Analysis of marketing practices and identification of factors influencing groundwater transfer in Tirupur district.

Abstract

Water transfers have recently increased as a way to meet water demands in domestic and industrial sectors. Groundwater transfer as the quickest, least expensive, and most environmentally friendly way to address the issue of large cities' water supply and reliability, given the success of the state water system. The water transfers generally focus on the purchase of water from willing sellers in agriculture to meet urban domestic and industrial water demand. Water transfers can generate three different types of impacts namely, direct, indirect and induced impacts. The present study was undertaken mainly to study why groundwater transfer has been an increasing phenomenon over years resulting in pollution hazards and reduction in irrigated area in Tirupur district. The impacts from groundwater transfer to water selling regions and effluent receiving areas are an important consideration in evaluating the impact of groundwater transfer activity. Without doubts groundwater transfer from agriculture to industrial uses would benefit individual sellers, buyers and the Nation as whole. The probability of water selling would increase by 0.1368 per cent, while the water selling intensity by 0.1538 per cent on average for the entire sample. The probability of selling water decreases by 3.62 percent, when farming is the major occupation as well as when profitability from on-farm activities is higher, which in turn made the farmer less reliance on income from water sales. Similarly, the elasticity of intensity of water sales would decrease by 4.07 percent.However, groundwater transfers would cause some economic impediment to local rural communities especially non-sellers. The adverse direct economic impact in groundwater selling or water transferring areas to total revenue in agriculture was Rs. 54.32 lakhs per every crop season. Scarcity of water resulted in shifting of irrigated agriculture to rainfed agriculture and labour intensive to labour less intensive crops.

Keyword: Groundwater transfer, Direct impacts, indirect impacts,Tobit Regression Analysis

1.Introduction

A growing threat to groundwater supplies is degradation of quality. The slow movement of groundwater relative to surface water ensures that groundwater is very much localized resource, it requires effect means for protection of the resource. Here to examine how groundwater marketing is serving the areas of success as well as that warranted effective improvement over the existing. Here related concepts and approaches were reviewed and presented.

Ronald C. Griffin and Fred O. Boadustudied the surface water marketing as it was conducted in Texas, USA, was identified areas of success as well as those meriting improvement. Surface water markets have assisted the state in responding to changed conditions. There was need for policy to repair the deficiencies of existing institutions. Concerned with the extension of market policy to groundwater management. It was suggested that groundwater in Texas should no longer be subject to the absolute ownership concept and instead be subject to a market-oriented system based on surface water law and experience.[1]. Recommendations for modifying both surface water and groundwater law were offered.

Katar Singh was of the view that the over-exploitation of groundwater in arid, semi-arid, and hard rock areas was due to the existing system of lack of well-defined property rights, rapid growth in water markets, and widespreaduse of modern water-extracting technologies[2].

In a different context, R.M.Saleth attributed the problem of groundwater overexploitation neither to groundwater market nor to private exploitation per se but to the de facto water rights system within which users' operate. Private exploitation, either with or without groundwater market, leads to overexploitation essentially because there was no legally set and enforced limits for both individual and collective water withdrawals. Consequently, the current system provided a wrong incentive for competitive water withdrawals[3].

R.Reddy and B.C.Barahstudied the groundwater markets in Rayalaseema in Andhra Pradesh, found that the establishment of a cooperative sugar mill in a low rainfall and scarcity region has led to the depletion of groundwater resources. Since most of the farmers who enjoyed the profit from sugar cane cultivation started drilling bore-wells or in-well bores which were financed by the cooperative sugar mills[4].

Mark W. Rosegrant, et.al, inferred that the rapid liberalization of developing countries encourages agricultural diversification and commercialization. Farmers' ability to reallocate resources in response to shifting incentives has typically been hampered by prevalent water allocation techniques. Reforms of water allocation mechanisms has been lagged behind other input sectors, largely because the physical, technological and economic characteristics of water resources pose special problems to establishment of water rights and market-based allocation of water. The study indicated that considerable evidence of sufficient physical flexibility in most irrigation systems to permit crop diversification; that water allocation and crop planting choices respond to the scarcity value of water. Markets for tradable water rights may be established successfully if water legislation, institutions, and regulations were designed appropriately.[5].

William K. Easter, et.al, stated that countries facing water shortages should consider water marketing as a way to reallocate water resources. It examined the prerequisites for the creation of effective water markets, talked about the benefits of water markets and organizational limitations, pointed out possible issues and provided solutions. It also used examples of several informal and formal water markets (India, Pakistan, USA, Canada, Chile, and Spain) already in operation to illustrate these problems and the solutions to them. The evidence indicated that appropriately designed water markets, supported by sound institutions, are an effective mechanism for reallocating scare water within or between sectors (agriculture, urban, industrial uses)[6].

One of the earth's most precious and widely distributed resources is groundwater. When surface and groundwater aquifers are misused, this most precious resource may not always be sufficient. Groundwater is impacted by the research area's extensive urbanization and diverse textile industry processes. Sixty-two bore well water samples have been collected and examined for various physic-chemical parameters in order to examine the groundwater.
Methodology stated by K.Arumugam et al.,[7].

Worldwide, it's anticipated that water transfers from agricultural to urban and environmental applications will become more frequent. Groundwater aquifers beneath many agricultural areas are crucial to their operations. Over time, out-of-basin surface water transfers will change how the groundwater aquifer system and agricultural production evolve by increasing aquifer withdrawals and decreasing recharge stated by Keith C et al.,[8].

Devineni, Net al., stated the exploitation and protection of groundwater resources depend on the identification of groundwater vulnerability. The current study evaluated the susceptibility of the Tiruppur taluk in the southern Indian state of Tamil Nadu, where groundwater pollution from industries (textile) and overpopulation is on the rise [9].

SivakumarV et al., used Optimization modelto demonstrate, by changing the geographic areas where crops are grown and procured from, the government's procurement targets could be met on average even without irrigation, while also increasing net farm income and halting groundwater depletion. We do this by utilizing over a century's worth of daily climate data as well as recent spatially detailed economic, crop yield, and related parameters. Permitting irrigation results in a 30% increase in average net agricultural income[10].

