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Decadal Impact of Tsunami 2004 on Agricultural Productivity and Income, Tamil Nadu, India*

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Decadal Impact of Tsunami 2004 on Agricultural Productivity and Income, Tamil Nadu, India*

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Abstract

Tsunami attacked the Indian coast on 26th December 2004 and one of the worst affected is Tamil Nadu state and it suffered maximum loss with the damage concentrated in four districts. A study was conducted in Nagapattinam district of Tamil Nadu State, India for the years 2006, 2007, 2008, 2010 and 2014 and interviewed for consecutive cropping seasons after tsunami disaster, i.e., 2004/2005, 2005/2006, 2006/2007, 2007/2008, 2008/09, 2009/10 and 2013/2014 with the sample of 240 households. During the study period, same farmers were contacted to assess the impact of tsunami on agricultural production. In the study area, the dominant production system is rainfed agriculture and farmers produce paddy, pulses, gingerly, groundnut, cashew nut, coconut, mango and others. 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. Results have indicated that about 65 per cent of the households cultivated paddy during 2005 and it was reduced to 44 per cent on next year immediately after Tsunami. After that the percentage was slowly increased and reached 58 per cent during 2014. The overall mean technical efficiency is around 84 percent indicating the scope for increasing the technical efficiency further by 16 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 cost of cultivation during the year 2006 is Rs8900/ha to Rs.24,400/ ha during 2014 and the profit was ranging from Rs. 3134/ha in 2006 to Rs 10504/ha in 2014 compared to adjacent non-tsunami regions which was ranging from Rs. 5600 to Rs 13500 /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.

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1. Background

Nagapattinam is a coastal district; covering a total area of 2,71,583 hectares. Out of the total area, around 1,26,149 hectares is classified as wetland, 61,880 hectares as dry land, and the remaining 83,548 hectares as 'poramboke'or Government land. Around 74% of the cultivators have less than one hectare of land, and another 15% hold between one to two hectares. The remaining 11% of the households own above two hectares of land. Though the area receives an average of 1337 mm of rainfall annually, nearly 76% occurs during the Northeast (Oct-Dec) monsoon, followed by 17.3% during the Southwest (June-Sep) monsoon period.

The soil is predominantly sandy in texture, and clayey in certain pockets, with slight salinity/alkalinity. The soil in the region belongs to Valudalakudi series; dark brown to brown, deep, sandy and possessing characteristics of mild to moderate alkalinity levels. The area lying between Nagapattinam and Vedaranyam, dominated by sand dunes, and the cultivated soils are mostly sandy in texture. Regarding the water table, fresh water is overlying saline ground water. The cultivation depends primarily on rainfall, supplemented by underground water. The area lying between north of Nagapattinam to the border of Cuddalore district is covered under the Cauvery delta irrigation system.

Agriculture in this region is dominated by rainfed and canal irrigated cultivation, supplemented by tank irrigation for the main crop of paddy, and small-scale irrigation using underground water for the secondary crop viz pulses, gingelly, groundnut etc. Paddy is the primary subsistence crop, being traditionally cultivated in different methods. More than two thirds of the farming communities are small and marginal landholders, and paddy is the most suitable staple crop. Groundnut, coconut, cashew, mango, vegetables like brinjal, cluster bean, lady's finger etc are cultivated using small scale irrigation. Cotton, and casuarina are the other commercially important crops. In some of the areas, pulses like green gram, black gram and cowpea are cultivated as secondary crops (relay crop) after first season paddy.

Livestock played a major role in strengthening their livelihoods, particularly the small ruminants. Generally small ruminants are reared in stall-fed system, using tree fodder, supplemented during lean season by open grazing in the agricultural fields. Agricultural work is the major livelihood for the agricultural labourers, supplemented by seasonal fish catch in the rivers/backwaters, prawn farms, coconut leaf mat-making, copra preparation, etc.

Between 1891 and 2000 (2010), nearly 26% of cyclones that formed in the Bay of Bengal struck the coast of Tamil Nadu; of which 55 severe cyclones crossed the region, mostly during the months of October and November. In addition to frequent cyclones, mid-season drought, floods, and water logging due to the flat topography, and improper/disturbed drainage systems, make the region more vulnerable. Thus the soil resources in this region show fluctuating characteristics of soluble salt concentration and soil pH [Thamizoli 2006]

2. Damage to Agriculture due to Tsunami

Focusing on damages to important natural resources like soil and water, there was major damage to drainage facilities, field bunds, sand dunes etc. The turbulent tidal waves eroded the top soil in the sloppy fields, damaged the field bunds, small canals/dikes on one hand, and on the other, it deposited clay and sand materials in the low lying fields. In both the cases, the field topography was affected, and the thickness of the sediments varied across the damaged area, depending upon the distance from the coast and the gradient. The soil as well as water sources were severely affected, and the type and intensity of the damaged soil varies across the affected area (Table 1).

This paper presents an analytical study on the impact of tsunami on agricultural production and farm households on a continuous basis from 2005 to 20014. Section one describes the methodology used to collect and analyse the data including the description of the technical efficiency in crop production and Gini co-efficient for assessing income equity. Section two deals with the problems faced by the tsunami affected households and section three covers the impact of the tsunami on crop productivity and income.

