Australian Academy of Business and Economics Review (AABER)
ISSN (Online) 2205-6726
ISSN (Print) 2205-6734

The Impact of Uneven Access to Water on Divergence of Income among Paddy Farmers in the Dry zone of Sri Lanka

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Abstract

This study examined the consequences of uneven access to irrigation water on the divergence of income, rural poverty, and technical efficiency of paddy farms in major irrigation schemes in the dry zone of Sri Lanka. The empirical study was conducted on a sample of 420 upstream and downstream farmer households covering three major irrigation schemes under different water stress. The Gini decomposition approach was applied to measure income and assets inequalities among households. The study found that uneven distribution of irrigation water within the schemes and between the schemes had a significant impact on income and assets variation among rural paddy farms. The downstream and high water risk farms appeared more productivity than did the upstream and low water risk farmers mainly due to variation of water availability throughout the year. The income and assets accumulation inequality across upstream and downstream were significantly high. Finally, the study proposed that participatory water management policies are more appropriate than market-oriented policies to overcome water disparities within (and between) the schemes in Sri Lanka.

Keywords: Irrigation; Disparity; Efficiency; Poverty; Inequality; Management

1. Background of the Problem

Water is becoming a scare resource in Sri Lanka as all another world due to increased use for irrigation, industry, and domestic purposes. The situation will develop into a crisis within the next two decades, due to competition for its use by various sectors (Ahmad, 2003). At the same time, the countrie's rice production has to be increased by another 1.5 million metric tons, by the year 2025 to feed the population. Do we have sufficient irrigation water to produce countries food requirement?. It is quite unlikely that we could expand the present irrigated area in the country, as they are hardly any water resources development is prohibitively expensive. Hence, an economically efficiency way of water utilization has come from irrigation within next decades.

In Sri Lanka, paddy being the staple food crop account for 25% of total cultivable land and more than 2 million farmer families are engaged in farming as their main occupation. Highly water-intensive rice cultivation consumes more than 70% of the total water allocated for food production in the country (Henegedara, 2002). The principle irrigated crop, paddy is grown on nearly 730,000 ha of land, and 243,000 of this total is grown under major irrigation system. Of the remaining 170,000 ha under minor irrigation and nearly 146,000 ha are under the Mahaweli development project which is the selected study area (Department of Census and Statistics Abstract, 2010). Beside there is another 171,000 ha which is nonirrigable paddy land sown by small scale paddy farmers under rainfed system, especially in wet zone (Henegedara, 2002).

It is important to emphasize that more than 76% of cultivated paddy land are under irrigation and more than 70% of paddy farmers belong to the "small farmer category" which own less than one hectare of land. More than 90% of irrigated paddy lands are locating in the dry zone including the irrigated land under Mahaweli development project (Department of Agriculture, 2011).

The rational output of this commodity has witnessed significant increase over the last three decades, and this can be traced primarily to the expansion of cultivated area as well as to increased productivity of inputs. The latter is an outcome of the application of newer research findings on a variety of aspects such as improvement in genetic constitution of the crop, introduction of superior quality fertilizer, newer method of plant establishment, better method of weed, pest, and weed control (Abeysekera, 1996).

Public investments in large-scale irrigation systems in Sri Lanka have enhanced domestic food production substantially since 1977. About 90% of the developed water resources of Sri Lanka are utilized by irrigated agriculture that produces approximately 80% of the main food staple, rice (Imbulana et al., 2000). High investment in irrigated agriculture resulted in productivity increases that have made the country nearly self-sufficiency of rice. Current rice production in Sri Lanka is sufficient to meet more than 89% of the domestic requirement (Central Bank Report, 2009). Within last four decades, Sri Lankan policy makers and various governments have been focused rural development through irrigation. The total public investment in irrigation was Rs. 45,000 million within last three decades (1979-2009) (Central Bank Report, 2009). Most agricultural research and development institution in developing the world have been discussed the linkages between irrigation and poverty eradication among rural community. Asian countries document strong evidence that irrigation helps to alleviate both permanent and temporary poverty, and also it helps to alleviate poverty in its worst forms, namely chronic poverty (Hussain and Hanjra, 2004).

