# INCOME INEQUALITY AMONG MAJOR IRRIGATION SCHEMES IN SRI LANKA: GINI DECOMPOSITION APPROACH

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## ABSTRACT

*Irrigation inequality and poverty in large-scale irrigation projects in Sri Lanka are closely related and a careful study of it gives some insights into the incidence of poverty. However in Sri Lanka the available literature does not provide empirical evidence with regard to the consequences of irrigation inequality on income inequality. This paper examines the impact of irrigation inequality on dynamics of income inequality. Beside this study analyzed the contributions of income sources and socio-economic factors to income inequality. A field survey was conducted to collect the necessary information for the analysis from a sample of 724 farmers in the selected two irrigation schemes (high water risk tank and low water risk tank) in the Dry-zone of Sri Lanka. Based on descriptive statistics measured the existing situation of income level and deferent income sources among settler households. The Gini index and Gini decomposition coefficient were used to measured income disparity. Results show that, income inequality is highly correlated with irrigation inequality within the reservoir and between the reservoirs. Farm income had the highest contribution to income inequality and income from paddy farming was the major source of income disparity between the reservoirs. The overall annual total income disparity between two tanks was 0.642.Gini coefficient for low water risk tank was 0.582 and high water risk tank was 0.782. It is worst situation in high water risk tank compare to the national level as well as rural level. In order to overcome the income inequality among major tanks, effective irrigation management and extension policies were suggested. Better economic opportunities and irrigation rehabilitation should be created for mainly in water risk tank areas to minimize inequality.*

***Key Words**: Irrigation inequality,, Income inequality, Gini index and Gini decomposition.*

## INTRODUCTION

In most conventional large-scale irrigation system imperfect matching between water supply and demand leads to operational spillages and contributes to low efficiency in use of water (Gowing, Qiongfangli, & Gunawardhna, 2004). Ideally, the allocation of water should be economically efficient and socially fair (kelman & Rafael, 2002) .In practices economically efficient and socially fair are quite conflict objectives. Economic efficiency is achieved when limited resources are allocated and used in a manner that generates the greatest net value (Wichelns, 1999). In the views of economic efficiency it does not matter with who are the beneficiaries. However, on the other hand, allocation with social equity seeks to distribute water in an attempt to protect the user's interests with less participation in the added economic benefit (kelman & Rafael, 2002). At present equity appears as a major objective of irrigation management level, specially in large-scale irrigation projects.Even though "equity appears to be the major objective on all water management level, the concept as such and its implication for water management are hardly explored with the professional water debate (Wegerich, 2007).

Most agricultural research and development institution in developing world have been discussed the linkages between irrigation and poverty eradication among rural community (Hussain, et al., 2005 ,Bhattarai, at al., 2006, Smith, 2004,Ahmad, 2003). But around the world, most irrigation projects have been considered as failures due to problem of inefficient management and also due to inequitable distribution of water (Fujikura, Nakayama, & Takesada, 2009, Bromley, Tylor, & Parker, 1980).

Although irrigation has enhanced agricultural production, most large-scale irrigation project have not generated the expected results by project planners, causing a decline in public funding for irrigation projects in recent years (Kelley & Johnsn, 1991). Poor performance has been caused by the failure of public agencies to collect fund from farmers to support operation and maintenance of large-scale irrigation schemes in developing countries (Johnson, 1990).

Inequality of economic conditions of settler farmers has been identified in many irrigation schemes in Sri Lanka. The differentiation between head and tail-enders is clearly distinguished and the inequitable distribution of irrigation water is the major for this disparity (Hemaratne, Abeygunawardena, & Thilakarathna, 1996). Several studies on water allocation between hed and tail reaches have reported that farmers at the tail end of the canal reseive a disproportionately small amount of irrigation water and at times no water at all. (Bhattarai, Sakthivadivel, & Hussain, 2002). The head-end farmers, however, receive an unduly large share of canal water (Chambers, 1988).

In large-scale irrigation schemes, the role of agribusiness entirely depend on the pattern of irrigation distribution since water is focal factor of their farming activities. As tail-end farmers receiving a small amount of water they have to have faced the high level of risk and uncertainty. Further they are unable to apply modern technology and modern inputs compare to head-end farmers. In fact it is commonly seen at tail-end farmers are less irrigation intensity, low level of agricultural intensification, widespread adoption of low yielding varieties and poverty stricken livelihood compared to the head-end (Bhattarai, Sakthivadivel, & Hussain, 2002).