Since the impact of groundwater transfer is on the negative side, the present study is mainly focused to quantify the negative effects of groundwater sales on farm and rural economy. To examine the impact of water sales on farm economy, the change in productivity approach was used. Even though the society as a whole would be affected indirectly due to water sales, its immediate effects are on the farm economy, such as decrease in employment to the local people, increasing costs of pumping and deepening to the landowners and groundwater users in many ways.

Similarly in the effluent water receiving area farms, problems of groundwater quality deterioration and degradation of potable water, reduced irrigated acreage are due to increased bleaching and dyeing industrial activities and urbanization in the Tiruppurdistrict. As in the case of groundwater polluted farms, the cultivation of crops are all most stop and drinking water requirements of farm animals could not be met. Keeping these things in mind, the following framework has been developed to quantify the above effects

This chapter provides a detailed outline of the methodology followed for the study which includes Selection of study area, Farm level survey on water transfer, sources of data, nature of data collected and quantitative/statistical tools employed for analysis of data are discussed in detail.

2. Materials and Methods

2.1. Selection of Study Area

2.1.1. Farm level survey on water transfer

Tirupur district in Tamil Nadu State has been purposively selected for the study in the context of its well-known history of the industrial development and particularly in the field of textiles and related industries, predominance of well irrigation and groundwater overexploitation[11]. This district is in the forefront of agricultural and industrial development in the entire state. In the field of hosiery industries, Tiruppur district hosts a knitwear industry that has been noted in literature for its dynamic growth since the early 1980s[12][13]. Its nature of sub-contracting system and the active role played by industrial associations have been well reputable in the case of employment and income generation. Because of its historic dynamism, demand for water to bleaching and dyeing units in Tiruppur is very high and after using the water transferred from agricultural sector in industrial production process, these industrial units let out the effluent water into river Noyyal, which leads to serious pollution problem in the downstream farms[14].

In Farming village in Tiruppur district, Palladam and Pongalur blocks were selected randomly. Ten villages are selected randomly in blocks in different directions and distances from Tiruppur municipality. Then 180 farmers were selected randomly from the selected villages and the selected farmers were post-stratified into three groups based on the distance of their fields from the town viz., inner (3-5 km radius), middle (6-10 km radius) and outer most rings (above 10 km radius). The sample was also post-stratified into three farm size categories viz., small (< 2 hectares), medium (2-4 hectares) and large (> 4 hectares) farms to study the farm characteristics (Table1).

Table1. Groundwater transfer – selection of sample farms

Location	Direction	Name of village	Distance (km)	Number of farms selected	Total
Outer ring (> 10 km)	KGM road	Vannanduraipudur	17	25	
	Dharapuram road	North Avinashipalayam	22	25	
	Palladam road	Ganapathipalayam	19	30	80
Middle ring (6-10 km)	KGM road	Maniyampalayam	9	20	
	Dharapuram road	Peruntholuve	10	20	
	Palladam road	Karaipudur	9	20	
	Mangalam road	Kolathupudur	7	20	80
Inner ring (3-5 km)	Dharapuram road	Sevanthampalayam	5	10	
	Palladam road	Veerapandi	4	5	
	Mangalam road	Andipalayam	4	5	20
		Total		180	180

2.2 Source of Data

To analyze the trend and intensity of water transfer and its relationship with other factors, the information on water sales like quantity, cost of water sales, investment made on water sales, data on asset position, income sources, cost of cultivation, reduction in irrigated acreage and socio-economic conditions were collected from the sample farms. In the case of pollution study, the information on well water sample, investment details on farm assets, cropping pattern, cost of cultivation, livestock details, damage on irrigated acreage and socio-economic conditions were collected from the sample farms.

2.3 Factors influencing water transfer - Tobit Regression Analysis

Economic theory holds that a farmer will sell his groundwater to urban uses if it maximizes his discounted utility. Considering that the utility of a groundwater holder who does not sell and continues to employ his groundwater in agriculture, groundwater used in farming produces a stream of profits from the sale of crops in both the current and future periods. The value in today's rupees from this profit stream is determined by the discount rate and the farmer's planning scenario. Other factors such as the farm size and off-farm employment may also influence a households' utility level, from alternatives such as crop cultivation and/or sale of groundwater.

Annual farming profits are determined by crop choices and input intensity, which are inturn influenced by more factors, such as land characteristics and personal attributes of the farmers. The most important farm specific characteristics are water availability, labour problem and farm size which may also affect farming profits due to economies (or diseconomies) of scale. As for the discount rate, a high discount rate is consistent with a debt problem or difficulty in obtaining credit. An individual's characteristic also affects the present value of groundwater sales. Experience in farming of the groundwater seller is the most direct determinant of his characteristics.

Farming requires lot of production inputs other than water and the decision to sell ground water, which is a decision to reduce production or to entirely leave farming due to less remunerative needs that these other production inputs be reallocated.

The present study considered the following factors, which might have contributed for groundwater holders' decision to sell water to the urban uses: (i). low annual farm profit per unit of water applied; (ii). uncertainties in groundwater supply; (iii). increased industrialization and urbanization; (iv) high value of labour in off farm sectors of the economy; (v). concentration and localization of groundwater buyers; and (vi) access to road and transportation.

Soil quality, off farm employment, labour problem, groundwater availability, ownership of tankers/dyeing units and other characteristics such as well ownership are described as discrete variables and continuous variables such as farm family size, distance to the town/city, farming experience, farm size and on-farm income all affects the level of groundwater sales.

Soil quality is one of the principal determinants of farm profit. Here soil type was used as a weighted average of each owner's acres in land capability classification given by Soil Atlas, Coimbatore District, Soil Survey and Land Use Organization, Department of Agriculture, Tamil Nadu, Coimbatore. A farm is defined as having at least half of its land under class I – III , then soil quality of farmland is good or otherwise bad.

Distance from the city/town has important implications for water quality and availability of groundwater and farms on the periphery of the city/town are having groundwater with low in quantity and quality aspects. Hence the distance in kilometers to the city will indicate the level/intensity of quality deterioration of groundwater. This measure also explains the difference in productivity and finally farm profits. Water availability, distance to the main irrigation canal or perennial irrigation source and to the city / dyeing and processing industries, high labour wage rate and acres owned will affect the level of annual farm profits. Water availability is also another principal determinant of farm profitability. The general relationship is shown in figure 1.

