Resilience of farming households to the Indian Ocean's Tsunami Disaster in Tamil Nadu of India

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Abstract

This paper investigates the magnitude of income shocks and their recovery of tsunami affected households during the post-tsunami period 2005-2008 in Nagapattinam District, Tamil Nadu, India. Most farmers suffered from decline of income and assets immediately after tsunami. During the 2005/06 planting season, our estimate indicates that farming households saw their farm income drop by as much as 60 percent. By 2007/08 agricultural season, households showed a near complete recovery of their incomes. After tsunami, there is a major transformation of the livelihood from agricultural production to wage labor. The major coping strategies dominated by receiving aid, borrowing money for most households. Other coping strategies included consumption reduction followed by removing children from school. The empirical results showed strong growth convergence during post-tsunami period. During the post-tsunami period, in nearly all categories of nominal incomes, the recovery was observed. However, when the price increase is taken into account, the effect of the recovery become less obvious. Shock sensitivity analysis indicated that the access to factor markets such as aid received, access to credit market and access to labor market, are important household resilience enhancing factors in terms of income shock recovery. As the results, the speed of the recovery was different in biophysical environment and in social environment in tsunami affected area. Government needs to carefully monitor soil and water to suggest recovery of agricultural production and support disaster affected people by providing access to factor market so that they can recover from income loss quickly.

1. Introduction

In the morning of 26th December 2004, a large scale earthquake that occurred in Indian Ocean and caused tremendous damage to the eastern coastal area of India. In India alone, the earthquake casualties reported were more than 16,000 (Miller, 2005). Most affected coastal areas were Tamil Nadu, Kerala, Andra Pradesh, and Andaman and Nicobal Islands. In Tamil Nadu state, three districts were mostly affected, namely Nagapattinam, Cuddalore, Kanniyakumari. Among three districts, the damage by tsunami in Nagapattinam was largest with more than 7,000 casualties and 5,000 hectares of agricultural lands. Tsunami also left people with psychological shocks since they never experienced such an incident for a century

(Miller, Rajikumar, Shanthasheela). It is of primary importance for government and communities to consider how and in what way the affected people and communities in coastal ecosystems recover from a huge disaster such as tsunami. There is an effort to promote integrated coastal management (ICM) to solve for resource use conflict and build more resilient coastal communities and environment (Wong 2009).

The concept of ecological resilience has been a focus of ecological research since defined in the seminal paper "Resilience and Stability of Ecological Systems" by C. S. Holling (1973). The earlier concept of resilience is called *engineering resilience* where resilience is defined as the recovery time for an ecological system to return to the initial equilibrium condition present before disturbance. Systems that return to initial equilibrium conditions more quickly are considered to be more resilient that systems that take a long period to recover after disturbances. The equilibrium concept was expanded to the concept of *ecological resilience*, which emphasizes capacity to endure disturbance, incorporating non-linearity, multiple equilibria and regime shifts. After the 1990s, the resilience concept focuses more on the properties of self-organization after disturbance. Recently researchers applied these resilience concepts used in ecology and engineering to complex social-ecological systems (Levin et al., 1998; Levin, 1999; Berkes, Fikret & Folke eds., 1998; Berkes, Colding & Folke eds., 2003, Umetsu 2010). Resilience is a particularly relevant concept for considering the recovery of communities affected by disasters and the development of rural societies whose livelihoods are highly dependent on natural resource base. Not only the fast recovery of social-ecological system, but the capacity to cope with uncertainty and surprise is required (Adger et al., 2005).

In the economic literature, there is a debate over what should be recovered for marginal agricultural households after environmental shocks like tsunami, hurricane, drought and earthquake. Asset smoothing circle asserts the existence of poverty trap, a critical minimum asset threshold, below which households are difficult to build up their productive assets and move up economically from poverty line (Carter and Barrett 2006; Little et al. 2006; Carter et al. 2007). On the other hand, income smoothing circles consider poverty in terms of income level and poverty is defined by the level of income where environmental shocks may push some marginal households to below poverty line (Dercon 2004). This debate has significant impacts since it immediately influences policy makers to consider what really should be restored after such a shock in the short-run and in the long-run.

The purpose of the paper is to consider how income of tsunami affected households recovered from a shock and to reveal the path and factors affecting recovery. We focus more on mid-term recovery and changes rather than short-run recovery immediately after tsunami. Particular emphasis is placed on income shocks and their recovery. The organization of the paper is as follows. First section reviews current literature of income shock and coping. Secondly we build a model for analyzing recovery and resilience to a major natural disaster. Thirdly we apply this method to tsunami affected agricultural households in Tamil Nadu, India. Last section concludes the paper and to provide policy recommendations for building resilience for rural communities during the post-disaster period.

