phenomenon. Since the beginning of dam building that marked the last half of the 1900s more that 364 large-scale inter-basin water transfer schemes (IBTs) have been established that transfer around 400km³/1,4125.80TMC of water per year (Shiklomanov, 1999). IBTs are now widely accepted as the quick fix solution to meeting escalating water demands. One estimate suggests that the total number of large scale water transfer schemes may rise to between 760 and 1,240 by 2020 to transfer up to 800km³/28,251.60TMC of water per year (WWF Germany, 2009).

However, Sharing the Colorado River water by the Colorado River Compact 1992 in the southwestern USA by seven states with Mexico is the best example of water sharing. Hence, the kitchen taps and power lines never fail for a second in these states even in the mega-drought since 2012.

The overall implementation of Interlinking of Rivers programme in India under National Perspective Plan would give benefits of 35million hectares of irrigation, raising the ultimate irrigation potential from 140million hectare to 175million hectare and generation of 34,000megawatt of power, apart from the incidental benefits of flood control, navigation, water supply, fisheries, salinity, pollution control, stopping soil erosion, additional recharge etc.

As per Thatte, C.D, Ph.D, 2006, by sharing the Indian excess water this nation would get the following benefits. Drought mitigation will accrue approximately 25lakh hectares in 11 states; enhance food production by 70Million tons. Fishery would significantly grow in new lakes and canals. The degradation of environment in the upstream will be reversed. In the downstream, it will improve by a better lean season flow due to regeneration and regulated releases of water. The water short cities, industries and rural habitations can augment about 12km^3. Several link canals can facilitate inland navigation reducing fossil fuel consumption. The migration of rural population to urban complexes would be arrested. The programme would generate about 50million jobs during the construction period and beyond, due to enhanced economic activities. Above all, the suicides of one farmer in every 32 minutes in India will be stopped in future. Further, this scheme holds immense potential to unite the people of the country through integration and hence it is socially needed. Therefore, this scheme is technically feasible, economically viable and environmentally sustainable.

Since, lack of water sharing will cause faster and larger level of social-environmental degradation; it is need of the hour to share the unutilized Indian water among the people of the nation.

6.2 Mitigation to avoid environmental impact in inter-basin water diversion

About half a million people may be affected or displaced due to reservoirs and canals by the proposed Indian inter-basin transfer. An improved rehabilitation and resettlement package will ensure a better status for them. Due to storages about 79,000ha forest-land is likely to be submerged. Compensatory afforestation, catchment area treatment and other conservation programmes will offset the loss. Ill-effects on bio-diversity, particularly in Himalaya could be taken care of through gene-banks for preservation and replication. However, sharing the east flowing Mahanadhi, Godavari, Krishna and Pennar Rivers with Tamil Nadu may not have such problems.

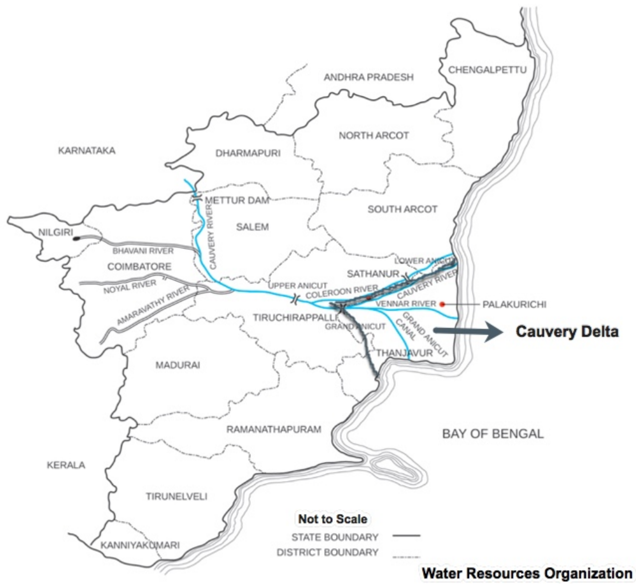
7. Tamil Nadu food and water securities are under threat without water

There was an 82.64lakh metric tonne of food grains production in Tamil Nadu in 2011. In 2014-2016 the food grain production was 127.95lakh tons. For the projected 104.5million population, this state needs 235lakh tons in 2050.

In the last 10years, cultivable land has shrunk by five-lakh hectares in this state owing to urbanisation and industrialisation, resulting in agriculture and allied sectors registering 0.69% growth in the first four years of the 11th Plan (2007-12) against the targeted 4%. Because of shrinkage of farmland coupled with monsoon failure in future as in 2015-2016 crop year, it may not be possible to achieve the above foodgrain production target. Hence, the food security of the state is under threat.

In 2016, water was not released from Mettur Dam in June 12th for kuruvai crop cultivation to Cauvery Delta–Figure 6. Due to the poor storage in this reservoir, water was unable to be supplied even for the samba crop to this delta and hence, there is more than 80% reduction in food grain production from the delta, the main dependable source of foodgrain to Tamil Nadu. Because of drought, there are more than 100 farmers' suicides in this state in 2016.

