POLICY INDUCED TRANSFORMATION IN DRYLAND AGRICULTURE: THE CASE OF THARATI VILLAGE IN KARNATAKA

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Abstract

The villages in SAT India have been exposed to an array of economic challenges in local agricultural production environment, markets and in socio-economic situations. Farm-level household panel data being gathered in the VDSA enable identification of the drivers of agricultural and economic transformation in the village economies. The present study was undertaken to understand the dynamics of agricultural transformation process in VDSA villages of Karnataka state. The project viz., Village Dynamics in South Asia, (VDSA) commonly called as Village level studies collects the panel data from the selected village households by employing resident Field Investigators by personal interview. In each village, the household data was stratified by land size holdings including landless and accordingly four groups have been categorized viz., large, medium, small and landless. The data relating to crop production, costs and returns and employment details for the 3 years period was extracted from the data. The costs and returns for different crops were computed by deducting all costs (cost C2) including value of family labour and rental value of land from the output value. There has been structural transition in the village economies with shift in the cropping pattern towards high value crops such as floriculture, beetle wine and areca nut. Till 2000, farmers of Tharati were cultivating Acarus calamus – Sweet Flag (medicinal plant), an annual rhizome in stagnant water, which virtually disappeared after 2000. With commercialization of agriculture there has been acute scarcity of groundwater. Households derived more income from non-agriculture than agriculture and within farming horticulture led development with access to groundwater is evident. The major drivers of change are access to groundwater irrigation, informal water markets, women involvement in floriculture and non-farm income, road connectivity and access to markets. In irrigated areas, the diversification towards high value horticultural crops like flowers, areca and betel vine contributed substantially for their economic improvement. Thus in order to promote high-value agriculture requires enabling policies, institutions, and infrastructure.

Keywords: SAT India, Karnataka, transformation, poverty.

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Introduction:

Karnataka is one of the states having largest proportion (79%) of the drought prone area in the country. Over 56 % of the population of Karnataka state depends on agriculture for its livelihood. A majority of these are small and marginal farmers with land less than 2 ha. Of late, the villages in SAT India have been exposed to an array of economic challenges in local agricultural production environment, markets and in socio-economic situations. Government policies both Central and state government has induced significant changes in farm and non-farm growth, food security and enhancing income of the farmers. For instance, the policy of subsidised loans for drilling irrigation wells coupled with free electricity to lift groundwater for agriculture enabled boom in groundwater extraction with rapid transformation of Indian agriculture from subsistence food to commercial crops. Similarly, some of the programmes like National Horticulture Mission, watershed development, MGNREGA have also created profound impact on changes in cropping pattern towards diversification of agriculture. In order to ensure food security and security of income of farmers, Government of India targeted Public distribution system for the poor who lack adequate purchasing power in India. This has implication on stimulating demand for grains like wheat and rice. All these policies and programmes did induce remarkable changes in crops grown, diversification towards high value crops, resource use pattern, adoption of technologies and income and employment generation leading to transformation of agriculture with a profound impact on livelihoods of smallholder farmers. In this regard, the present study was undertaken to understand the dynamics of agricultural transformation process in VDSA villages of Karnataka state.

Focus of the Paper:

The main focus of the paper is to analyze the dynamics of policy induced transformation in dry land agriculture and identifying the prime drivers of transformation in SAT India in a typical semiarid village viz., Tharati in Peninsular India.

Methodology:

The project viz., Village Dynamics in South Asia, (VDSA) commonly called as Village level studies collects the panel data from the selected village households by employing resident Field Investigators by personal interview. In each village, the household data was stratified by land size holdings including landless and accordingly four groups have been categorized viz., large, medium, small and landless. However, the labour category has been deleted from the analysis as they do not have substantial crop based activities. The data relating to ground water irrigation, morphological changes in the groundwater structures and their investments, investment on coping mechanisms of groundwater scarcity, crop production, costs and returns and employment details for groundwater buyers and sellers was extracted from survey on groundwater markets. The data relating to crop production, costs and returns and employment details for the 3 years period was extracted from the VLS data. The costs and returns for different crops were computed by deducting all costs (cost C2) including value of family labour and rental value of land from the output value. The transition in agricultural transformation at the macro level was assessed by estimating the transitional probabilities in land use at district level and in crop pattern at village level using the Markov chain analysis.

Study villages profile

In Karnataka, Bijapur and Tumkur districts have been chosen for the VDSA project since 2009. The villages selected include Markabinahalli (BasavanaBagewadi, Taluk) and Kapanimbargi (Indi, Taluk) in Bijapur, Tharati (Korategere, Taluk) and Belladamadugu (Madhugiri, Taluk) in Tumkur district. The salient features of VDSA villages are provided in the table (table 1)**.**

Backdrop of the village:

The village Tharati, is located 18 km from the district viz., Tumkur and 6 km from the taluk headquarters viz., Korategere and 80 km from the capital city Bangalore. It is well connected to the national highway facilitating connectivity to the key business centres. The annual rainfall of the village ranges between 453-717 mm, of which more than 55% is received in the *kharif* season. The striking feature of the village is that it is land locked, as the village is bounded by hillocks and thus there is no scope for horizontal expansion. The land holdings are small ranging from 0.5 to 5 acres. Thus, the village is dominated by small and marginal farmers with agriculture and allied activities as the main source of livelihood. Out of 401 households, landless labour households accounts for 28% of the total households. The average land holding is around 1 ha with a family size of 6 members. The gross cropped area in the village is about 172 ha, of which over 38% of the area is irrigated through groundwater. Groundwater is the main source of irrigation in the village. Due to prolonged drought; the discharge of groundwater in the bore-wells has gone down drastically. The shallow bore-wells have completely dried up, leading to loss of investments. Hence, deepening of bore-wells is continuing. In response to borewell failures and scarcity of water, some of the farmers drilled deeper bore-wells (700-900ft) in the area.