2. Method

2.1 Empirical strategies

Our empirical approach is inspired by Carter, Little, Mogues and Negatu's (2007) asset growth model that allows transitional dynamics and shocks to play explicit roles in determining the growth of household wealth (e.g. asset or income). In this model, growth rate is related to an initial level of income, shocks and a host of factors determining efficiency and steady state. The model is applied to examine resilience to shock as defined by a capacity to recover asset or income to a pre-shock level by using data from pre- and post-shock periods. In the context of panel study of household incomes of N households ($N= 1, 2,..., i$) over t periods, the model can be specified as:

$$\ln y_{it} - \ln y_{it-1} = \alpha + \beta \ln y_{it-1} + \gamma \ln S_{it} + \delta Z_{it} + \eta X_i + \varepsilon_{it} \quad (1)$$

Here, S_{it} denotes shocks (e.g. income shock, asset shock) and Z_{it} and X_i represent, respectively, time-varying and fixed characteristics of the households determining, for example, saving or investment in human capital. The constant term, α, is a common source of growth to all households; and the ε_{it} is an error term with mean of zero. In the context of pre- and post-shock situation, one may substitute $\ln y_{it-1}$ with the pre-shock income denoted by $\ln y_{ib}$ and the $\ln y_{it}$ is the post-shock recovery income stretching several periods as follow:

$$\ln y_{it} - \ln y_{ib} = \alpha + \beta \ln y_{ib} + \gamma \ln S_{it} + \delta Z_{it} + \eta X_i + \varepsilon_{it} \quad (2)$$

A standard use of this model is to determine whether the conditional convergence exist in the household data. The $\beta < 0$ would signal the existence of conditional convergence which is an equilibrium income that all household incomes in the data grow toward. The income convergence condition implies that the lower income group would have a growth accumulation process that is faster than that of the higher income group. The model can be adapted to examine whether a shock has persistent effects on income growth by augmenting a distributed lag terms as follow:

$$\ln y_{it} - \ln y_{ib} = \alpha + \beta \ln y_{ib} + \gamma_1 (\ln S_{it} - \ln S_{it-1}) + \gamma_2 (\ln S_{it-1} - \ln S_{it-2}) + \delta Z_{it} + \eta X_i + \varepsilon_{it} \quad (3)$$

The shock persistence is identified when γ_2 that is significantly less (greater) than zero for negative (positive) persistent effects on growth.

To identify income recovery, we follow Carter et al.'s approach by incorporating income loss term, ω_{it}, normalized by the pre-shock income. The simple growth model is modified as follow:

$$\ln y_{it} - \ln y_{ib} = \alpha + \beta \ln y_{ib} + \theta(y_{ib}, K_i, L_i)\,\omega_{it} + \gamma_1(\ln S_{it} - \ln S_{it-1}) + \gamma_2(\ln S_{it-1} - \ln S_{it-2}) + \delta Z_{it} + \eta X_i + \varepsilon_{it} \quad (4)$$

The $\theta(y_{ib}, K_i, L_i)$ is a parameter to be estimated conditional on pre-shock income level, access to capital market, K_i, and access to labor market, L_i. The household incomes have not yet recovered if the θ = -1 which means that a 10 percent income loss results in a 10 percent growth reduction. The θ < -1 signals that the households have further lost their capacity to generate income, for example, by not being able to afford necessary inputs such as fertilizers or labor employments. Household income recovery is identified if θ > -1. We use a general model in (4) to investigate determinants of income growth in a reduced form regression.

2.2 Data

The study site is located in Nagapattinam District of Tamil Nadu State, India where the damage was highest among districts affected by 2004 tsunami (Figure 1). Twenty four sample villages in coastal area were selected (Table 1), and about ten households in each village were selected for the long term tsunami-impact household survey. The total sample size is 240 households. All sample households are residents of tsunami affected area.

We conducted household survey in 2006, 2007 and 2008 and interviewed for consecutive four cropping seasons after tsunami disaster, i.e., 2004/2005, 2005/2006, 2006/2007, 2007/2008. Cropping season starts from summer season (February to May), Karif/Kuruvai season (June to September), and Rabi/Samba/Thaladi season (October to January). Karif season, which is the major paddy season that generates farm income in this area, is during North-east Monsoon season (Figure 3). The normal annual precipitation in Nagapattinam is 1341.7mm and that for North-east Monsoon is usually 886.4 mm. North-east Monsoon and South-west Monsoon are the two major rainy seasons in Nagapattinam. In 2004 and 2005, the North-east Monsoon season caused heavy rain and floods in Nagapattinam District. The 2004/2005 cropping season was directly hit by tsunami just before the harvest in January. And the subsequent three cropping seasons, 2005/2006, 2006/2007, 2007/2008 indicates post-tsunami period of recovery.

