# Income dynamics in Tamil Nadu, India from 1971 to 2003: changing roles of land and human capital

Kei Kajisa*
*International Rice Research Institute (IRRI) and*
*Foundation for Advanced Studies on International Development (FASID)*
and
N. Venkatesa Palanichamy
*Tamil Nadu Agricultural University*
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Abstract

This paper examines the changing role of physical and human capital in income dynamics in Tamil Nadu, India, using detailed daily records of farming households from 1971 to 2003. We find that income growth until the early 1990s is attributed to the rice Green Revolution and the associated development of non-rice farm sector. Further growth after the 1990s became possible due to the rapid non-farm sector development which has been stimulated by the liberalization of Indian economy since 1991. In accordance with this change in income structure, the importance of physical and human capital has changed. Human capital was important in the early 1970s to take advantage of the rice Green Revolution technology. Once the new technology became standard among farmers, human capital became an insignificant factor. The importance of human capital has revived in a different manner in recent years firstly because it has increased farmers' access to non-farm job opportunities, and secondly because farm management has become more knowledge intensive in the face of increasing scarcity of labor and water. The contribution of physical capital increased during the Green Revolution period, while it started declining after that. The changing mechanism is characterized as the shifting importance from physical to human capital in accordance with the changing engines of income growth from the Green Revolution to the development of non-farm sector.

JEL classifications: O13, O14, O15, Q12
Key Words: poverty, income dynamics, Green Revolution, human capital, India

* Corresponding author: 7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, Japan. Tel: +81(3)5413-6034, Fax: +81(3)5413-0016, email: kajisa@grips.ac.jp

## 1. Introduction

Aggregate national level statistics in India showed steady decline in poverty from about 50% in the early 1970s to about 30% in the late 1990s in terms of the head count index. However, the number of poor remains appreciably high in India. The estimation by Datt and Ravalion (2002) shows that about one-third of the poor in the world in the mid-1990s lived in India.[1] A clear message from this fact is that without India's success, the alleviation of poverty to the level declared in the Millennium Development Goals is not possible.

A number of attempts, therefore, have been made to understand the mechanism of income dynamics of this country. One strand of the literature uses long term state level data to figure out macro level dynamics (Datt and Ravallion, 1998, 2002; Ravallion and Datt, 2002; Fan et al., 2000; Fan and Hazell, 2000). This literature is valuable to understand the importance of agricultural development, infrastructure construction, and the improvement in literacy rates. However, the scope to understand the detailed mechanism of causes and effects is limited. The other group of studies relies on micro level data to explore in more detail mechanism of income growth and poverty reduction (Krishna, 2006; Foster and Rozenzweig, 2004; Metha and Shah, 2003).

[1] The estimation uses an international poverty line of $1 per day measured at 1993 purchasing power parity exchange rate.

However, given the unavailability of large sample micro data sets that cover the long term period, it is difficult for them to uncover long-term income dynamics.

It is obvious that the nature of income dynamics has changed in the course of India's economic development; it has been characterized by the Green Revolution since the 1960s and by the rapid industrialization since the economic liberalization of the early 1990s. Such long-run dynamics, however, have seldom been explored with a large micro level data set in the existing literature.[2] Particularly, there is a paucity of literature covering the period late enough to evaluate the impact of the liberalization. Some of the arguments in the existing literature may be already outdated, thus misrepresenting the present Indian economy.

The aim of this paper is to explore the changing nature of income dynamics in the course of structural transformation of rural economies in India with the use of long term micro data. Our analyses rely on farm household data in Tamil Nadu from 1971 to 2003 collected under the Cost of Cultivation of Principal Crops (CCPC) scheme. The CCPC data set is one example of India's tradition of exhaustive household survey

[2] Long term longitudinal village studies are useful to understand income dynamics. However, most of them rely on data from only one or at most a few villages. Although there is a useful review of such village studies by Jayaraman and Lanjouw (1999) for generalization of their implications, we still need analyses based on large micro data that cover long term period to derive more general implications with statistical confidence.

schemes like the well-known survey conducted by the National Sample Survey (NSS) Organization. In the CCPC scheme, enumerators live close to survey villages and keep daily records of sample farmers' farm and non-farm activities throughout a year. This intensive data collection work has been conducted every year over the last three decades. The advantage of this data set is the availability of household income data by source. Because of this advantage, we can assess the changing composition of household income over time and identify changing role of possible determinants of the growth of each income component. Among others, we closely explore the changing role of physical and human capital during the era of the rice Green Revolution and that of recent industrialization. The disadvantage of this data set is the restriction of the sample to farming households, excluding not only urban but also landless rural households. However, the data set includes marginal farmers, so we will be able to shed new light on poor households' income dynamics.

The next section of this paper provides an overview of changes in income and poverty in Tamil Nadu since 1971. Methodology and hypotheses are explained in Section 3. After explaining the CCPC data set in Section 4, we present the results of our statistical analyses on income dynamics by source in Section 5. The final section concludes this paper.

## 2. Dynamics of poverty reduction and income growth in Tamil Nadu

This section reviews the dynamics of poverty reduction and income growth using Figures 1 to 3, which show, respectively, changes in (1) the head count index of poverty, (2) mean real monthly household income per capita, and (3) decomposed mean real monthly household income per capita by income source. Two remarks are in order about these figures. First, we show five year moving average of our CCPC statistics in order to analyze the trend of dynamics clearly by reducing year-to-year fluctuations of income caused mainly by weather and other random shocks. Second, Figures 1 and 2 show not only CCPC statistics but also corresponding statistics computed from NSS survey by Datt (1988) and Jha (2000) for the confirmation of the consistency between the two series of data. Remarkably, although NSS and CCPC use different samples and different questionnaires, they show similar patterns in both figures.[3] In general, we are confident that our CCPC income data fairly accurately capture the income dynamics of the State. Small differences in two series can be attributed to the difference in the coverage of samples.

Our CCPC statistics in Figure 1 show that poverty had declined steadily

[3] NSS surveys expenditure data, while CCPC surveys income data.

throughout the 1970s and the 1980s, then jumped shortly once in the early 1990s, and then the speed of decline was accelerated in the late 1990s. The dynamics of mean income depicted in Figure 2 matches this pattern: a steady increase throughout the 1970s and the 1980s, followed by a temporary drop in the early 1990s, and then rapid increase in the late 1990s.

Figure 3 reveals which income components play a major role in forming this pattern. First, we observe a steady increase in rice income until the early 1990s, reflecting the success of the rice Green Revolution which started in the mid 1960s in Tamil Nadu. Second, we observe a faster increase in non-rice crop income in the same period. This is attributed to the fact that, alongside the rice Green Revolution, the high yielding varieties of other cereals, pulses, sugarcane cotton, and groundnuts has been continuously released from local agricultural research institutes since the early 1970s. Thus, the income growth until the early 1990s is largely attributed not only to the rice Green Revolution but also to the associated development of non-rice crops.