2. Problem Statement

At present, irrigation inequalities are a common problem in irrigation management policies, and it has defined by several ways. There are two basic ways of experiencing inequality: In accessing the resource, for example, people upstream (head-end) have better access compared to those downstream (tail-end); and in its use, or the amount or share of the water people get, which is farmers in high water risk (HWR) getting relatively small quantity of water compare those farmers in low water risk (LWR) (Chokkakula, 2009). In both cases, further probing of the conditions that underpin or drive the differential experienced by people suggest that inequities and inequalities mutually construct and perpetuate each other: Unequal access to resources generates inequity, and inequitable distribution of resource leads to inequality (Chokkakula, 2009).

The ultimate outcome of these inequalities is the dynamic of economic and social differentiation among local communities. This difference directly associated productivity differences and income inequalities within (intra) and between (inter) the households which are farming and livelihood under different irrigation schemes. Such inequalities lead to rural poverty and economic inefficiency of irrigated agriculture, especially paddy farming under irrigation schemes. Furthermore, increasing inequalities can lead to conflict and social unrest (Chokkakula, 2009).

It is, therefore, critical to understand the reasons for and consequences of irrigation inequalities more deeply. How are the inequalities produced and how are they mitigating? More fundamentally, how can inequalities are best understood and how can that knowledge be used to improve lives? These questions have long been of interest to researchers studding justice and equity issues in present irrigation.

Unequal water distribution of large-scale irrigation schemes is one of the focal factors caused to inequality, poverty, and inefficiency in large-scale irrigation schemes. Several studies on water allocation between head and tail reaches have reported that farmers at the tail end of the canal receive a disproportionately small amount of irrigation water and at times no water at all (Bhattarai et al., 2006). Farmers whose fields are furthest from the water source frequently have the least secure water supply, while the head-end farmers, however, receive an unduly large share of canal water (Chambers, 1988). This is, however, still one of the unresolved issues in water distribution policies in irrigation commands in large-scale irrigation projects in developing countries (Bhattarai et al., 2006). The ultimate repercussion of this situation is the tail-end farmers face a high level of uncertainty and income fluctuation in their farming. Further, due to lack of irrigation water, tail-end farmers cannot adopt the modern agricultural technology. Likewise, other irrigation water induced crises commonly seen at tail-end reaches 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 et al., 2006).

Inequality of economic conditions of settler farmers has been identified in many irrigation sachems in Sri Lanka. The differentiation between head and tail-enders is clearly distinguished, and the inequitable distribution of irrigation water is the major cause for this disparity (Hemaratne et al., 1996). Further, uneven water availability across the schemes also very common in Sri Lanka and it has too developed different type of inequality among farmer household in the large-scale irrigation project. Until irrigation water is common pool resources, the market-oriented approaches are inapplicable to capture the optimization objectives of limited irrigation water in Sri Lanka. One party is better off by overutilizing irrigation water, and another party is worse off due to a lack of irrigation water since irrigation water is considered as free input in Sri Lanka. The inevitable consequence of this situation is enormous income expenditure and assets inequality among settler households in the large-scale irrigation schemes in the dry zone.

3. Research Objectives

The general objective of this study is to examine the impact of uneven access to irrigation water on dynamics of income inequality, rural poverty, and technical efficiency of paddy farming under major irrigation condition.

4. Research Methods

4.1. Site selection

Sri Lanka (5-9°N; 79-82°E) is a tropical island lying 50 km to the South West of Peninsular India. It is relatively small for a continental island, with maximum width and length of 240 km and 435 km, respectively (Murray and Little, 2000). Sri Lanka has almost no natural lakes, yet it has 3 ha of inland water per km^2 of land - almost 2% of the land surface. The three principle climate divisions of the country and their average monthly rainfall are: The dry zone (125-187 cm); the intermediate zone (187-250 cm); and the wet zone (>250 cm). The dry zone covers the 70% of total land in the country. Irrigation is widespread in the drier areas of Sri Lanka, where the rainfall pattern requires water storage for successful irrigated cropping. The irrigated area in the dry zone expanded to this level between 1850 and the year 2000. At present, there are around 600,000 ha of irrigated land in the country and 80 percent of that extent locating in the dry zone (IWMI, 2005). There are 99 major irrigation schemes in the dry zone and it is around 83% of the total major schemes in the country (Stanbury, 1998). Nearly two-thirds of the national rice output comes from the surface irrigated areas (Samad, 2005). The total irrigated area in the country is about 0.6 million ha. Out of that 0.4 million ha under major irrigation schemes (above 80 ha) and balance 0.2 million ha under minor irrigation schemes (below 80 ha). There are 13 districts in the dry zone, and Anuradhapura district consists the largest irrigable extent among the dry zone. Further, both ancient schemes, as well as newly constructed and rehabilitated large-scale irrigation schemes, are presented in Anuradhapura district. More than 70 % households in Anuradhapura district were engaging in irrigated paddy industry as their main occupation. Being concerned those information the study selected the Anuradhapura district in the dry zone as study location. The following figure shows the principle climate division by district in Sri Lanka.

