Impact of Tsunami on the Farm Households of Coastal Tamilnadu State, India*

K.Palanisami[1], Chieko Umetsu[2], Takashi Kume[2] and M.Shantha Sheela[3]

[1]International Water Management Institute (IWMI), Hyderabad, India

[2]Research Institute for Humanity and Nature (RIHN), Kyoto, Japan

[3]Tamilnadu Agricultural University, Coimbatore, India

Abstract

Tsunami attacked the Indian coast on 26th December 2004 and the worst affected areas along the Indian coast were in Tamil Nadu, Kerala, and Andhra Pradesh states. Tamil Nadu state suffered maximum loss with the damage concentrated in four districts. A study was conducted in Nagapattinam district of Tamil Nadu State, India during 2005-08 with a sample of 240 households. Results had indicated that about 77 per cent of the households were with farming before tsunami and it has reduced to 25-37 percent after tsunami. In the non-farm sector, 10 per cent of the households were involved in non farm activities before tsunami and this has increased to 24 – 38 per cent after tsunami. The percent distribution of labour households is about 50 percent after tsunami compared to only 11 percent before tsunami. The overall mean technical efficiency is around 83 percent indicating the scope for increasing the technical efficiency further by 17 percent. The results of the soil and water analysis further indicated that the agricultural environment of the district recovered rapidly after the tsunami. Paddy is the major crop in the region and the profit was ranging from Rs 3695/ha in 2006 to Rs 6405/ha in 2007 compared to adjacent non-tsunami regions which was ranging from Rs 5600 to Rs 8500 /ha confirming the coastal risks in paddy production. Crop management practices and incorporation of crop insurance in agriculture programs are suggested to increase the farm income and minimize the risk in agriculture.

1. Introduction

On 26th December 2004, out of the 7516 km long coastline of India, more than 4500 km stretch was badly affected by the 9.0 magnitude earthquake-triggered tsunami, resulting in the total destruction of living environment along the coast. The worst affected areas along the Indian coast were in Tamil Nadu, Kerala, and Andhra Pradesh states. Tamil Nadu state suffered maximum loss with concentration in 4 districts (Figure 1).

---

* Paper presented at the IHDP Open Meeting 2009 – 7th International Science Conference on the Human Dimensions of Global Environmental Change, 26-30 April, 2009, Bonn, Germany.

The paper is a preliminary product of the joint research study undertaken between the Research Institute for Humanity and Nature (RIHN), Kyoto, Japan and Tamilnadu Agricultural University, Coimbatore, India during 2005-2008.

Tamil Nadu is located in the northern hemisphere in the Torrid Zone between 8^0 and 13^0N latitude, and between 78^0 and 80^0E longitude. It is the 11^{th} largest state in India, has a population over 60 million, and occupies an area of about 130,058 km^2. The climate along the coast is warm and humid, and the rainy season is marked by the onset of the northeast monsoon between mid-September and mid- December. Cyclonic storms occur during this period due to depression in the Bay of Bengal (Krishna, 2005).

It was reported that due to 26 December, 2004 Tsunami in Tamil Nadu state, 0.896 million people were affected, 376 villages had heavy damage, 7951 human lives lost, 1000 KM coastal length is affected, the sea water penetrated 1-1.5 KM distance into the main land, 128394 dwelling units affected, 9559 cattle lost, 10245 ha cropped area affected, 42655 boats damaged. (GOI, Ministry of Home Affairs, 09.01.2005). Many felt that impact will be very serious and it will take years to resume normal activities in the region. Keeping this as the base, a collaborative study between Research Institute for Humanity and Nature (RIHN) Kyoto and Tamilnadu Agricultural University, Coimbatore, India was taken up during 2005-2008. This paper presents an analytical study of the impact of tsunami on agricultural production, household income of the farm households on a continuous basis from 2005 to 2008.

The first section describes the review of the tsunami impact studies, the second section deals with the methodology used to collect and analyse the data including the description of the technical efficiency in crop production. The third section deals with the impact of the tsunami on household occupation, and crop production. The results of the technical efficiency analysis in paddy cultivation and brief discussion on the tsunami on soil and water is also made.2. Review of Tsunami impact studies

2. Review of Tsunami impact studies

In The Republic of Maldives, at 9:00 AM (1:00 PM in Japan local time) on 26th December, tsunami attacked this region. Maldives is a group of about 1,200 coral islands, and its maximum height is only 1.8m. Almost all the roads in the capital city Male were flooded. There were no vacancies in hotels because it was Christmas vacation season (time). So, there had happened severe damage by that tsunami. There was no tsunami warning system in the Indian Ocean premises. In some coastal areas, the people could not feel ground motion; so, the inhabitants of that area were suddenly attacked. (Imamura, *et al, 2005*)

The estimated total financial losses in India - as reported by the Government of India - exceed US$1.2 billion. This includes damages to infrastructure, such as roads, bridges, ports and around 154,000 houses. Public buildings, such as schools, Integrated Child Development Services (ICDS) and health centers were equally affected.

Two years after Tsunami people affected by the Tsunami were housed in temporary shelters with basic sanitation, childcare and nutrition services. Some of these people still live in those shelters;

however, the Government has taken up the challenge to rebuild almost 100,000 new homes in all the affected States. As of November 2006, close to 30% of these have been completed. Infrastructure such as water supply, latrines and electricity is being provided in the new sites and destroyed infrastructure like roads and fishing harbours are being rebuilt. At the same time, the livelihoods of fishing communities are being restored and strengthened through a variety of initiatives. Destroyed and damaged schools were rebuilt - some of them received furniture for the first time ever.

Psychosocial and healthcare programmes, aimed at dealing with the immediate physical and mental impact of the Tsunami, were initiated. These are designed to give support on a long term basis. Livelihoods of fishermen were restored with better equipment and programmes were undertaken to increase revenues and offer alternatives to fishing.