Third, although the level is not high, milk income had increased initially in the 1980s and then again in the late 1990s. The national level project for the dairy sector development called “Operation Flood” was launched in Tamil Nadu in 1970, after

which, due to its success, was eventually termed as the "White Revolution."[4] The growth of milk income in the 1980s is attributed to this Revolution. Its growth in the late 1990s is likely to be associated with the increased production incentive due to the liberalization of milk processing and marketing since 1992, together with increased milk demand in urban areas.

Fourth, we observe a sharp increase in non-farm income since the mid 1990s. In the same period, the agricultural labor income also increased due to an increase in the real wage rate, which can be considered as a side effect of the development of non-agricultural sector.[5] The increase in these two sources of income has enabled rapid income increase and thus faster poverty alleviation in this period, while crop income (rice and non-rice) has shown no appreciable increase. Hence, the growth in this period is largely attributed to the expanded employment opportunities due to the non-farm sector development.

In summary, the engines of farmers' income growth have changed from agriculture to non-agriculture during the 1990s. A critical question is, through this transformation, how the roles of physical and human capital have changed. Our

[4] The essence of the success is the improvement of dairy marketing system through the formation of milk producers' cooperatives (Sharfuddin and Reddy, 1984).

[5] The annual growth rate of agricultural wage was 2.5 % from 1971 to 1990, while it went up 3.2 % from 1991 to 2001.

methodology and hypotheses to answer this question will be shown in the next section.

## 3. Methodology and hypotheses

Methodology

In order to explore the changing determinants of income, the methodology we use is to estimate an income determination function by era that is divided by epoch making events which occurred in India's economic history, namely the Green Revolution and recent economic liberalization. The rice Green Revolution started in the mid 1960s in Tamil Nadu, and by the mid of 1980s the first generation of the high yielding varieties had been almost completely adopted throughout the State (Ramasamy et al., 1994; Hazel and Ramasamy, 1991).[6] We define the era from 1971 to the mid 1980s in our survey period as the early Green Revolution, and the period thereafter as the late Green Revolution. The other epoch making event, that is the liberalization of the economy, started in 1991. Hence, the era after the early 1990s is referred to as the post Green Revolution liberalization era.

We try to identify the determinants of not only total income but also each

[6] The adoption rate of modern varieties at the study site of Ramasamy et al. (1994) had reached 80 to 90 % in favorable locations by the early 1980s. The same study shows even in unfavorable locations it had reached about 70 % by the mid 1980s. The adoption rate at the study site of Hazell and Ramasamy (1991) had reached about 90% by the early 1980s.

income component. Thus, the dependent variable of our income determination function is either total, rice, non-rice, milk, agricultural labor, or non-farm income per capita in real monthly term. The explanatory variables consist of the physical and human capital variables of sample households. Among others, land characteristics and education are the most important determinants in a set of our explanatory variables.

## Hypothesis

We advance hypotheses by era in this subsection which are summarized in Table 1.

*Early Green Revolution (1971 – the mid 1980s)*. The literature on Green Revolution argues that modest management ability is required to take advantage of this technology (Rozenzweig and Foster, 1996; Feder, 1985). To understand the appropriate use of modern inputs such as high yielding varieties (HYVs) and chemical fertilizers, a moderate level of formal schooling plays an important role. Thus, we hypothesize that the acquisition of a moderate level of education increases rice income. The same applies to non-rice crops whose high yielding varieties have been released since the early 1970s. Another important factor for the adoption of HYVs is the access to irrigated land. The impact of irrigation on rice production becomes greater if timely application of

sufficient water becomes possible under modern systems such as wells or wells-cum-canal systems, rather than traditional systems such as tank or canal systems. The same applies to non-rice crops cultivated in Tamil Nadu such as sugarcane, cotton, pulses, banana, and groundnuts. Although they are less water demanding, cultivation on irrigated land appreciably increases the productivity of these crops. Hence, we hypothesize that greater access to irrigated land increases both rice and non-rice income with greater impact from modern irrigation systems than that from traditional systems. On the other hand, farmers without irrigation and those having less education must rely on agricultural labor income. Thus, we hypothesize the smaller the irrigated area and the lower the education level, the higher the agricultural labor income.

The Operation Flood program aims to improve the livelihood of marginal and landless farmers through dairy development. Nevertheless, an increase in milk income still depends on landholdings to the extent that the access to credit is important for the adoption of productive crossbred cows and also that the availability of fodder is constrained by landholding size (Thankur et al., 1980). We hypothesize that landholding size has a positive impact on milk income but the magnitude of impact is smaller than the case of crop income. We also expect the importance of a moderate level of education because modern dairy management is required to raise crossbred cows.

In this pre-industrialization period, non-farm activities available in rural areas were limited to the agriculture related self-employment businesses such as processing (e.g. milling and spinning) and trading in farm products.[7] Given an imperfect credit market, such local non-farm activities were started by large farmers in villages. We hypothesize that the larger the landholdings, the larger the non-farm income. The level of education may not matter so much for these kinds of businesses.

*Late Green Revolution (the mid 1980s – the early 90s).* By the time this era began, the rice HYVs had become standard technology among the farmers. Hence we expect that education had non-significant impact on rice income. Meanwhile, the returns to irrigated land had continuously increased as second generation HYVs that were modified to the local ecological conditions to produce much higher yields than the proto-type first generation became available. Since the structure of the dairy sector and the non-farm sector did not change much in this era, the role of physical and human capital would not change from the previous era. Given these hypotheses, household income in this era is expected to be determined predominantly by access to irrigated land.

[7] The data in 1982-83 used by Hzaell and Ramasamy (1991) shows that dominant non-farm activities in their study area include trading of agricultural input and output, rice mills, oil extraction mills, textiles, general grocery shops, and construction contractors.

*Post Green Revolution liberalization (the early 1990s – 2003).* The liberalization of the economy since 1991 has significantly stimulated the expansion of non-farm job opportunities in urban business and local industrial sectors. To obtain jobs in such sectors, the acquisition of a higher level of education is crucial (Lanjouw and Shariff, 2004). We hypothesize, therefore, that non-farm income in this era increases with higher level education. Furthermore, many non-farm activities that have emerged in this era have been available in urban areas or have come to rural areas from urban areas. Hence, in contrast to the early GR era, we hypothesize that the landholding size has no positive impact on non-farm income in this era.

Due to the rapid development of the non-farm sector, the agricultural sector has began to face labor scarcity. As the scarcity increases, the replacement of permanent laborers by casual laborers, referred to as the casualization of labor, has proceeded (Jayaraman and Lanjouw, 1999). Gough (1987) demonstrates the casualization process in Tamil Nadu by showing a movement from in-kind to cash payments because permanent laborers tend to be paid in kind. We observe the same trend in our data set.[8] As the casualization proceeds, more skillful labor management is required. The adoption of newly available labor saving technologies has been also important to

[8] CCPC data show the proportion of in-kind payment in total payment to hired laborers has declined from 40% to 20% between the 1970s and the 2000s.

mitigate labor scarcity. Hence, farming has become more knowledge intensive.