"At the core of these inequalities are the dynamics of social differentiation among local communities. While physical access to water is important, inequalities experienced in accessing and using water are largely driven by local social and power relations. The spatial and social variability in irrigation distribution affect agricultural productivity, which exacerbates social and economic inequalities. Furthermore, increasing inequalities can lead to conflict and social unrest." (Chokkakula, 2009).

However in Sri Lanka the available literature does not provide empirical evidence with regard to the consequences of head-tail water inequality on agribusiness and income inequality. Further there is a scant of studies that were endeavored to identify the interrelation between uneven allocation of water on income disparity, performance of agribusiness and rural poverty. Therefore, the problem addressed in this study is to investigate uneven irrigation distribution effect on income disparity, return of agribusiness and rural poverty of paddy farming under large-scale irrigation schemes in Sri Lanka

**Objectives**

The main objective of the study is to investigate the impact of uneven availability of irrigation water across the tanks and within the tank on income disparity among households in the large scale irrigation schemes in Sri Lanka.

## MATERIALS AND METHODS

**Study Locations**

The Rajanganaya and Huruluwaway irrigation schemes were selected for the study based on the degree of water risk in the dry season (*Yala Season*). Rajanganaya scheme was considered as low water risk tank (LWR), since it has full capacity throughout the year. It was set up in 1962 by Irrigation Department with 2,000 farmer families and approximately 15,000 ha of irrigable land. At present about 9,500 families are living under this tank. The distribution network consists of 58.00 km of main canals, 70.0 km of distributary cannels and 316 km of field channels. Each farmer was given 1.2 ha of irrigable extent and 0.4 ha of high land when they have settled in the project. Both wet and dry seasons farmers are cultivating around 15,000 acres under this scheme.

Huruluwewa scheme is considered as high water risk tank (HWR) since naturally tank getting limited water due to limited catchment area and poor water sources. In wet season (*Maha Season*) around 10,400 acres of irrigable land were cultivated. However, during dry season (*Yala Season*) cultivated irrigable land was reduced up to 4,272 acres due to shortage of water. Under this scheme also each farmer was given 1.2 ha of irrigable extent and 0.4 ha of high land when they have settled in the project. The distribution network consists of 39 km of main canals, 56 km of distributory canals and 183km of field canals.

**Sampling Framework**

The target groups of the field survey were authorized paddy farmers in selected schemes. Their income mainly depend on agriculture and related activities, especially paddy farming. Thus, total sample population was 13,761 settler households in Rajanganaya and Huruluwewa irrigation schemes. Stratified random sample techniques were used to select the sample under two stge. At first stage farmers were clustered as head, middle and tail based proximity of water sources to the irrigable land. Because, in practice, Farmers whose fields are furthest from the water sources frequently have least secure water supply, while the farmers whose fields are closer to water source receive an unduly large share of channel water. The irrigation engineers and technical officers involved in the development of head, middle and tail regions of each schemes. In second stage determined sample size under the Morgan (2001) approach.

**Table 1: Population and Sample Framework**

| Scheme | Clusters | No of Households | Sample Size |
|---|---|---|---|
| Rajanganaya | Head | 3200 | 125 |
| | Middle | 3100 | 120 |
| | Tail | 3200 | 125 |
| Sub Total | | 9,500 | 370 |
| Huruluwewa | Head | 1630 | 128 |
| | Middle | 1456 | 114 |
| | Tail | 1414 | 112 |
| Sub Total | | 4,500 | 354 |
| Grand Total | | 14,000 | 724 |

**Model Specification**

There are number of inequality measures, each coming with its own praises and caveats and each has its own strengthe and weekness (Atkinson,1970). Thus, more desirable inequality measurements need to choose based on goals of the study. However previous researchers have provided four necessary conditions that should satisfied for reasonable inequality index. Those conditions are: (1) the Pigou-Dalton condition, (2) mean independence, (3) population-size independency, and (4) decomposability (Allison, 1978;Braun, 1988).