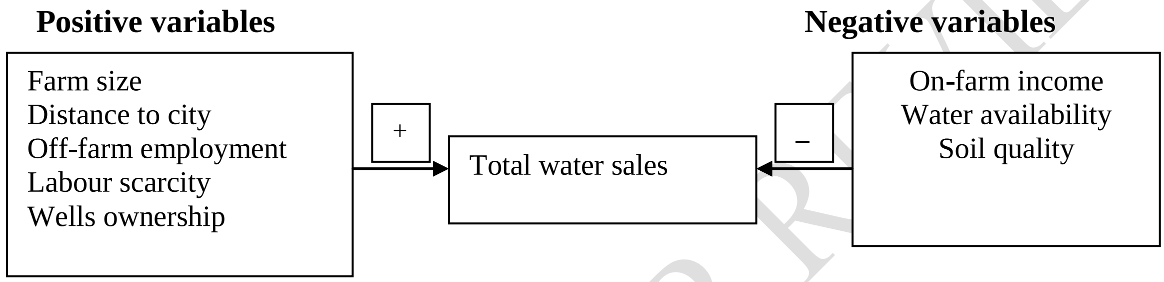


Figure 1: **Positive and Negative variables**

2.3.1Model Specification

To estimate an econometric model that explains a farmer's decision to sell water is a function of personal, financial and farm characteristics. The exogenous variables used to explain the water sales decision are farm size, distance to the city, on-farm income, off-farm employment, soil quality, labour problem, well ownership, ownership of dyeing units and tankers and water availability.

Assuming that each well owner has well defined utility over the groundwater sales, he will compare the utility from groundwater sales to that of non-water sales. Define the utility U_{i1} if a well owner decides to sell his groundwater and utility U_{i0} otherwise. The utility of either choice is derived from the economic and non-economic factors describe above plus a random error term. The equations in reduced form are:

$$U_{i0} = x_i' \gamma_0 + e_{i0} \quad (1)$$

$$U_{i1} = x_i' \gamma_1 + e_{i1} \quad (2)$$

Where X_i is a K x 1 vector of the K economic and non-economic attributes of the groundwater sales decision for each individual i, $\gamma_{0,}\ \gamma_1$ are parameter factors, and e_{i0} and e_{i1}

are random error terms. An individual owner will choose well water sales only if $U_{i1} > U_{i0}$. This can be studied through tobit model.

The tobit model is as follows, let IWS = Intensity of water selling, IWS^* = the solution to utility maximization of the farmers intensively involved in water selling subject to a set of household characteristics and conditional on being above certain limit, IWS_0, the minimum level of water selling practiced by individual households. Here $IWS_0 = 0$ means particular farmer do not involved in the water selling activity. Therefore,

$$\begin{aligned} IWS &= IWS^* \ \ if \ \ IWS^* > IWS_0 \\ IWS &= 0 \ \ if \ \ IWS^* <= IWS_0 \end{aligned} \qquad (3)$$

Equation (1) represents a censored distribution of intensity of water selling, since the value of IWS for non-sellers equals to zero.

Following J. Tobin (1958)[15], the expected intensity of water selling practiced by the farmer is given by E(IWS)[1]:

$$E(IWS) = X\beta F(z) + \sigma f(z) \qquad (4)$$

Where X is a vector of explanatory variables, F (z) is the cumulative normal distribution of z; f (z) is the value of the derivative of the normal curve at a given point (i.e., unit normal density). z is the Z score for the area under normal curve, β is the vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

McDonald and Moffitt (1980) show that the marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\delta E\ (IWS)/\delta X_i = F\ (z)\beta_i \qquad (5)$$

Also, the change in the probability of selling water is independent variable X_i changes explained by:

$$\delta F\ (z)/\delta X_i = f\ (z)\beta_i/\sigma \qquad (6)$$

And, the change in intensity of water selling with respect to a change in an explanatory variable among adopters is:

$$\delta E\ (IWS^{*})/\delta X_i = \beta_i\ \{1 - z\ f\ (z)/F\ (z) - f\ (z)^{2}/F\ (z)^{2}\} \qquad (7)$$

There were two types of negative effects viz., direct and indirect impacts as shown in Figure 2.