Concurrently with increasing labor scarcity, the farm sector has also began to suffer water scarcity, which has its roots firstly in the lowering of quantity and quality of surface water due to industrial and urban sector development, and secondly and more seriously in the depletion of groundwater due to the problem characterized as the tragedy of the commons and also due to free electricity for water pumping. Facing increasing labor and water scarcity, agricultural management has become more knowledge intensive.

At the same time, as the Green Revolution has reached the matured stage and also as water shortage has become serious, the productivity of irrigable land does not increase, or may even decline. We hypothesize that in the farm sector (rice and non-rice) the contribution of education increases, while the contribution of irrigated land does not increase, or may even decline. Therefore, in summary, *in both at farm and non-farm sectors*, we expect that the importance of irrigated land declines and that of education increases in this era.

*Summary of hypotheses.* By way of summarizing the above hypotheses on the income dynamics, we show the changing role of physical (irrigated land) and human (education) capital in the dynamics of changes in income components over the three

eras (Table 1). We expect that the contribution of physical capital (access to irrigated land) to household income increases from the first to the second era, while human capital (education) plays a modest role in both eras. Education will have a negative impact on agricultural wage income, as it is an unskilled job. Once the Green Revolution reaches the matured stage and the development of non-farm sector starts (the third era), a decrease in the contribution of irrigated land and an increase in that of human capital (particularly higher level of education) are expected to be observed.

We also advance a hypothesis regarding the impact of the number of adults in a household on per capita household income (not shown in Table 1). Controlling for farm size, we would observe very strong negative relationship between the number of adults and per capita income when farming was the dominant income source because per capita income is strongly determined by farm size per working adults. However, when non-farm activities became an important income source, the negative relationship would become weaker because the contribution of working adults is not constrained by landholding size.

## 4. Data

The data have been collected annually by Tamil Nadu Agricultural University

since 1971 with the aim of surveying cultivation costs of principal crops. The sampling involves three stages. First, districts are classified into six agro-climatic zones, and then districts in each zone are selected so that the crop area of sample districts becomes proportional to the crop area of the zones. Second, villages in each district are selected so that the crop area of sample villages becomes proportional to the crop area of districts. Third, in each selected village, farming households are selected in accordance with the size of land holdings. The five size classes are operational holdings with areas less than one hectare, between 1 and 2 hectares, between 2 and 4 hectares, between 4 and 6 hectares, and greater than 6 hectares. In each size class, two households are selected by simple random sampling, generating a sample of 10 farmers in each village.[9] The survey year corresponds to the cropping calendar, starting July and ending June of the following year. For simplicity hereafter we refer only to the beginning year of survey years. For example, the annual data covering from 1971-July to 1972-June is indicated as the data in the 1971 survey year.

From 1971 to 1980, the sampling of 40 villages was carried out every year (i.e. 10 rounds of sampling). Although the villages selected in current and previous years are removed from the following years' selection, given the huge number of villages in the

[9] If in any villages, a particular size class does not contain even two households, more households are selected from the adjacent size group to make up the deficit.

State, we can safely regard the samples of this period as randomly selected pooled data from 10 rounds of sampling. Since 1981, sampling of 60 villages has been carried out every three years (i.e. 8 rounds of sampling up to the latest 2002 sampling) and the same households were surveyed for three consecutive years until the next round of sampling, generating 3-year panels every three years.[10] Hence, the samples since 1981 can be regarded as 3-year rotating panels of 8 rounds of sampling.[11]

To deal with the data set having these characteristics, a few technical aspects need to be addressed here. First, CCPC has been sampling farmers in a non-stratified manner (i.e. two farmers from every operational holdings group). We weight the sample with the population distribution of operational holdings that is obtained from the population census in Tamil Nadu (Government of Tamil Nadu, 2002). The CCPC data of each survey year is weighted by the distribution of the nearest census year.[12] Second, in order to deal with pooled or panel data, we apply treatments that fit our research purpose. We apply a village fixed model to the pooled data from 1971 to 1980. The panel data could be treated either with household fixed effects or random effects. Given

[10] Only in the first round of 3-year panels, i.e. the 1981-1983 round, sampling of 40 villages was carried out in 1981 and then 20 new villages were added in 1983.

[11] The design of the questionnaire has been consistent throughout the survey rounds, although a major revision was made in 1993.

[12] The census is available in 1976-77, 1979-80, 1985-86, 1990-91, and 1995-96. The distribution of operational holdings has not been changing appreciably throughout these periods.

that our purpose is to identify the contribution of physical and human capital to income, we must give up using a household fixed effect model as it fails to capture the impacts from the factors that are almost time invariant within a three-year panel period. Thus, we apply a random effect model to the data from 1981 to 2003. Third, the CCPC data set allows us to compute total household income but not total household expenditure. Agriculture in Tamil Nadu is subject to monsoons that are never steady over years and across regions (Hazell and Ramasamy, 1991). Velappan (1986) stresses that agriculture in Tamil Nadu has been literally a gamble on the monsoons, with farmers' income being vulnerable to negative weather shocks, resulting in huge fluctuations. In order to mitigate year-to-year fluctuations and identify overall trends, we have shown five year moving averages in the previous figures. In computation of income, due to limitations of data, we could not incorporate credit transactions. Hence, some farmers who suffer from a crop failure end up with negative income. This is a reason for our lower mean income and higher poverty index than those of the NSS survey. Since the number of such farmers is non-negligible, we use the level of real income, rather than the log income, as our dependent variable in the following regression analyses.

## 5. The determinants of income

## Model

We run regression models using a set of physical and human capital characteristics as explanatory variables. The physical capital is measured by (1) the size of operational land irrigated by modern irrigation systems (wells, canals-cum-wells, or tanks-cum-wells) (2) land irrigated by traditional irrigation systems (canals or tanks), and (3) land with no irrigation (in hectares). We control for land tenure status by including (4) the proportion of farm area under owner cultivation, expecting a positive sign for its coefficient. Human capital consists of (5) the number of adults in a household, (6) the number of children in a household, (7) the proportion of adult members with primary schooling, (8) the proportion with secondary schooling, and (9) the proportion with post secondary schooling. Using these nine explanatory variables, we run our model by periods having a length varying from 4 to 6 years depending on the division points of the three eras and the survey round of panel data. Thus, one era consists of one or more periods. For the sake of interpretation, the regression results present the elasticity of some selected variables.