During the past year, the recovery work has shifted gradually from immediate needs to long-term recovery. Particular attention was given to the equitable distribution of aid and benefits and to sharing best practices. The establishment of a National Disaster Management Authority has guided the expansion and acceleration of programmes for disaster risk reduction. This has facilitated the move from restoring and delivering services, to strengthening policy and capacity building and the upgrading of infrastructure with the goal to “Build Back Better”. (The United Nations, the World Bank and the Asian development Bank, 2006)

3. Methodology and Data Analysis

The study was conducted in Nagapattinam district of Tamil Nadu State, India, which is bounded on the north by Cuddalore district, south by Palk Strait, east by Bay of Bengal and west by Thiruvarur district.

Two hundred and forty respondents from twenty four villages of coastal Nagapattinam district were selected. From 2004 onwards every year upto 2008 (consecutively 4 years) the same respondents were contacted to assess the impact of tsunami on agricultural production, household income of the farm households. Year 2004 represents the year of tsunami and the crop pattern during the period will represent before tsunami situation and the subsequent years will represent the after tsunami situation. Surface soil samples from hundred sites of same farm holding were collected and analyzed to study the changes in the pH and EC from 2004 to 2007 due to the tsunami. The surface water resources meant for irrigation and drinking were affected by the ingress of sea water in all the areas. The massive quantity of sea water that inundated the coastal agricultural lands for 0.5 to 2.0 km area inland, due to reasons of poor drainage, stood for a few days affecting the quality of soil and groundwater. The thicknesses of deposits left in fields were 0.02 to 0.2 m (Chandrasekharan et al. 2005).The electrical conductivity (EC) of soil and shallow groundwater increased by about ten times and 15 times respectively, and the degree of variations differed from place to place. To assess this ten bore holes were drilled in the affected fields. Every month from June 2006 to March 2008 water samples were collected from the bore holes and .the groundwater EC was measured monthly.

The stochastic frontier production function is given by

$$y_i = f(x_i;\beta)\exp(\varepsilon_i) \qquad (1)$$

where i=1,2,….n refers to farms, β is a vector of parameters and ε_i is an error term and the function $f(x;\beta)$ is called the 'deterministic kernel'. The frontier is also called as 'composed error' model because the error term ε_i is assumed to be the difference of two independent elements,

$$\varepsilon_i = v_i - u_i \qquad (2)$$

where v_i is a two sided error term representing statistical noise such as weather, strikes, luck etc which are beyond the control of the farm and $u_i \geq 0$ is the difference between maximum possible stochastic output (frontier) $f(x_i;\beta)\exp(v_i)$ and actual output y_i. Thus u_i represents output oriented technical inefficiency. Thus the error term ε_i has an asymmetric distribution. From (1) and (2), the farm-specific output-oriented technical efficiency is given by

$$TE_i^o = \exp(-u_i) = y_i / \{ f(x_i;\beta)\exp(v_i)\} \qquad (3)$$

Since $u_i \geq 0$, $0 \leq \exp(-u_i) \leq 1$ and hence $0 \leq TE_i^o \leq 1$. When $u_i = 0$ the farm's output lies on the frontier and it is 100% efficient. Thus the output oriented technical efficiency tells how much maximum output is possible with the existing usage levels of inputs. It can be shown that

$$E(u/\varepsilon) = \int uf(u/\varepsilon)du = \mu_* + \sigma_*\phi\left(-\frac{\mu_*}{\sigma_*}\right)\left[1-\Phi\left(-\frac{\mu_*}{\sigma_*}\right)\right] \qquad (4)$$

and

$$TE_i = \exp(-E(u_i/\varepsilon_i)) \qquad (5)$$

where $\sigma_* = \frac{\sigma_u\sigma_v}{\sigma}$ and $\mu_* = -\frac{\varepsilon\sigma_u^2}{\sigma^2}$ and $\phi(.)$ and $\Phi(.)$ are respectively the density function and cumulative density function of the standard normal variate. Formula (4) and (5) are used to compute the technical efficiencies. The Cobb-Douglas functional form was used to estimate the technical efficiencies.

4. Results of the Tsunami Impact Analysis

4.1 Impact of on Household Occupation

It could be observed from Table 1 that before Tsunami (2004), 77 per cent of the respondents involved in farming as agriculture was the predominant occupation in villages. However, after Tsunami it has been drastically reduced to 25 per cent, and it has increased to 37 percent during 2007.

The tsunami had left behind a thick (2 to 20 cm) layer of sea sediments as a slushy black layer over rice fields. The standing crops of rice (*Oryza sativa*) and groundnut (*Arachis hypogea*) in different growth stages were dried up due to induced exosmosis (i.e. the passage of a fluid through a semipermeable membrane toward a solution of lower concentration, especially the passage of water through a cell membrane into the surrounding medium) inflicted severe damage. This impact was felt in crop production during 2005. Further, the flood occurred during October-November 2006 affected the standing crops. This may also one of the reasons for a slow recovery from the tsunami induced shock in the agriculture sector. In addition, agriculture fields near to the coastal areas were affected by sea water intrusion which made the field unfit for cultivation. Many have reported that to avoid risk in farming, they were reluctant to take up farming as a primary occupation.

In the non-farm sector, 10 per cent of the sample households were involved in non farm activities such as small scale fish vending, shell collection and selling, fish net knitting and other similar activities before tsunami and the shift towards non-farm activities had increased after the tsunami, viz., 24, 38 and 20 per cent in 2005, 2006 and 2007 respectively. Later they slowly shifted to their farming activities.

Before tsunami almost 11 per cent of the sample respondents were farm labourers. Subsequently, almost 50 per cent turned to be the farm labourers looking for relief from different agencies. Because of tsunami, many foreign agencies and Indian Government pumped money to the affected areas and to receive the relief packages, many discontinued the agriculture and called them as labourers. Hence, there is a close negative relationship between the number of households in farming and in labour categories.

During 2006, the percentage of farm labourers has reduced to 33 and in 2007 it has been increased to 40 per cent. In addition, few households got employment in the National Rural Employment Guarantee Scheme (NREGS) [1] to sustain their livelihood requirements. This might be another reason for high percentage of respondents in this category. In fishing sector no change in the sample respondents' occupation. Similarly, in the case of unemployment and temple land cultivation, no difference was observed. The chi-square test shows that there was a significant shift from farming to farm labour categories after tsunami (Table 1).