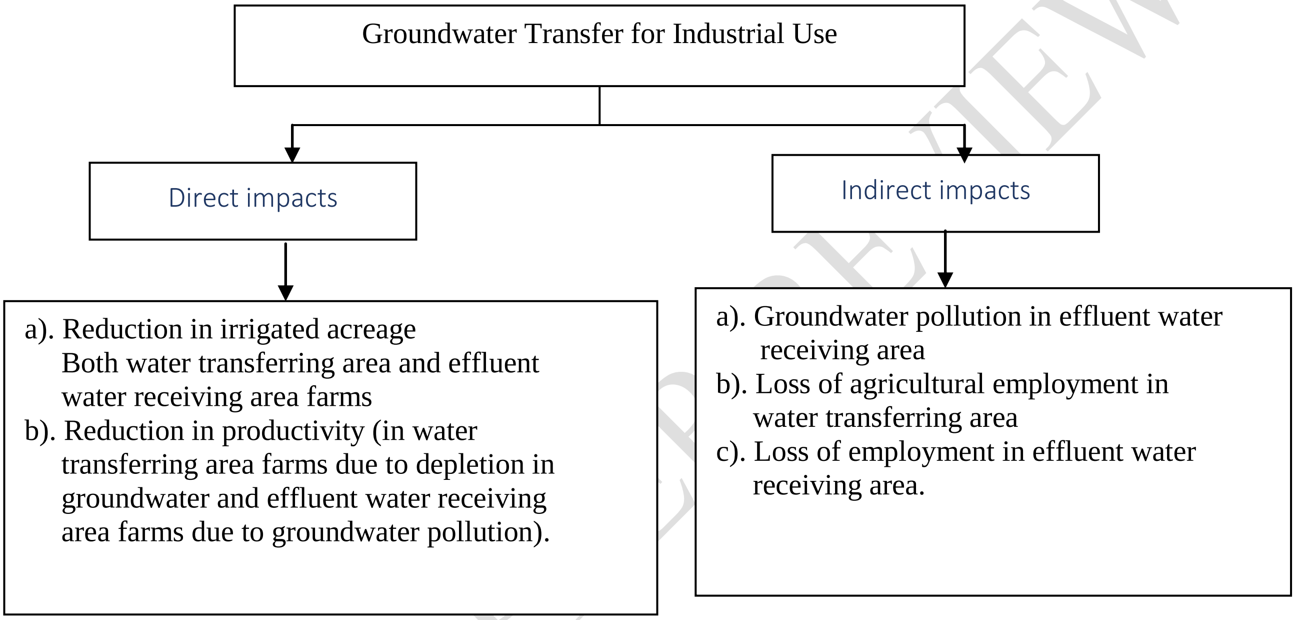


Figure 2: Groundwater Transfer for Industrial Use

2.4Quantification of direct impact of water transfer

Assessment framework links the groundwater transfer and its related groundwater pollution due to the industrial use of the transferred water, in lowlands through changes in productivity and benefits forgone. The framework emphasizes on the comparison between groundwater seller and non-seller in the water transferring area to the bleaching and dyeing units and in lowlands between farms facing polluted and non-polluted groundwater due to effluents from bleaching and dyeing industries.

The indirect costs and benefits are not reflected in farmers' decision to sell water but they are an integral part of the economic impacts of groundwater transfer and pollution. In this approach, the negative externality of water transfer and pollution is quantified in terms of the value of the crop production lost and the changes in employment.

3. Result and Discussion

3.1 Analysis of Personal and Farm Level Characteristics and Marketing Practices related to Water Sales

3.1.1. Factors influencing the groundwater transfer from agriculture to industrial uses

Groundwater market mechanism is becoming an important tool for reallocating water from agricultural to the industrial uses. Most economists presume that such urban water trading will be efficient, since groundwater holder reveals their valuations of water by selling to the industrial/urban uses. It induces the farmers to use water more efficiently by modern water saving techniques like drip irrigation for crop cultivation. Those with comparatively lower income from agriculture used to sell water to industrial/urban uses and others who realised higher efficiency in the water use remained in agriculture. However, the short-term valuations of water in agriculture based on the income realised are conditional on the personal and socio-economic characteristics of the concerned farmers.

The farm level survey data were used to estimate the Tobit model that explains farmers' decision to sell water as a function of personal and farm characteristics. The exogenous variables used to explain the sales decision are farm size, distance to city, on-farm income, off-farm employment, labour scarcity, water availability, well ownership and soil quality.

The total elasticity of a change in the level of water sales characteristics perceived by the farmers consisted of two effects: (a). Change in the elasticity of the water sale intensities of groundwater from agriculture to industrial uses, for those farmers who were already sellers; and (b) Change in the elasticity of the probability of being a seller.

The overall fit of the statistical model is good. Tables 2 and 3 present the model estimates. Influence of the relevant characteristics on total water sales and their significance are explained by the estimated coefficients of the model. However, the elasticity estimates had shown the inelastic responses to the changes in farm size, on-farm income, labour scarcity, water availability, well ownership, and soil quality characteristics. In the case of distance to city and off-farm employment characteristics, the response was elastic in nature. Farm sizes significantly and positively influenced the water sales and for each hectare of additional holding by a seller, the probability of water selling would increase by 0.1368 per cent, while the water selling intensity by 0.1538 per cent on an average for the entire sample. This suggests that a 10 per cent increase in the farm size characteristics be expected to result in about 2.91 per cent increase in the participation and intensities of water sales by the sample farmers.

Table 2. Results of farmers' decision model using farm characteristics

Variables	Normalised Coefficients	Asymptotic Standard Errors	Asymptotic T – ratio	Regression Coefficient
Dependent variable				
Total water sale	0.75416E-02	0.5028E-03	14.999***	
Independent variables				
Constant	0.70592	0.70487	1.0015***	93.604
Farm size	0.25589E-01	0.14589E-01	1.7540*	3.3931
Distance to city	0.14291	0.24783-E01	5.7663***	18.949
On-farm income	-0.15600E-03	0.69877E-04	-2.2325**	-0.20685E-01
Off-farm employment	1.5328	0.33341	4.5973***	203.24
Labour scarcity	0.14298	0.19274	0.74184^{NS}	18.959
Water availability	-2.7952	0.96542	-2.8954***	-370.64
Well ownership	1.0102	0.26209	3.8544***	133.95
Soil quality	-0.41623	0.18281	-2.2768**	-55.192
Pseudo R^2		0.648609		
Log – likelihood function		-818.028		
Sigma (σ)		155.37		
Limit observations (Non-sellers)		58		
Non limit observations (Sellers)		122		

Note: *** - 1%, ** - 5%, * - 10% level significance and NS – non significant

The elasticity of the distance to city variable has shown that one kilometre increase in the distance of the farm from city would result in 1.22 per cent increase in intensity of water sales, where the probability of participation in water selling could increase by 1.08 per cent. It might be expected that lands closer to city could be sold for urbanisation and industrial development and groundwater source available within the short distance would be of poor in quality (TDS > 1200 mg l^{-1}), which would not suitable for dyeing processes. Hence, water has been transferred from the farms, located faraway and with good quality groundwater.

Owners whose major occupation was farming have been less likely to participate in the water selling. A 10 percent increase in the on-farm income is expected to result in about 7.69 per cent decrease in the participation and expected intensity of water transfer. The probability of selling water decreases by 3.62 percent, when farming is the major occupation as well as when profitability from on-farm activities is higher, which in turn made the farmers less reliance on income from water sales. Under these situations, the elasticity of intensity of water sales would decrease by 4.07 percent.