## Regression Results

We start with the discussion about the changing importance of the determinants

of total household income and then explore how each income component contributes to this change. Table 2 shows the estimation results of the determinants of the total household income. The elasticities of land size under modern irrigation system shows an increasing trend up to the late Green Revolution period and a declining trend after that, which are consistent with our hypotheses. It is worth noting that the elasticity becomes insignificant in the last period (1999-03); the reason will be explained in the following paragraph. Secondary level schooling has a positive impact but not statistically significant in the first period (1971-74). Meanwhile, we can clearly observe significant and positive coefficients of secondary and post-secondary schooling in the last period (1999-03). As we will see below, this means that the fuel for the engine of growth has changed from physical to human capital in recent years. Because of this, as we have expected, the elasticity of the number of adults becomes less negative overtime.

Table 3 shows the estimation results for rice income. The elasticities of land size under modern irrigation systems show a similar pattern to those for total income. In the last period (1999-03), the elasticity becomes insignificant, reflecting the serious water scarcity problem. Regarding the impact of education, the proportion of adults with secondary schooling is positive and significant in the first period (1971-74). This

indicates that although secondary schooling was important for rice income, it was marginally so for total income. After the first period, secondary schooling had been insignificant until the period before the last, indicating that new HYV technology became the standard technology among the farmers by the mid 1970s. The positive and significant coefficients of secondary and post secondary schooling in the last period (1999-03) indicate that rice farming has become a knowledge intensive activity as we have hypothesized.

The results for non-rice income in Table 4 show a similar structure to those for rice income. These findings reinforce the validity of our hypotheses. Since rice and non-rice are two major income components throughout the survey period (Figure 3), the regression results of total income function are similar to the results of these two sectors.

Table 5 shows results for milk income. The elasticities of land size under modern irrigation are positive and significant in most of the cases and the magnitudes are smaller than those in rice and non-rice sectors, which are consistent with our hypotheses. Surprisingly, education does not matter for management of newly introduced crossbred cows, presumably due to well organized extension service provided by milk cooperative societies.

We now turn to the discussion about agricultural income. Since there exist a

significant number of households having no income from this source, we apply the Tobit model. In addition, since many villages have only one household with this source of income, we do not include village dummies in analyzing pooled data from 1971-80. Panel data are analyzed with the random effect Tobit model. The results are shown in Table 6. They are consistent with our hypotheses; the more marginal and the less educated, the more farmers rely on this income source. This structure has been prevalent throughout the periods.

For the same reason as the case of agricultural labor income, the Tobit and the random effect Tobit are applied to non-farm income analyses. Regarding physical capital, Table 7 shows that although the land size under modern irrigation had a positive and significant relationship with non-farm income in the early periods, it became insignificant after the liberalization and even became negative and significant in the latest period.

Education was not important for the growth of non-farm income in the early periods, but it became important, particularly the higher level of education, in recent periods. These results indicate that, as we have hypothesized, the growth of this income stemmed initially from physical capital endowments, but lately has stemmed from human capital endowments. Therefore, as non-farm employment opportunities have

increased after the liberalization, the per capita non-farm income tends to increase as the number of working adults increases as long as they are educated. Supporting this argument, the results show that the coefficient of the number of adults changes from negative (insignificant) to positive (significant). Reflecting this change, the elasticity of number of adults in total income results shows a declining trend as we have hypothesized.

## 6. Conclusion

This paper explored the changing determinants of income in Tamil Nadu, India, using detailed daily records of farming households from 1971 to 2003. A key finding is the changing roles of physical and human capital through the course of development from the early to the late Green Revolution eras and then further to the post Green Revolution industrialization era. The analyses show that human capital (secondary level schooling) was important in the early 1970s to take advantage of the rice Green Revolution technology. However, once the new technology became standard among the farmers, human capital became an insignificant determinant. The importance of human capital has revived in a different manner in recent years firstly because it has increased farmers' access to non-farm job opportunities that have been rapidly emerging since the

liberalization of the Indian economy, and secondly because farm management has become more knowledge intensive in facing increasing labor and water scarcity. It is worth pointing out that since the development of the non-farm sector is one major reason for increasing scarcity of labor and water, we argue that this development is the major factor that raises the importance of human capital not only in the non-farm sector but also in the farm sector.

The contribution of physical capital (land irrigated by modern irrigation systems) shows an increasing trend from the early toward the late Green Revolution period. However, once the Green Revolution reached the mature stage and water scarcity became serious in the early 1990s, its contribution started declining. This declining trend has been accelerated by the recent development of the non-farm sector because newly emerging non-farm activities are not agro-based and independent from the area of irrigated land.

In summary, the changing mechanism is characterized as the shifting importance from physical to human capital in accordance with the changing engines of growth from the Green Revolution to the development of the non-farm sectors. An implication from this finding for designing effective policies is that since the economy has been experiencing fast and dramatic structural changes, policies derived from the

results of non-fresh data sets may be irrelevant or even mislead the economy. Particularly, the implications derived from the data before or right after the economic liberalization would no longer be relevant. Therefore, based on the results on the recent periods, we claim that for further poverty reduction in poor rural communities in Tamil Nadu, human capital development is crucially important. To the extent that high education is disproportionately pursued by the rich, there is a danger that human capital development will increase inequality without reducing poverty. A critical policy question is how to promote schooling of children of poor households. Further in-depth research is called for in order to address this question.

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Table 1: The hypothesized impacts of physical (irrigated land) and human capital (education) on each component and total income

| Income component | | Early Green Revolution (1971 - mid 80s) | Late GR (mid 80s - early 90s) | Post GR liberalization (early 90s - 2003) |
|---|---|---|---|---|
| Rice | L | + | ++ | + |
| | E | + | 0 | ++ |
| Non-rice | L | + | ++ | + |
| | E | + | 0 | ++ |
| Milk | L | + | + | 0 |
| | E | + | + | 0 |
| Agricultural labor | L | - | - | - |
| | E | - | - | - |
| Non-farm | L | + | + | 0 |
| | E | 0 | 0 | ++ |
| Total | L | + | ++ | + |
| | E | + | 0 | ++ |

