07
2016

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

PROSOPIS JULIFLORA IN THE IRRIGATION TANKS OF TAMIL NADU

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Introduced as an alternative for fuel wood, Prosopis juliflora has become established as an invasive weed in India and many parts of Asia and Africa. In our exploration, we found that most villagers know that P. juliflora sucks groundwater through its deep roots; creates health problems like asthma and respiratory diseases; acts as an excellent hiding place for robbers, wild boars and stray dogs; prevents desiltation of tanks and essentially sounds the death knell for tank irrigation. Some farmers even attribute reduction in rainfall to pervasive prosopis infestation. However, getting rid of it is not easy and villagers' response to infestation varies depending on the economic benefits they derive out of it. Not only is it widely used for fuelwood; it has also become an important livelihood source for many poor farmers who use it for making charcoal. This Highlight looks at the spread of P. juliflora in Tamil Nadu with a view to understanding: [a] its impact on irrigation; and [b] various mitigation strategies adopted by communities.

Prosopis juliflora in the Irrigation Tanks of Tamil Nadu*†

Research highlight based on Sakthivadivel (2016).

1. Context

There appear to be several competing histories pertaining to the introduction of *Prosopis juliflora* into the Indian sub-continent, with no doubt that it first occurred in the nineteenth century. Reddy (1978) provides the most compelling account of the request for *P. juliflora* seed made by Lt. Col. R.H. Bedome (Conservator of Forests of Northern Circle, Madras Presidency) to the Secretary of the Revenue Department of Madras in 1876. Lord Bedome suggested the introduction of these trees as fuel plantations in the dry districts of Cudappa by procuring seeds from the British Consuls at Galveston and San Francisco. The Jamaican origin *P. juliflora* seeds were sown in 1877 and out planted in 1878 (Reddy, 1978). This may have been the origin of Prosopis in India. Raizada and Chatterji (1954) state that the first introductions were of Mexican origin in 1877, with two supplies of seed received through the India office of Kew Gardens, UK in 1878. Whichever account is preferred, *P. juliflora* was certainly widespread throughout India, Pakistan and Sri Lanka by the turn of the twentieth century.

In Tamil Nadu, Shri Kamaraj Nadar (Chief Minister of Tamil Nadu in 1959) recommended plantation of *P. juliflora* as a hedge plant to overcome fuel shortage. As a result, *P. juliflora* also called *Seemai Karuvalam* or *Kamarajar Karuvelam* in tamil, was introduced. These hedge plants can be recycled once in three to four years and is today very much prevalent in Ramanathapuram district where blocks like Trichuli, Paramakkudi and Devipattnam have many *P. juliflora* plantations. Tanks like RS Mangalam and Ramnad Big tanks are fully infested with *P. juliflora*.

Thus, *P. juliflora* gradually started invading the cultivable fertile lands and tank beds of Tamil Nadu in early 1960s. During continuous drought period in the southern districts of Tamil Nadu, *P. juliflora* invasion became very severe and established strongly. These *P. juliflora* trees/ bushes could not be removed manually; heavy machinery was required which further aggravated the cost of removal. As a result, fertile agriculture lands were degraded and water supply from tanks reduced considerably. Failure of monsoon and reduced water supply further aggravated the infestation. Small farmers and landless laborers were affected the most due to combined natural and anthropogenic activities; severely affecting livelihood activities.

2. Objectives and Methodology

A preliminary analysis of the hydro economic and ecological impact of *P. juliflora* on tank irrigation in Tamil Nadu was undertaken with funding from IWMI to answer the following questions:

1. What is the extent of *P. juliflora* infestation in tank beds and foreshores?
2. What are the socio economic benefits of *P. juliflora* in tank beds?
3. What is the hydrological impact of *P. juliflora* infestation on water *storage*, *evapotranspiration (ET)*, and water availability for tank irrigation and tube well recharge?
4. Has any attempt been made to remove *P. juliflora* as a part of tank rehabilitation program?
5. What would be the cost of *P. juliflora* eradication using manual labor as well as machine labor?
6. Can *P. juliflora* removal contribute to significant increase in water availability?