Table 3 Tobit total elasticity decomposition for changes in the water sales characteristics perceived by sellers

Variables	Elasticity of Water sales probability	Expected water sales intensity	Total elasticity
Farm size	0.1368	0.1538	0.2906
Distance to city	1.0809	1.2147	2.2956
On-farm income	-0.3627	-0.4075	-0.7702
Off-farm employment	0.4611	0.5182	0.9793
Labour scarcity	0.0578	0.0664	0.1242
Water availability	-1.2088	-1.3585	-2.5673
Well ownership	0.4175	0.4692	0.8867
Soil quality	-0.1568	-0.1763	-0.3331

Off-farm employment opportunity significantly influenced the farmer participation in water selling. The elasticity of intensity of the off-farm employment had shown that one percentage increase in the off-farm employment would result in 0.98 per cent increase in water sales. The probability of participation in water sales could increase by 0.46 percent as off-farm employment increases, while the intensity of water would increase by 0.52 percent. A 10 percent improvement in the case of groundwater availability characteristics is expected to result in 25.67 decrease in the participation and intensity of water sales by the farmers. Then, the probability of participation will decrease by 12.09 percent, while the elasticity of intensity of water transfer would decrease by 13.59 percent. The water availability will increase the farming activities such as vegetables cultivation as the farms close to city centres would get more remunerative price than selling water.

Ownership of well has the largest influence on participation and intensity of water sales. A one per cent increase in ownership of well has the impact on the probability of participation by 0.42 per cent and intensity of water sales by 0.47 per cent.

Owner farms with good soil are less likely to sell their water than those with land of poor quality. The elasticity of probability of participation in water sales could fall by 0.1568, whereas the elasticity of intensity of water sales could decrease by 0.1763, as soil quality is good. This result is intuitive since owners of low quality farmland might have lower yields and hence lower revenues, thus making agriculture less profitable.

Difference among water sellers and non-sellers with respect to labour scarcity is not significant. They might still however, have indirect influences on water sales. Interview with sellers revealed that these factors did motivate few farmers to sell their water to the industrial uses.

Many farmers cited non-profitability due to low price for agricultural produces and low yields due to inadequate water as factors in their decision to sell water. Yet another reason was that the farmers were simply tired of the increasing demand for water in the area and decided to begin farming outside the particular region or quit the farming due to off-farm activities.

The agricultural community centred in Tiruppur is small both interms of land area and population compared to urban population. Many of the farmers have been living in this area for the past several decades even though some farmers used to continue agriculture even if agriculture is non-profitable. A number of recent happenings have contributed for the reduced water availability and uncertainty over future water supplies. First is the frequent and serious drought in the region[2]. The second is the reduction in water supplies due to changes in operational procedures in the ParambikulamAliyar Project. The PAP system was designed to hold of 30 TMC (Thousand Million Cubicfeet) of water annually. In practice only about 28 TMC of water could be available for irrigation and the amount of water realised during the past three decades was only 18 TMC. Previously PAP system command area was divided into three zones and water was released to each zone for irrigation, once in 18 months for 135 days on seven days on/off turn basis. Later 1992, additonal ayacut of 1.75 lakh acres was brought under PAP system. Hence, operational procedure has changed to four-zone pattern, wherein the farmers were able to get water once in 24 months, subject to a normal rainfall in the catchment areas of reservoirs. Otherwise, the intervening period might even exceed the above said duration of 24 months. These events have made many farmers concerned about their future of agriculture in the area.

Future water demand from urban and industrial sectors is a major issue for many non-selling farmers. The uncontrolled growth of this urbanisation and the corresponding rapid increase in urban demand for water is seen as a threat to future irrigated agriculture in the region. Other related concern was the government inactiveness on future planning for meeting the increasing water demand. Although the other farmers did not oppose groundwater being transferred to the urban domestic uses, they have opposed to reallocating groundwater from agriculture to industrial uses. Since quantum of water transferred was very high and impact of water selling on neighbouring farms was very serious, damage on irrigated agriculture is considered irreversible.

3.1.2. Reasons for water transfer from agriculture to industrial uses

There are many reasons as explained above for water sales from agriculture to industrial uses in the study area. It could be inferred from the Table 4 that major constraints in irrigated agriculture are less remunerative price for agricultural produce, high agricultural wage with low labour productivity, inadequate water availability for agriculture and increased input costs.

Table 4. Reasons for water transfer

S.No.	**Reasons**	**Mean Garrett score (N=122)**	Rank
1.	High demand for good quality water in industrial sector	46.72	V
2.	Increased inputs cost	50.82	IV
3.	Less remunerative price for agricultural produce	77.87	I
4.	High returns from water selling than from farming	42.89	VI
5.	High agricultural wage with low labour productivity	69.67	II
6.	Inadequate water availability for agriculture	59.02	III
7.	Increased off-farm employment opportunity	12.30	VIII
8.	Accessibility to water selling such as road and investment	37.42	VII

In the case of labour problems, in terms of wages, agricultural labours were demanding more wages (Rs. 100/day) but their work efficiency was declining steadily, since their work hours have reduced from eight hours to six hours per day. In industrial (hosiery) sector, the case is different, as each and every work has been carried out by contract basis, hence workers would get more wages (Rs. 150/day) only when they complete the work assigned. The productivity of labour is comparatively very low in agriculture (Rs. 100/day) and farmers were unable to continue in the farming. Nevertheless, the increased inputs cost compared to output prices received for agricultural produce had demoralised the irrigated agriculture since it accounted for more investment than rainfed agriculture. As a result, several farmers repeatedly did water selling after all of water requirements for standing perennial crops and livestock were met. Certain farmers have cultivated entire cropland during canal irrigation period; later during non-canal period cultivated only about 20-35 per cent of their field, mainly to meet the fodder requirements.

3.2. Pattern of groundwater use in industrial sector and marketing practices related to groundwater

The ownership rights over land and groundwater, the two most significant productive inputs in crop cultivation awarded vast ability to any individual. The direct effect is that groundwater is exclusively used only by landowners. The non-landowners of the population are kept out from groundwater use, except where groundwater has been provided for domestic use by government sponsored public wells. Even among the landowners, availability of groundwater depends on groundwater hydrology. In addition, there is heavy competition between agricultural and non-agricultural sectors over water in Tamil Nadu due to two reasons: i). Rapid urbanisation and the ever increasing urban water needs for industrial and domestic purposes; and ii). Pollution by industries, where discharge of effluent into open lands and water bodies.