During the study period, we interviewed the same farmers to assess the impact of tsunami on agricultural production, household income including farm income, non-agricultural income including allied activities and wage income. In the study area, the dominant production system is rainfed agriculture and farmers produce paddy, pulses, gingerly, groundnuts, cashew nuts, coconuts, mango and others. Most farmers are marginal and about 74 percent of farmers own less than one hectare of land (Palanisami et al., 2010).

When tsunami hit the study area, sea water intrusion caused salinity level to rise in agricultural land and groundwater. In addition, ten observation wells were constructed to monitor changes in groundwater quality every month from June 2006 to March 2008. Also soil samples were analyzed for electric conductivity and pH values (Kume et al. 2009).

Data used in this analysis are a panel of 240 households over a four-year period starting from 2004/05 to 2007/08 agricultural season and covering 24 tsunami affected villages of the Nagapattinam District, Tamil Nadu State. We supplement our social household survey with ecological examinations of soil's and water's chemistry in our study villages to determine the extent to which the tsunami has altered their physical properties and their subsequent effects on households' income generating capacity.

The livelihood of more than three out of four households in our study areas directly and indirectly depends on agriculture, both as farmers and as farm labors (see Table 2).

Table 3 shows that merely 2.5 percent of the sampled households suffer physical injury. The majority of the households experience losses directly to their income or to their income generating capacity (e.g. job losses and productive asset losses). During the 2005/2006 cropping season, one year after tsunami, farmers replied declined income (73.5%), production asset loss (52%), and unemployment (50%). These incidents were reduced in 2006/2007 season, two years after tsunami, and became marginal during 2007/2008 season, three years after tsunami.

Table 2: Self-Report of Household Main Occupations, India

Main HH Occupation	2004/05 (Pre-Tsunami)		2005/06		2006/07		2007/08	
	No.	%	No.	%	No.	%	No.	%
Agriculture	176	73.3	59	24.6	60	25.0	92	38.3
Farm and Non-farm labor	48	20.0	164	68.3	165	68.8	136	56.7
Business	14	5.9	15	6.3	13	5.4	10	4.2
Missing	2	0.8	2	0.8	2	0.8	2	0.8
Total	240	100	240	100	240	100	240	100

Source: RIHN, TNAU, Tsunami Survey 2006, 2007 and 2008.

Table 3: Effects of Tsunami on Household Welfare, India

Category	**2005/06**		**2006/07**		**2007/08**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Declining income	175	73.5	113	47.5	6	2.5
Physical injuries due to Tsunami	6	2.5	0	0	1	0.4
Production asset loss	124	52.1	60	25.2	8	3.3
Unemployment	119	50.0	54	22.7	8	3.3
House damaged	0	0	0	0	0	0
Household durable loss	0	0	0	0	0	0
Cash and jewels loss	0	0	0	0	0	0

Source: RIHN, TNAU, Tsunami Survey 2006, 2007 and 2008.

The households cope with the impact of tsunami in a variety of ways. Receiving aid (97.5%) and borrowing money (98.3 %) are their main coping strategies. Nearly every household reports to engage in both activities. The second most popular coping behavior is consumption reduction (49.6%), following by removing children from school (26.7%) perhaps to smooth income. One-tenth of the households attempted to smooth income by engaging in government employment scheme (10.8%). Interestingly, a 20 percent of households indicate no change in their behaviors.

The extent of expected income losses is reported in Table 4. On average, income losses linearly increase by household income level. Transfer and relief are generally small in size and able to offset only half of the income losses from crop failure. The lowest income quartile appears to be the only group to receive aid more than offset their income losses.

Table 4: Average Income Losses and Relief Received by Pre-Shock Income Quartile (Rs./household)

Category	Income Quartile			
	I	II	III	IV
Income loss	2,349	5,201	6,320	8,980
Transfer and aid	2,771	2,884	3,294	4,705
Aid as percentage of income loss	117.9	55.4	52.1	52.4

Source: RIHN, TNAU, Tsunami Survey 2006, 2007 and 2008.

Table 5: Share of Aggregate Income by Income Sources (Rs./household)

Income Share	2004/05	2005/06	2006/07	2007/08
Farm income	26.5	10.3	15.0	29.8
Livestock income	7.2	8.5	4.4	7.2
Non-farm income	9.7	9.2	6.2	4.2
Employment income	56.6	72.0	74.4	58.8
Total	100	100	100	100

Source: RIHN, TNAU, Tsunami Survey 2006, 2007 and 2008.