Area shifts in food and non-food crops

The trends of cropping pattern in the 4 villages indicates that the share of food crops has been decreasing and the share of non-food crops/commercial crops has been increasing between 2000 to 2010 (table-2, Fig-1, 2, 3, 4, 5). The non-food crops are notably horticultural enterprises in the two villages viz., Kapanimbargi and Tharati. This shows that farmers are concerned more with economic security rather than food security. The probable reasons for the fall in area under food crops could be 1) considering input and out prices, production of food crops are not remunerative compare to commercial crops 2) Food grains like wheat and rice are being distributed through fair price shops at subsidised prices hence food security is not an issue for most of the smallholder households. 3) In irrigated area, the productivity of the food crops has increased over time. Hence, farmers are producing the same amount of grain in less land and allocating the saved land to other crops.

In Bijapur, the Markabinahalli village is completely dependent on monsoon for agriculture without any assured source of irrigation either from surface or groundwater sources. In this village, the share of horticulture crops is miniscule, as there is no assured source of irrigation. Even in this village, the area under food crops decreased from 324 ha to 158 ha during 2000 to 2010, reflecting a significant fall of 51 % exhibiting a negative growth rate of 7 % per annum. Similarly, In Kapanimbargi, where there is access to groundwater, the area under food crops dipped from 417 ha to 334 ha indicating a modest fall of 30 % recording a negative growth.

In Belladamadugu village, non-food crops exhibited an impressive growth rate of 5.5 % in the last decade. The major non-food crop is groundnut and it has a relative comparative advantage of growing over other crops because of shallow red sandy and gravel loose soils. The area under groundnut is increasing after 2005 and area under other food crops has been declining. Under groundwater irrigation, flower crops like chrysanthemum is grown for the market. In addition, perennial crops like coconut, arecanut, guava, sapota and mango are established on small scale. In spite of groundwater irrigation in this village, the horticulture has not picked up mainly because of poor infrastructure, market bottlenecks, poor road connectivity and lack of efficient supply chain.

Trends in area share of horticultural crops:

Between 2000 to 2010, the trends in cropping pattern indicates that the % area share of horticultural crops in Kapanimbargi village has been doubled from 6 to 13 % recording an impressive growth rate of 6 % per annum. On the contrary, area share under agriculture has been decelerating at the rate of 0.66 % per annum. Similarly, in Tharati village, there has been drastic shift in the area from food crops to horticultural crops notably flowers, arecanut and betel vine, coconuts and banana witnessing an impressive growth rate of 5 % per annum. The area share under horticultural crops increased from 18 to 31 %, while area share under agricultural crops decreased from 82 to 69 % (table 3). Thus there has been transition of agriculture from low value food crops to high value commercial crops such as floriculture. This shift is mainly due to access to groundwater and water markets in some villages.

Further, Karnataka has comparative advantage to grow a variety of horticultural crops due to salubrious climate, long growing-season, diversity in soils and other natural endowments, markets, infrastructure and favourable government policies. Horticultural led growth was witnessed very rapidly since 2-3 decades in the state. The National Horticultural Mission a Centrally sponsored scheme has been greatly responsible for its fastest growth in the state.

Dynamics of crop pattern change in Tharati village

The dynamics of crop pattern changes in Tharati are examined considering the crop pattern followed by farmers over a decade or longer. One of the studies conducted in tharati village (Lokesh, 1998) recorded the crop pattern during 1998. Matching this with the ICRISAT, VDSA, apparently, the crops grown during 2011 were orthogonal to those in 1998.

In 1998, Tharati had ample groundwater resources, as the low lying areas were surrounded by hillocks, and with good recharge, the shallow dug/open wells were providing groundwater for irrigation. With impressive groundwater resources, Tharati was the only village (in India and the world) cultivating the most water intensive crop of *Acarus calamus* (sweet flag), a medicinal rhizome, which grows in swamp for 10 to 12 months. However, the area under the most water intensive crop – sweet flag, virtually reduced to zero by 2013. Similarly, paddy was yet another most water intensive crops cultivated in the village and its area has drastically reduced as evident from the table 4. The finger millet, a staple food crop of the households in the village, its area has steeply decreased. Thus, the Tharati crop pattern had a *volte face* treatment, with the water intensive sweet flag almost replaced by low water flower crops such as chrysanthemum, china aster and buttons. The major factors responsible for the predicament are (1) illegal sand mining which began during 2000 and is continuing unabated and (2) deforestation of hillocks. One of the reasons for excellent recharge of groundwater in dug wells during 1998, was the sumptuous sand layer which held the rain water and later percolated as groundwater in dug wells. However, due to illegal sand mining, the groundwater holding capacity of aquifer reduced gradually. The denudation of forests in surrounding hillocks exacerbated the predicament. Currently, Tharati is in the conundrum of groundwater scarcity due to both manmade and climate change effects. Unless the illegal sand mining activity is checked in Tharati, farmers continue to face the predicament of acute water scarcity. With the rapid reduction in the area under sweet flag (*Acarus calamus*), the market price of Acarus calamus which was Rs. 2700 per quintal during 1998 has shot up to a whopping Rs. 23000 per quintal in 2013. Considering the transitional probability given in Table 4, the probability of the area under sweet flag shifting to flower crops is 0.90. Similarly, the probability of paddy and ragi moving to perennial crops is 0.25. The probability of moving from the state of groundnut crop moving to flower crops is 0.15. Thus, diversification holds the key for development in the post green revolution period while specialization held the key during the green revolution period.

Importance of groundwater irrigation in semiarid regions

Groundwater has been lifeline in water starved peninsular parts of India playing a key role not only in improving food security but also largely responsible for bringing out diversification of farming systems in favor of high value enterprises. It largely enabled to increase cropping intensity, enhanced productivity, and stabilising production by providing buffer against the vagaries of monsoon. Thus, groundwater irrigation richly contributed towards commercialisation of agriculture, employment generation and economic growth in rural areas. Indeed, groundwater has turned the pockets of arid and semiarid areas into agricultural growth centres. Groundwater contribution towards stabilization of agricultural output and minimizing drought effects has been very crucial.