Tiruppur illustrates the impact of rapid urbanisation and industrial development particularly knitwear industries, which are having increased water demand and use pattern. There are about 800 currently functioning bleaching and dyeing units and their operations mainly depend on high quality water. In the absence of any other surface water source, these units have been transporting groundwater from agricultural areas by water (lorry) tankers. According to New Tiruppur Area Development Corporation Limited (NTADCL), official estimate of daily water requirement for the bleaching and dyeing units would be about 100 million litres per day (mld), where private water supply alone account for 70 mld or 70 per cent[3]. Groundwater is transferred from several villages in a radius up to 30 kilometres. According to Tiruppur Dyer's Association, the industrial owners through their own water tanker lorries, make 80 per cent of water transfer. In the agricultural areas large number of farmers have participated in the water selling to the industries.

The market for water appeared to be working worthy and many big firms started buying one or two lorries of their own and the lorry owners who have transported, thought that it is a booming business and they too started introducing more number of lorries. Some units have their own lorry made still worthwhile, since they could save even up to Rs. 150-

200 per load of water. The total cost of the supplied water varied with the quality and the distance the water had to be transported and for good quality water, the well owner would demand a higher price and during summer it was necessary to go for longer distance to find good water. At a greater distance from Tiruppur, the price of well water was low, but transport costs were higher, which were increasing every year.

These are reasons for water transfer and development of water markets in the Tiruppur region. Brief details on groundwater transfer characteristics are given in the Tables 5 and 6

Table 5. Percentage of acquisition of groundwater infrastructure ownership

S.No	Particulars	Percentage
1.	Wells owned by industrialists	9
2.	Wells and water tanker lorry owned by industrialists	20
3.	Water tanker lorry owned by industrialists	19
4.	Wells owned by farmers and water tanker lorry owned by industrialists	35
5.	Water tanker lorry owned by transporter	17

Source: Status report prepared by New Tiruppur Area Development Corporation Limited

Water supply to Tiruppur largely depends on private tankers. Bleaching and dyeing industries' 71 per cent of water requirements are met from private well owners. The remaining 10 per cent of the transferred water go to domestic and commercial establishments. It is estimated that there is about 235 tanker lorries with an average capacity of 12000 litres involved in water transfer from agriculture to industrial uses. Generally, each lorry operates at an average of 8-12 trips per day and drivers are working day/night turn basis. The water transfers are taking place from villages in and around the Tiruppurdistrict at a radius of 7-30 kilometres and village agricultural wells act as main source for industrial water supply. The water table in the wells had ranged from 24-150 meters, since Tiruppurdistrict belongs to the groundwater over-exploited (dark) region. Groundwater yields are very low in summer months and good during monsoon period in the region and groundwater is recharged whenever canal water from ParambikulamAliyar Project (PAP) is released for irrigation.

Table 6. Average month-wise water transfer and its characteristics

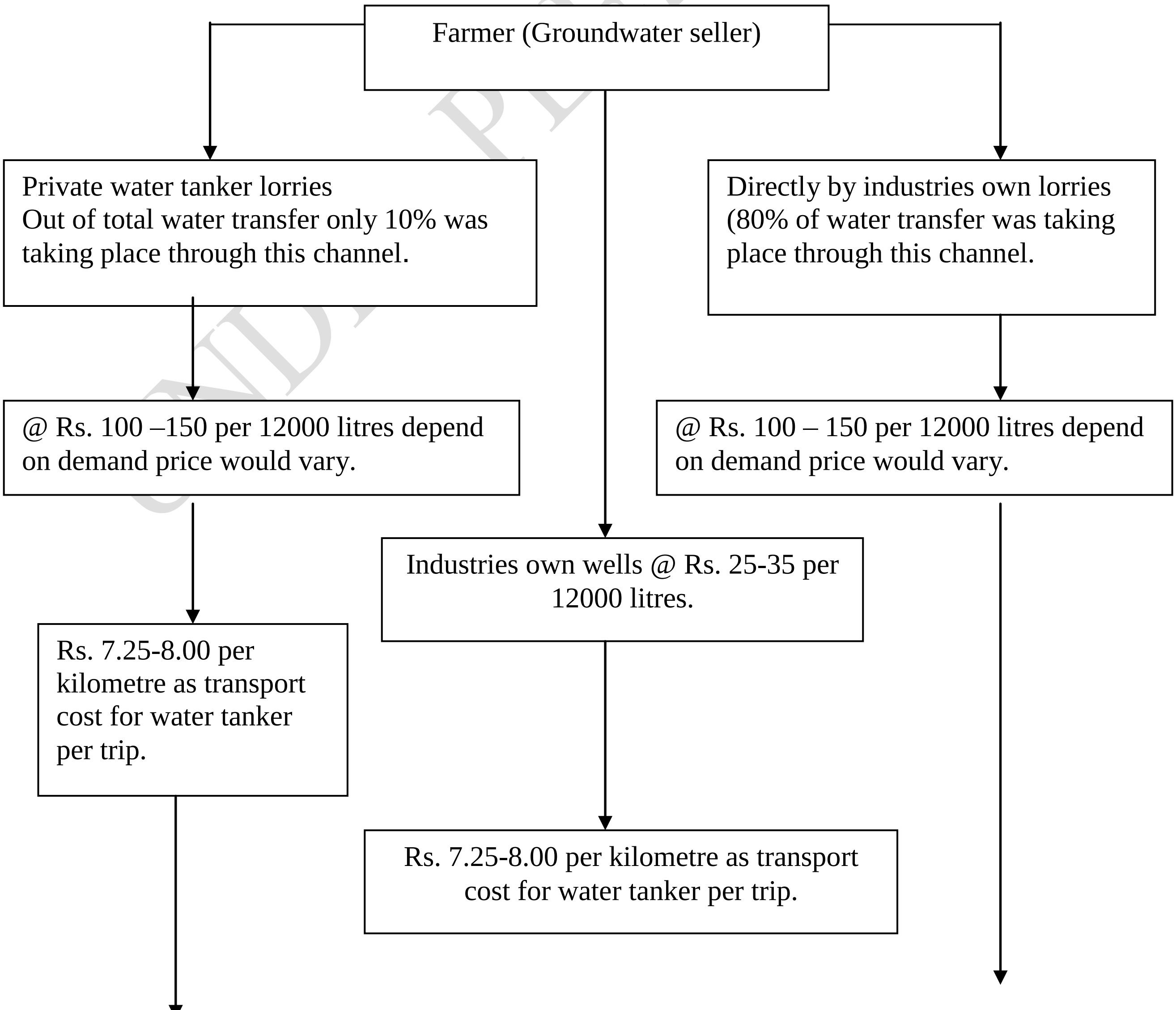
Season/Month	Average number of lorry tankers per day	Distance between town and water sellers' (km)	Buying price (Rs. /tanker)	Selling price (Rs./tanker)
October (P)	2120	7-12	100 – 120	350 – 550
November (P)	2280	7-12	100 – 120	350 – 550
December (P)	2340	7-12	120 – 150	400 – 550
January (P)	2250	7-15	120 – 150	400 – 550
February (P)	2080	7-18	120 – 175	400 – 550