Note: Households' farm incomes of the 2004/05 are estimated.

Table 5 displays structure of aggregate income of data households. Although the majority of the respondents indicate agriculture as their main occupations, the largest share of household pre-shock earned incomes is from employment (56.6%). Agriculture accounts for only one-fourth of the total earned income. The share of labor income increased to 72 and 74.4 percent at the expense of reduction in the share of farm income in 2005/06 and 2006/07 respectively. The increase is pushed in part by crop failure and pull by the attractiveness of wage income, made available by various government employment schemes. For there are various restrictions on government employment schemes, farmers quickly returned to agriculture as the soil productivity is restored.

It is worth noting that the household farm income of 2004/05 is estimated based on peer's production efficiency. Since the tsunami occurred at the very end of the cropping season of 2004/05, farmers were able to provide us with near complete details of their income and input utilizations for the entire 2004/05 agricultural season. The input usage, productivity and crop sales of unaffected agricultural households in our sample and the pre-tsunami farm production of villages in Nagapattinam District in the 2003/04 season are used to estimate expected farm incomes for our data households in the 2004/05 season. This expected farm income is subsequently used to estimate crop income loss from tsunami both for the 2004/05 and the following seasons.

Table 6: Average Nominal and Real Income by Income Sources, India (2004=100) (Rs./year/household)

Income	N	2004/05	2005/06	2006/07	2007/08
Nominal					
Farm income	240	7,299	2,395	4,137	7,869
Allied activity income	240	1,971	1,977	1,200	1,908
Non-farm income	240	2,679	2,156	1,721	1,113
Employment income	240	15,603	16,840	20,561	15,555
Total earned income	240	27,552	23,368	27,619	26,445
Transfer & relief	240	0	9,444	555	67
Total income from all sources	240	27,552	32,812	28,174	26,511
Per capita earned income	238	8,772	7,423	8,693	8,631
Per capita total income	238	8,772	10,466	8,871	8,650
Real					
Farm income	240	7,299	2,303	3,761	6,842
Allied activity income	240	1,971	1,901	1,091	1,659
Non-farm income	240	2,679	2,073	1,564	967
Employment income	240	15,603	16,192	18,692	13,526
Total earned income	240	27,552	22,470	25,108	22,995
Transfer & relief	240	0	9,080	505	58
Total income from all sources	240	27,552	31,550	25,613	23,053
Per capita earned income	238	8,772	7,138	7,903	7,505
Per capita total income	238	8,772	10,064	8,065	7,522

Source: RIHN, TNAU, Tsunami Survey 2006, 2007 and 2008. The 2004/2005 income is estimated.

Table 6 shows trends of nominal and real average income per household and per capita over time. Full income recovery seems to be indicated by nearly every category of nominal incomes. For example, the post-shock farm income dropped from the pre-shock level of Rs 7,299 in 2004/05 to Rs 2,395 in 2005/06; by 2007/08 the average farm income has recovered to slightly above the pre-shock level at Rs. 7,869. However, when inflation is factored in, it is less evident whether or not income recovery is reached. We now turn to empirical analyses to determine the status of household income recovery or resilience to shock.

3. Results

We examine the process of income recovery based on the simple growth model given in (4) above. The results of parameter estimates are reported in Table 7 and 8. Table 7 and 8 differs in that the distributed lag of the percentage change in soil EC value is specified in the Table 7 to test for persistency of tsunami impact. As such, the panel of our data is reduced to a single cross-section and the period of our data analysis is reduced from 2004/05-2007/08 to 2004/05-2006/07 due to the unavailability of the EC measurements in the 2007/08 season; OLS estimator is used. In Table 8, the model specify only a lag percentage change of the soil EC values and that allow us to take advantage of the panel nature of our household data. In each table, two alternative specifications of (4) are displayed. The first is a restricted model that specify income growth rate as a function of initial or pre-shock income level, the shock variables and demographic factors. The second is the full model that adds shock mitigating factors such as aid received, access to labor market and credit market into the specification. Wald tests clearly reject the null hypothesis of no mitigating factors. Overall, the restricted and the full model and the OLS and the panel estimator produce qualitatively similar results.

A strong pattern that emerges out of all equations is a clear growth convergence. The convergence appears to be at a faster speed for the OLS estimates (ranging from -0.56 to -0.68) than for the maximum likelihood estimator (MLE) which varies in range from -0.35 to -0.49. The faster speed of convergence is probably a result of government and NGO’s interventions which were pro-poor. In addition, the relief efforts were discontinued before the 2007/08 season in which the MLE covers.