Unless decomposability condition all other conditions are satisfied by Gini index for suitable for inequality measures. The Gini coefficient is only decomposable if the partitions are non-overlapping, that is the sub-groups of the population do not overlap in the vector of income (Oyekala & Ogunnupe, 2005). However the Gini index is highly sensitive to changes near the center of an income distribution (Allison, 1978;Braun, 1988). Therefore, it is uniquely suited to studies most concerned with changes in middle income categories of a population over time (Allison, 1978). By changing near the center of Lorenz curve will derive greater impact on the area of concentration rather than changing upper or lower bounds (Allison, 1978;Braun, 1988). Thus, based on Gini index, it would be possible to analyze the income disparity with respect to mean income. Further, when transfer of income from lower category to an upper category; it will lead to change both ends of the Lorenz curve away from the perfectly equal distribution (Pflueger, 2005). It means, Gini index satisfy the Dalton's principle of transfer.

In order to calculate Gini-coefficient, Morduch and Sicular (2002) explained that where incomes are ordered so that $Y_1 \leq Y_2 \leq Y_3 \leq Y_4 \leq \ldots\ldots\ldots \leq Y_n$, the gini-coefficient can be computed as:

$$I_{Gini}(Y) = \frac{2}{n^2\mu}\sum_{r=1}^{n}\left(a_{i(r)}\right)Yi = \frac{2}{n^2\mu}\sum_{r=1}^{n}\left(r - \frac{n+1}{2}\right)Yi \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where n is the number of observation, μ is the mean of the distribution, $Y_i$ is the income of *ith* household and r is the corresponding rank of income.

**Decomposition Based On Gini-Coefficient**

Following Pyatt *et al* (1980), the Gini-coefficient can be decomposed as follows:

$$I_{Gini}(Y) = \frac{2}{n\mu}Cov\,(Y,r) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where n is the number of observations, Y is the series of total income and r is the serious of corresponding ranks.

The Gini coefficient of the *ith* source of income, $G_i$ can be expressed as

$$G_i = \frac{2}{n\mu i}\mathrm{Cov}\,(Y_i, r_i) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where $Y_i$ and $r_i$ refer to the serious of income from the *ith* source and corresponding ranks respectively. Since total income is the sum of source income, the covariance between the total income and its rank can be written as the sum of co variances between each source income and rank of total income. The total income Gini can then be expressed as a function of the source Gini coefficient.

$$I_{gini}(Y) = \sum\frac{\mu i}{\mu} R_i\, G_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

Where $R_i$ is the correlation ratio expressed as:

$$R_i = \frac{Cov\,(y,r)}{Cov\,(yi,ri)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

Where cov (y,r )is the covariance of toal income and crresponding rank respectively and $cov_i(y_i,r_i)$ the coverience of the *ith* source of income and corresponding rank.

The decomposition of Gini coefficient can be further expressed as:

$$\sum w_i\, g_{i=1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

$$w_i = \frac{\mu i}{\mu} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

$$g_i = R_i\frac{Gi}{G} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where $w_ig_i$ is the factor income inequality weight of the *ith* source in overall income inequality, $w_i$ is the source income weight and $G_i$ is the relative concentration coefficient of the *ith* source in overall inequity. An income source increase overall income when $G_i$ is greater than one and it decrease overall income inequality when $G_i$ is less than one.

## RESULTS AND DISCUSSION

**Table 1: Descriptive Statistics of Some Variables in the Data Set (1$=Rs120)**

| Variables | Low Water Risk Tank (LWR) | High Water Risk Tank (HWR) |
|---|---|---|
| Household size | 5.1 (2.43) | 5.12 (2.56) |
| Age (Years) Head of Household | 52.15 (15.63) | 53.162 (17.98) |
| Total income (Agri+Non Agri.)* | 129,117 (34,546) | 101,377 (55,768) |
| Total Income from Agribusiness* | 68,318 (35,567) | 39,223 (22,456) |
| Total income from Non Agriculture* | 60,799 (23,567) | 62,154 (35,675) |
| Per capita income | 23,665 (8,767) | 19,380 (12,676) |
| Employment income* | 31,890 (23,675) | 46,200 (25,678) |
| Income from paddy* | 61,177 (32,345) | 35,390 (20,786) |
| Income from other field crop* | 2,821 (1,354) | 618 (345) |
| Income from perennial crops* | 1,100 (545) | 1,065 (657) |
| Income from livestock* | 3,220 (1,556) | 2150 (789) |
| Nonfarm businesses* | 1,622 (876) | 2,717 (897) |
| Other Income | 27,287 (15,675) | 13,237 (8976) |

Note:* Is net income Rs/HH/Year, Figures in the parentheses representing standard errors.