The methodology is to look at the published literature in this topic; then discuss with *P. juliflora* those involved in irrigation tanks infested with *Prosopis juliflora*, social forestry in tanks and tank rehabilitation work in *P. juliflora* affected tanks. These reviews and meetings with concerned professionals set the stage to select the sample districts for survey and methodology to be adopted. Questionnaire survey, focus group discussion, key informants interview, mobility mapping, resource mapping, mathematical modeling and remote sensing and GIS analysis are the tools used to achieve the objectives. Considerable data collected by the Ground Water Division of the State Remote Sensing Centre on tanks were made use of to map the *P. juliflora* in tanks of Tamil Nadu.

3. Results and Discussion

3.1 Estimating the areal extent of *P. juliflora* infestation

Applying the remote sensing method of un-supervised classification and analysis of the IRS P6 LISS III imagery of March, 2013, with the help of Arc GIS 10.3 software, the

*This Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the CGIAR Research Program on Water, Land and Ecosystems (WLE). It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners.
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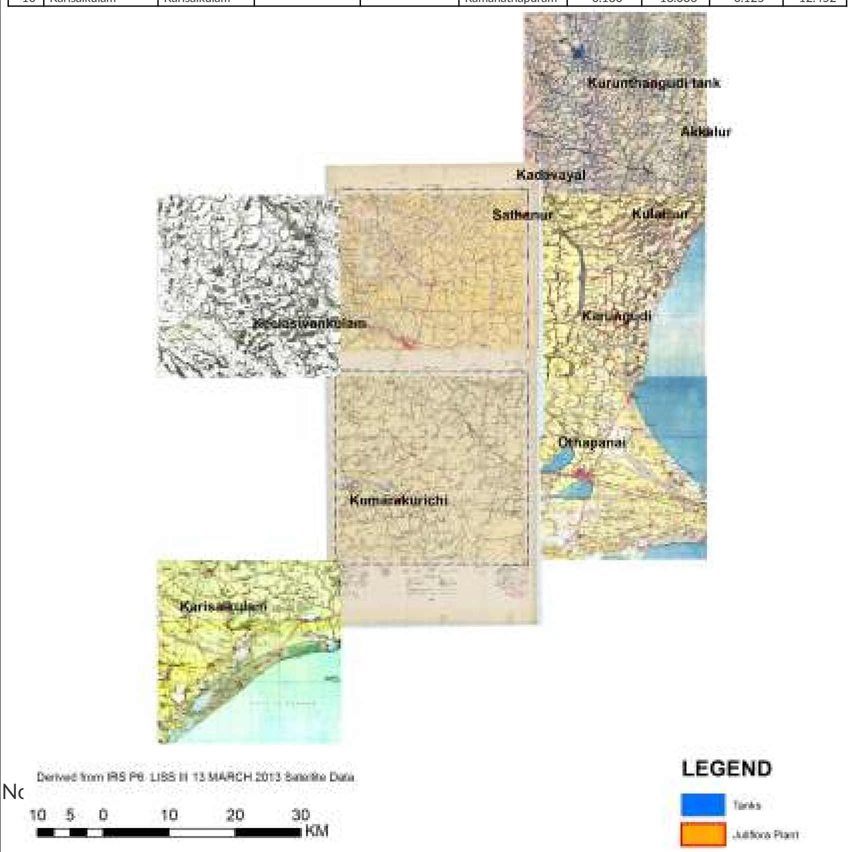
Figure 1: *P. juliflora* infestation in Ramanathapuram District