L: irrigated land

E: education

+/-: positive/negative moderate impact

++/-- positive/negative strong impact

0: no significant impact

Table 2: The determinants of total household income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | 10.647 | 11.033 | 16.237 | 19.145 | 10.238 | 0.873 |
| | (8.51)** | (13.34)** | (17.16)** | (13.39)** | (11.01)** | (0.77) |
| Trad irrig ha. | 6.545 | 12.902 | 11.790 | 19.070 | 10.220 | 6.536 |
| | (8.83)** | (9.34)** | (14.34)** | (9.52)** | (4.73)** | (2.38)* |
| No irrig ha. | 1.318 | 3.368 | 3.310 | 2.136 | 0.633 | 2.065 |
| | (1.25) | (5.30)** | (2.99)** | (1.21) | (0.52) | (1.09) |
| Owner cultivation % | 7.163 | 21.407 | 2.239 | -6.053 | 6.053 | -13.902 |
| | (2.53)* | (4.06)** | (0.67) | (0.93) | (2.54)* | (2.01)* |
| *Human Capital* | | | | | | |
| No. of adults | -4.645 | -4.993 | -4.419 | -5.100 | -3.728 | -2.983 |
| | (3.21)** | (8.51)** | (9.83)** | (5.01)** | (8.10)** | (3.07)** |
| No. of children | -3.201 | -4.395 | -4.837 | -4.818 | -4.188 | -5.140 |
| | (5.49)** | (9.24)** | (8.39)** | (3.53)** | (7.76)** | (4.53)** |
| Primary prop | -0.357 | -2.205 | -5.357 | -10.043 | -0.442 | 3.839 |
| | (0.09) | (0.69) | (1.92) | (1.45) | (0.18) | (0.96) |
| Secondary prop | 18.283 | -5.776 | 0.445 | -8.486 | 4.630 | 12.581 |
| | (1.51) | (1.47) | (0.15) | (1.41) | (1.92) | (2.04)* |
| Post Secondary prop | 5.193 | -3.288 | 6.190 | 6.350 | 2.942 | 34.225 |
| | (0.55) | (0.37) | (1.01) | (0.47) | (0.54) | (3.16)** |
| Constant | -1.385 | 2.403 | 27.747 | 40.586 | 22.689 | 44.196 |
| | (0.16) | (0.20) | (6.74)** | (5.10)** | (6.44)** | (5.07)** |
| *Elasticity* | | | | | | |
| Modern irrig ha. | 0.425 | 0.368 | 0.570 | 0.613 | 0.516 | 0.067 |
| | (9.83)** | (13.81)** | (22.53)** | (13.78)** | (16.40)** | (0.80) |
| Trad irrig ha. | 0.270 | 0.333 | 0.230 | 0.276 | 0.160 | 0.084 |
| | (7.26)** | (9.35)** | (15.81)** | (9.41)** | (5.23)** | (2.47)* |
| No irrig ha. | 0.048 | 0.106 | 0.067 | 0.048 | 0.007 | 0.021 |
| | (1.23) | (5.38)** | (3.06)** | (1.23) | (0.52) | (1.11) |
| No. of adults | -0.914 | -0.864 | -0.476 | -0.532 | -0.467 | -0.431 |
| | (3.66)** | (9.47)** | (10.26)** | (4.79)** | (8.46)** | (3.22)** |
| No. of children | -0.273 | -0.268 | -0.152 | -0.123 | -0.110 | -0.135 |
| | (6.00)** | (9.80)** | (8.48)** | (3.46)** | (7.81)** | (4.65)** |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Village FE | Village FE | HH RE | HH RE | HH RE | HH RE |

* significant at 5% level; ** significant at 1% level

Robust *t*-statistics in parentheses for the regression coefficients of village FE models and semi-robust *z*-statistics for those of HH RE models. Z-statistics in parentheses for elasticities.

Table 3: The determinants of rice income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | 5.008 | 4.883 | 7.741 | 7.994 | 4.278 | 0.202 |
| | (8.80)** | (11.42)** | (18.57)** | (9.32)** | (8.17)** | (0.65) |
| Trad irrig ha. | 5.369 | 10.109 | 10.651 | 16.056 | 7.813 | 11.742 |
| | (9.70)** | (8.50)** | (14.47)** | (13.36)** | (6.01)** | (7.57)** |
| No irrig ha. | 0.524 | 0.571 | 0.333 | 0.177 | -0.489 | 0.425 |
| | (1.67) | (2.38)* | (0.55) | (0.17) | (0.46) | (0.36) |
| Owner cultivation % | 5.509 | 8.747 | 2.000 | 0.766 | 3.692 | 0.648 |
| | (3.41)** | (3.76)** | (1.24) | (0.20) | (2.07)* | (0.30) |
| *Human Capital* | | | | | | |
| No. of adults | -2.217 | -2.709 | -2.338 | -2.074 | -1.885 | -0.927 |
| | (6.32)** | (7.22)** | (7.95)** | (3.40)** | (6.59)** | (2.31)* |
| No. of children | -1.729 | -2.341 | -2.837 | -1.793 | -1.866 | -2.337 |
| | (6.50)** | (7.79)** | (8.64)** | (2.19)* | (6.12)** | (4.56)** |
| Primary prop | 1.643 | 0.312 | 0.928 | -6.116 | -0.441 | 1.764 |
| | (0.75) | (0.17) | (0.44) | (1.47) | (0.24) | (1.00) |
| Secondary prop | 5.422 | 1.057 | 0.386 | -5.752 | 3.003 | 4.467 |
| | (2.02)* | (0.45) | (0.22) | (1.60) | (1.58) | (2.04)* |
| Post Secondary prop | 1.094 | 8.025 | -0.915 | 3.753 | -0.427 | 13.787 |
| | (0.20) | (1.43) | (0.33) | (0.46) | (0.11) | (2.63)** |
| Constant | -0.065 | 7.658 | 11.165 | 12.797 | 9.763 | 8.720 |
| | (0.02) | (0.85) | (5.34)** | (2.67)** | (3.57)** | (3.06)** |
| *Elasticity* | | | | | | |
| Modern irrig ha. | 0.396 | 0.339 | 0.556 | 0.539 | 0.461 | 0.037 |
| | (9.74)** | (10.79)** | (22.45)** | (9.79)** | (10.92)** | (0.66) |
| Trad irrig ha. | 0.439 | 0.542 | 0.426 | 0.490 | 0.262 | 0.358 |
| | (9.95)** | (8.79)** | (18.63)** | (10.95)** | (7.11)** | (8.94)** |
| No irrig ha. | 0.038 | 0.037 | 0.013 | 0.008 | -0.011 | 0.010 |
| | (1.66) | (2.38)* | (0.55) | (0.17) | (0.46) | (0.36) |
| No. of adults | -0.865 | -0.974 | -0.515 | -0.456 | -0.504 | -0.316 |
| | (7.02)** | (8.01)** | (8.49)** | (3.28)** | (7.04)** | (2.39)* |
| No. of children | -0.293 | -0.296 | -0.182 | -0.097 | -0.104 | -0.145 |
| | (6.98)** | (8.16)** | (9.51)** | (2.16)* | (6.31)** | (4.73)** |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Village FE | Village FE | HH RE | HH RE | HH RE | HH RE |

* significant at 5% level; ** significant at 1% level

Robust *t*-statistics in parentheses for the regression coefficients of village FE models and semi-robust *z*-statistics for those of HH RE models. Z-statistics in parentheses for elasticities.