3. Methodology and Data Analysis

The study site is located in Nagapattinam District of Tamil Nadu State, India where the damage was highest among the districts affected by 2004 tsunami. In the district, details of most affected villages were collected. Based on the list prepared, agriculturally damaged villages were short listed and in order to cover entire coastal area of the district, 24 villages which evenly spread over the coastal area have been chosen as study villages. About 10 percent of the population of the study villages was randomly selected as sample respondents. The 24 villages are distributed in five taluks of Nagapattinam district. The villages selected in this region are 0.25 Km to 2.5 Km distance from the sea. Two hundred and forty respondents from the 24 villages of coastal Nagapattinam district were selected. Majority of the respondents (73.33 %) selected were close to the sea. The distance between the respondents' farm and Sea is less than 0.25 KM. The sea water penetration was 1-1.5 KM distance into the main land. So the impact of tsunami in the selected respondent's field was high in this region.

We conducted household survey in 2006, 2007, 2008, 2010 and 2014 and interviewed for consecutive cropping seasons after tsunami disaster, i.e., 2004/2005, 2005/2006, 2006/2007, 2007/2008, 2008/09, 2009/10 and 2013/2014. Cropping season starts from summer season (February to May), Karif/Kuruvai season (June to September), and Rabi/Samba/Thaladi season (October to January). Rabi season, which is the major paddy season that generates farm income in this area, is during North-east Monsoon season. The normal annual precipitation in Nagapattinam is 1341.7 mm and that for North-east Monsoon is usually 886.4 mm. Northeast 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 cropping seasons, 2005/2006, 2006/2007, 2007/2008, 2008/09, 2009/10 and 2013/2014 indicates post-tsunami period.

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.

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.

3.1 Analysis of farm specific technical efficiency

The stochastic frontier production function is given by

$$y_i = f(x_i;\beta)\exp(\varepsilon_i) \tag{1}$$

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,

$$\varepsilon_i = v_i - u_i \tag{2}$$

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

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

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

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

and

$$TE_i = \exp(-E(u_i/\varepsilon_i)) \tag{5}$$

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. The stochastic frontier function was formulated by Aigner et al.[1977] and subsequently it has been used in measuring farm level technical efficiency[Idiong 2007; Mythili and Shanmugam1981]

3.2 Analysis of income equity using Gini-coefficient

Given the income differences across the sample and years, it is important to analyse how the inequity is distributed across the farms and years using the Gini coefficient (G) where G is a measure of inequality, defined as the mean of absolute differences between all pairs of individuals for some measure [Gini 1912]. The minimum value is 0 when all measurements are equal and the theoretical maximum is 1 for an infinitely large set of observations where all measurements but one has a value of 0, which is the ultimate inequality. A low Gini coefficient indicates a more equal distribution, with 0 corresponding to complete equality, while higher Gini coefficients indicate more unequal distribution, with 1 corresponding to complete inequality. The Gini coefficient can be interpreted as the expected income gap between two individuals randomly selected from the population.

The classical definition of G appears in the notation of the theory of relative mean difference:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_i - x_j \right|}{2n^2 \bar{x}}$$

Where, x is an observed value, n is the number of values observed and x bar is the mean value.

4. Problems faced by Tsunami affected households

4.1 Family related problems

Agriculture was the major source of income to farmers. Due to the intrusion of tsunami water, the standing crops were completely wiped off. Three fourth of the respondents (73.53 %) during January, 2005 lost their crop and this was the major reason for declined income. Only 2.5 percent of the respondents were hurt and wounded by tsunami waves. During the year 2006 because of slow reclamation on agriculture fields, 47.9 percent stated that income declined and in the year 2007 almost all (97.5 %) recovered from the earlier loss and came back to normal position (Table 2).

Half (52.10 %) of the respondents production asset (land) was damaged due to huge sea water inundation, loss of livestock, devastation of standing crops and fodder. In the second year, 25 per cent of the respondents land is not reclaimed because of the slow response to the agronomic rehabilitation measures and in the third year the lands were ready to do farming and there was no complaint from the farmers.

Fifty percent of the unemployment was also noticed in the first year. Subsequent years it was reduced to 22.69 percent and 3.33 percent. Due to sweeping of standing crops and degradation of land, in the initial years the agricultural laborers didn’t get any work in the farms. After the revival of agriculture, the agricultural labours got regular employment and wage for their subsistence living.

4. 2. Soil related problems

During tsunami, the sea water intruded in the farm lands caused salanization, coastal soil accumulation, undulation of land, accumulation of debris and problem in water infiltration. These were the physical damages caused by tusunami waves and rendered the land unfit for cultivation. The next year after tsunami, 33.61 percent experienced salanization of land, 8.40 percent on coastal soil accumulation, 7.56 percent on undulation of land and accumulation of debris and 10.92 percent on problem in water infiltration (Table 3). In the year 2007 the farmers reclaimed the land through agronomic rehabilitation measurers and there was no report on the problem of land exhibited due to tsunami.

Later, after 2008 the land salanized because the canals and tanks were not properly desilted. If the good quality water stored or run in the surface level it reduces the salanization of land. Due to interstate water dispute, Nagapattinam area did not get enough water for cultivation. Over usuage of ground water also causes salainity of soil.