RAMANATHAPURAM DISTRICT TANKS - JULIFLORA PLAN

Sl.No.	Tank_Name	Village	Block	Taluk	District	Tank Area		Juliflora Plant Area	
						Area_Sqkm	Area_Ha	Area_Sqkm	Area_Ha
1	Kurunthangudi tank	Kadambur	Thiruvadanai	Thiruvadanai	Ramanathapuram	0.199	19.931	0.091	9.124
2	Akkalur	Akkalur	Thiruvadanai	Thiruvadanai	Ramanathapuram	1.212	121.217	0.373	37.273
3	Karungudi	Karungudi	R.S.Mangalam	Thiruvadanai	Ramanathapuram	0.659	65.892	0.242	24.231
4	Kulathur	Kulathur	Thiruvadanai	Thiruvadanai	Ramanathapuram	0.868	86.789	0.480	48.031
5	Sathanur	Sathanur	R.S.Mangalam	Thiruvadanai	Ramanathapuram	0.694	69.401	0.156	15.647
6	Othapanai	Bogalur	Ramanathapuram	Ramanathapuram	Ramanathapuram	0.230	22.990	0.053	5.323
7	Kumarakurichi	Kumarakurichi	Mudukulathur	Mudukulathur	Ramanathapuram	0.618	61.796	0.450	44.975
8	Keelasivankulam	Keelasivankulam	Paramakudi	Paramakudi	Ramanathapuram	0.204	20.380	0.079	7.876
9	Kadavayal	Kadavayal			Ramanathapuram	0.105	10.522	0.048	4.799
10	Karisalkulam	Karisalkulam			Ramanathapuram	0.180	18.036	0.125	12.452



extent of *P. juliflora* area and the water spread area of the 10 selected tanks in each of the following districts: Pudukottai, Sivagangai, Ramanathapuram, Thiruvallur, and Tuticorin of Tamil Nadu was estimated. The results for a typical district – Ramanathapuram– are shown in Figure 1. For Kancheepuram District, a total enumeration of all tanks with area covered by *P. juliflora* was carried out.

The results show that *P. juliflora* infestation varies from 22.6 per cent to 72.8 per cent of the tank water spread area in Ramanathapuram district. For Kancheepuram district, a frequency analysis of the number of tanks having percentage of *P. juliflora* area as function of water spread area shows that 920 out of 2654 tanks in the district do not have any *P. juliflora* infestation; nearly 700 tanks have infestation between 5 to 10 percent; and about 100 tanks have a maximum infestation between 25 and 30 per cent (Figure 2). The average percentage of infestation for the district as a whole is 24.15 per cent.

3.2 Computation of average percentage of *P. juliflora* in tank beds of Tamil Nadu

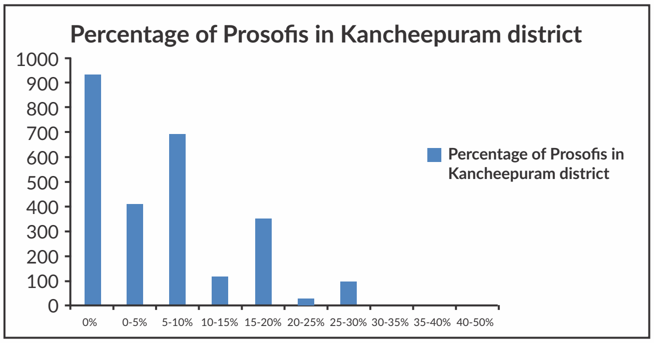
The average percentage of *P. juliflora* spread area in the tank beds of Tamil Nadu is worked out based on the per cent infestation obtained from the representative sample of 50 tanks from five districts, then classifying the infestation percentage according to tank density of the districts and applying that percentage for all the districts coming under that category to get the average for the whole of Tamil Nadu. From this analysis, it is estimated that roughly one third of water spread area (36.85 per cent) of nearly 40,000 tanks in Tamil Nadu is infested with *P. juliflora.*