Currently, the groundwater resource in hard-rock areas of study villages is facing the threat of overexploitation. This has led to much faster rate of depletion of groundwater than the natural rate of recharge resulting in secular drop in water tables, well interference, failure of dug-wells, dug-cum-bore-wells and shallow tube wells and subsequent investment loss. In SAT states of

India, where there is no assured source of surface irrigation, the landowners are recklessly investing on drilling wells and pumping water infinitely without caring for its regeneration. This is a kind of “tragedy of commons” wherein every well owner tries to capture as much water as he can and deplete the resource.

Morphological changes in groundwater structures

Wave 1: The well irrigation in Karnataka state emerged during 1950’s. In the first wave, the dug-wells continued to be the dominant means of groundwater extraction until the mid-60’s. Though traditional dug-wells existed during the 1950s, their number and spread were limited, and the water lifting devices were labor intensive. There was an effective conjunctive management of water between tank and well irrigation. During the 1960s, dug-well irrigation emerged due to fillip given to the rural electrification program of the Rural Electrification Corporation. The life of these wells was around 15 years and they continued till the 1970's**.**

Wave 2*:* With the rapid expansion of commercialized agriculture, the traditional open-wells ability to support the increased demand for groundwater virtually shrunk (Hence, in order to enhance the yield of the wells, in the second wave, during the early 1970’s one or more bore(s) were drilled inside dug wells called dug-cum-borewells. The inbores had depth ranging from 150 ft to 250 ft. This phase was coincided with the introduction of green revolution technologies. There was the rational and efficient use of water, as farmers were paying electricity charges based on metered value. In this period, the traditional water lifting devices declined drastically with the access to extraction technology. There has been boom in the groundwater based agriculture with substantial increase in income and employment. Government intervention continued to provide subsidized institutional credit for well drilling and purchasing water lifting devices. In addition electricity subsidy on flat rate was also introduced during this phase.

Wave 3**:** The dug-cum-bore-wells were the dominant structures till the 1980's. Due to proliferation of bore-wells across all directions, shallow wells became defunct, indicating early symptoms of groundwater over exploitation. Consequent to failure of dug-cum bore-wells, farmers ventured drilling surface bore-wells with a depth ranging from 200 to 400 ft since 1990s in the third wave. Thus, bore well intensity increased with drop in water tables as well as drying up of shallow bore-wells. With diversification of agriculture towards high value crops, investments on groundwater exploration and extraction further triggered. The rate of returns to the investment on groundwater was manifold (Nagaraj, 1995). Thus, this wave manifested secular decline of groundwater water table. There has been increase in the real cost of pumping groundwater implying physical and economic scarcity of groundwater.

Wave 4**:** From the early 1990's, with further improvement in technology of exploration and extraction, surface bore-wells (with a diameter of 6 ft and a depth of more than 400 ft with submersible pumps of 5 to 10 Horse Power) have become popular due to the advent of exploration of rig technology implying the fourth wave of change. In the fourth wave, the depth of bore-wells increased beyond 900 ft with access to supra-technology. Thus, groundwater extraction exceeded the threshold limits of maximum sustainability yield leading to groundwater drought. The groundwater based bubble bursts with deep groundwater crisis. In the process the small and marginal farmers were worst hit.

Groundwater development at different vintages in VDSA villages

The vintage of borewells at different points in time reflect the degree of water extraction and the associated costs. The villages in Tumkur and Bijapur districts in Karnataka state are a classic case of intensive groundwater development representing a typical hard-rock area witnessing a boom and a turning point of bust. In these villages, more than 70 percent of irrigation is met by groundwater. The study area is in proximity to metro markets and obviously influenced by urbanization. Thus, high value horticultural crops comprising flowers, fruits, vegetables and plantation crops are being cultivated for the markets in urban areas. The intensification of agriculture in response to strong urban market force in this region is possible due to irrigation through ground water already subject to overdraft. This has pushed the groundwater economy to a critical stage in the region demanding adoption of water use efficient irrigation technologies.

Temporal changes:

The temporal changes in groundwater development in the study villages indicated that the depth of the bore wells increased from 100 ft to 400 ft. during 1980 to 2000 and thereafter, the depth of wells doubled more than 800ft as evident from the (Fig.7). The discharge of the wells decreased from 3000 gallons.hr to 1500 gallons/hr. This trend is common across dry districts of the state. The investment on wells is further triggered by uncertainty in rainfall. The mode of extraction of groundwater during 1970s and 80s in all the systems was from the ordinary 3-4 HP pumpset, later in the 1980s, these were replaced by submersible pumpsets to extract water from the deeper layer of the aquifer. The investment per well increased alarmingly from Rs 50, 000 to 400,000 since two decades indicating a growth rate of 3.5 % per annum. Thus groundwater based agriculture prospered with groundwater boom and reached a turning point leading to burst. The implication is that due to depletion of groundwater the groundwater scarcity emerged on different scales. Consequently, the investments on well deepening and drilling new borewells increased massively. Many farmers are resorting to dryland agriculture due to widespread failure of bore-wells and extreme scarcity of groundwater in the villages. This has become a threat to livelihood security of large number of farmers who are depending on directly or indirectly on this valuable resource. Now, the challenge is how to promote sustainable use by introducing some of the corrective measures focusing on resource management and conservation.

Coping Mechanisms

Coping mechanisms are the investment by farmers to cope with the groundwater scarcity situation at least to maintain the pre-failure level of incomes. Due to low discharge of water in the borwells, and unscheduled power cuts farmers have been pumping water during night and storing water in the small earthen/concrete ponds and irrigating in the day time. In response to groundwater scarcity, the farmers are resorting to different coping mechanisms to manage the reduced supply of groundwater through drilling new wells, deepening existing wells, adoption of drip irrigation system, sprinkler irrigation, investment on improved storage structures, conveyance, shifting cop pattern, buying water (Figure 8). The cost of coping mechanisms is swelling due to negative externalities of groundwater depletion. Studies indicated that there has been rise in the cost of groundwater extraction from Rs. 51 to Rs. 82 on to Rs. 264 per acre-inch reflecting scarcity of groundwater between 1980’s to1990’s and 2000 respectively (Nagaraj and Chandrashekar 2003). Thus, there have been manifestations of both physical and economic scarcity of groundwater.