From the above table it could be clear that due to tsunami 67 per cent of the respondents opined that salt deposition was the major problem, followed by coastal soil accumulation (28.75 %), accumulation of debris (25 %) and problem in water infiltration (23.75 %).

Half of the respondents (47.90 %) reported the salinity of irrigation water followed by shortage of drinking water (30.25 %), ground water level variation (29.83 %) and contamination of water (29.41 %). In the subsequent year 2006, 24.79 percent expressed water salinity, 13.03 percent expressed ground water level variation, 18.49 percent on shortage of drinking water. In the year 2007, 32.35 reported that ground water level variation, 30.25 percent on shortage of drinking water and 29.41 percent on water contamination. In 2014 also the majority of the respondents (92.00 %) reported shortage of drinking water followed by ground water level variation (71.00 %) and salinity of irrigation water (67.00 %) (Table 4).

The respondents' farm near to seashore was affected due to massive quantity of sea water inundated the coastal agricultural lands for 0.5 to 2.0 km area inland. Due to poor drainage, sea water stood for a few days affected the quality of groundwater. 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. [Chandrasekharan et al. 2005]

One respondent from Vellapallam village (Rajendran) pointed out the depth of drainage canal is shallow (2 ft.). So, even during flood the salt deposited due to tsunami was leached upto the depth of drainage canal beyond that level (more than two feet) the salt will be there. The salt accumulation in the soil didn't affect the field crop but accumulation of salt was persistent in groundwater. Based on the depth of ground water the salt content varied. If the ground water level goes down the salt level in the water will be high and if the groundwater level is high the salt level will be low. It in turn affected the field crops.

Tsunami affected about 60 per cent of the cultivated crops which failed during 2005 crop period, 30 per cent of the crops failed in the second year(2006) and no crop failure was noticed during 2007 (Table 5). The other factors like reduction in yield (5.88 %), poor germination (2.5 %), failure to cultivable regular crops (1.26 %) and land unsuitable for cultivation (0.42%) were expressed by very few respondents in the first year after tsunami and 10.08 percent reduction in yield and 7.56 percent opined that land become unsuitable for cultivation. The third year after tsunami, only 2.94 percent expressed decline in yield. In 2008 42.92 percent expressed reduction in yield and 21.67 percent during the year 2009.

5. Impact of tsunami on crop productivity and income

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 6).

5.1 Cropping season and cultivation of crops

Summer________Karif/ Kuruvai _____Rabi/ Samba /Thaladi
(Feb-May)   (June- September)   (October- January)

Paddy is the main crop of the district and depending upon water availability and other factors, the farmers grow two crops viz., Kharif/Kuruvai ((June-September) and Rabi/Thaladi (or Samba (October- January)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 2012].

During summer season more than 95 per cent of the respondents had not cultivated seasonal 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. 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 damages to the standing field crops and soil. Hence, many farmers had reported that they could come back to normal cultivation only during the Rabi season (October 2007 to January 2008) (Table 7).

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 aculeata*, 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. All these practices had impact on crop yield and income.

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 has 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. Hence it is important to examine how the technical efficiency in crop production varies among the farms over years after tsunami. This will help to derive the needed policies for improving the crop productivity in the region.

5.2 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 8 & 9. It is observed that there is no significant difference in the overall mean technical efficiency of the farmers after tsunami. However, few farmers are still under below average technical efficiency levels of less than 50%. The overall mean technical efficiency is around 84% indicating the scope for increasing the technical efficiency further by 16% through improved crop management practices.

5.3 Economics of crop production

Regarding the cost of cultivation, before tsunami 44 per cent of the paddy cultivating respondents had the expenditure upto Rs.6000/ha (Table 10). The cost of cultivation of paddy has increased slowly from 2004 to 2014. Before tsunami, 86 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 13 per cent of the farmers had a cost of cultivation of more than Rs.6000/ha, and it has gradually increased. During 2014 the cost of cultivation increased to above Rs.15000/ha indicating the magnitude of cost increase in crop production.

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 8900/ha and it has been increased to Rs 24440 /ha in 2014 (9.5 % increase) (Table 11). 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 12). In the subsequent seasons, (Oct 06 – Jan 07, Oct 07 – Jan 08, Oct 08 – Jan 09, Oct 09 – Jan 10 and Oct 13 – Jan 14) the gross income increased. This indicates 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.3500 during 2005, Rs 9400 during 2006 and Rs 27600 during 2014 (Table 13). Given the higher cost of cultivation, the profit level is much less. It is observed that during 2006, the profit is about Rs 3135/ha which has increased to Rs.10505/ha in 2014 indicating the risks in paddy cultivation in the coastal regions. 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]. If we workout the state value is very high. During the same period, the profit level in paddy cultivation in Tamil Nadu state was ranging from Rs 5600 to Rs 28624 /ha [CARDS 2014].

5.4 Income sources and inequity among households

In addition to agricultural income, households used to earn money from other sources such as livestock, poultry, non-farm sources such as shops, and hired labour income. The distribution of average income per household (using all the sample households) is given below (Figure 1).