It is also important to see the number of family members involved in farming after tsunami. It could be revealed from Table 2 that after tsunami, involvement of only single family member in

[1] The National Rural Employment Guarantee Act was enacted in September 2005. The National Rural Employment Guarantee Scheme was launched on 02.02.2006 and is being implemented in Nagapattinam district. The National Rural Employment Guarantee Act, 2005 (NREGA) guarantees 100 days of employment in a financial year to any rural household whose adult members are willing to do unskilled manual work. This Act is an important step towards the realization of the right to work. It is also expected to enhance people's livelihoods on a sustained basis, by developing the economic and social infrastructure in rural areas. The Village Panchayat will issue job cards to every registered individual. Payment of the statutory minimum wage and equal wages for men and women are the notable features of the scheme.

farming has increased and reached to 91 per cent. In allied activities (livestock, poultry) and non-farm sector (shop), there is no change in percentage of respondents before and after tsunami.

In all the cases, one member from the family was involved in agriculture and allied activities. Only in the hired work category, more than two family members were involved indicating less importance given to agriculture and allied activities by the households due to tsunami.

4.2 Impact of Tsunami on crop production

Annual normal rainfall of the region is about 1341.7 mm. The North-east monsoon (October to December) contributes about 65% of the total annual rainfall. The South West monsoon (June to September) contributes about 20% of the total annual rainfall. The summer and winter rain accounts for the rest. Normally the cropping season coincides with the North-east monsoon season and if adequate water facility is available, farmers will raise the crop, otherwise the land will be kept fallow. The rainfall pattern shows that in 7 out of 13 Years, the North-east monsoon was deficit and in 5 years, it was surplus thus indicating the climate vulnerability of the region.(Table 3; Figures 2 & 3).

Out of the total geographical area of Nagapattinam district (271583 ha), cropped area accounts for 65.53 percent and 74.5 percent of the agricultural holdings are less than 1 ha. The Forest cover is very minimum accounting for only 1.31 percent of the total area. The district has 10,054 ha of waterlogged lands and 11,047 ha are totally affected by salinity.

Paddy is the main crop of the district and depending upon water availability and other factors, the farmers grow two crops viz., Kuruvai (April to July) and Thaladi (Aug to Nov) or Samba (Aug to Nov) crops. Other cereal crops like Cumbu (*Panicum miliaceum)*, Ragi (*Eleusine coracane),* Cholam (*Sorghum vulgare)*, etc., account for a very small area only. Similarly, some pulses like Red gram (*Cajanus cajan),* Green gram (*Vigna radiata)* and Black gram (*Vigna mungo)* are grown in small area (Statistical Handbook of Tamil Nadu, 2006).

It could be inferred from Table 4, during summer season more than 95 per cent of the respondents had not cultivated annual crops such as paddy (*Orysa sativa)*, cumbu (*Panicum miliaceum),* ragi (*Eleusine coracane)*, vegetables etc,. in their field in all the years. Only few farmers have grown perennial crops such as coconut (*Cocos nucifera),* cashew (*Anacardium occidentale)* and mango (*Mangifera indicum)* crops that exists in the summer season.

Regarding Kharif (June- Sep) season crops, based on the availability of water only few farmers (2 %) were able to cultivate paddy during 2004 and 2005 and this also reduced over years (Table 5). However during Rabi (Oct-Jan) season, immediately after tsunami, 20 per cent reduction in paddy cultivation was observed. Drastic reduction in paddy cultivation during October 2006 to January 2007 was due to flood in November 2006 which washed away the standing crops (GoTN, 2006). Cyclonic storm brings havoc normally once in 3 or 4 years and heavy downpour during North-east monsoon leads to flooding of the district and damaged the field crops and wealth of soil. Hence, many farmers had reported that they could come back to normal cultivation during the Kharif season (October 2007 to January 2008) due to flood damages.(Table 6).

Agronomic interventions

Due to tsunami, the sea water intrusion affected the soil and water quality. To overcome this, site specific reclamation strategies like deep ploughing, land smoothening, strengthening field bunds and providing adequate drainage, spreading and incorporation of sand/clay deposits in the field, *in situ* ploughing of green manures like *Sesbania aculeate*, and leaching, wherever required, depending upon soil EC were adopted. To enhance the soil microbial activity, farm yard manure (FYM) at the rate of 5 t/ha and salt tolerant strains of biofertilizers such as phosphobacteria, azospirillum and pseudomonas species at the rate of 2 kg/ha were applied.

In order to see the economics of crop cultivation after tsunami, detailed cost of cultivation was worked out. The cost of cultivation has increased after tsunami due to the above agronomic practices even though the government also provided these inputs at subsidized prices. As indicated earlier, during tsunami year, the standing crop was totally devastated and the year after tsunami, about 70 per cent of the crop had failed due to poor soil quality.

Regarding the cost of cultivation, before tsunami 44 per cent of the paddy cultivating respondents had the expenditure upto Rs.7500/ha. The cost of cultivation of paddy has increased slowly from 2004 to 2007. Before tsunami, 27 per cent of the paddy cultivating respondents had a cost of cultivation of less than Rs.5000/ha and this percentage has reduced in the subsequent years. During 2004, about 28 per cent of the farmers had a cost of cultivation of more than Rs.12000/ha, and it has gradually increased to 44 per cent during 2007 indicating the magnitude of cost increase in crop production (Tables 7 & 8; Figure 4). Among the components of the cost of cultivation, fertilizer and manure accounted for more share, followed by seeds, machine power and human labour.

The average cost of cultivation in 2006 was about Rs 14155/ha and it has increased to Rs 15502 /ha in 2007 (9.5 % increase). About 11 percent farmers were able to get higher income (Rs 21250 to 23750/ha) due to their favourable farm location. There are also few more farmers in the year who obtained still higher income (Table 9). In the subsequent seasons, (Oct 06 – Jan 07 and Oct 07 – Jan 08) more than 55 per cent of the households had a gross income of more than Rs. 25,000/ha. There are also few farmers in these seasons who had a higher income of more than Rs 36,000/ha, indicating that with good management of the land and water it is possible to improve the crop productivity and income. Hence it is important to see the good management practices followed by the farmers in these locations The average gross income per hectare from paddy cultivation was fluctuating over years i.e., Rs.7500 during 2005, Rs 17850 during 2006 and Rs 21900 during 2007.