Informal Water Markets:

Groundwater markets are informal institutions providing access to groundwater irrigation benefiting resource-poor farmers who are constrained to invest on expensive and risky bore well irrigation. Water markets for groundwater have emerged in Tharati because of surplus water from wells in relation to their irrigated area and due to extremely small size of holdings in the village, where well owners selling the surplus water to their neighbours. Some of the farmers, whose wells failed, are involved in buying water as a coping mechanism to sustain their income levels. In the village, there are 40 water buyers and 20 water sellers, indicating for every one seller there are two buyers. On an average, the seller had 1.09 ha of cultivated area as against 0.76 ha of buyers. The water markets are highly seasonal and the prevailing water rate is around 1/3rd of the total output value. The major commercial crops exclusively grown by sellers and buyers of water are flower crops viz., chrysanthemum in all the 3 seasons. However, vegetables like carrot and brinjal were also grown on a small scale. Tharati is one of the model villages for flower cultivation, generating lucrative income. The study found that groundwater sellers realized higher net returns than the groundwater buyers (table 5). The figure 9 indicates that around 17% of the total income realised is through selling water. On an average the net income realised by the seller is 2.5 times higher than the water buyer.

Floriculture in Tharati:

Technology driven intensive agriculture development is the striking feature of farming in the village with high input use intensity per unit area. It is one of the model villages for flower cultivation (Chrysanthemum) under small scale. It is interesting to note that both sellers and buyers of groundwater are involved not only in flower production but also in stringing the flowers by employing own family labour and hired women labour from the landless households. If flowers are sold on bulk without sorting, cleaning and stringing, it fetched around Rs. 60-70 per Kg, while sorting and stringing flowers and selling at retail market fetched double the price. The additional cost involved in stringing the flowers is Rs.10/per kg and the resulting value addition is to the tune of Rs. 50 to 60.Thus flower production has created not only value addition but also generated additional employment for women on the farm preventing migration of labour. The agricultural growth exhibited in this village is impressive and a kind of inclusive growth through water markets facilitating commercial floriculture in the village.

Women employment in Horticulture:

In case of floriculture, women employment has been very impressive accounting more than 60 % of the total man-days engaged over the years. Women were involved in almost all the crops grown in the village from sowing, weeding, harvesting and threshing operations. Most female labour is involved not only in flower production but also in stringing the flowers. This has created not only value addition to the flower production but also generated additional employment for women on the farm. Thus, the feminization of horticulture is evident. This is mainly because of "pull" factors such as higher wages and better economic opportunities in the peri-urban and urban areas, the male members of the labour households move out from rural to peri-urban, while women are engaged in agriculture.

Changes in the sources of income

Irrespective of the all groups, a large proportion of income has been derived from non-farm income, followed by income from horticulture and livestock. The agricultural income share has become inconspicuous due to labour scarcity and frequent droughts. Compare to horticultural crops, farmers incurred loss in growing agricultural crops in some years due to prolonged droughts. As discernible from figure 10, the proportion of non-farm income derived increased with increased farm size. Thus the size of net margins realised from agriculture has been drastically reducing. Thus, the meagre earning from crop production especially in dry land situation has deterred farmer’s interest in agriculture leading to shift from farming to non-farming sources of income. Hence farmers have been deriving more income from non-farm sources such as salaried jobs like brick making, bullock renting, sand mining, leaf plate making, petty business, construction, transport and so on, business, remittances, rental, interest etc..

With structural transformation in the economy, and rise of non- farm wages, there is shift of labor from agriculture to non-agriculture. Small size of holding for a large number of households is unable to provide full time employment and an income level which will satisfy the aspiration level of youth.

Major drivers of change:

The village witnessed tremendous changes in terms of change in cropping pattern from subsistence to commercial crops, from water intensive to less water intensive crops, from groundwater abundance to extreme scarcity, changes in sources of income and so on. The major drivers of this change inter alia include access to groundwater irrigation, informal water markets promoting viable commercial floriculture, adoption of modern technology with high input use intensity, women empowerment and non-farm income, markets and infrastructure.

Conclusions and Policy implications

Due to favourable policies, there has been structural transition in the village economy with shift in the cropping pattern towards high value non-food crops that include horticultural enterprises and more income being derived from non-agriculture than agriculture and within farming horticulture led development with access to groundwater. Till 2000, farmers of Tharati were cultivating water intensive crops like Acarus calamus – Sweet Flag (medicinal plant), an annual rhizome in stagnant water and paddy which are virtually disappeared after 2000. With commercialization of agriculture there has been acute scarcity of groundwater. Since 4 decades, the groundwater extraction exhibited a trajectory of initial utilization, boom, growing scarcity and eventually bust with rapid fall in groundwater tables. Due to failure of wells both physical and economic scarcity of groundwater is evident over time. In response, there has been increasing trend in investments on coping mechanisms leading to increased irrigation cost and reduced returns. Water markets for groundwater have emerged in Tharati because of surplus water from wells in relation to their irrigated area and due to extremely small size of holdings in the village. Water markets enabled small farmers to take up commercial floriculture in the village with high returns per ha promoting inclusive growth. Farmers are involved not only in flower production but also in stringing the flowers especially women. This has created not only value addition to the flowers but also generated additional employment for women on the farm. The study highlighted that overexploitation of natural resources such as groundwater in Tharati is responsible for transition in land use and crop patterns. Accordingly steps need to be taken towards sustainable use of groundwater. In order to promote high-value agriculture/horticulture requires enabling policies, institutions, and infrastructure.