A second important pattern these equations signals is income recovery. The coefficients of the income losses normalized by pre-shock income are negative and lying between 0 and -1. Wald tests clearly reject the null hypotheses of negative unitary of the income shock coefficients in all equations. The parameters of the income shock variable vary in range from -0.14 to –0.40 which means that a 10 percent income shock is related to a reduction of income growth by 1 to 4 percent. It is worth noting that the income shock coefficients in the full model of Table 7 are negative and not significantly different from zero after controlling for mitigating factors. One should be cautious not to prematurely interpret this as an evidence of full income recovery. Households losing productive asset, which is a dummy variable, are likely to see further reduction in their income growth. However, the variable does not carry much weight because the coefficients are not statistically different from zero.

To examine whether tsunami has persistent effects on income growth, we use the distributed lags of the percentage change of the soil EC to proxy physical effects of the tsunami. We expect the coefficients of the tsunami surrogate to have either negative or no effects on income growth because the soil EC quickly returns to the pre-shock level a year after the tsunami. Contrary to our expectations, nearly all equations appear to indicate that tsunami has persistent and positive effects on income growth. The coefficients of the lag soil EC growth are all positive and significantly different from zero in all but the restricted panel equations. Two possible explanations are in order. First, what comes with tsunami is not only salinity but also a variety of sediment deposits. As rain and flood helps the salinity level to quickly return to its pre-shock level, certain types of sediment deposits have high organic materials which help to increase soil minerals and improve soil fertility. This can lead to an increase in farm income and the overall earned income. Secondly, the lag of the soil EC growth rate indicates quicker recovery of soil salinity to its pre-shock level. A quicker is the recovery of soil salinity, the higher is the farm productivity and the household income.

Table 7: OLS Estimates of Income Growth Model, 2004/05-2006/07

Explanatory Variables	Earned Income		All Income		Earned Income		All Income	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Preshock income	-0.5633 ***	0.1486	-0.6128 ***	0.1462	-0.6788 ***	0.1765	-0.6873 ***	0.1763
Land per adult (A)	-1.7797 ***	0.6881	-1.9608 ***	0.7007	-2.8361 ***	1.0906	-2.8304 ***	1.0924
A^2	0.9750	0.8776	1.0505	0.9037	2.3644 *	1.3261	2.3398 *	1.3322
Income shock (ω)	-0.2929 ***	0.1074	-0.3102 ***	0.1072	-0.1405	0.1240	-0.1411	0.1246
Asset shock	-0.2758	0.3292	-0.1938	0.3031	-0.0539	0.3699	-0.0840	0.3686
Soil EC_t	0.1066 **	0.0433	0.0868 **	0.0429	0.0529	0.0419	0.0501	0.0420
Soil EC_{t-1}	0.1175 **	0.0472	0.1053 **	0.0469	0.1146 **	0.0489	0.1142 **	0.0491
Aid received					-0.2384 **	0.1047	0.1227	0.1032
Access to credit					0.5391	1.1681	0.3215	1.0486
Access to credit*ω					-0.0967	0.0780	-0.0822	0.0724
Access to labor market					2.4144 *	1.3283	2.4564 *	1.3221
Access to labor market*ω					-0.0609	0.0530	-0.0630	0.0529
Education of HH head	0.1120	0.1788	0.1315	0.1764	0.0585	0.1499	0.0679	0.1497
Age of HH head	0.2773	0.3286	0.2478	0.3237	0.2111	0.3224	0.2098	0.3224
Average adult's education	-0.0408	0.2850	-0.0643	0.2807	0.0092	0.2443	0.0009	0.2432
Farmer	0.1764	0.1915	0.1791	0.1889	0.2163	0.2941	0.2228	0.2947
Labor	-0.0134	0.2199	-0.0976	0.2118	-0.3625	0.3027	-0.3778	0.3021
Constant	4.9003 ***	1.7147	5.5764 ***	1.6708	6.0782 ***	1.9392	6.1783 ***	1.9384
R^2	0.1781		0.2075		0.2676		0.2676	
N	225		225		225		225	
F Statistics	7.95 ***		9.21 ***		8.26 ***		9.41 ***	

Note: ***, ** and * denote significant at 0.01, 0.05 and 0.10 level respectively.
Soil $EC_t = \ln EC_t - \ln EC_{t-1}$ and Soil $EC_{t-1} = \ln EC_{t-1} - \ln EC_{t-2}$.