Given the higher cost of cultivation, the profit level is much less. It is observed that during 2006, the profit is about Rs 3695/ha which has increased to Rs 6405/ha in 2007 indicating the risks in paddy cultivation in the coastal regions.(Table 10). During the same period, the profit level in paddy cultivation in neighbouring district of Tanjore was ranging from Rs 5600 to Rs 8500 /ha (CARDS, 2007).

4.3 Technical Efficiency in Paddy production

The technical efficiency estimates of the stochastic frontier production and the frequency distribution of the technical efficiency among the farmers in different years are given in Tables 11 and 12. It is observed that there is no significant difference in the overall mean technical efficiency of the farmers after tsunami. The technical efficiency level of 80-90% has increased marginally during 2006 and 2007. However, few farmers are still under below average technical efficiency levels of less than 40%. The overall mean technical efficiency is around 83% indicating the scope for increasing the technical efficiency further by 17% through improved crop management practices.

4.4 Effect of Tsunami on Soil and Water

The average soil EC before the tsunami was 1.0 dS m^{-1}, within the range of 0.4 to 4.9 dS m^{-1}. The average soil EC immediately after the tsunami was 5.9 dS m^{-1}, within the range of 0.3 to 23.1 dS m^{-1}. In 2006 and 2007, the average soil ECs were 0.8 dS m^{-1} and 0.6 dS m^{-1}, respectively, within ranges of 0.01 to 11.0 dS m^{-1} and 0.3 to 3.8 dS m^{-1}, respectively.(Figure 5)

Before the tsunami, soil pH ranged from 6.9 to 8.6 with an average of 7.6. Afterwards, it ranged from 6.3 to 9.6 with an average of 8.0, and decreased to 7.8 in 2006. In 2007, average soil pH was 7.9, and ranged from 6.5 to 8.8. (Figure 6).

The average groundwater EC of ten bore hole wells are shown in Figure 7. The groundwater EC ranged from 1.6 to 3.1 dS m^{-1}. Although the increase trend in groundwater EC was observed, we consider that this level should be lower than just after tsunami. Because, immediately after the tsunami the groundwater EC ranged from 3.9 to 46.0 dS m^{-1} (Chaudhary et al. 2006) and it should be more that 20 dS m^{-1} (Chandrasekharan et al. 2008).

The results of the soil and water analysis had shown that the salt deposited by seawater during the tsunami was rapidly leached out by rainfall. From these results, we conclude that the agricultural environment of the district recovered rapidly after the tsunami as shown by Kume et al., 2009.

5. Summary and Conclusions

The results had indicated that about 77 per cent of the households were with farming before tsunami and it has reduced to 25-37 percent after tsunami. In the non-farm sector, 10 per cent of the sample households were involved in non farm activities before tsunami and this has increased to 24 – 38 per cent after tsunami. The percent distribution of labour households is about 50 percent after tsunami compared to only 11 percent before tsunami. The technical efficiency in paddy production was ranging from 80-90% and few farmers are still under below 40 percent technical efficiency. The overall mean technical efficiency is around 83% indicating the scope for increasing the technical efficiency further by 17% through improved crop management practices.

The results of the soil and water analysis had shown that the salt deposited by seawater during the tsunami was rapidly leached out by rainfall, and the vegetation rapidly recovered. From these results, it is concluded that the agricultural environment of the district recovered rapidly after the tsunami.

The profit has marginally increased from Rs 3695/ha in 2006 to Rs 6405/ha in 2007 compared to adjacent non-tsunami regions which was ranging from Rs 5600 to Rs 8500 /ha confirming the coastal risks in paddy production.

5.1 Policy recommendations

Since farmers are incurring crop losses in the region, incorporation of crop insurance programmes in agriculture should be given high priority. Both commercial banks, agricultural extension departments of the Government and NGOs should initiate actions on this.

The technical analysis had indicated that still technically efficiency is as low as 60 percent in few cases. Hence proper exposure to crop management practices should be made. The yield gap among the upper efficiency levels should be bridged.

Flooding is a recurrent phenomenon in the region. Proper land management practices including watershed management in the upstream should be planned as a long-term strategy.

References

Centre for Agriculture and Rural Development Studies (CARDS). 2007. Cost of Cultivation of Principal Crops. Unpublished reports. Tamil Nadu Agricultural University. Coimbatore.

Chandrasekharan, H., Singh, V.P., Rao, D.U.M, Nagarajan, M., Chandrasekaran, B. 2005. Effect of tsunami on coastal crop husbandry in parts of Nagapattinam district, Tamil Nadu, Curr Sci, 89 (1), 30-32

Chandrasekharan, H., Sarangi, A., Nagarajan, M., Singh, V.P., Rao, D.U.M, Stalin, P., Natarajan, K., Chandrasekaran, B., Anbazhagan, S. 2008. Variability of soil–water quality due to Tsunami-2004 in the coastal belt of Nagapattinam district, Tamilnadu, J Environ Manag, 89 (1), 63-72

Chaudhary, D.R., Ghosh, A., Patolia, J.S. 2006. Characterization of soil in the tsunami-affected coastal areas of Tamil Nadu for agronomic rehabilitation, Curr Sci, 91 (1): 99-104

Government of Tamil Nadu. 2006. Flood Damages in Coastal Districts of Tamil Nadu. Draft report. Agriculture Department. Chennai.

Imamura F., S.Koshimura, K.Goto, H.Yanagisawa and Y.Iwabuchi, 2005. Global Disaster Due to the 2004 Indian Ocean Tsunami, *Tohoku University*

India – Two Years After. New Delhi.

Krishna, T. 2005. “Tamil Nadu”, Surya Books Private Limited, Chennai.