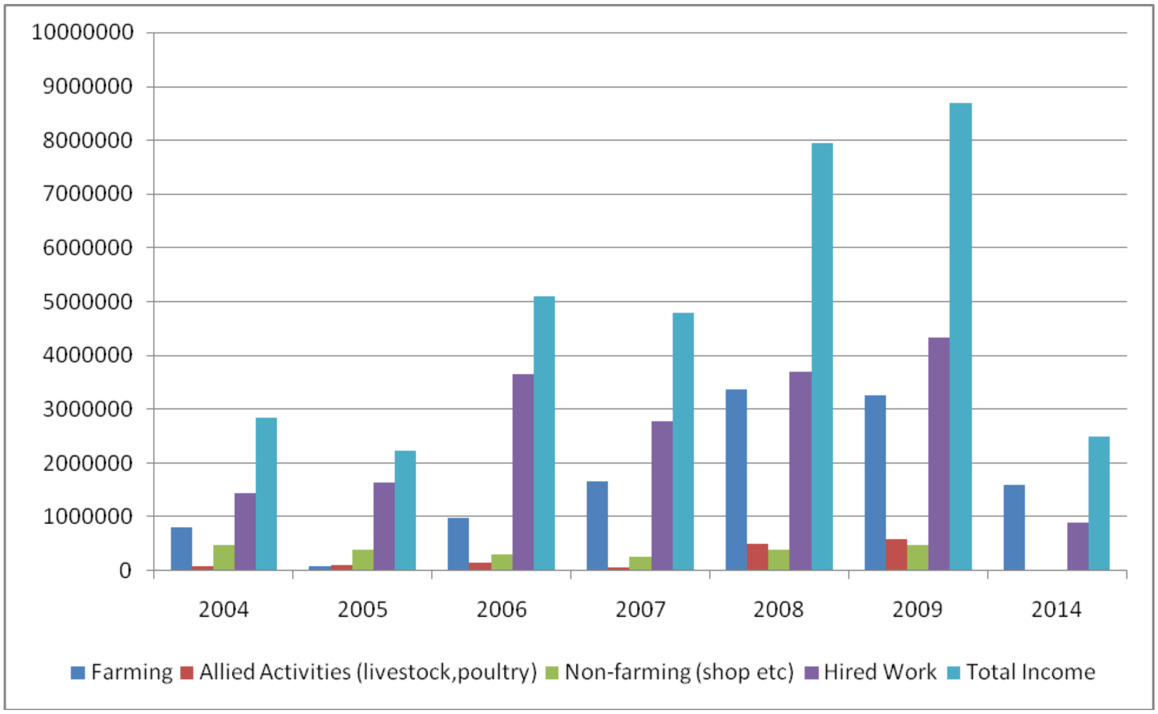

Fig.1. Average Income of the sample of farmers from different sources

Farming income dropped to the lowest level of Rs.405 in 2005 due to Tsunami. Thereafter it steadily increased implying the resilience from the tsunami shock. Further, for most of the farmers hired income is the main source of income followed by farming.

Table 14 provides average income of farmers who derive income from different sources. It is evident that there is a drastic reduction in income from farming due to tsunami in 2005. There is a steady increase in income from farming in 2006 to 2014 implying that farmers have overcome the negative effects of tsunami. However, during the tsunami year, farmers were able to supplement their income from allied activities like livestock, poultry etc. Hired work, which is a main source of income for most of the farmers had a severe setback in 2005 and it recovered from the shock in the following years. Overall the average income dropped to the lowest level in 2005 and it recovered after that. It could be inferred that the recovery from tsunami impact has taken about 2-3 years itself.

5.5 Gini Coefficient for sample data

Table 16 provides the income distribution of farmers over ten years from Tsunami. The Gini coefficients were computed for the observed data of total income of the farmers for ten years 2004 to 2014. The computed values are given in Table 16. The Gini coefficients shows that the income inequality was higher during 2004 and 2005 and it was highest during 2005, the year just after tsunami. After tsunami, from 2006 to 2014, the Gini coefficient has reduced implying that farmers were able to cope-up with the after-effects of tsunami. Thus post-tsunami period is a 'resilience' period.

6. Conclusions and Recommendations

Tsunami occurred in the region when the agriculture production was also affected due to continuous flooding during October – November, 2004. Soon after the tsunami, the problem was compounded and at that time there were no concrete scientific recommendations available for implementation based on proper survey and situation analyses. Hence, most of the crops failed in the next year after tsunami. Many farmers had reported that they could come back to normal cultivation only during the Kharif season in the subsequent years.

Even though the number of farmers growing paddy had declined over years, still the technical efficiency is comparatively higher after the tsunami indicating that the farmers are recovering from the tsunami impact slowly. Given the increased cost of cultivation over years, the profit level has increased marginally over years after tsunami. The profit at current price was about Rs 8900/ha in 2006 which has increased to Rs.24440/ha in 2016 (a 3 times increase over 10 year period). In constant prices, the profit during the same periods had increased about 4 times (i.e. from Rs 5600/ha in 2006 to 28624/ha in 2014). The results of the income analysis also highlighted that the income inequity is minimal after 2-3 years of tsunami thus confirming that the recovery from the tsunami impact takes about 3 years.