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Table 1: Salient features of VDSA Villages in Karnataka

Particulars/villages	Bijapur		Tumkur	
	Markabinahal li	Kapanimbar gi	Tharat i	Belladamadug u
# of HH's	392	320	401	276
Total geographical area (Ha)	1001	826	519	496
Cultivated area (Ha)	911	876	172	355
% of Irrigated area	0	20	42	27
% of landless households	28	33	28	10
Family size	6.47	6.23	4.24	4.43
Literacy	64	60	24	49
Size of holding (Ha)	3.29	3.6	1.03	1.45
Seasonal migration (% of HH)	-	12	-	-

Table 2: Area coverage under Food and Non-food crops in VDSA villages of Karnataka (ha)

Villages/ F-NF	2000	2005	CGR (2000-05)	2010	CGR (2005-10)	(% change during 2000-10)	CGR (2000-10)
Belladamadugu							
Food	99	103 (4)	0.81%	82 (-21)	-4.49%	-17	-1.88%
Non-Food	136	149 (10)	1.90%	232 (56)	9.26%	71	5.51%
Tharati							
Food	140	124 (-12)	-2.48%	99 (-20)	-4.35%	-29	-3.42%
Non-Food	87	100 (14)	2.64%	136 (36)	6.37%	55	4.49%
Kapanimbargi							
Food	417	249 (-40)	-9.80%	334 (34)	6.05%	-20	-2.19%
Non-Food	405	582 (44)	7.55%	518 (-11)	-2.33%	28	2.49%
Markabinahalli							
Food	324	202 (-38)	-8.97%	158 (-22)	-4.85%	-51	-6.93%
Non-Food	562	680 (21)	3.89%	720 (6)	1.15%	28	2.51%

Table 3: Cropping pattern of VDSA villages in Karnataka from 2000 to 2010

Particulars	Year			CAGR b/w 2000 to 2010
	2000	2005	2010	
Kapanimbargi village				
Area under Horticulture (%)	6	12	13	6.81
Area under Agriculture (%)	94	88	87	-0.66
Total area under cultivation (ha)	**748 (100)**	**702 (100)**	**1030 (100)**	2.92
Tharati village				
Area under Horticulture (%)	18	22	31	5.08
Area under Agriculture (%)	82	78	69	-1.59
Total area under cultivation (ha)	**223 (100)**	**218 (100)**	**228 (100)**	0.19
Belladamadagu village				
Area under Horticulture (%)	2	3	5	8.10
Area under Agriculture (%)	98	97	95	-0.24
Total area under cultivation (ha)	**232 (100)**	**249 (100)**	**310 (100)**	2.66
Markabinahalli village				
Area under Horticulture (%)	1	0	6	21.55
Area under Agriculture (%)	99	100	94	-0.49
Total area under cultivation (ha)	**875 (100)**	**872 (100)**	**868 (100)**	-0.08

Table 4: Transitional probabilities of cropping pattern in Tharati village in Tumkur district of Karnataka (1998 to 2011).

Crops	Paddy & Ragi	Ground nut	Chrysanthemum & China aster	Sweet flag	Perennial crops	Area in base year (1998) (ha)	Area in Terminal year (2011) (ha)	% change
Paddy & Ragi	0.7471	0.0000	0.0000	0.0000	0.2529	15.6	8.06	-48.31
Groundnut	0.7629	0.0000	0.1477	0.0894	0.0000	4.14	0.44	-89.27
Chrysanthemum & China aster	1.0000	0.0000	0.0000	0.0000	0.0000	0.00	4.50	-
Sweet flag	0.0000	0.0964	0.9036	0.0000	0.0000	8.47	0.2	-97.61
Perennial crops	0.0000	0.0000	0.0000	0.0000	1.0000	3.2	3.8	21.19

Note: Perennials crops include Arecanut, Coconut, Jasmine, Beetle vine, Mulberry and Banana.

Table 5: Share of net income among different sources for groundwater buyers and sellers

Particulars	GW Buyer	GW Seller
Total Area cultivated (ha)	0.76	1.09
Livestock	17940	13625
Chrysanthemum	231000	262500
Finger millet	7700	17000
Pigeon pea		1500
Maize		5000
Paddy		25500
Perennials		55667
Total income of crops	238700	367167
Average income per ha	310000	336850
Total income (excluding water value)	256640	380792
Cost incurred by selling water	(-)79567	(+)79567
Total income per year	177073	460359

Table 6: Total labour days and share of female labour for Agriculture and Horticulture (per ha)

Crops		2009		2010		2011	
		Total man days	% of Female to total labour	Total man days	% of Female to total labour	Total man days	% of Female to total labour
Agriculture	**Finger millet**	116	74	115	69	101	73
Horticulture	**Arecanut**	431	39	720	28	593	27
	Chrysanthemum	208	64	339	67	225	69
	Jasmine	462	64	659	57	568	58
	Coconut	65	9	161	21	115	6

Table 7: Source wise share of income derived across different farm groups

Particulars	Large			Medium			Small		
	2009	**2010**	**2011**	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**
Agriculture (%)	3	3	3	3	5	4	3	3	1
Horticulture (%)	27	16	9	8	14	11	8	10	44
Livestock (%)	10	17	11	14	13	11	16	21	9
Non-Farm income (%)	61	64	77	75	68	74	73	65	45
Total income (Rs)	100391	131557	185343	57947	82444	107854	52365	92877	241846