March (P)	1940	12-20	150 – 180	400 – 550
April (L)	1820	17-25	150 – 180	300 – 550
May (L)	1800	18-30	80 – 100	300 – 450
June (L)	1780	18-30	80 – 100	300 – 450
July (L)	1820	15-30	80 – 120	300 – 450
August (L)	1880	12-25	100 – 150	300 – 400
September (L)	1900	12-25	100 – 150	300 – 400

P = Peak season in hosiery garments production; L = Lean season in hosiery garments production

The price of tanker water supply has ranged from Rs. 300 – 550 according to season and distance. Generally, as distance increases, the quality of water also increases since, within the 4-km radius groundwater resource is highly polluted due to effluent released from the bleaching and dyeing industries. The average price offered to the industrial user has ranged from Rs. 25 to 45 per 1000 litres. The water market is characterised by perfect competition, as there are many sellers and buyers and prices are fixed by demand and supply factors. The area of operation of water tankers also increases according to demand and availability of good quality water particularly in the peak seasons. The marketing channel and price spread are presented through flow chart in Figures. 3 and 4.

Figure. 3. Flow Chart of Groundwater Marketing Channel



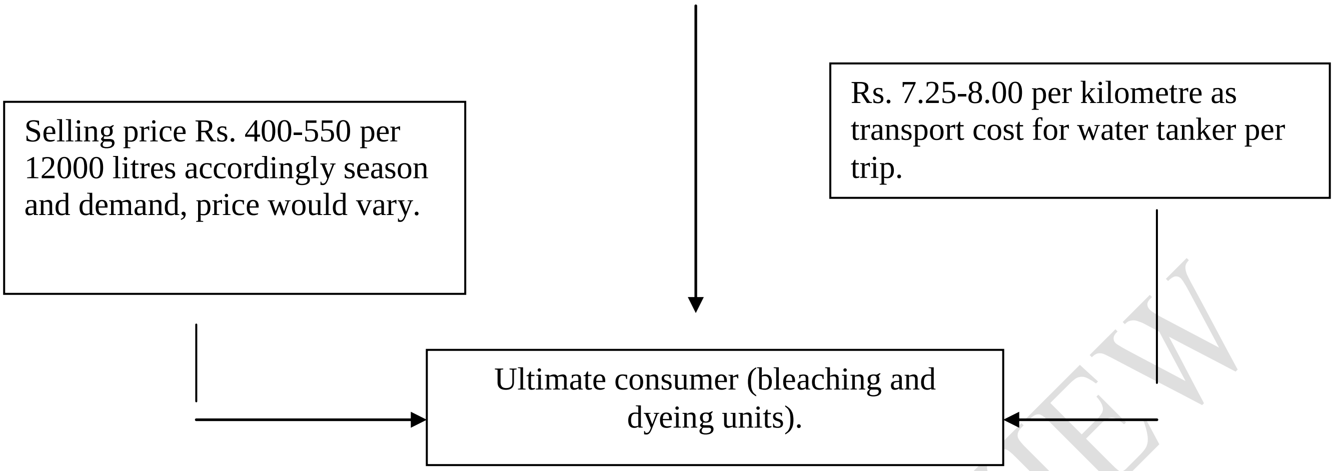
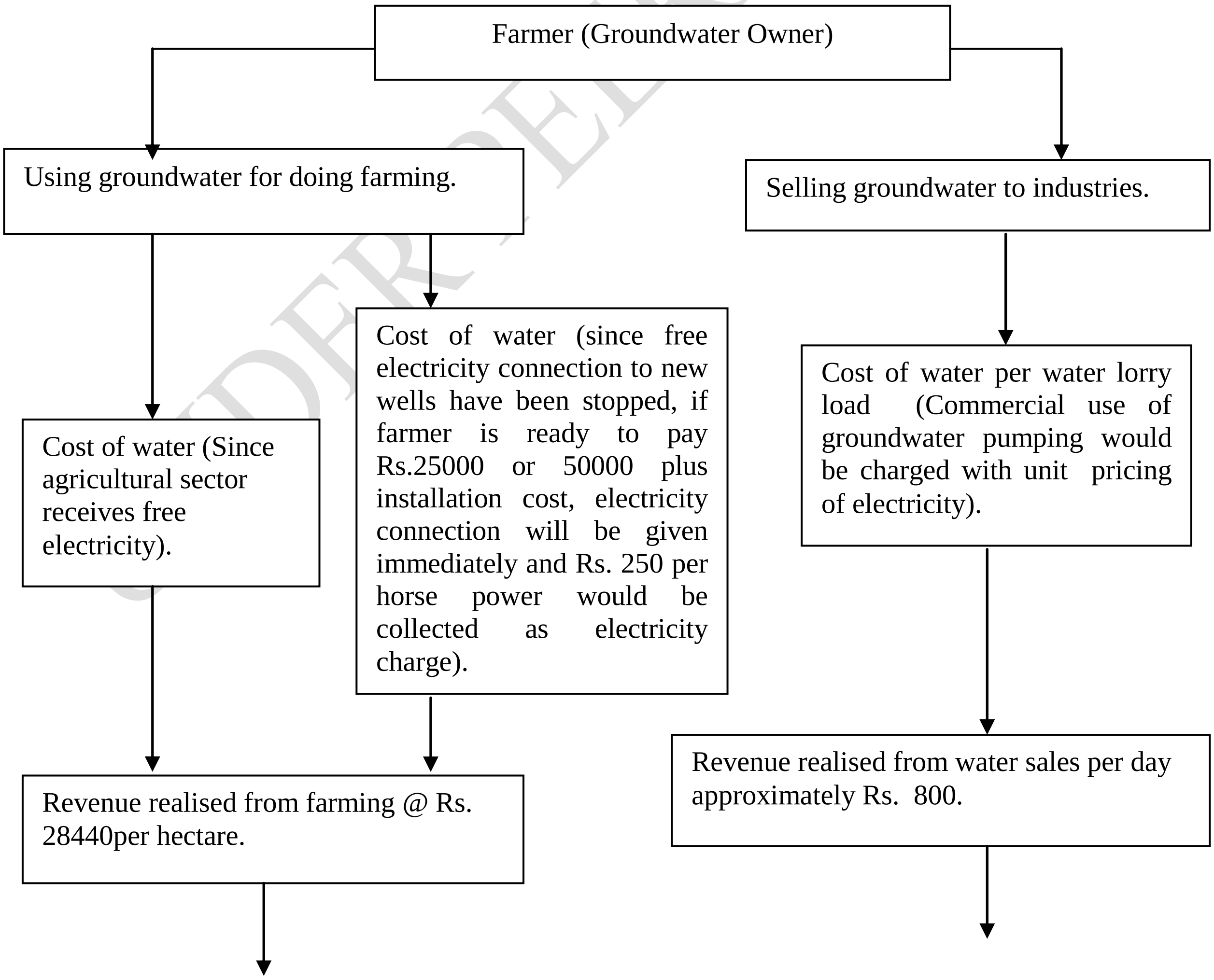
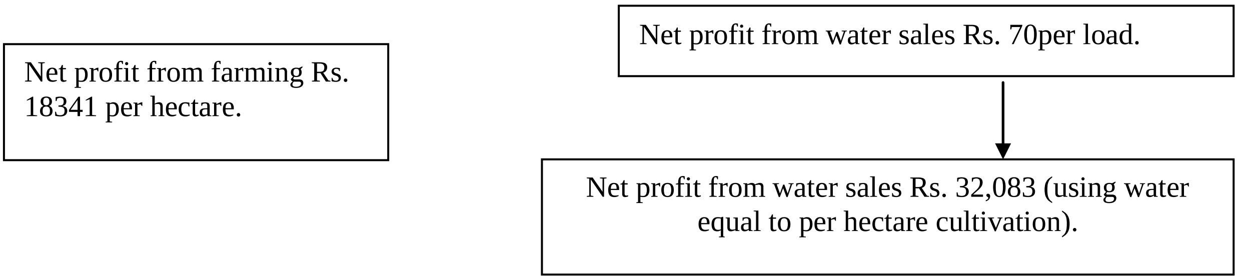