The United Nations, the World Bank and the Asian Development Bank. 2006. Tsunami

Kume, T., Umetsu, C., K. Palanisami, 2009, The role of monsoon rainfall in desalinization of soil-groundwater system and in vegetation recovery from the 2004 tsunami disaster in Nagapattinam district, India, From Headwaters to the Ocean: Hydrological Changes and Watershed Management, M. Taniguchi et al. (Eds.), Taylor and Francis, UK, 409-414

Statistical Hand book of Tamilnadu 2006 Directorate of Economics and Statistics. Chennai.

Acknowledgements

The support and services extended by the research staff of CARDS in the collection and tabulation of the data, Dr C.R.Ranganathan and S. Senthilnathan for data analysis are acknowledged.

Table. 1. Effect of Tsunami on Occupation of the Households

Occupation category	Before tsunami		After tsunami					
	2004		2005		2006		2007	
	No	%	No	%	No	%	No	%
Farming	184	76.67	58	24.17	61	25.42	89	37.08
Non farming	23	9.58	57	23.75	90	37.50	48	20.00
Farm labour	26	10.83	117	48.75	80	33.33	96	40.00
Fishing	5	2.08	5	2.08	5	2.08	5	2.08
Unemployed	0	0.00	1	0.42	1	0.42	0	0.00
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Total	240	100.00	240	100.00	240	100	240	100.00
Degrees freedom			5		5		5	
Calculated chi-square value			105.48		93.9		60.63	
Table chi-square value (5% level)			11.07		11.07		11.07	
Test of significance			Significant		Significant		Significant	

Table. 2. Participation of Family Members in Different Occupation Categories

No. of family members	2004		2005		2006		2007	
	No	%	No	%	No	%	No	%
i) Farming								
1	105	78.36	5	55.56	63	80.77	132	91.03
2	24	17.91	3	33.33	14	17.95	12	8.28
3	4	2.99	1	11.11	1	1.28	1	0.69
4	0	0.00	0	0.00	0	0.00	0	0.00
5	1	0.75	0	0.00	0	0.00	0	0.00
Total	134	100.00	9	100.00	78	100	145	100
ii) Allied activities (livestock, poultry)								
1	5	62.5	5	62.5	4	57.14	5	71.43
2	3	37.5	3	37.5	3	42.86	2	28.57
Total	8	100	8	100	7	100	7	100
iii) Non - farming (shop, etc)								
1	10	76.92	8	72.73	10	76.92	9	75
2	3	23.08	3	27.27	3	23.08	3	25
Total	13	100	11	100	13	100	12	100
iv) Hired work								
1	117	63.93	123	64.06	119	63.30	114	68.67
2	56	30.60	57	29.69	59	31.38	40	24.10
3	10	5.46	11	5.73	10	5.32	12	7.23
v) old age pension scheme	0	0.00	1	0.52	0	0.00	0	0.00
Total	183	100	192	100	188	100	166	100

Table. 3. Seasonwise Rainfall Distribution in Nagapattinam District (mm)

Year	South-west Monsoon	North-east Monsoon	Winter Rainfall	Summer Rainfall	Annual Rainfall
1993-94	349.5	665.6	119.5	41.7	2418.3
1994-95	89.4	700.6	80.1	196.5	2308.6
1995-96	275	556.1	9.7	67.3	2150.1
1996-97	509.7	1070.4	31.8	61	2914.9
1997-98	251.3	1417.2	22.5	122	3055
1998-99	230.9	1036	103.8	99.5	2712.2
1999-2000	113.2	897.3	394	26.5	2673
2000-01	200.7	742.9	6	133.6	2325.2
2001-02	257.9	818.1	338.7	32.2	2688.9
2002-03	147.3	777.7	9.5	63.5	998
2003-04	257.5	786.6	14.2	347.7	1406
2004-05	347	1085.3	2.8	226.3	1661.4
2005-06	291.1	1165.9	36.7	128.6	1622.3

Normal rainfall: South-west Monsoon: 274.1 mm; North-east Monsoon : 886.4 mm; Winter Rainfall: 81.5 mm; Summer Rainfall: 99.7 mm. Annual rainfall: 1341.7 mm