3.3 Infestation Characteristics

Infestation of *P. juliflora* bush in tanks is not a recent phenomenon; it has been there for the last 40 to 50 years albeit with sparse coverage. What is happening now is that the infestation is spreading at an accelerated rate during the last decade and a half. Many reasons can be attributed to such an accelerated spread. The most important one is that the tanks do not get filled regularly and most of the time they remain dry without water. This non-filling of tanks and not holding water for extended period of 3 to 6 months or more is the major reason. The withdrawal of Social Forestry scheme from the tank beds by Forest Department starting 2002 has also accelerated the *P. juliflora* growth in the tank beds. The third reason is that allowing animals such as goats and sheep to graze freely in the tank beds has aided in easy transmission of the seeds from one place to another. The fourth is, keeping the tank command fallow wherein *P. juliflora* grow and the seeds migrate through livestock to the tank beds thus accelerating the growth of *P. juliflora* in the tank; the sheer inability on the part of village people to eradicate this tree/bush within the tank through easily available human labor is another reason and finally tank irrigation itself becoming non-remunerative due to vagaries of tank inflow causing the tanks not get filled regularly, diminishing water supply available for agricultural production thereby inducing very little maintenance of *P. juliflora* infested tanks have all added to the fast growth of this species in recent times.

Most of the *P. juliflora* under the tank environment grows as bush rather than as tree. Their spatial distribution within the tank bed is such that it occupies roughly 40 to 45 per cent of the central tank bed area which is on a somewhat raised level compared to the sluice level, 30 to 35 per cent of foreshore area, 10 to 15 per cent on the water front side of tank bunds

Figure 2: Percentages of *P. juliflora* infestation in Kancheepuram district



and only 5 per cent in the regular water storing areas adjacent to tank bunds and little on the tank bund proper.

The growth of *P. juliflora* under tank environment is very vigorous and luxurious. The average number of bush per ha varies between 1,000 and 1,500, its height varies from 3 to 8 meters. Its bio-mass production per ha varies from 35 to 45 tons of 5 to 6 years old. *P. juliflora* grows and spreads as a bush in tank beds without any management actions. Communities living with *P. juliflora* indicate that complete eradication of *P. juliflora* is next to impossible but it can be controlled and managed with continuous maintenance. With its plasticity of root system, the tap root extending up to 30m or more, sucks the groundwater in the dry season and uses the soil water with lateral roots in the wet season. Most of the native plants growing around *P. juliflora* tree become withered or dead for want of water.

3.4 People's Response

People's response to *P. juliflora* infestation varies from place to place and the replies received depend on the economic benefit that they get out of this. Local communities in all the villages visited had the following to say:

- Even today, a substantial number of households are dependent on *P. juliflora* for fuel wood for heating water. Therefore, *P. juliflora* trees/ bushes should not be removed completely from the village environment.
- For many marginal and landless people, *P. juliflora* provided part-time employment when they cannot find a job. One estimate is that they can earn ₹ 1,500 to ₹ 2,000 per month by cutting and selling the *P. juliflora* wood.
- Because of *P. juliflora* grow on the fore shore and surrounding tank bunds, encroachment within the tank bed is curtailed.
- Many farmers who have gone for tube wells and dug wells to cope with inadequate supply of water from tanks are finding that the water depth in the well goes on decreasing year by year from 40 feet to 90 feet and also some wells have become dry due to not having water for extended period in the tanks.
- Increase in drought conditions, erratic rainfall and monsoon, agriculture failure, decrease in regular cultivation of crops in the tank command – all are creating favorable situation for multinationals and Corporates to purchase land at low prices from these fragile communities causing severe land alienation. This they dislike very much and do not know how to prevent.

The presence of *P. juliflora* in the tank bed is a loss to the farming community and livestock owners while the Panchayat gets benefitted by a portion of the auction money of the *P. juliflora* tree once every 4 to 5 years. Although the landless and marginal farmers feel that they get some benefit, they consider that their loss in terms of health and loss of water outweighs the benefits and therefore, they are for eradication of *P. juliflora* from tank beds with provision for community managed *P. juliflora* woodlot in village common land for their fuel wood requirement.