Table 4: The determinants of non-rice income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | 6.339 | 6.462 | 8.883 | 11.682 | 5.641 | 0.962 |
| | (5.95)** | (9.24)** | (8.74)** | (9.27)** | (9.04)** | (1.03) |
| Trad irrig ha. | 2.482 | 3.154 | 2.265 | 3.486 | 3.335 | -4.341 |
| | (4.90)** | (3.77)** | (4.49)** | (1.97)* | (1.19) | (2.53)* |
| No irrig ha. | 1.269 | 3.127 | 3.953 | 2.979 | 1.791 | 2.240 |
| | (1.30) | (6.33)** | (4.88)** | (1.91) | (2.44)* | (2.20)* |
| Owner cultivation % | 2.933 | 3.425 | 2.670 | -6.409 | 4.175 | -8.771 |
| | (1.35) | (2.26)* | (1.40) | (1.12) | (3.18)** | (1.27) |
| *Human Capital* | | | | | | |
| No. of adults | -0.857 | -1.730 | -1.929 | -3.270 | -1.829 | -1.411 |
| | (2.38)* | (6.25)** | (5.51)** | (3.65)** | (5.42)** | (1.75) |
| No. of children | -1.368 | -2.001 | -1.787 | -2.820 | -2.070 | -1.310 |
| | (4.34)** | (7.44)** | (4.02)** | (2.34)* | (5.60)** | (1.57) |
| Primary prop | 0.468 | -0.465 | -2.958 | -2.958 | -0.278 | 1.805 |
| | (0.22) | (0.25) | (1.66) | (0.48) | (0.19) | (0.75) |
| Secondary prop | 4.893 | -0.480 | -0.402 | -2.564 | 1.007 | 8.682 |
| | (1.99)* | (0.29) | (0.17) | (0.48) | (0.64) | (1.53) |
| Post Secondary prop | -4.617 | -2.113 | 7.335 | 4.111 | -1.240 | 14.549 |
| | (1.09) | (0.42) | (1.56) | (0.35) | (0.25) | (2.84)** |
| Constant | -5.102 | 1.491 | 10.701 | 26.176 | 9.023 | 18.715 |
| | (1.42) | (0.48) | (4.32)** | (3.74)** | (3.86)** | (2.35)* |
| *Elasticity* | | | | | | |
| Modern irrig ha. | 0.549 | 0.459 | 0.609 | 0.705 | 0.616 | 0.212 |
| | (6.63)** | (9.57)** | (13.17)** | (9.12)** | (17.29)** | (1.18) |
| Trad irrig ha. | 0.222 | 0.173 | 0.086 | 0.095 | 0.113 | -0.159 |
| | (5.03)** | (3.72)** | (4.88)** | (2.04)* | (1.28) | (2.33)* |
| No irrig ha. | 0.101 | 0.210 | 0.157 | 0.126 | 0.043 | 0.066 |
| | (1.29) | (6.29)** | (4.92)** | (1.99) | (2.65)** | (2.18)* |
| No. of adults | -0.365 | -0.637 | -0.405 | -0.642 | -0.496 | -0.580 |
| | (2.40)* | (6.38)** | (5.89)** | (3.43)** | (5.98)** | (1.90) |
| No. of children | -0.253 | -0.259 | -0.109 | -0.136 | -0.117 | -0.098 |
| | (4.51)** | (7.74)** | (3.98)** | (2.29)* | (6.28)** | (1.66) |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Village FE | Village FE | HH RE | HH RE | HH RE | HH RE |

* significant at 5% level; ** significant at 1% level

Robust *t*-statistics in parentheses for the regression coefficients of village FE models and semi-robust *z*-statistics for those of HH RE models. Z-statistics in parentheses for elasticities.

Table 5: The determinants of milk income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | 0.319 | 0.488 | 0.342 | 0.460 | 0.746 | -0.121 |
| | (3.95)** | (6.21)** | (3.65)** | (2.76)** | (5.63)** | (2.08)* |
| Trad irrig ha. | 0.290 | 0.447 | 0.182 | 0.469 | 0.409 | -0.427 |
| | (2.69)** | (2.56)* | (1.73) | (2.01)* | (1.11) | (1.59) |
| No irrig ha. | 0.838 | 0.242 | 0.434 | 0.349 | 0.126 | 0.927 |
| | (1.50) | (3.61)** | (3.66)** | (1.68) | (0.67) | (1.82) |
| Owner cultivation % | -0.163 | 0.606 | 1.029 | 1.153 | -1.169 | 1.384 |
| | (0.32) | (1.62) | (2.81)** | (1.53) | (1.31) | (1.98)* |
| *Human Capital* | | | | | | |
| No. of adults | -0.306 | -0.181 | -0.334 | -0.236 | -0.254 | -0.122 |
| | (3.00)** | (3.31)** | (3.49)** | (1.99)* | (2.10)* | (0.98) |
| No. of children | -0.063 | -0.236 | -0.290 | -0.472 | -0.179 | -0.030 |
| | (0.65) | (3.24)** | (3.52)** | (2.97)** | (1.11) | (0.15) |
| Primary prop | 0.907 | 0.323 | -0.633 | 0.659 | -0.173 | 1.295 |
| | (1.65) | (0.67) | (0.83) | (0.82) | (0.24) | (1.38) |
| Secondary prop | -0.895 | -0.093 | 0.146 | 0.553 | 0.293 | 2.261 |
| | (1.58) | (0.20) | (0.15) | (0.79) | (0.37) | (2.08)* |
| Post Secondary prop | 6.017 | 0.669 | 0.097 | -0.943 | 1.105 | 1.176 |
| | (1.22) | (0.69) | (0.13) | (0.60) | (0.60) | (0.83) |
| Constant | 1.198 | 0.030 | 2.631 | 1.050 | 4.028 | 1.014 |
| | (1.32) | (0.06) | (3.82)** | (1.14) | (3.71)** | (0.82) |
| *Elasticity* | | | | | | |
| Modern irrig ha. | 0.180 | 0.227 | 0.172 | 0.284 | 0.381 | -0.089 |
| | (3.57)** | (6.48)** | (3.66)** | (3.04)** | (6.15)** | (2.02)* |
| Trad irrig ha. | 0.170 | 0.161 | 0.051 | 0.131 | 0.065 | -0.052 |
| | (2.51)* | (2.58)* | (1.68) | (2.07)* | (1.15) | (1.63) |
| No irrig ha. | 0.440 | 0.106 | 0.126 | 0.151 | 0.014 | 0.091 |
| | (1.58) | (3.51)** | (3.54)** | (1.76) | (0.68) | (1.86) |
| No. of adults | -0.855 | -0.435 | -0.516 | -0.745 | -0.322 | -0.167 |
| | (3.48)** | (3.41)** | (3.94)** | (1.92) | (2.18)* | (1.00) |
| No. of children | -0.075 | -0.200 | -0.131 | -0.233 | -0.047 | -0.007 |
| | (0.65) | (3.44)** | (3.81)** | (2.79)** | (1.11) | (0.15) |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Village FE | Village FE | HH RE | HH RE | HH RE | HH RE |

* significant at 5% level; ** significant at 1% level

Robust *t*-statistics in parentheses for the regression coefficients of village FE models and semi-robust *z*-statistics for those of HH RE models. Z-statistics in parentheses for elasticities.