Table 8: Maximum Likelihood Estimates of Random Effect Model, 2004/05-2007/08

Explanatory Variables	Earned Income		All Income		Earned Income		All Income	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Preshock income	-0.3518 ***	0.0664	-0.3872 ***	0.0653	-0.4772 ***	0.0668	-0.4942 ***	0.0661
Land per adult (A)	-1.8588 ***	0.3608	-2.1004 ***	0.3550	-1.6174 ***	0.3614	-1.7031 ***	0.3578
A^2	1.1505 ***	0.3343	1.2968 ***	0.3289	1.1030 ***	0.3257	1.1571 ***	0.3225
Income shock (ω)	-0.3753 ***	0.0890	-0.4016 ***	0.0876	-0.2536 **	0.1008	-0.2599 ***	0.0998
Asset shock	-0.2004	0.3252	-0.1184	0.3199	-0.0795	0.3117	-0.1100	0.3086
Soil EC_{t-1}	0.0222	0.0222	0.0187	0.0218	0.0522 **	0.0218	0.0534 **	0.0216
Aid received					-0.1304	0.1298	0.2211 *	0.1285
Access to credit					-0.5192	0.4290	-0.5007	0.4247
Access to credit*ω					-0.0184	0.0266	-0.0177	0.0264
Access to labor market					2.3881 ***	0.4225	2.5080 ***	0.4184
Access to labor market*ω					-0.0234	0.0187	-0.0254	0.0185
Education of HH head	0.0602	0.0879	0.0668	0.0864	0.0451	0.0834	0.0451	0.0826
Age of HH head	0.0917	0.1750	0.0994	0.1722	0.0983	0.1661	0.1230	0.1645
Average adult's education	-0.0411	0.1085	-0.0463	0.1067	-0.0097	0.1032	0.0012	0.1022
Farmer	0.2571	0.2115	0.2441	0.2081	0.1328	0.2211	0.0979	0.2189
Labor	0.1132	0.2177	0.0595	0.2142	-0.1238	0.2096	-0.1551	0.2075
Constant	3.2561 ***	0.9907	3.6595 ***	0.9746	4.2200 ***	0.9587	4.3050 ***	0.9492
σ_u	0.0000	0.1279	0.0000	0.1178	0.0000	0.2050	0.0000	0.1730
σ_e	0.9025	0.0302	0.8879	0.0297	0.8553	0.0286	0.8468	0.0283
ρ	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N	448		448		448		448	
Log likelihood	-589.731		-582.421		-565.651		-561.187	
LR $\chi^2(11)/(16)$	76.00		92.28		124.16		134.74	

Note: ***, ** and * denote significant at 0.01, 0.05 and 0.10 level respectively.

Soil $EC_{t-1} = \ln EC_{t-1} - \ln EC_{t-2}$.

Another important policy question is how successful and by how much is the access to factor market mitigate the tsunami impact. We specify aid received, access to credit market and access to labor market as key mitigating factors. The aid received is defined as a summation of transfer from friends and relatives and relief normalized by the pre-shock income. The indicator for access to credit market is a dummy variable equal to one if the households have no excess demand for credit and zero otherwise. The labor market access indicator is defined as average labor income per village and scaled to lie within zero and one. The use of the average community's instead of the households' employment income is to avoid endogeneity bias resulting from household labor supply decision.

It is found that the aid received has positive effect on income growth in the all income equations but counter-intuitively negative in the total earned income equation. It is possible that the significant amount of aid received may have disincentive effects to engage in livelihood activities. In 2005/06 when the amount of aid is at its peak, 6 percent of the data households reported no earned income and probably survive solely on relief funds.

Access to credit appears to be positive in some equations and negative in another. In all equations, the coefficients are not significantly different from zero. However, the interaction term of the credit market access indicator and the income loss variable shows consistent negative effects on income growth but not significantly different from zero. This probably means that credit market plays only minor role in mitigating the impact of shock since the majority of households have no full access to credit.

The access to labor market plays very important roles as a shock mitigator. The coefficients of the labor market access indicator are consistently positive and relatively large in all equations.

Table 9: Shock Sensitivity and Resilience

	No shock (ω=0)	20% Income Shock (ω=0.2)		
		Unaided & Poor Market Access	Aided & Poor Market Access	Aided & Good Market Access
Pre-shock income (Rs)	19,592	19,592	19,592	19,592
Post-shock income (Rs)	24,040	12,382	14,185	20,764
Post-shock income/No Shock Income (%)	100	49.7	57.2	84.3
Growth in three years (%)	22.7	-36.8	-27.6	6.0
Average growth rate/year (%)	7.6	-12.3	-9.2	2.0

To highlight the significance of the shock mitigating variables, we calculate post shock income from the full model of the all income equation of the panel estimator using different market access scenarios. Table 9 displays our findings. Under the counter-factual no shock scenario, real household income is expected to grow by 7 percent per annum and the expected income is expected to be Rs. 24,040 by the 2007/08 season. For a 20 percent income shock which is an average income loss over a three year period, the post-shock income will fall further by 36.8 percent over our study period or an average of -12.3 percent/year under an unaided and poor factor market access condition. However, aid provision alone without improving market access will slightly improve income from unaided scenario by 14.5 percent but still fall below the pre-shock level with a negative growth of 27.6 percent for a period of three years or -9.2 percent/year. With aid and good access to factor markets, the income improves over the aid and poor market access by 46 percent and put the household on to positive growth trajectory within three years with an average annual income growth rate of 2 percent. Access to factor markets is an important household resilience enhancing factor.