Table 1: Costs and benefits *of P. juliflora*

	DIRECT COSTS		DIRECT BENEFITS		
NEGATIVE EXTERNALITIES	Weeding costs due to transport of *P. juliflora* to tank command (per ha per year)	₹ 500	Fuel wood for own consumption (per family per year)	₹ 1,500	POSITIVE EXTERNALITIES
	Crop production losses (per ha per year)	₹ 28,125	Income from sale of wood (per family per year)	₹ 3,000	
	Losses due to livestock injuries (per family per year)	₹ 1,000	Income from charcoal making (per ha per year)	₹ 10,000	
	Losses due to human injuries (per family per year)	₹ 100	Pods as feed for animals, especially goats (per ha per year)	₹ 200	
	TOTAL DIRECT COST (per ha.)	₹ 29,725	TOTAL DIRECT BENEFITS (per ha.)	₹ 14,700	
	INDIRECT COSTS		INDIRECT BENEFITS		
	Loss of grazing lands	***	Fencing material	***	
	Loss of native species	**	Shade for animals	**	
	Clogging of drainage channels and tank beds	*****	Green cover	*	
	Lower groundwater levels	****	Substitutes native flora for firewood needs thereby protecting native species	**	
	Wild animal menace	***			
	Note: Number of * indicate the extent, degree, severity or scale of costs and benefits				

Table 2: Decrease in irrigated command over the years

S.No.	Tank Name	Name of the Respondents	Year-wise acres of land cultivated					Remarks
			1995	2000	2005	2010	2015	
1	Abirahmam	Nagalingam	12	10	6	4	0	Agriculture stopped; started *P. juliflora* fuel wood store
2	Abirahmam	Balamurugan	4	2	0	0	0	
3	Kannurkanmai	Muthuramalingam	1	1	1	1	1	
4	Kannurkanmai	Rajagopal	6	4	1	1	0	
5	Kannurkanmai	Sivachidhambaram	3	1	1	1	0	
6	Katikulam	Karthikeyan	2.5	2	1	1	1	80 per cent of area is *P. juliflora*
7	Melapassalai	MeenachiSundaram	3	3	3	3	3	open well 1990; bore well 2000
8	Pulankudi	Saravannan	3	3	3	3	3	No bore well; starting 2012 water level reduced
9	Pulankudi	SaravannanMungudan	4	4	4	4	4	open well 2010;
10	Pulankudi	Syed Ibrahim	10	10	10	10	10	one open well; one bore well
11	Abirahmam	Veerapandian	8	8	5	3	0	
12	Abirahmam	Rajaji	2	0	0	0	0	
13	Abirahmam	Murugan	5	3	2	1.5	1.5	3.5 acres is *P. juliflora*; ₹50,000 income for three years

3.5 Removal of *P. juliflora* from tank beds

Mixed mechanical and chemical methods have often proved more effective than either alone. Several integrated programs that mix mechanical and chemical methods with fire have had reasonable success but are costly and require a high level of management input. Weedy invasions of *P. juliflora* can be successfully adapted to agro forestry systems by a conversion process. This conversion requires three main management interventions: thinning, pruning and treatment of under storey. In response to a High Court Order, the government of Tamil Nadu is auctioning the uprooting of *P. juliflora* from tank beds to private contractors at a cost of ₹ 15,000 per ha. Farmers believe that it is not possible to remove *P. juliflora* completely with deep roots at such prices; they estimate anywhere between ₹ 30,000 to ₹ 40,000 per acre for complete removal. The farmers opined that *P. juliflora* can be uprooted and cleared by using machinery like JCB but then it can be done only by government with the help of community. According to farmers, the cost of removing *P. juliflora* of 5 to10 year old using JCB in conjunction with human labor will vary anywhere between ₹ 80,000 and ₹ 100,000 per ha of which 20 to 25 thousand rupees can be recovered from the sale of *P. juliflora* tree trunks, branches and roots. With manual labor, they can uproot only the top portion of the *P. juliflora* bush. Even this cannot be done properly by manual labor because of the dense growth of *P. juliflora* and presence of thorns, snakes and other harmful insects and health hazards.