4.2. Sampling framework

This study will based on primary and secondary data collecting from the selected irrigation schemes in the dry zone in Sri Lanka. To gather primary data, the study has applied household-level survey and secondary data collected from relevant state line agencies which are managing selected irrigation schemes. For each irrigation schemes, the sample has drawn using multistage sampling method. In the first stage, the study has categorized major tanks in Anuradhapura district with respect to the degree of water scarcity as HWR schemes and LWR. In stage two, selected three schemes divided into 48 cluster by main canals (e.g., head middle and tail) based on length of main, distributory and field canals. In stage three, four clusters were select from each scheme (24 clusters from three tanks) to distinguish between head-tail inequalities and total households under these clusters were considered as the population of study. In the next stage, determine sample size following by Morgan's approach based on total population in the three schemes. Total sample size was 420 households and it has equally distributed among head-end and tail-end as population size was almost same among two groups. Hereafter total sample in each group (head-end group and tail-end group) proportionately distributed within each cluster among two groups. At this stage, it will be completed sampling frame for each of the selected clusters. Finally, systematic random sample techniques were applied for chosen the sample households at field level.

4.3. Measurement tools

There are a considerable amount of literature in the last have been used commonly: The Gini index (GI), Theil's entropy measure or Theil index (TEM), Atkinson's index (AI) and the coefficient of variation (CV) for measuring inequality.

The GI has extensively used for inequality measurement during last decades, with recently proposed decomposability property has further support to enhance the application of GI for inequality measurements by researchers. Thus, it has satisfied the general criteria for an inequality measures. The GI is highly sensitive to changes near the center of an income distribution (Allison, 1978). 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 GI, it would be possible to analyze the income disparity with respect to mean income. Further, when transfer of income from a 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 GI satisfy the Dalton's principle of transfer.

Being considering all those properties and the study objectives the study applied GI for inequality measurements. More specifically, the study not only concentrated about the inequality measurement but also the poverty and technical efficiency measures under parametric approach. Thus, normal distribution of income was one of the important assumptions under parametric approach. Therefore, each measurement needs to be comparable to construct a better link between the research objectives. If the study used TEM, and AI or CV indices it may be contradicted with the assumption of normality as those indices are sensitive to upper part or lower part. Besides, the study only decomposed the income only by sources and not by groups. Thus, with the application of GI, the study sufficiently decomposed the income by sources.

4.4. Analytical framework of Gini coefficient

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:

$$I_{Gini}(Y) = {}^{2}\!/_{n^2\mu} \sum_{r=1}^{n} (a_i(Y)Y_i = {}^{2}\!/_{n^2\mu} \sum_{r-1}^{n} \left[r - \frac{n+1}{2} \right] Y_i \qquad (1)$$

Where n is the number of observation, μ is the mean of the distribution, Y_i is the income of i^{th} household, and r is the corresponding rank of income.

4.5. Decomposition by income sources based on Gini coefficient

Following Pyatt et al. (1980), and Fei et al. (1978) the Gini coefficient of the total income can be written as:

$$G = \frac{2}{n\mu} Cov(Y, r) \tag{2}$$

Where n is the number of observations, μ is the mean income from all sources, Y is the series of total income, and r is the serious of corresponding ranks.

The Gini coefficient of the i^{th} source of income, G_i can be expressed as:

$$G_i = \frac{2}{n\mu_i} Cov(Y_i r_i) \tag{3}$$

Where μ_i refers to the mean income from all sources, n is number of households and Y_i and r_i refer to the serious of income from the i^{th} 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 covariances between each source income and rank of total income. The total income Gini can then be expressed as a function of the source Ginis. By combining G and G_i the form:

$$G = \sum \frac{\mu_i}{\mu} R_i G_i \tag{4}$$

Where R_i is the rank correlation ratio which can be expressed as:

$$R_i = \frac{Cov(Y_i r)}{Cov(Y_i r_i)} \tag{5}$$

Where cov ($Y_1 r$) is covariance between source income amount and total income rank and cov ($Y_i r_i$) is convenience between source income amount and source income rank.