Demographic/human capital factors appear to show no significant explanatory power. This does not mean that human capital and demographic factors have no effect on income growth. The lack of statistical power is probably a result of low variations in these factors.

We also examine whether the household pre-shock occupation matters in their recovery. It is found that initial occupation has no effect on income growth which means that they all have equal growth.

4. Discussion and Conclusion

This paper investigates the magnitude of income shocks and their recovery of tsunami affected households during the post-tsunami period 2005-2008. The important findings are as follows:

Most farmers suffered from decline of income and assets immediately after tsunami. During the 2005/06 planting season, our estimate indicates that farming households saw their farm income drop by as much as 60 percent. By 2007/08 agricultural season, however, households have showed signs of re-accumulation of their productive assets to their previous growth trajectory and a near complete recovery of their incomes.

After tsunami, there is a major transformation of the livelihood of agricultural households in the sample area. Households whose main occupation is agriculture reduced from 73.3% in pre-tsunami reduced to 38.3 %. On the other hand, farm and non-farm labor increased from 20% to 68 % immediately after tsunami and 56.7% three years after tsunami.

The major coping strategies dominated by receiving aid, borrowing money for most households. Other coping strategies included consumption reduction followed by removing children from school.

The empirical results showed strong growth convergence to its pre-shock income level. The implication of the growth convergence is that the lower income group has more rapid income growth than its higher income counterpart.

During the post-tsunami period, in nearly all categories of nominal incomes, the recovery was observed. However, when the price increase is taken into account, the effect of the recovery becomes less obvious. Evidences from our empirical analyses indicate the income recovery of the sampled household has probably attained.

Shock sensitivity analysis indicated that the access to factor markets such as aid received, access to credit market and access to labor market, are an important household resilience enhancing factors in terms of income shock recovery.

In the tsunami affected agricultural area in Nagapattinam, the recovery of social system and natural system indicated different recovery paths. It is shown in the previous studies (Chandrasekharan et al. 2008; Kume et al. 2009) that the biophysical environment for agricultural production in this area largely recovered from tsunami by the following cropping season due to heavy rainfall. Although the physical environment recovered rather quickly, the farm production and household income did not immediately recover from tsunami that many farmers reported that they could come back to the normal agricultural production during the agricultural season 2007/2008 as indicated in Palanisami et al. (2010). It took them almost three years until agricultural production recover fully to pre-tsunami level. In addition, the structure of livelihood has shifted from agricultural production to wage labor.

For the recovery of huge disaster like 2004 tsunami, it is important not only the fast recovery of social-ecological system, but the building the capacity to cope with uncertainty and surprise (Adger et al., 2005). As the results of the study suggests, the speed of the recovery may be different in biophysical environment and social environment. Government needs to carefully monitor soil and water to suggest recovery of agricultural production and support disaster affected people by providing access to factor market so that they can recover from income loss quickly.

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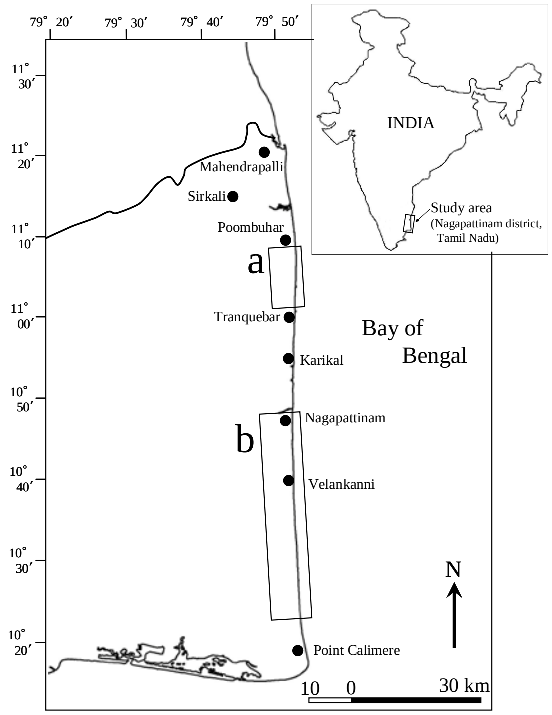