3.6 Comparing costs and benefits of *P. juliflora* in tank beds

As shown in Table 1, the direct loss will be ₹ 29,745 per annum/ family as against the direct benefit of ₹ 14,700 per annum/family. Similarly, the indirect costs as perceived by the farmers will be 57 per cent against indirect benefits of only 40 per cent.

3.7 Environmental impact of *P. juliflora*

Existence of *P. juliflora* in tanks near cities is rampant and is a public health hazard, source of environmental pollution, and causes respiratory diseases. These tanks must be cleared of *P. juliflora* and be made as groundwater recharge structures for domestic purposes. As per the community interviewed, strict regulations and penalty mechanisms should be imposed on the encroachers of catchment, supply channel, and foreshore area and prevent growth of *P. juliflora*.

3.8 Loss of tank irrigation due to *P. juliflora* in the tanks

Table 2 gives a snapshot of farmers of Ramanathapuram district losing their tank irrigated land over the years. This is a graphic revelation as to how farmers are affected by invasion of *P. juliflora* in their tanks.

4. Mathematical model for simulating Rainfall Recharge in a *P. Juliflora* infested tank

A mathematical model developed for comparing withdrawal of groundwater from a tank with and without *P. juliflora* is presented in Figure 3. This is a simple model to illustrate the impact of *P. juliflora* in tank beds on groundwater abstraction.

Equations and Nomenclature

R_t = Daily Rainfall at time (t) t in days (1 -365 day) (in mm)

R_{tg} = Rainfall reaching the tank bed after interception losses

I_t = Interception loss due to prosopis (in mm per day)

I_t = $0.05\ R_t$ (for all t); $I_t = 2.5$ if $I_t > 2.5$

ET_t = 8.1 mm for t= 157-281; 9.1 mm for t=1-31 and 282-365; and 6.8 mm for t= 32-156 (this is for prosopis tank) here

ET_t = 6 mm for all t for non-prosopis tank

S_t = Storage in the tank in mm

Se_t = Seepage at time t in mm

= 0.4 times S_t If $S_t >= 2.5$ mm, otherwise = 0 if $S_t < 2.5$ mm

P_t = Percolation in mm

= $0.15\ S_t$ if $S_t > 0$; otherwise 0, if $S_t < 0$

$S_t = S_{t-1} + R_{tg} - ET_t - Se_t - P_t$

(*when there is no inflow to and outflow from the tank*)

$S_t = S_{t-1} + R_{tg} + Runoff - ET_t - Se_t - P_t$

(*when there is inflow to and no outflow from the tank*)

Initial condition $S_t = 0$ if t =0

H_t = Depth to groundwater in mm at time t

= $H_{t-1} - (P_t/0.4) - 0.2 * Se_t/0.4$

Initial condition H_0 =10,000 mm

4.1 Data input

Daily rainfall of Morekulam Station in Ramanathapuram district for the year 2000 was used for simulation.

Percolation loss is taken as 15 per cent of tank storage; Seepage is 40 per cent of tank storage of which 20 per cent goes into groundwater. Interception losses are assumed to be 5 per cent of direct rainfall on tank bed subject to a maximum of 2.5 mm; runoff coefficient is taken as 0.4; catchment to water spread area is taken as 15 times; groundwater depth at the start is assumed to be 10 m (10,000 mm). Evaporation on the water spread is taken as 6 mm, ET from *P. juliflora* is 9.1 mm (for t=1-31), 6.8 mm (for t=32-156), 8.1 mm (for t= 157-281); 9.1 mm for (t=282-375) (TNAU 2005); no out flow to irrigation is considered; porosity is 0.4.