Table 1 shows the descriptive statistics of some variables in the data set. Average household size was 5.1 for both tanks and average age of house head was 52 for HWR tank and 53 for LWR tank. The results of this study show that the inequality of the economic conditions among LWR tank and HWR tank farmers were apparent mainly due to divergence of water availability between two tanks. Average total annual income obtained by LWR farmers were Rs.129, 117 with variability index of 26.7 percent. The HWR farmers' average annual income was Rs. 101,377 with 55 percent variability index. It is apparent that the LWR farmers' annual earning capacities were 27.4 percent greater than HWR farmers. More than 50 percent of annual income in LWR farmers were depends on irrigated paddy cultivation, while this figure in LWR farmers was just 38.7 percent. It reflects greater involvement of irrigation by LWR farmers than the HWR farmers. Farther, LWR farmers' average annual income from paddy farming was 72.8 percent greater than the LWR farmers due to law productivity as well as low extent cultivated, particularly during the dry season. HWR farmers' paddy productivity was 28 percent and 7.8 percent lesser than the LWR farmers in Dry and wet season respectively. This information clearly shows that since paddy is the major source of income depends on water availability, the variation of the income from paddy cultivation was major reason for the prevailing inequality. It was hypothesized that the farm income will vary negatively with the distance of flow of irrigation water on the ground. In Sri Lanka there is considerable evidence to prove this situation with large scale irrigation schemes.

### Gini-Inequality Indices

Inequality indices of the HWR and LWR households are presented in table 2. The results show that income inequality indices in both LWR tank and HWR tank households were high among all the income sources unless income from paddy under LWR tank. However, under HWR tank paddy income source has the highest inequality index which was 0.7534. This is mainly due to irrigation inequality across the different track in the tank or between the head-end and tail-end farmers under HWR tank. Compare to LWR tank, HWR tank households were reflected high income disparity among all income sources. Total income inequality was higher in HWR tank with Gini-coefficient of 0.7112. However, total income inequality in LWR tank households were 0.5845 indicating the inverse relationship between water availability and income inequality. Between the tanks or intra disparity indices in all the income sources were very high compare to the national level inequality indices in similar income sources. Between the tanks, higher Gini-coefficient has reported under paddy income source and lowest coefficient was under income from perennial crops.

### Contribution of Income Sources to Overall Income Inequality

Table 3 shows the contribution of the income sources to overall income inequality in LWR tank. It reveals that incomes from paddy farming accounted for the largest share of total income with 48.6 percent and contributed 39.6 percent to total income inequality. Second highest income share to total income was employment income (25%), and contributed 30 percent to total income inequality. Income from others sources accounted for 21.7 percent of total income, but contributed 25.2 percent to total income inequality. However, income from other field crops, perennial crops and non-farm business were not significant impact on total income inequality in Low Water Risk (LWR) tank.

**Table 2: Gini-Inequality Indices for LWR Households and HWR Households**

| Type of Income | Inter Disparity (Within the tank) | | Intra Disparity (Between the Tanks) |
|---|---|---|---|
| | Low water Risk Tank | High Water Risk Tank | |
| Total income* | 0.582 | 0.724 | 0.642 |
| Employment income* | 0.699 | 0.711 | 0.621 |
| Income from paddy* | 0.476 | 0.765 | 0.712 |
| Income from other field crop* | 0.567 | 0.753 | 0.533 |
| Income from perennial crops* | 0.587 | 0.542 | 0.314 |
| Nonfarm businesses* | 0.786 | 0.521 | 0.678 |
| Other Income | 0.678 | 0.687 | 0.587 |

Source: Authors computation, . * Is net income Rs/HH/Year

**Table 3: Contributions of Income Sources to Overall Income Inequality in LWR Tank.**

| Income Sources | Coefficient of Concentration | Income Share | Relative Contribution | Absolute Contribution |
|---|---|---|---|---|
| Total income* | - | 1.000 | 1.000 | 0.582 |
| Employment income* | 0.699 | 0.253 | 0.303 | 0.177 |
| Income from paddy* | 0.476 | 0.486 | 0.396 | 0.231 |
| Income from other field crop* | 0.567 | 0.022 | 0.021 | 0.012 |
| Income from perennial crops* | 0.587 | 0.009 | 0.009 | 0.005 |
| Nonfarm businesses* | 0.786 | 0.013 | 0.017 | 0.010 |
| Other Income | 0.678 | 0.217 | 0.252 | 0.147 |

Source: Authors computation, . * Is net income Rs/HH/Year

Table 4 shows the contribution of the income sources to overall income inequality in HWR tank. It reveals that income from paddy farming accounted for the largest share of total income and accounted for 48.5 percent of total income inequality. This is expected because under HWR tank, divergence of water distribution among head region and tail region is much more and it would directly impact on productivity as well as extent cultivated in paddy among households. Employment income accounted for 35.7 percent to total income and 37.7 percent to total income inequality under HWR tank. However, all other income sources were not showed much influences on total income inequality.