Fig.1 Map of study area (Nagapattinam District, Tamil Nadu, India)

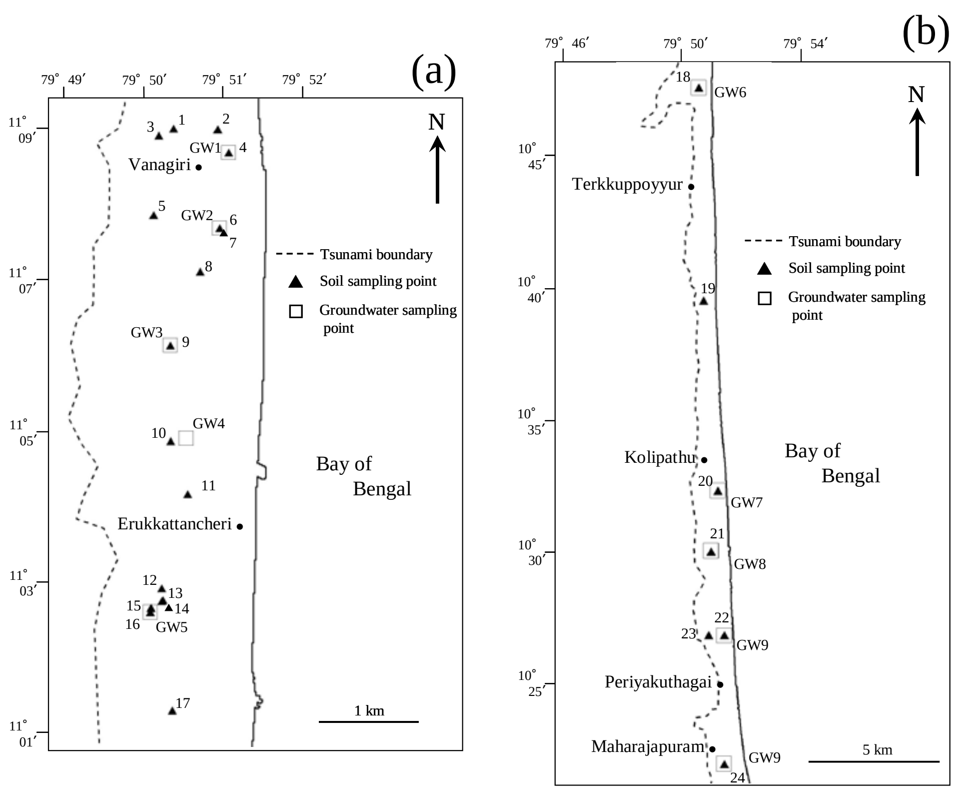

Fig. 2 Location of sample villages (These map locations correspond with areas 'a' and 'b' shown in Fig. 1)

Table 1. Names of Sample Villages

S.No	Village name	Block Name	Taluk Name	Altitude (meter)*
1	Tirumullaivasal	Kollidam	Sirgali	9
2	Puthuthurai	Sirgali	Sirgali	13
3	Vettangudi	Kollidam	Sirgali	10
4	Keelaiyur	Sirgali	Sirgali	5
5	Tennampattinam	Sirgali	Sirgali	10
6	Vanagiri	Sirgali	Sirgali	1
7	Melaiyur	Sirgali	Sirgali	8
8	Nepathur	Sirgali	Sirgali	10
9	Maruthampallam	Tarangampadi	Tarangampadi	1
10	Neithavasal (Veppangudi)	Sirgali	Sirgali	5
11	Vilunthammavadi	Kilvelur	Kilvelur	11
12	Prathamaramapuram	Kilvelur	Kilvelur	10
13	Vettaikaranirruppu	Kilvelur	Kilvelur	13
14	Poigainallur (North+South)	Nagapattinam	Nagapattinam	6
15	Vadakku palpannaicheri	Nagapattinam	Nagapattinam	8
16	Terkku palpannaicheri	Nagapattinam	Nagapattinam	8
17	Manigapangu	Tarangampadi	Tarangampadi	4
18	Satangudi (Erukattacheri)	Tarangampadi	Tarangampadi	4
19	Kovilpathu	Talainayiru	Vedaranyam	10
20	Periyakuthagai	Vedaranyam	Vedaranyam	13
21	Pushpavanam	Vedaranyam	Vedaranyam	10
22	Agasthiyampalli (Maniyanthevu)	Vedaranyam	Vedaranyam	5
23	Vellapallam	Talainayiru	Vedaranyam	13
24	Naluvedapathi	Talainayiru	Vedaranyam	10

* Avove mean sea level

Fig. 3. Seasonwise Rainfall Distribution in Nagapatttinam District, Tamilnadu, India (mm)