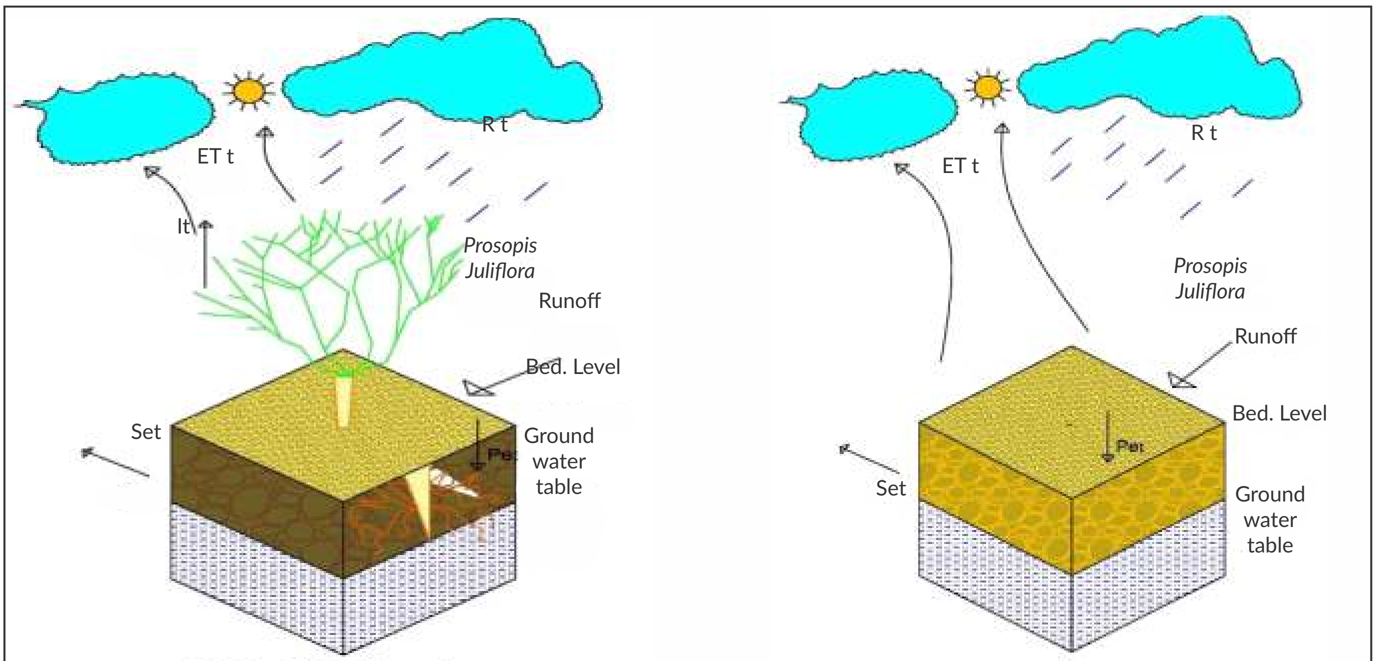
Based on these values, simulation was carried out for two conditions: one is percolation and seepage is taking place and no inflow from catchment and outflow from tank. The second one is to have runoff entering into the tank while no outflow from the tank. The results are given in Figure 4.

Simulation results indicate that a *P. juliflora* infested tank can suck 7 to 10 m of groundwater more than a non-infested tank. This occurs when there is no inflow to the tank. This works out to 2,800 mm to 4,000 mm of water per year from a tank. This has big ramification with regard to tank irrigated agriculture. The tanks are not getting sufficient water because *P. juliflora* in the supply channel to the tank reduces the inflow by 10 to 15 per cent as per farmers' observations. The water enters into the tank goes to fill up the groundwater first and there is not sufficient water in the tank to start the irrigation in time. The *P. juliflora* bush within the tank bed reduces the volume of storage in addition to reducing the direct rainfall falling on the tank water spread by its interception losses.