Figure. 4. Economics of Groundwater Use by Agriculture and Industrial Sectors





Generally, the average expenses for each tank operator are around Rs. 8 per kilometre. Thus, at a radius of 12-18 kms, total expenses would be about 24-36 kms X Rs. 10 gives about Rs. 190-290.

The Tiruppur hosiery industries are very active during winter month, since demand for knitwear products in foreign countries is high during summer months there. Hence, exporters of knitwear products would start production of knitwear items from September onwards. So that entire period can be divided into two seasons, one is peak season (October to March) and second is lean season (April-September). During peak season, if rainfall is normal in that year and PAP canal water for irrigation is released, then tank operators will transfer water from short distance of 7-15 kms. Otherwise, tank operators have to go far away distance because water availability is reduced as the recharge in the wells will be very poor.

The situation in Tiruppur seems to be an example of the classical problem of negative externalities from one economic activity, affecting another and thereby causing a conflict between water transferring area and effluent water receiving area. The bleaching and dyeing units can be described as economic actors who do not bear the total costs of their activities but instead externalise them to other water users such as households and farmers. In economic literature it is generally argued that this type of situation is not optimal and that externalities should be internalised, so that each party bears the full cost of his activities.

4.Conclusion

Water transfers have recently increased in importance as a way to meet water demands in domestic and industrial sectors. Groundwater transfer is the quickest, least expensive, and most environmentally friendly way to address the issue of large cities' water supply and reliability, given the success of the state water system.

The water transfers generally focus on the purchase of water from willing sellers in agricultural to meet urban and industrial water demand.

Water transfers can generate three different types of impacts namely, direct, indirect and induced impacts. An important task is to appraise the actual extent and impact of groundwater transfer from agriculture to urban/industrial uses and its related groundwater pollution in effluent receiving agricultural areas.

The water transfers took place from villages in and around the Tiruppurdistrict at a radius of 7-30 kilometres and village agricultural wells acted as main source for industrial water supply. The water table in the wells had ranged from 24-150 metres, since Tiruppurdistrict belonged to the groundwater over-exploited (dark) region.

Multiplying the MPP of water with price of concerned output price provided the Value of Marginal Product (VMP) of water. In the case, VMP of water in crop production is greater than price of water, it could be inferred that further use of water in the agriculture sector until, VMP of water equal to marginal cost is recommended. Otherwise, VMP of water in crop production is less than price of water; it is economical to transfer water from agriculture to industrial use, where VMP will be higher.

Farm sizes significantly and positively influenced the water sales and for each hectare of additional area by a seller, the probability of water selling would increase by 0.1368 per cent, while the water selling intensity by 0.1538 per cent on average for the entire sample. Owners, whose major occupation was farming, are less likely to participate in the water selling. The probability of selling water decreases by 3.62 percent, when farming is the major occupation as well as when profitability from on-farm activities is higher, which in turn made the farmer less reliance on income from water sales. Similarly, the elasticity of intensity of water sales would decrease by 4.07 percent.

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