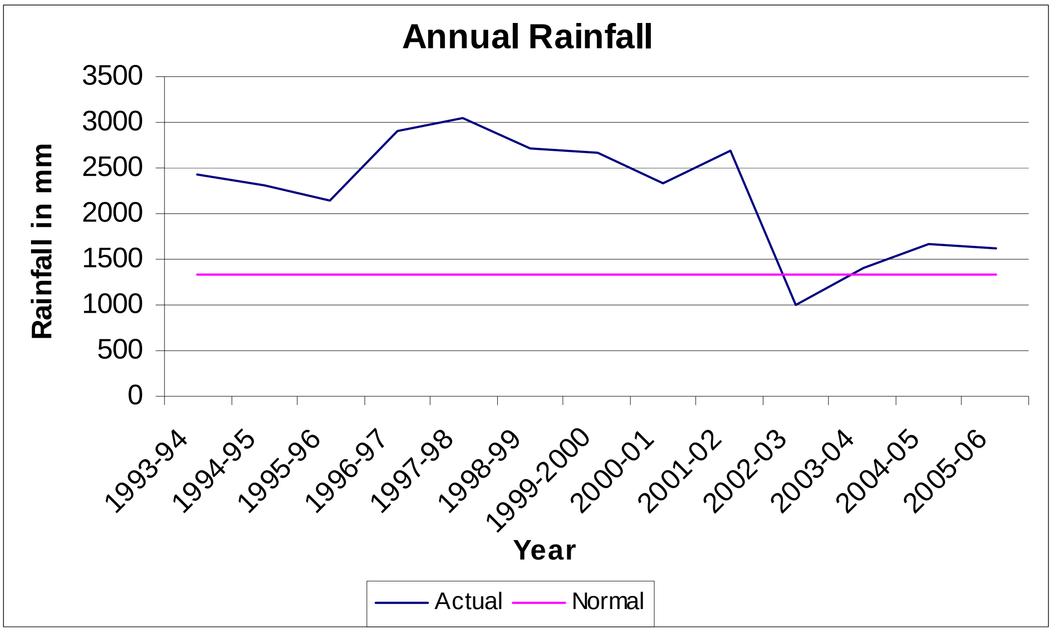

Fig.2. Total Annual Rainfall of Nagapattinam District

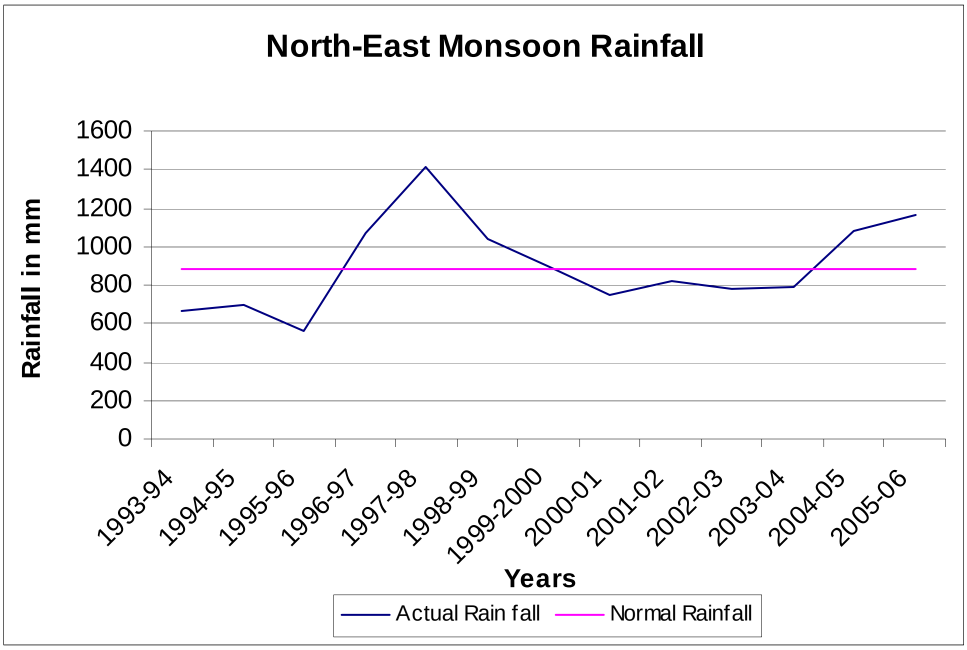

Fig.3. North-East Monsoon Rainfall of Nagapattinam District

Table. 4. Crop Production in summer season (Jan-May).

Category	2004		2005		2006		2007	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	229	95.42	229	95.42	236	98.33	235	97.92
Cultivating Cashew (*Anacardiumoccidentale)*	1	0.42	1	0.42	0	0.00	1	0.42
Cultivating Coconut (*Cocos nusifera)*	3	1.25	3	1.25	1	0.42	2	0.83
Cultivating Mango (*Mangifera indica)*	2	0.83	2	0.83	0	0.00	0	0.00
Cultivating Blackgram (*Vigna mungo)*	0	0.00	2	0.83	0	0.00	0	0.00
Current Fallow	1	0.42	0	0.00	0	0.00	0	0.00
Leased out	2	0.83	1	0.42	1	0.42	0	0.00
Total	240	100.00	240	100.00	240	100.00	240	100.00

Table. 5. Crop Production in Season I (June- September)

Category	2004		2005		2006		2007	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	231	96.25	231	96.25	236	98.33	237	98.75
Cultivating Paddy (*Oryza sativa*)	5	2.08	5	2.08	1	0.42	0	0.00
Cultivating Ragi (*Eleusine coracane)*	2	0.83	2	0.83	1	0.42	1	0.42
Total	240	100.00	240	100.00	240	100.00	240	100.00

Table. 6. Crop Production in Season II (October – January)

Category	2004 (Oct 04– Jan 05)		2005 (Oct 05– Jan 06)		2006 (Oct 06 – Jan 07)		2007 (Oct 07- Jan 08)	
	No.	%	No.	%	No.	%	No.	%
Temple land	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	80	33.33	128	53.33	176	72.92	94	39.17
Cultivating Paddy(*Oryza sativa*)	155	64.58	105	43.75	61	25.83	144	60
Cultivating Black gram (*Vigna mungo)*	1	0.42	0	0	0	0	0	0
Cultivating Fodder Sorghum (*Sorghum vulgare)*	1	0.42	1	0.42	0	0	0	0
Cultivating Cassuarina (*Caurina eqisetifolia)*	0	0.00	1	0.42	0	0	0	0
Leased out	1	0.42	3	1.25	1	0.42	0	0
Total	240	100	240	100	240	100	240	100

Table 7. Cost of Cultivation of Paddy in Season II (Rs/ha)

Cost category (Rs/ha)	2004 (Oct 04 – Jan 05		2005 (Oct 05 – Jan 06)		2006 (Oct 06 – Jan 07		2007 (Oct 07 – Jan 08)	
	No	%	No	%	No	%	No	%
Upto 5000	42	27.10	10	9.52	0	0.00	17	11.81
5000-7500	27	17.42	27	25.71	5	8.20	24	16.67
7500-10000	25	16.13	23	21.90	18	29.51	22	15.28
10000-12500	18	11.61	13	12.38	7	11.48	18	12.50
>12500	43	27.74	32	30.48	31	50.82	63	43.75
Total	155	100.00	105	100.00	61	100.00	144	100.00