5. Way Forward

The basic problem of rapid *P. juliflora* infestation in irrigation tanks of Tamil Nadu is insufficient inflow to fill the tanks and

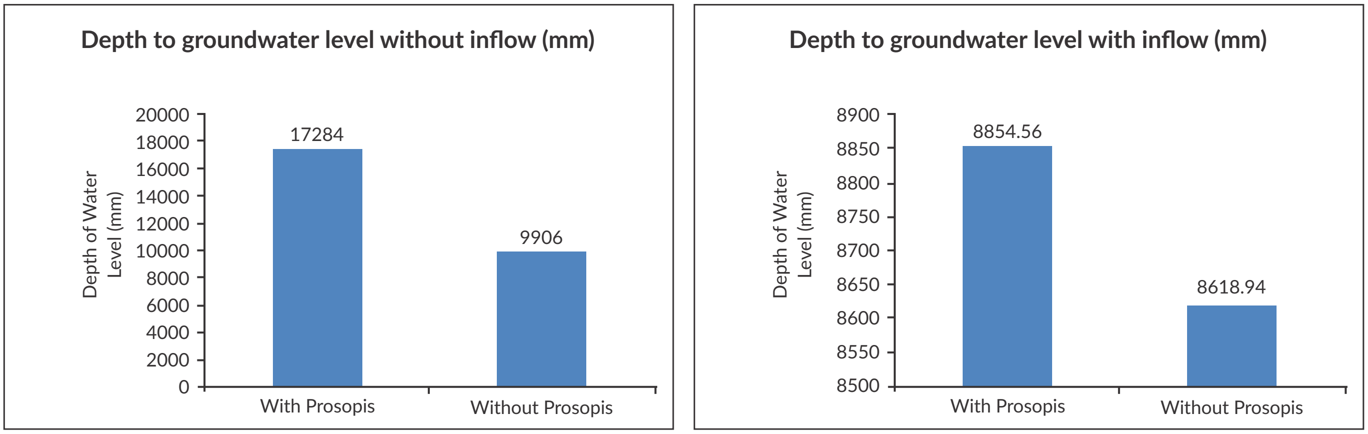
Figure 3: Definition sketch with and without *P. juliflora* in Tank bed



Definition Sketch of *Prosopis Juliflora* in Irrigation Tank Bed

Definition Sketch without *Prosopis Juliflora* in Irrigation Tank Bed

Figure 4: Depth to groundwater level with and without *P. juliflora* in tank beds



keep the tank under water for considerable period of time in a year. Field observations indicate that in tanks which store water regularly for more than 6 months, the spread of *P. juliflora* is limited. Tanks having storage between 3 to 6 months do have *P. juliflora* bush but their spread is not that acute. They can be controlled if not eradicated. Tanks having irregular water supply with storage less than three months are not only completely infested with *P. juliflora* but their irrigation command area is also infested with *P. juliflora*, because they are being kept fallow. So, tank rehabilitation and tank management must take these factors into account while planning for rehabilitation.

One suggestion that comes out of this exploratory research is that only those tanks which get and store water regularly for 6 months or more need be taken up for tank rehabilitation and increasing tank water productivity. Tanks which get irregular supply and store water between 3 to 6 months can be converted into recharge tanks with provision for abstracting water through dug and tube wells using solar power and/ or the command area can be irrigated with coarse cereals which require less water. Tanks which are getting sporadic water supply with less than 3 months storage can be converted into agro forestry with managed *P. juliflora*; its command area also can go for *P. juliflora* agro forestry. Since the enactment of the Electricity Act in 2003, which completely deregulated participation of private companies in the electricity generation industry, the new usage of *P. juliflora* has been on the increase: several small-scale electricity generating plants have begun to utilize this tree as an energy source. As a result, the demand for *P. juliflora* trees is rapidly increasing and the real price of raw wood has more than doubled since 2003. The income generated from *P. juliflora* expansion can compensate for the decline in cropping, and contribute to an increase in the net household income, especially for landless laborers and marginal and poor farmers.


FGD at Kancheepuram District


A fully grown Prosopis tree


Tank infested with *Prosopis juliflora*

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About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

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