In order to improve the crop production and its sustainability, farmers should be given intensive training in improved crop production practices such as use of balanced nutrients, and crop protection practices. Small farm mechanization will reduce the cost of cultivation. The existing extension services should be geared up to meet the increased challenges in crop production including input supplies and marketing.

It is important to focus on the integrated rehabilitation measures both at medium to long-term basis to help the farmers revive and strengthen the production systems. Based on the farmers past experiences with flooding situations, necessary interventions can be incorporated for better reclamation and management of agricultural field. Traditional Knowledge plays a vital role in mitigating the localized problems. The knowledge available among the local communities and used over a period of time in the region can be exploited for application in a larger scale with due analysis of science behind such traditional wisdom.

Since allied activities could play a key role in stabilizing the income flow, it is equally important that investment scenarios for strengthening these activities should be created as part of the post tsunami development package in the region. The Government of India initiated National Rural Employment Guarantee Scheme (NREGS) will be much useful to these regions as more emphasis is given in the NREGS for restoration of water bodies and generation of employment opportunities to the rural households. A weather based crop insurance product can be introduced at a larger scale to cover both crop and livestock which will help farmers to minimize their risk in crop production.

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Table 1. Damage to Soil and Water Bodies in Nagapattinam District

Type of damages	Area in ha.
Total area affected	4675 ha
Total area affected due to soil salanization	4675 ha
Sand/ silt castings	1367 ha
Silting of farm ponds	3200 nos
Silting of community ponds	142 nos
Standing crop damage to Paddy	4021 ha
Standing crop damage to Groundnut	1186 ha

Source: GOTN, 2006.

Table 2. Family related problems faced by the tsunami-affected households

Category	2005		2006		2007		2008		2009		2014	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Income declining	175	73.53	113	47.48	6	2.5	47	19.58	24	10.00	67	67.00
II. Physical injuries due to Tsunami	6	2.52	0	0	1	0.42	0	0.00	0	0.00	0	0.00
III. Production asset loss	124	52.1	60	25.21	8	3.33	0	0.00	0	0.00	0	0.00
IV. Unemployment	119	50	54	22.69	8	3.33	1	0.42	2	0.83	0	0.00
V. House damaged	0	0	0	0	0	0	0	0.00	0	0.00	0	0.00
VI. Host hold durable lost	0	0	0	0	0	0	0	0.00	0	0.00	0	0.00
VII. Cash and jewels loss	0	0	0	0	0	0	0	0.00	0	0.00	0	0.00

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 3. Soil related problems faced by the tsunami-affected households

Category	2005		2006		2007		2008		2009		2014	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Salanization	160	67.23	80	33.61	3	1.26	95	39.58	55	22.92	67	67.00
II. Coastal soil accumulation	69	28.99	20	8.4	0	0	0	0.00	0	0.00	0	0.00
III. Undulation of land	25	10.5	18	7.56	0	0	0	0.00	0	0.00	0	0.00
IV. Accumulation of debris	60	25.21	18	7.56	0	0	0	0.00	0	0.00	0	0.00
V. Problem in water infiltration	57	23.95	26	10.92	0	0	0	0.00	0	0.00	0	0.00

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 4. Water related problems faced by the tsunami affected households

Category	2005		2006		2007		2008		2009		2014	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Salinity	114	47.9	59	24.79	2	0.84	51	21.25	49	20.42	67	67.00
II. Ground water level variation	71	29.83	31	13.03	77	32.35	33	13.75	21	8.75	71	71.00
III. Shortage of drinking water	72	30.25	44	18.49	72	30.25	36	15.00	27	11.25	92	92.00
IV. Contamination of water	70	29.41	0	0	70	29.41	21	8.75	13	5.42	3	3.00

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 5. Crop related problems faced by the tsunami affected households

Category	2005		2006		2007		2008		2009		2014	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
I. Crop failure	144	60.5	72	30.25	0	0	8	3.33	2	0.83	0	0.00
II. Poor germination	6	2.52	4	1.68	0	0	12	5.00	7	2.92	0	0.00
III. Yield declining	14	5.88	24	10.08	7	2.94	103	42.92	52	21.67	0	0.00
IV. Failure to cultivable regular crops	3	1.26	4	1.68	1	0.42	3	1.25	1	0.42	2	2.00
V. Land become unsuitable for cultivation	1	0.42	18	7.56	0	0	0	0.00	0	0.00	0	0.00
VI. Labor problem	1	0.42	0	0	1	0.42	1	0.42	1	0.42	0	0.00
VII. Pest and Disease out break	0	0	0	0	0	0	0	0.00	0	0.00	0	0.00

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 6. Seasonwise Rainfall Distribution in Nagapattinam District (mm)

Year	South-west Monsoon	North-east Monsoon	Winter Rainfall	Summer Rainfall	Annual Rainfall
1993-94	258.2	1356.4	119.5	41.7	1775.8
1994-95	89.4	700.6	80.1	196.5	1066.6
1995-96	275	556.1	9.7	67.3	908.1
1996-97	490.9	912.45	22.8	88.1	1514.25
1997-98	251.3	1417.2	22.5	122	1813
1998-99	230.9	1036	103.8	99.5	1470.2
1999-00	113.2	897.3	394	26.5	1431
2000-01	200.7	742.9	6	133.6	1083.2
2001-02	257.9	818.1	338.7	32.2	1446.9
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
2006-07	180.1	898.7	36.9	20.6	1136.3
2007-08	361.6	1065.5	76.5	370.5	1874.1
2008-09	175.8	1222.4	58.3	288.1	1744.6
2009-10	159.1	1340.1	57	110.7	1666.9
2010-11	386.2	1041.6	45.3	78.9	1552
2011-12	213.9	743.3	0.5	34.3	992
2012- 13	234.6	749.4	53.8	40.4	1078.2