Table 6: The determinants of agricultural labor income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | -2.578 | -2.182 | -1.237 | -1.332 | -1.552 | -1.896 |
| | (2.75)** | (5.94)** | (7.41)** | (9.35)** | (7.12)** | (8.05)** |
| Trad irrig ha. | -3.487 | -1.849 | -1.096 | -1.246 | -2.961 | -2.597 |
| | (2.99)** | (5.46)** | (5.65)** | (6.95)** | (7.22)** | (5.50)** |
| No irrig ha. | -1.051 | -0.569 | -0.674 | -0.135 | 0.247 | -1.246 |
| | (2.54)* | (3.49)** | (3.22)** | (0.94) | (0.73) | (2.21)* |
| Owner cultivation % | -4.123 | -0.123 | -1.729 | -2.956 | -2.524 | -8.034 |
| | (3.14)** | (0.14) | (3.83)** | (7.20)** | (4.04)** | (15.77)** |
| *Human Capital* | | | | | | |
| No. of adults | 0.234 | 0.063 | 0.356 | 0.269 | 0.479 | 0.202 |
| | (1.12) | (0.38) | (3.89)** | (3.86)** | (4.01)** | (1.55) |
| No. of children | -0.164 | -0.121 | -0.378 | -0.152 | -0.131 | 0.035 |
| | (0.73) | (0.63) | (3.55)** | (1.64) | (0.90) | (0.21) |
| Primary prop | -5.621 | -4.485 | -1.656 | -4.151 | -1.118 | -0.466 |
| | (1.86) | (3.09)** | (2.97)** | (9.22)** | (1.80) | (0.67) |
| Secondary prop | -8.160 | -6.906 | -3.853 | -5.241 | -2.015 | -3.977 |
| | (2.18)* | (5.06)** | (6.54)** | (12.83)** | (3.14)** | (5.34)** |
| Post Secondary prop | -33.697 | -14.783 | -8.608 | -14.452 | -5.368 | -2.947 |
| | (2.21)* | (3.50)** | (7.57)** | (9.11)** | (3.15)** | (2.18)* |
| Constant | 4.467 | 1.199 | 0.754 | 4.104 | 0.776 | 7.462 |
| | (2.94)** | (1.12) | (1.31) | (8.09)** | (0.89) | (9.62)** |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Tobit | Tobit | HH RE Tobit | HH RE Tobit | HH RE Tobit | HH RE Tobit |

* significant at 5% level; ** significant at 1% level

Rrobust *z*-statistics in parentheses for the regression coefficients of Tobit models and *z*-statistics for those of HH RE Tobit models.

Table 7: The determinants of non-farm income per capita

| Era | Early Green Revolution (GR) | | | Late GR | Post GR liberalization | |
|---|---|---|---|---|---|---|
| Period | 1971-74 | 1975-80 | 1981-86 | 1987-92 | 1993-98 | 1999-03 |
| *Physical Capital* | | | | | | |
| Modern irrig ha. | 1.763 | 2.463 | 3.744 | 3.372 | 0.935 | -2.281 |
| | (1.61) | (3.00)** | (5.67)** | (6.24)** | (1.55) | (3.35)** |
| Trad irrig ha. | -0.592 | 2.772 | 3.090 | 2.594 | 1.400 | 0.035 |
| | (0.58) | (2.12)* | (3.45)** | (3.26)** | (2.33)* | (0.12) |
| No irrig ha. | 0.366 | -0.328 | 0.148 | -0.743 | -0.620 | -0.815 |
| | (0.48) | (0.51) | (0.13) | (0.94) | (0.47) | (0.65) |
| Owner cultivation % | 2.105 | -3.021 | -6.365 | -3.586 | -3.280 | -3.111 |
| | (0.46) | (0.78) | (2.07)* | (1.35) | (1.79) | (2.63)** |
| *Human Capital* | | | | | | |
| No. of adults | -1.790 | -0.413 | 0.822 | 0.610 | 0.836 | 0.839 |
| | (1.05) | (0.60) | (1.37) | (1.41) | (2.22)* | (2.82)** |
| No. of children | -2.303 | -0.766 | -0.191 | -0.924 | -0.434 | -1.455 |
| | (1.62) | (1.01) | (0.27) | (1.51) | (0.80) | (3.42)** |
| Primary prop | 1.839 | -3.515 | -1.699 | 6.048 | -2.674 | -4.072 |
| | (0.31) | (0.64) | (0.41) | (1.87) | (1.11) | (2.15)* |
| Secondary prop | 21.380 | -5.816 | 6.639 | 10.391 | 5.164 | 0.367 |
| | (1.12) | (1.07) | (1.71) | (3.71)** | (2.38)* | (0.20) |
| Post Secondary prop | -11.671 | -20.533 | -1.359 | 12.744 | 15.248 | 6.857 |
| | (0.60) | (1.78) | (0.23) | (2.27)* | (3.81)** | (2.05)* |
| Constant | -27.621 | -21.423 | -43.711 | -39.339 | -16.339 | 6.305 |
| | (2.29)* | (2.85)** | (10.28)** | (10.78)** | (5.48)** | (3.40)** |
| Census year for weights | 1976-77 | 1976-77 | 1985-86 | 1985-86 | 1995-96 | 1995-96 |
| Model | Tobit | Tobit | HH RE Tobit | HH RE Tobit | HH RE Tobit | HH RE Tobit |

* significant at 5% level; ** significant at 1% level

Rrobust *z*-statistics in parentheses for the regression coefficients of Tobit models and *z*-statistics for those of HH RE Tobit models.

Figure 1:

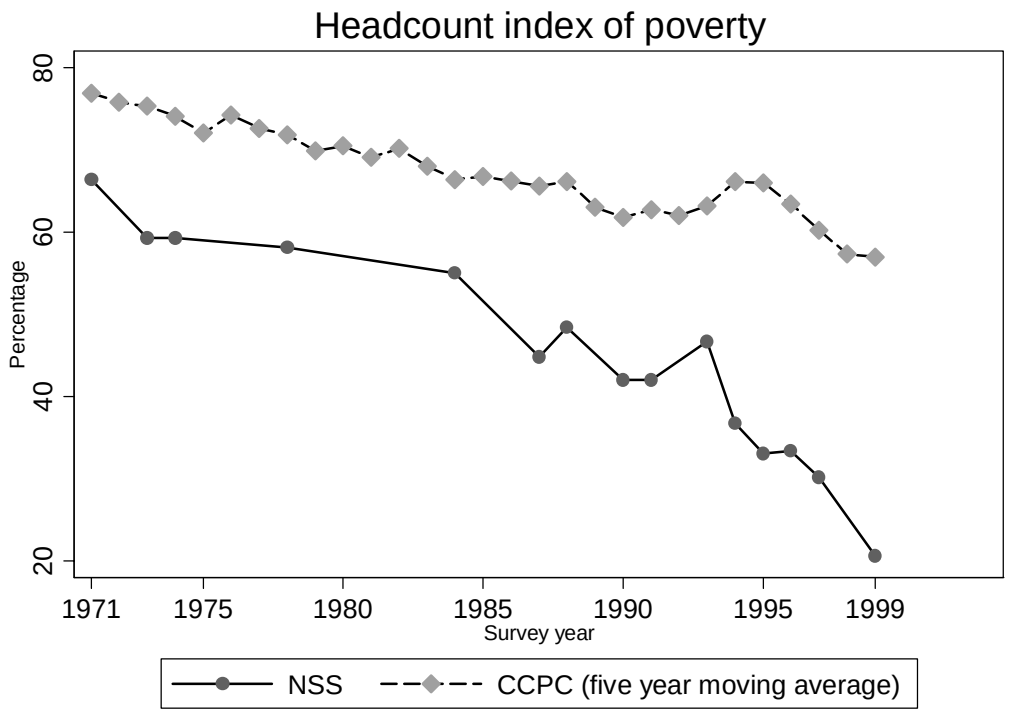

Headcount index of poverty
Percentage
20
40
60
80
1971
1975
1980
1985
1990
1995
1999
Survey year
NSS
CCPC (five year moving average)

Figure 2:

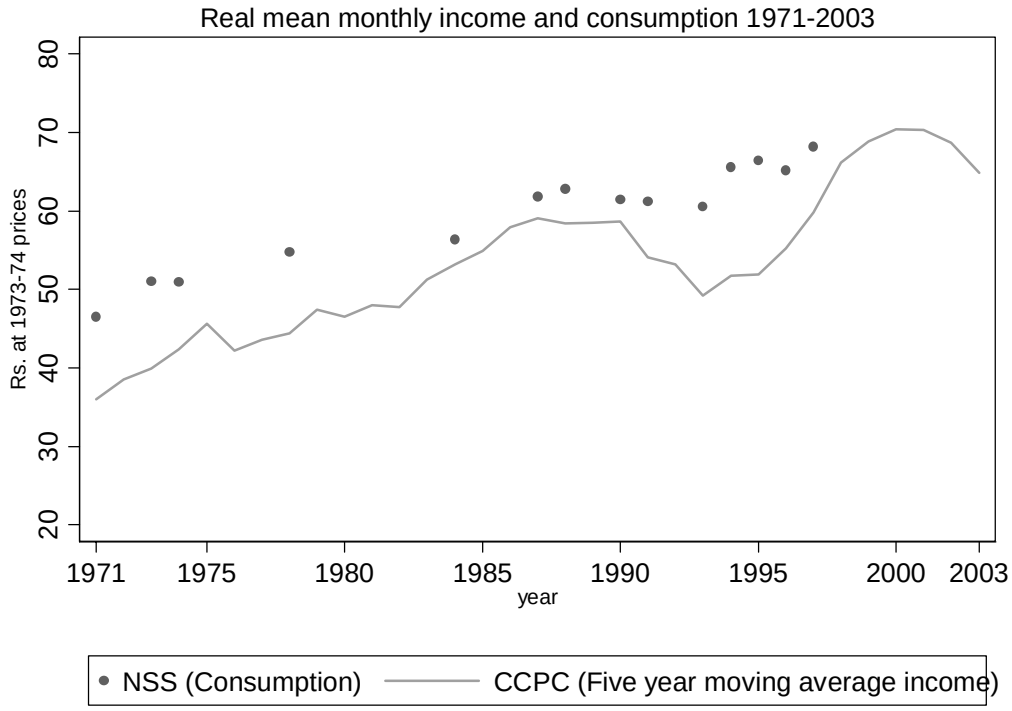
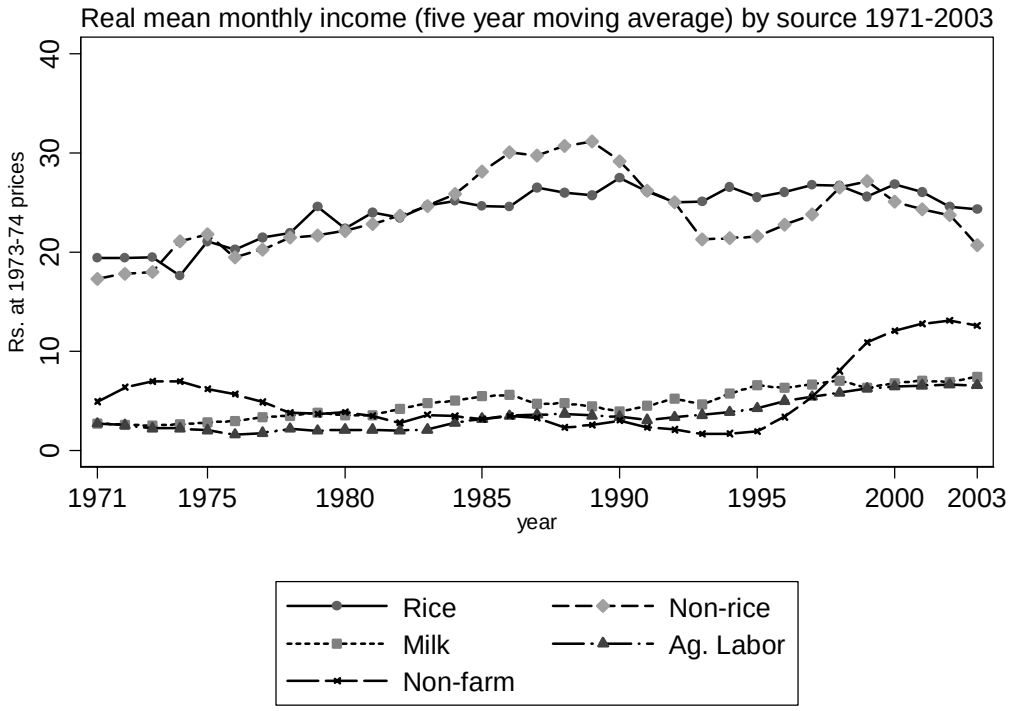

Real mean monthly income and consumption 1971-2003
Rs. at 1973-74 prices
20
30
40
50
60
70
80
1971
1975
1980
1985
1990
1995
2000
2003
year
NSS (Consumption)
CCPC (Five year moving average income)

Figure 3:


Real mean monthly income (five year moving average) by source 1971-2003
Rs. at 1973-74 prices
0
10
20
30
40
1971
1975
1980
1985
1990
1995
2000
2003
year
Rice
Non-rice
Milk
Ag. Labor
Non-farm