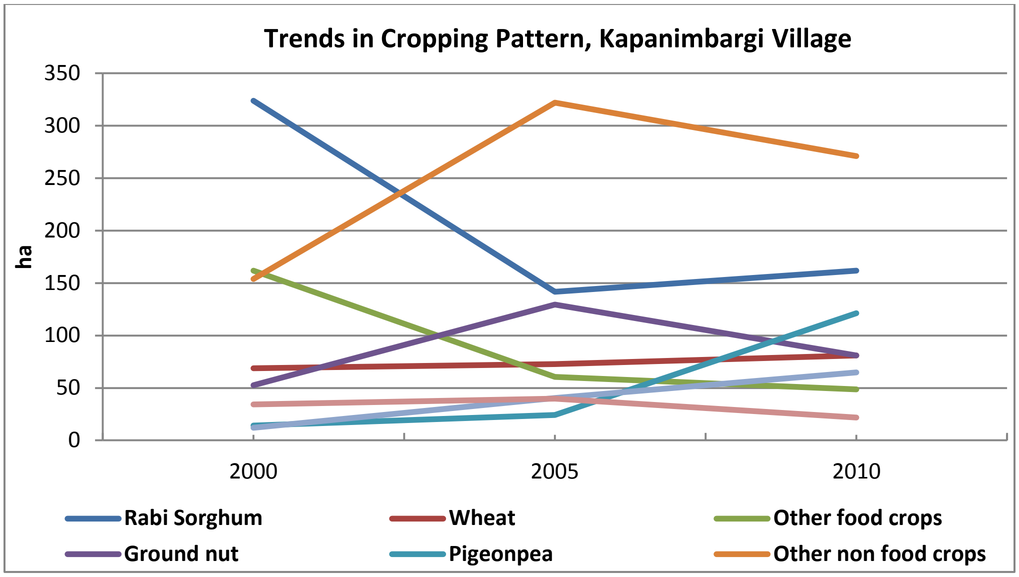

Figure 1: Trends in cropping pattern, Kapanimbargi

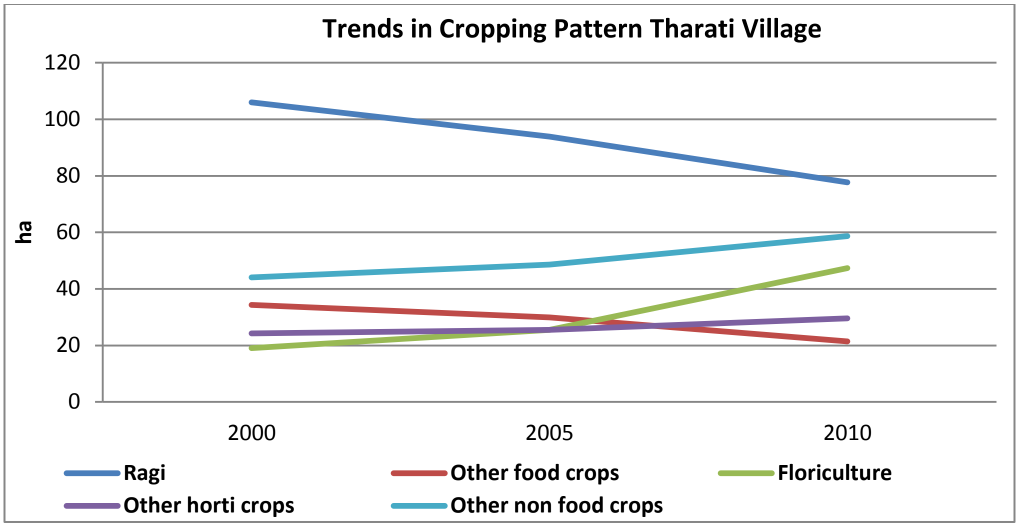

Figure 2: Trends in cropping pattern, Tharati

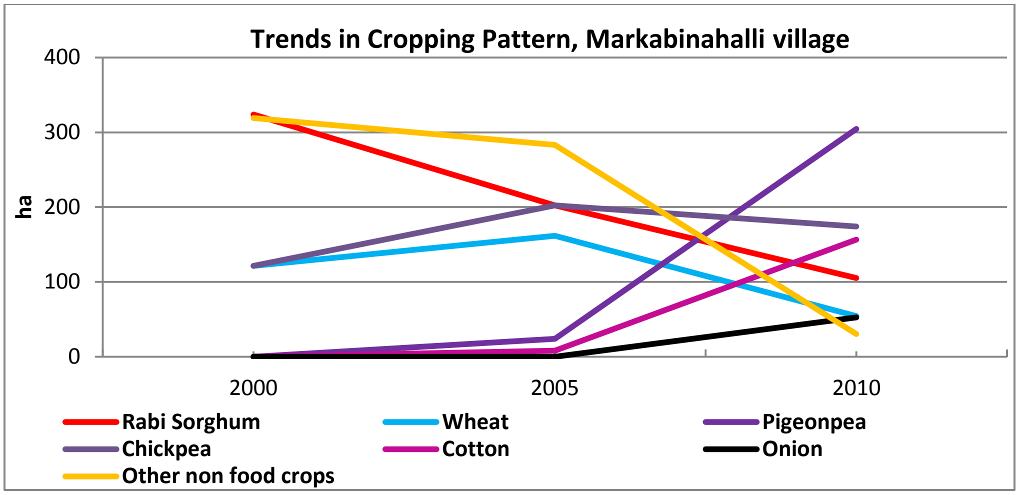

Figure 3: Trends in cropping pattern, Markabinahalli

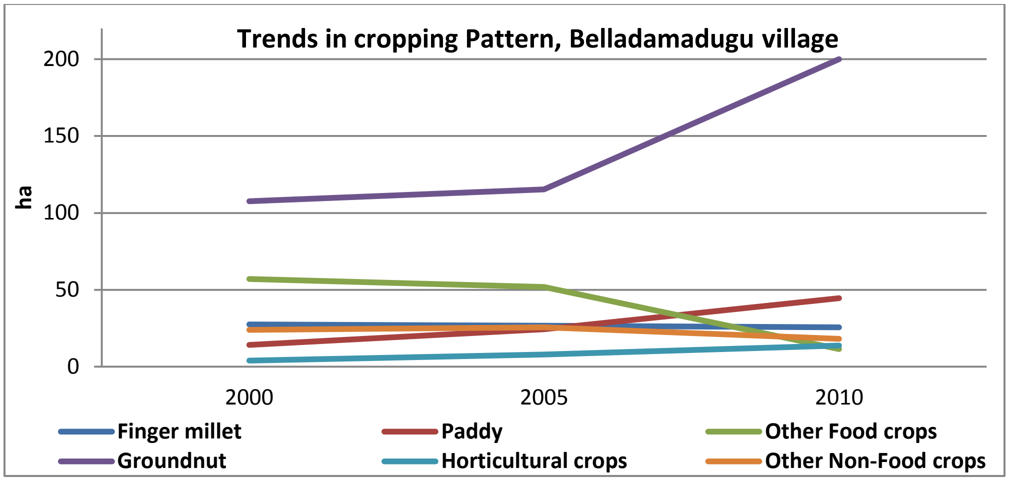

Figure 4: Trends in cropping pattern, Belladamadugu