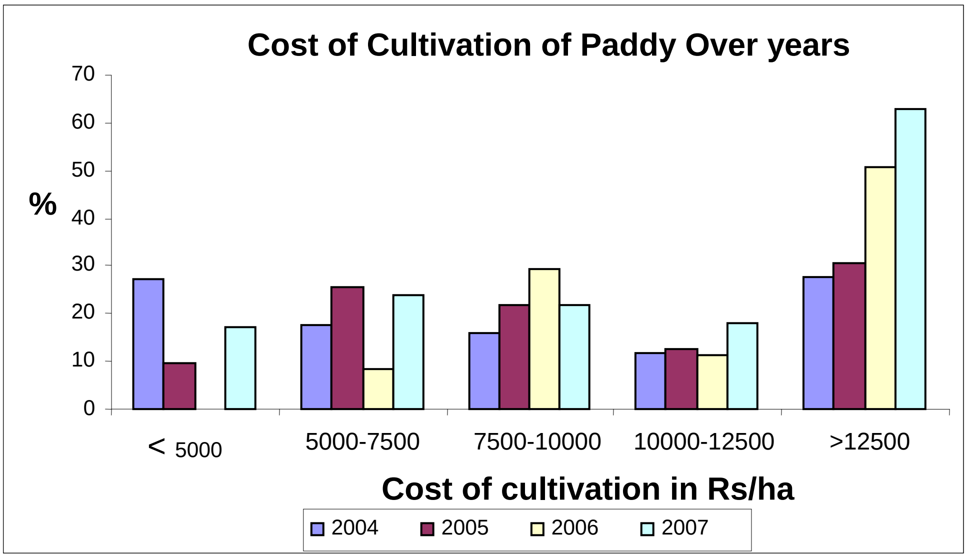

Fig.4. Cost of cultivation of Paddy for consecutive four years

Table 8 .Detailed Cost of Cultivation of Paddy (Rs/ha)

Items	2004		2005		2006		2007	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1.Seedrate (kg)	95	540	100	500	140	1077	148	1284
2.Fertilizers (kg)	460	2550	508	2633	360	2270	300	2066
3. No of chemical Spraying	2	502	2.67	566	2	290	2	283
4.Green manure (t)	0	0	0	0	0	0	2	500
5. FYM (t)	2.25	1565	2.23	1816	2.3	1150	2	1006
6.Machine power for land preparation (hrs)	5.5	1475	6.33	1792	1.8	810	30	3037
7.Machine power for harvesting/ threshing (hrs)	0.91	135	0	0	2	500	0	0
8. Labour (days) for:								
Land preparation	0	0	4.33	93.33	24.4	2120	2	911
Sowing/planting	6.65	580	6.67	558.33	26.8	1608	26	1507
Chemical spraying	1.82	164	2.17	208.33	1.8	255	2	272
Fertilizer Application	2.25	205	1.83	183.33	1.8	255	2	278
Weeding	15.25	655	9.83	458.33	22	1320	18	1087
Harvesting/ Threshing	0	0	4.33	260.00	30.6	2500	39	3272
Cost of cultivation		**8371**		**9068.66**		**14155**		**15502**
Yield :								
1. Main product (kgs)	Crop failed		Crop failed		2600	16900	2760	20923
2. By product (kgs)					1100	950	1222	983
Gross income						**17850**		**21907**

Table. 9. Distribution of Gross Income Among Farmers (Rs/ ha)

Income Category (Rs/ha)	2004 (Oct 04 – Jan 05)*		2005 (Oct 05 –Jan 06)		2006 (Oct 06 – Jan 07)		2007 (Oct 07– Jan 08)	
	No	%	No	%	No	%	No	%
Crop failure	240	100	74	70.48	1	1.64	0	0
upto 8750	0	0	0	0	0	0	0	0
8750-11250	0	0	0	0	0	0	2	1.39
11250-13750	0	0	0	0	2	3.28	11	7.64
13750-16250	0	0	0	0	2	3.28	10	6.94
16250-18750	0	0	0	0	3	4.92	10	6.94
18750-21250	0	0	0	0	11	18.03	20	13.89
21250-23750	0	0	12	11.43	5	8.2	24	16.67
23750-26250	0	0	6	5.71	10	16.39	21	14.58
26250-28750	0	0	9	8.57	15	24.59	12	8.33
28750-31250	0	0	4	3.81	8	13.11	17	11.81
31250-33750	0	0	0	0	2	3.28	11	7.64
33750-36250	0	0	0	0	0	0	3	2.08
>36250	0	0	0	0	2	3.28	3	2.08
Total	240	100	105	100	61	100	144	100

Table 10. Gross and Net Income of the Paddy Farmers in the Coastal Area (Rs/ha)

	2004	2005	2006	2007
Gross Income	0*	7500	17850	21907
Cost of cultivation	8837	9068.66**	14155	15502
Net income	-8837	-1568.66	3695	6405

*crop failure due to tsunami

** Poor yield and income due to flooding and poor soil quality

Table 11. Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Production Function (after Tsunami)

Variables	2005		2006		2007		Pooled	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Intercept	5.6063	70.2372	5.2579	6.3806	6.0309	5.6221	5.3173	8.6641
Area (ha)	0.8436	5.2584	0.1279	0.6141	0.2826	1.3304	0.4729	3.4742
Seed rate (kg)	0.3710	4.7254	0.2083	1.1001	0.4013	2.3221	-0.0441	-0.3432
Fertilizer (kg)	0.1010	2.7692	0.1870	1.5590	-0.2679	-2.1813	0.3145	3.9251
FYM (tons)	0.1356	1.4969	0.1682	1.3432	-0.0143	-0.2004	0.0743	1.2879
Labour (man days)	-0.0830	-0.9587	0.1575	0.8374	0.3206	4.0400	0.2223	2.7847
sigma-squared	0.0603	5.5234	0.0693	1.9892	0.0684	3.5095	0.1391	4.5919
Gamma	1.0000	420.8932	0.9034	4.5254	0.8859	10.3915	0.8806	10.4901
Log likelihood value	21.36		21.26		17.53		1.5302	

Table 12. Frequency Distribution of Technical Efficiency of the Farms (After Tsunami)

Technical Efficiency	Frequency Distribution			
	2005	**2006**	**2007**	**Pooled**
30-40	0 (0.00)	0 (0.00)	1 (2.17)	1 (0.75)
40-50	0 (0.00)	0 (0.00)	0 (0.00)	3 (2.26)
50-60	2 (6.25)	2 (3.64)	0 (0.00)	9 (6.77)
60-70	2 (6.25)	6 (10.91)	2 (4.35)	30 (22.56)
70-80	7 (21.88)	9 (16.36)	9 (19.57)	20 (15.04)
80-90	11 (34.38)	21 (38.18)	20 (43.48)	50 (37.59)
90-100	10 (31.25)	17 (30.91)	14 (30.43)	20 (15.04)
Total	32 (100.00)	55 (100.00)	46 (100.00)	133 (100.00)
Mean	82.97	82.91	83.88	77.21
Maximum	99.93	96.34	96.64	96.07
Minimum	55.29	52.52	39.03	38.53

Figures in brackets are percent to total.