Normal rainfall: South-west Monsoon: 286.1 mm; North-east Monsoon : 941.04 mm; Winter Rainfall: 85.7 mm; Summer Rainfall: 80.5 mm. Annual rainfall: 1393.3 mm
Source: India Meteorological Department, Chennai-6.

Table 7. Crop Production in Season II (October – January)

Category	2005		2006		2007		2008		2009		2014	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Temple land	2	0.83	2	0.83	2	0.83	2	0.83	2	0.83	2	0.83
Not cultivating	76	31.67	124	51.67	175	72.92	91	37.92	94	39.17	92	38.33
Cultivating Paddy (*Oryza sativa*)	155	64.58	105	43.75	61	25.42	144	60.00	137	57.08	139	57.92
Cultivating Cashew (*Anacardium occidentale)*	1	0.42	1	0.42	0	0.00	1	0.42	3	1.25	3	1.25
Cultivating Coconut (*Cocos nusifera)*	3	1.25	3	1.25	1	0.42	2	0.83	2	0.83	2	0.83
Cultivating Mango (*Mangifera indica)*	2	0.83	2	0.83	0	0.00	0	0.00	2	0.83	2	0.83
Cultivating Blackgram	1	0.42	3	1.25	1	0.42	0	0.00		0.00		0.00
Total	240	100	240	100	240	100	240	100	240	100	240	100

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 8. Mean technical efficiency (TE) in tsunami affected farms

Particular	2005		2006		2007		2008		2009		2014	
	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error	Coefficient	Standard-error
Intercept	-15.53***	0.99	7.75***	0.08	6.17	0.38	7.68***	0.58	16.70***	0.27	4.80***	1.27
Area in (ac)	-10.15***	0.22	0.27***	0.04	0.56**	0.08	0.92	0.05	-2.25***	0.05	-0.01	0.05
Seed in kgs	3.78*	1.04	0.11	0.06	-0.04	0.06	0.0048	0.12	.61	0.01	1.41	0.06
Fertilizer in kgs	-2.54*	0.83	0.19***	0.01	0.17*	0.05	-1.51	0.04	-2.71***	0.04	1.98*	0.07
Machine Labour in hrs	5.94***	0.53	0.14***	0.01	0.00	0.05	-0.11	0.07	-1.68	0.07	-1.95*	0.12
Labour Cost in Rs	2.17*	1.08	0.05*	0.02	0.32**	0.05	-0.03	0.07	2.10**	0.01	-0.27	0.16
Age in yrs	-0.09	0.06	-0.13	0.25	0.07	0.04	-2.56**	0.05	-2.46***	0.05	-3.82***	0.07
Education in yrs	0.35*	0.15	-0.01	0.05	0.29	0.17	0.73	0.12	0.94	0.08	0.21	0.21
Sigma-Squared	18.49	0.93	0.50	0.04	1.75	1.09	3.26	0.02	3.98	0.02	2.71	0.03
Gamma	0.03	0.30	1.00	0.00	0.99	0.01	3.00	0.22	4.54	0.15	3.04	0.24
Mean TE	0.77		0.81		0.82		0.83		0.83		0.84	

*, ** & *** significant at 10, 5 & 1 percent level respectively

Table 9. Distribution of technical efficiency (TE) levels over years

TE Range	2005	2006	2007	2008	2009	2014
0-10	0	1	0	0	0	0
11-20	3	1	0	0	0	0
21-30	2	0	1	0	0	0
31-40	3	0	3	0	0	0
41-50	3	0	3	0	0	0
51-60	2	2	6	1	2	1
61-70	10	8	6	10	11	4
71-80	13	7	21	33	39	18
81-90	58	21	70	76	67	32
91-100	8	16	37	13	16	17
Total	102	56	147	133	135	80
Mean TE	0.77	0.81	0.82	.83	.83	.84

Table 10. Cost of Cultivation of Paddy in Season II (Rs/ha)