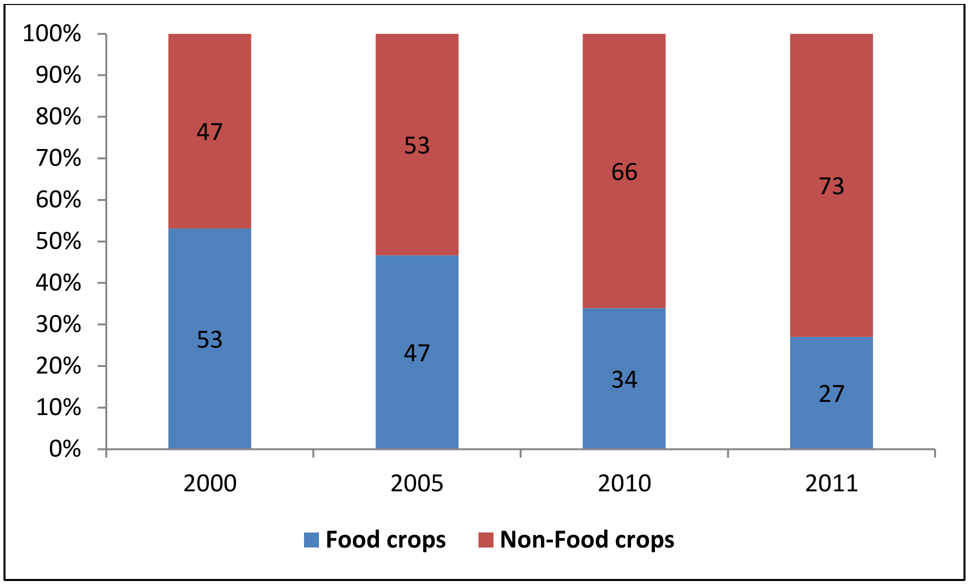

Figure 5: Percentage area coverage under Food and Non-food crops

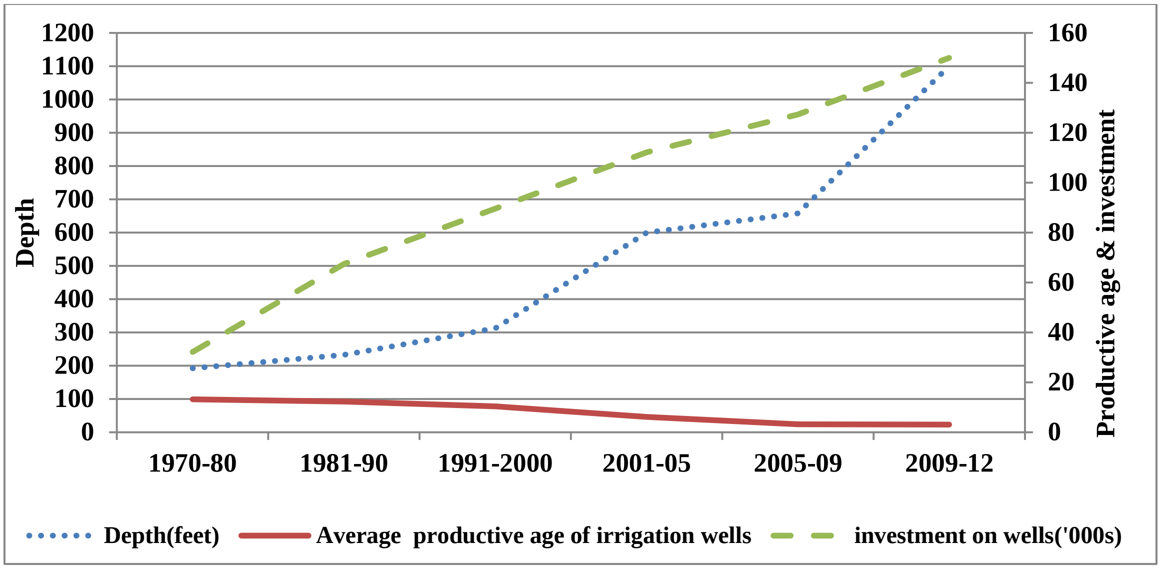

Figure 6: Morphological changes in groundwater structures in Eastern Dry zone of Karnataka

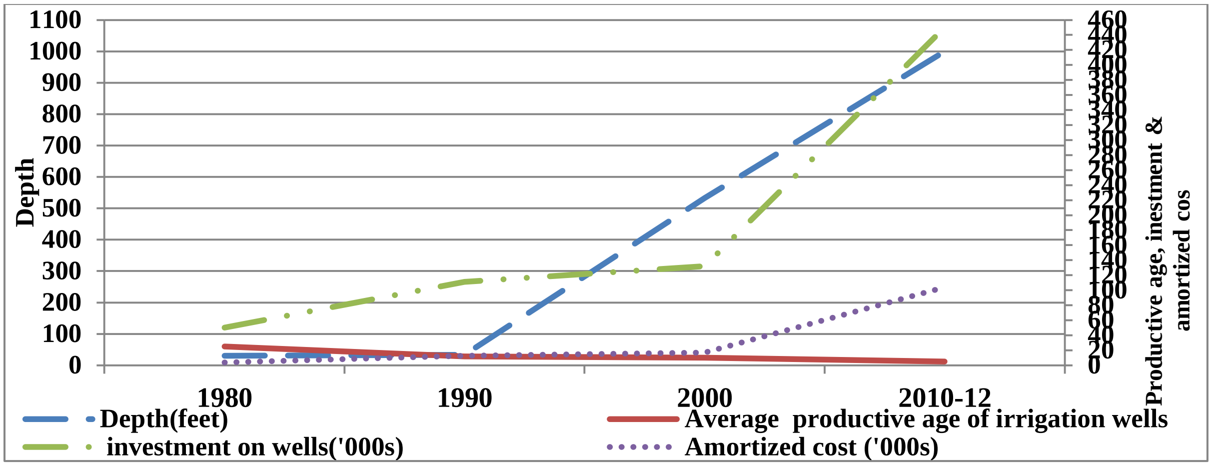

Figure 7: Morphological changes in groundwater structures and their investments in Tharati Village, Tumkur District