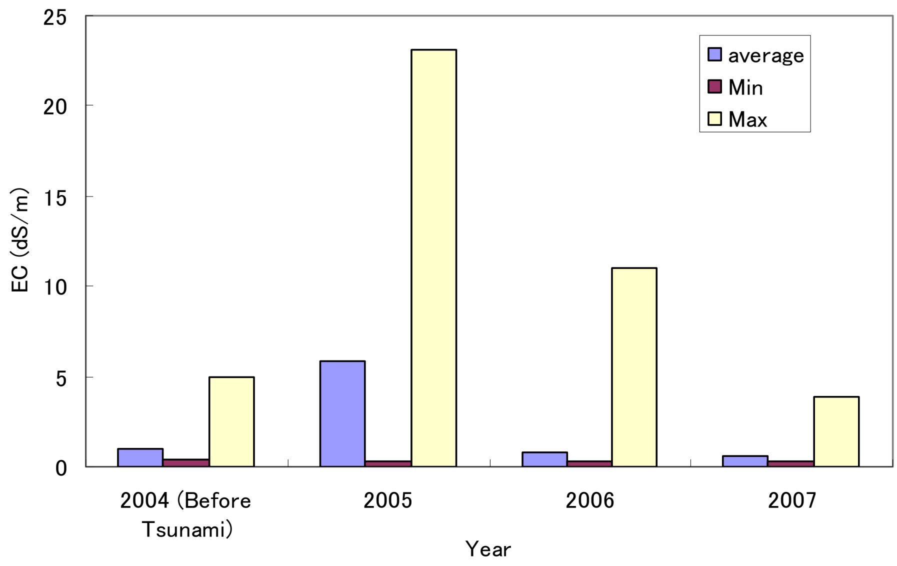

Fig 5. Changes in soil EC pre (2004) and post the tsunami (2005-2007)

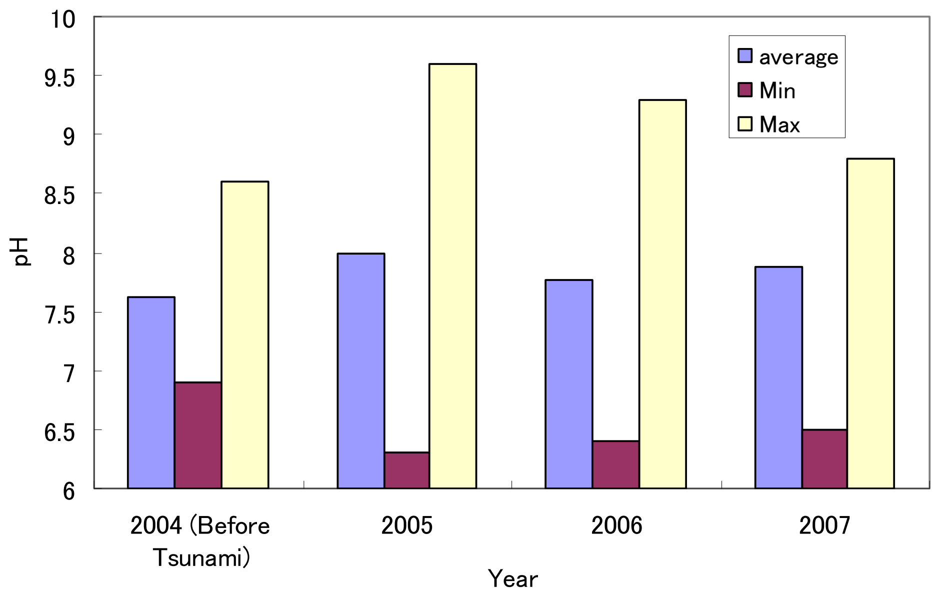

Fig 6. Changes in soil pH pre (2004) and post the tsunami (2005-2007)

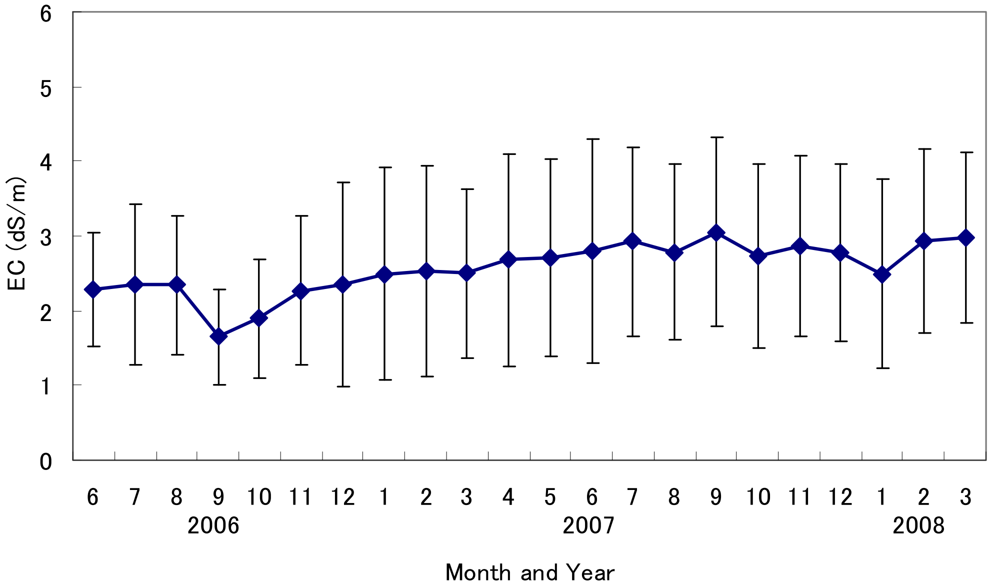

Fig 7. Monthly changes in average value groundwater EC between June 2006 and March 2008