Cauvery Delta - Figure 6



To arrest the above miseries in future, water management pathways and sharing the unutilized water of the Indian rivers are necessary to achieve sustainable agricultural production in Tamil Nadu, where the farm income is the main source of the livelihood security of more than 70% of population. ***Hence, without water sharing, the state might loose water, food, livelihood, hygiene, energy, environmental securities and above all the farmers' suicides might swell, and hence the growth of the state is under threat.***

8. Funds to implement the water security projects in Tamil Nadu

Since water scarcity is a disaster, the Indian Disaster Mitigation Fund should be utilized to improve the per capita annual water resources of Tamil Nadu to the Falkenmark Water Stress Indicator standard at 1700m^3 by water management and water sharing.

9. Conclusions

There are several approaches to improve the water resources and stop Tamil Nadu water miseries. However, transbasin water diversion is the permanent option. It is sad to state that in the 70years of independence, appropriate action has not been taken to improve/save the water resources of this State and this is the reason for the existing water miseries and the sad occurrence of farmers' suicides. Therefore, the minimum basic demand of 50litres per capita per day clean water cannot be supplied to the people and hence mothers, sisters and daughters of this state are spending much of their prime time to bring water for the daily use of their family without economic activity.

Who is going to bell the cat and arrest the water woes of Tamil Nadu? Perhaps the Water Resources Organization, Government of Tamil Nadu along with the stakeholders' participation has to initiate action to implement the water security pathways, including inter-basin water transfer suggested in this paper by an ***'Action Plan'***.

If inter-basin water transfer is not achieved, the country has to lose about Rs.30.51lakh crores/$412,318million in terms of paddy cultivation every year. The water that can supply domestic use at the WHO standard for 5years to the present population of the world (7,252million), or to India for 28years (1,270million), or to Tamil Nadu for 483years (72.59million), or to Chennai city for 7,461years (4.7million) is lost every year, while 180million Indians have no access for clean water. It is pathetic that so much quantity of fresh water is allowed into the sea without the attention of the people and the Indian Government, while the nation is suffering by varieties of water miseries.

Hence, for a water misery free and water related socioeconomic divide free India, water sharing is the need of the hour. Indians should understand that the water resources of India would get secular and democratic status only by sharing among the people. Therefore, Indians should untie to share the excess water to arrest the water miseries.

For the successful water sharing, a strong political will and legal intervention of India are necessary, at least now after 70 years of independence.

Acknowledgement

The author would like to thank Mr. U.R.Sankar, Senior Developer, ADP, USA and Mrs. P.M.N Abirami, Senior Engineer, Magellan, USA and P.M.N.Ambalavanan, Vice President, City Bank, Singapore for typing, preparation of maps and other supports in successfully completing this research paper.

References:

1. Amber Brown Marty D. Matlock, Ph.D., P.E., C.S.E (April 2011) University of Arkansas. *A Review of Water Scarcity Indices and Methodologies FOOD, BEVERAGE & AGRICULTURE.* The Sustainability Consortium White Paper #106.
2. Ashvani K. Gosain, (2014). *Assessing policy influences on people's relationship to water ecosystem services: The Indian experience.*
3. Chapagain, A.K, Hoekstra, A.Y and Savenije H.H.G (2006). *Water saving through international trade of agricultural products.* Published by Copernicus GmbH on behalf of the European Geosciences Union.
4. Dhananjoy Dutta and Bishnu Charan Mahato, (2012). *Productivity improvement and water saving under the system of rice intensification (SRI): a study in eastern India.*
5. Falkenmark. *"The massive water scarcity threatening Africa-why isn't it being addressed."* Ambio 18, no. 2 (1989): 112-118.
6. *Global Clean Water Desalination Alliance "H2O minus CO2"* CONCEPT PAPER, 1st December 2015.
7. Hilton, H. Cooper, JR., Francis A. Kohout, Harold R. Henry, and Robert E. Glover, (1964). *Sea Water in Coastal Aquifers*. United States Government Printing Office, Washington.
8. Natarajan, P.M, Ph.D and Shambhu Kallolikar, (2004). *Rainwater Harvesting New Approaches for Sustainable Water Resources Development.* Sarma Sanatorium Press, Pudukkottai.
9. Palanisami K, Upali A. Amarasinghe and R. Sakthivadivel, 2008. *Policy Interfacing and Irrigation Development in Tamil Nadu*.
10. PLANNING COMMISSION GOVERNMENT OF NDIA, (May 2009). *REPORT OF THE TASK FORCE ON IRRIGATION*.

11. Renee Cho (April 4, 2011). *From Wastewater to Drinking Water, State of the Planet*, Earth Institute, Columbia University.
12. Thatte C.D, Ph.D (2006). *Inter-basin water transfer for augmentation of water resources in India - a review of needs, plans, status and prospects.*Occasional Paper.
13. The Deccan Chronicle, (February 11, 2016). *Water issues to be key signpost in party manifestos.*
14. The Hindu, (June 23, 2014). *State can gain 100 tmcft from RWH: expert.*
15. Upali Amarasinghe, A, Palanisami, K, Singh, O.P and Sakthivadivel, R. *State of Irrigation in Tamil Nadu: Investments and Returns*.
16. WWF Germany, (2009). *Interbasin water transfers and water scarcity in a changing world - a solution or a pipedream?*