**Table 4: Contributions of Income Sources to Overall Income Inequality in LWR Tank.**

| Income Sources | Coefficient of Concentration | Income Share | Relative Contribution | Absolute Contribution |
|---|---|---|---|---|
| Total income* | - | 1.000 | 1.000 | 0.724 |
| Employment income* | 0.765 | 0.357 | 0.377 | 0.273 |
| Income from paddy* | 0.753 | 0.466 | 0.485 | 0.354 |
| Income from other field crop* | 0.542 | 0.006 | 0.004 | 0.003 |
| Income from perennial crops* | 0.521 | 0.011 | 0.007 | 0.005 |
| Nonfarm businesses* | 0.687 | 0.027 | 0.025 | 0.018 |
| Other Income | 0.534 | 0.133 | 0.098 | 0.071 |

Source: Authors computation, . * Is net income Rs/HH/Year

Table 5 shows the contribution of the income sources to overall income inequality for total sample households. According to inequality measurement, the income from paddy farming accounted for the largest share of total income which was 47.6 percent and accounted for 29.5 percent of total income inequality. This is too expected because irrigation inequalities within the tank and between the tanks were common practice among dry-zone tanks in Sri Lanka. Divergence of water distribution within the tank and between the tanks has directly impact on productivity and cropping intensity of each tank. Employment income accounted for 35.7 percent to total income and 37.7 percent to total income inequality under HWR tank. However, all other income sources were not showed much influences on total income inequality.

**Table 5: Contributions of Income Sources to Overall Income Inequality for Total Sample.**

| Income Sources | Coefficient of Concentration | Income Share | Relative Contribution | Absolute Contribution |
|---|---|---|---|---|
| Total income* | - | 1.000 | 1.000 | 0.642 |
| Employment income* | 0.687 | 0.305 | 0.209 | 0.209 |
| Income from paddy* | 0.621 | 0.476 | 0.295 | 0.295 |
| Income from other field crop* | 0.712 | 0.014 | 0.009 | 0.009 |
| Income from perennial crops* | 0.533 | 0.01 | 0.005 | 0.005 |
| Nonfarm businesses* | 0.314 | 0.02 | 0.006 | 0.006 |
| Other Income | 0.678 | 0.175 | 0.118 | 0.118 |

Source: Authors computation, . * Is net income Rs/HH/Year

## CONCLUSIONS AND RECOMONDATION

The analyses presented in this study have shown that income inequality between farmers is still very high in large scale irrigation project. Specially, difference in income drawn from irrigable land was accounted for the highest portion of inequality between the tanks and within the tanks. Bad irrigation practices of head-end farmers; mainly wastage of irrigation water was identified as main reason for within disparity. However, existing poor canals maintenance system and technical failures and divergence of water sources were identified as intra (between the tanks)) disparity of income. Efforts to ensure a more equitable distribution of irrigation water should therefore be made focus on participatory irrigation management practices to reduce inter (within the tank) disparity of income among households.

Conclusively, income inequality is detrimental to economic growth and development according to conventional economic theories. Achieving the Millennium development Goal (MDG) of reducing poverty by 2015 is nightmare in Sri Lanka without conscious efforts to minimize rural poverty by reducing water inequality among large scale irrigation projects. The Sri Lankan government should therefore respond by ensuring equal irrigation facilities among settler households which are living under large scale irrigation projects. In principle, it is possible that better management of canal water and more equitable distribution of water across head-end and tail-end could potentially improve total social benefit and water productivity of an irrigation system. Farther tradable water right system to attain economic efficiency may achieve neither efficiency nor effectiveness in the allocation of water. So the major lesson is the significance of participatory approaches in formulating water policies to minimize unequal water distribution of large scale irrigation schemes in Sri Lanka.

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