Cost (Rs/ha)	2004		2005		2006		2007		2008		2009		2014	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Upto 1000	1	0.61	1	0.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1000-2000	1	0.61	4	3.74	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2000-3000	1	0.61	13	12.15	2	3.17	1	0.68	0	0.00	0	0.00	0	0.00
3000-4000	71	43.56	32	29.91	1	1.59	6	4.11	0	0.00	0	0.00	0	0.00
4000-5000	67	41.10	47	43.93	7	11.11	34	23.29	1	0.88	2	1.48	0	0.00
5000-6000	21	12.88	10	9.35	22	34.92	35	23.97	24	21.24	11	8.15	0	0.00
6000-7000	0	0.00	0	0.00	19	30.16	43	29.45	40	35.40	25	18.52	0	0.00
7000-8000	0	0.00	0	0.00	7	11.11	17	11.64	30	26.55	22	16.30	0	0.00
8000-9000	0	0.00	0	0.00	4	6.35	9	6.16	18	15.93	17	12.59	0	0.00
9000-10000	0	0.00	0	0.00	0	0.00	1	0.68	3	2.65	16	11.85	0	0.00
10000-11000	1	0.61	0	0.00	0	0.00	0	0.00	8	7.08	14	10.37	0	0.00
11000-12000	0	0.00	0	0.00	0	0.00	0	0.00	7	6.19	7	5.19	0	0.00
12000-13000	0	0.00	0	0.00	1	1.59	0	0.00	2	1.77	6	4.44	2	2.70
13000-14000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	4.44	5	6.76
14000-15000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	3.70	3	4.05
15000-16000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	2.22	8	10.81
16000-17000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.74	23	31.08
17000-18000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	13	17.57
18000-19000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	14	18.92
19000-20000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	1.35
>20000	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	6.76
Total	163	100	107	100	63	100	146	100	133	117.7	135	100	74	100.00

Total Number of respondents = 240

Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table 11. Detailed Cost of Cultivation of Paddy (Rs/ha)

Items	2004		2005		2006		2007		2008		2009		2014	
	Qunty (Kg)	**Value**	**Qunty (Kg)**	**Value**	**Qunty (Kg)**	**Value**	**Qunty (Kg)**	**Value**	**Qunty (Kg)**	**Value**	**Qunty (Kg)**	**Value**	**Qunty (Kg)**	**Value**
1.Seedrate (kg)	80	516	92.38	535	99	726	97.65	1268	129	1092.77	136.39	1342.76	101	1990
2.Fertilizers (kg)	455	2352	459	2367	240	1563	243	1879	333	2529	263.96	2076.29	262.42	3325.84
3. No of chemical Spraying	2	525	2.23	563.29	1.44	248	1.91	470.61	1.4	332	1.51	387.56	2.65	1277.7
5. FYM (t)	2.15	1545	2.16	1478	2.01	982	2.4	1160	4.67	2315.86	4.98	2884.52	2.86	2902.03
6.Machine power for land preparation(hrs)	4.4	1195	4.89	1304	1.81	746	3.31	1414	2.26	1203.16	2.26	1345.48	2.78	1919.26
7.Machine power for harvesting/ threshing (hrs)	0.2	18.4	0.58	206	1.16	293	1.27	1330	0.92	941.73	0.93	1043.7	1.74	2440.54
8. Labour (days) for:Land preparation	5.04	364	5.09	359.12	16.92	1506	11.47	1226	13.04	1541.02	14.72	2013.15	17.51	2989.19
Sowing/planting	6.17	538	7.24	563	20.08	1260	13.2	968.3	10.51	901.25	10.81	1054.26	2.82	1129.73
Chemical spraying	1.97	303	2.19	211	1.56	183.33	2.62	342.07	1.87	241.35	2.01	298.41	3.09	1229.73
Fertilizer Application	2	181	1.88	182	1.7	186.5	2.77	359.05	2.42	305.34	2.58	374.07	3.97	1430.41
Weeding	30.36	1364	30.07	1330	20.06	1171	18.84	1149.18	25.79	1999.17	28.04	2567.67	18.82	2887.97
Harvesting/ Threshing	0.09	5	5.87	320.28	20.19	1607	17.35	1460.27	26.8	2737.71	29.43	3627.3	5.76	918.92
Cost of cultivation		8906.4		9418		10472		13026.48		16140.36		19015.17		24441.32
Yield :														

1. Main product (kgs)	Crop failed	1107	2413	16900	42.02	14698.17	39.11	18348.33	32.17	21571.47	30.49	27601.20
2. By product (kgs)			200		1338.89	988.10	893.19	849.66	1621.02	1633.42	23.00	2359.63
Gross income			2619			15686.27		19197.99		23204.89		29960.83

Total Number of respondents = 240
Source: RIHN, TNAU, Tsunami Survey 2006, 2007, 2008, 2010 and 2014

Table. 12 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)		2008 (Oct 08 - Jan 09)		2009 (Oct 09 - Jan 10)		2014 (Oct 13 - Jan 14)	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Crop failure	144	100	74	70.48	1	1.64	0	0	0	0	0	0	0	0
upto 8750	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8750-11250	0	0	0	0	0	0	2	1.39	2	1.50	0	0	0	0
11250-13750	0	0	0	0	2	3.28	11	7.64	9	6.77	1	0.74	0	0
13750-16250	0	0	0	0	2	3.28	10	6.94	10	7.52	14	10.37	0	0
16250-18750	0	0	0	0	3	4.92	10	6.94	12	9.02	13	9.63	4	5.41
18750-21250	0	0	0	0	11	18.03	20	13.89	17	12.78	19	14.07	6	8.11
21250-23750	0	0	12	11.43	5	8.2	24	16.67	16	12.03	17	12.59	3	4.05
23750-26250	0	0	6	5.71	10	16.39	21	14.58	21	15.79	19	14.07	9	12.16
26250-28750	0	0	9	8.57	15	24.59	12	8.33	18	13.53	21	15.56	13	17.57
28750-31250	0	0	4	3.81	8	13.11	17	11.81	16	12.03	11	8.15	12	16.22
31250-33750	0	0	0	0	2	3.28	11	7.64	3	2.26	6	4.44	7	9.46
33750-36250	0	0	0	0	0	0	3	2.08	2	1.50	5	3.70	10	13.51
>36250	0	0	0	0	2	3.28	3	2.08	7	5.26	9	6.67	10	13.51
Total	0	0	105	100	61	100	144	100	133	100	135	100	74	100