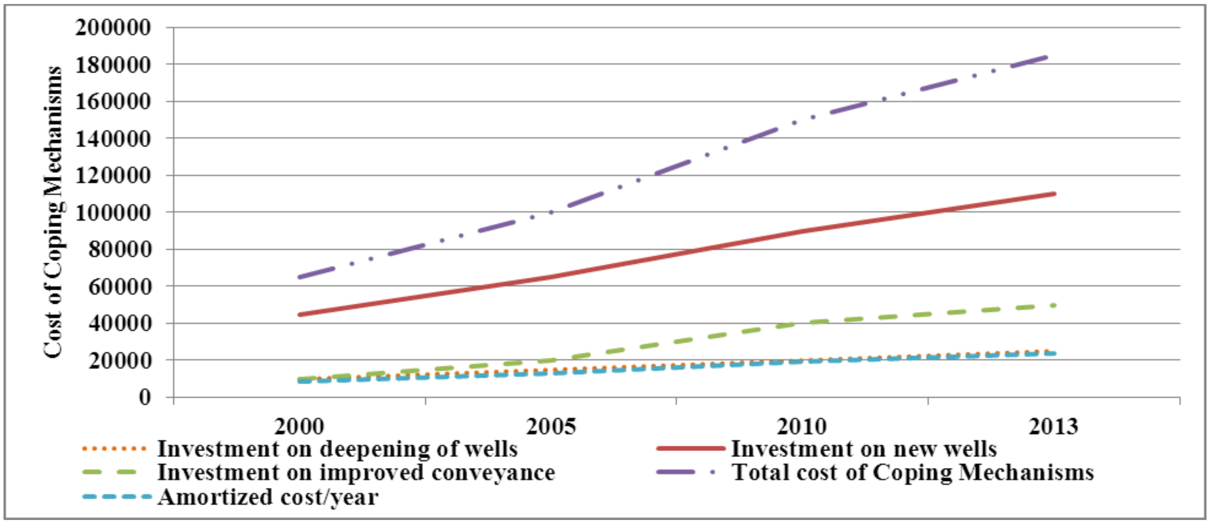

Figure 8: Cost of coping mechanisms and amortized irrigation cost per well

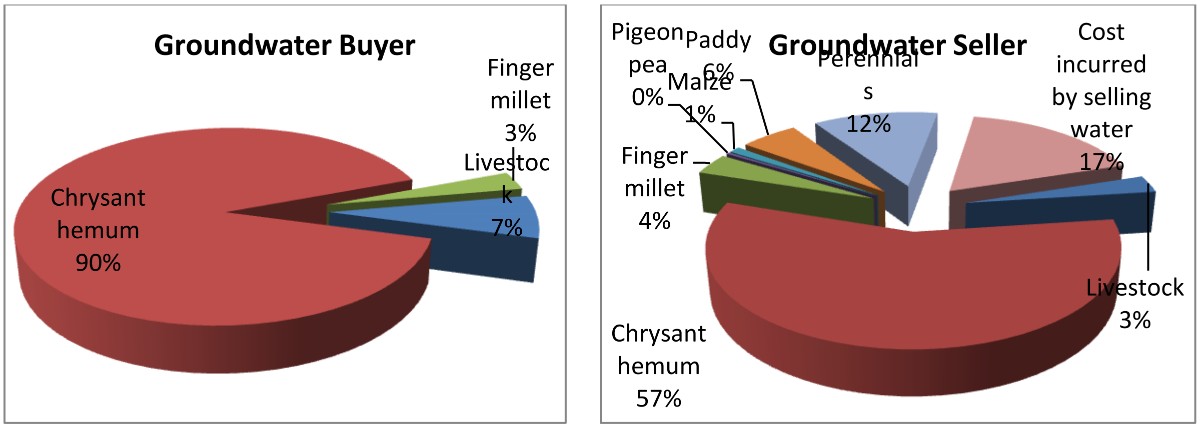

Figure 9: Percentage share of net income from different enterprises from groundwater buyers and sellers.

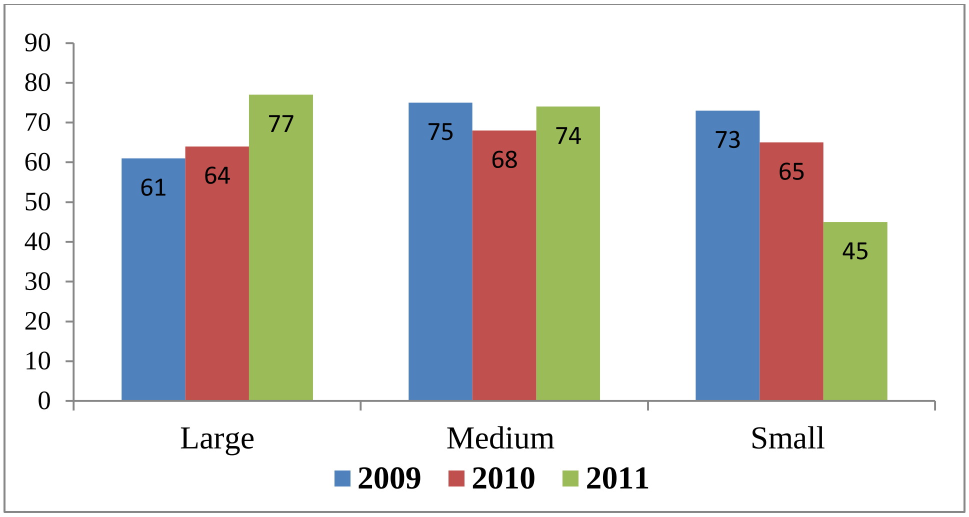

Figure 10: Share of Non-farm income to total income among different size groups