Table 13. Gross and Net Income of the Paddy Farmers in the Coastal Area (Rs/ha)

Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2014**
Gross Income	0*	3471.53	9336.54	8412.01	9922.85	18807.6	27601.2
Cost of cultivation	4147.1	3903.61	6202.26	5873.39	7456.87	8924.64	17096.78
Net income (current price)	-4147.1	-432.08**	3134.28	2538.62	2465.98	9882.99	10504.42
Net income (constant price of 2004)	-4147.1	-432.08**	2599.46	2028.18	1798.29	6616.10	6549.59

*crop failure due to tsunami
** Poor yield and income due to flooding and poor soil quality

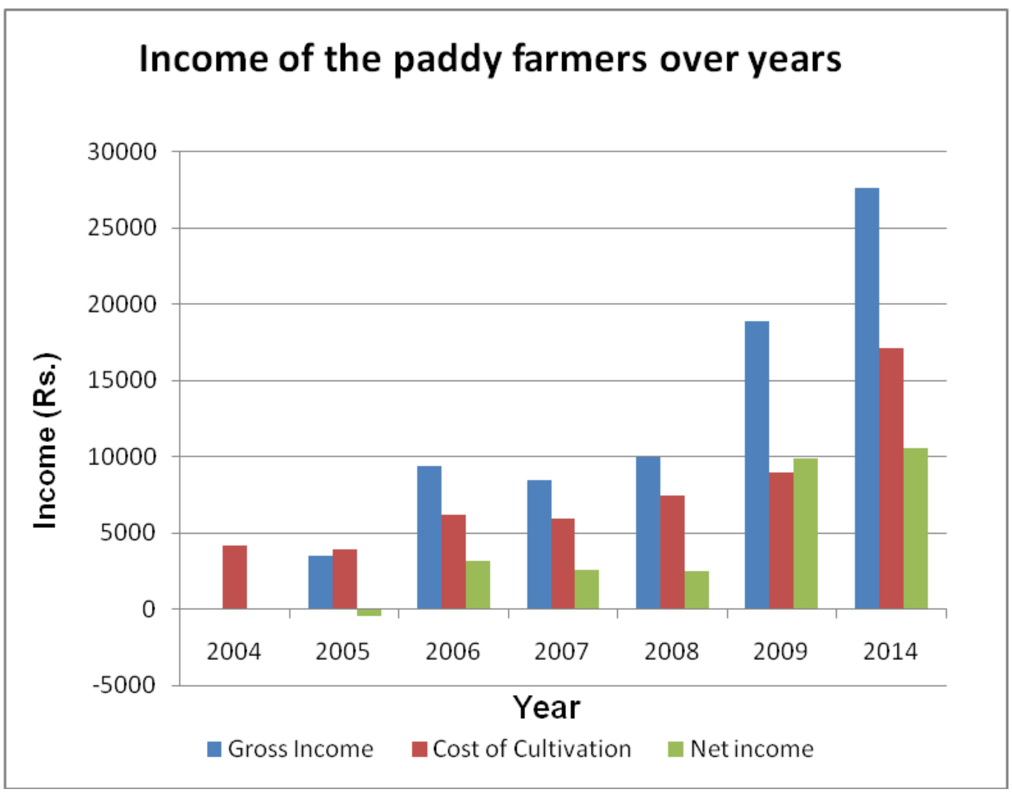

Table 14. Income from farming and allied activities (Rs./household)

Year	Sources of Income				
	Farming	Allied Activities (livestock, poultry)	Non-farming (shop etc)	Hired Work	Total Income
2004	3357	404	2050	6030	11841
2005	405	431	1623	6867	9326
2006	4108	646	1250	15240	21244
2007	6922	300	1113	11616	19951
2008	14000	2124	1627	15382	33134
2009	13625	2452	2000	18089	36166
2014	15947	5492	3028	8995	33461

Table 15. Total income range and distribution of households (Rs/household)

Total Income (Rs) less than or equal to	Number of farm households						
	2004	2005	2006	2007	2008	2009	2014
0	19	28	6	18	24	24	4
10000	142	141	79	71	35	26	19
20000	50	54	60	69	67	46	22
30000	11	11	50	37	47	65	23
40000	8	2	22	22	8	17	19
50000	3	1	10	12	5	8	3
60000	1	1	4	4	7	10	4
70000	2	0	3	3	10	3	3
80000	2	1	4	2	12	11	2
90000	0	0	0	0	4	9	0
100000	0	0	0	0	6	5	0
>100000	2	1	2	2	22	21	1

Table 16. Gini-coefficient for income distribution

Year	Gini Coefficient
2004	0.335
2005	0.215
2006	0.412
2007	0.381
2008	0.504
2009	0.49
2014	0.347