Equation (4) shows that G is a product of three terms: (1) The share of the i^{th} income source in the total income (μ_i/μ), (2) correlation of the i^{th} source income with the rank of total income (R_i), and (3) Gini coefficient of the i^{th} income source (G_i).

To express the contribution of the i^{th} income source as a fraction of total inequality, Equation (4) can be manipulated to form:

$$1 = \sum W_i G_i$$

Where $W_i = \mu_i/\mu$ and $G_i = R_i = G_i/G$ is the relative concentration coefficient. If G_i>1, the i^{th} income source is inequality increasing.

Similarly $\sum W_i G_i = 1$

$$W_i = \frac{\mu_i}{\mu}$$

$$G_i = R_i \frac{G_i}{G}$$

Where $W_i = \mu_i/\mu$ and $G_i = R_i(G_i/G)$ is the relative concentration coefficient. if G>1, the i^{th} increasing.

5. Results and Discussion

5.1. Mean comparison of net household income

According to income analysis presented in Table 1, annual per capita net income in head-end farmers was 28 % greater than the tail-end farmers. Such disparity has mainly recorded with greater variation of farm income between two groups. According to empirical results, both groups were getting more than 60% annual income from farming activities. While tail-end farmers earning capacity from farming were 25% lower than the head-end farmers. The substantial impact on this divergence has recorded from annual paddy income. Because, head-end farmers annual earnings from paddy is more than 80% ahead compare to the tail-end farmers. This is mainly due to low productivity and low annual cropping intensity among tail-end farmers mainly due to a lack of irrigation facilities during the dry season.

Table 2 shows the average household net annual income by different sources in HWR and LWR farmers. Average total annual net income obtained by a LWR household was Rs. 406, 171 with variability index of 69.1%. The HWR farmers' average annual income was Rs. 324,345 with 72.7% variability index. It is apparent that the LWR farmers' annual earning capacities were 25.2% greater than HWR farmers. As it is compare with per capita income, the HWR farmers' per capita annual net income was 11.5% greater than the LWR farmers. More than 15% annual earning depends on irrigated paddy farming in both HWR and LWR farmers. However, LWR farmer's annual earning capacity from paddy farming was 47.5% higher than the HWR farmers. This variation is mainly due to low productivity as well as low extent cultivation during the dry season by HWR farmers. The root course of such divergence is different water accessibility among two groups. Conversely, HWR farmers were more committed for earning income from other field crops (OFC). The LWR farmers have recorded 49 present higher incomes from overall farming activities compare to the HWR

Table 1: Descriptive statistics of annual net income – head and tail (Rs/household)

Income sources	Head-end farmers		Tail-end farmers	
	Mean	SD	Mean	SD
Paddy	85,710.6	50887.5	47,225	35,324.5
OFC	56,169.5	294.8	70,318.6	139,098.0
Perennial crops	26,609.5	2277.4	25,241.9	25,899.3
Livestock	1,714.3	7379.9	3,602.3	24,410.8
On farm employment	105,395.7	65,768.98	73371.4	54,765.54
Total farm income	275,599.5	117290.6	219,759.2	149,537.0
Off farm employment	86,232.9	232602.9	110,057	165,039.0
Business	19,714.3	9975.0	19,154.3	60813.2
Total nonfarm income	105,947.2	98,989.6	129,211.5	102,321.98
Total income	381,546.7	297660.1	348,970.7	220,162.0
Monthly income	31,795.6	24805.0	29,080.8	18346.8
Per capita income (per day)	275.6	223.8	215.3	115.7

SD: Standard deviation, OFC: Other field crops

Table 2: Average annual net income by sources – HWR and LWR (Rs/household)

Income sources	HWR		LWR	
	Mean	SD	Mean	SD
Paddy	53,690.3	29770.7	79,244.8	58026.9
OFC	39,185.2	51204.3	87,302.8	155,262.0
Perennial crops	20,513.3	27378.0	31,338.1	54339.2
Livestock	5,316.6	25257.5	-	-
On farm employment	80.190	62,567.76	100,397.1	85,876.33
Total farm income	198895.4	76744.8	2,98282.8	171,266.0
Employment	98,010.0	190,721.0	96,440.0	211,723.0
Business	27,440.0	104,404.0	11,428.1	52438.0
Total nonfarm	125,450	101,544.09	107,888.6	98,765.09
Total income	324,345.0	236,078.0	406,171.4	280,701.0
Monthly income (per capita)	6,689.3	19673.1	8,036.6	23391.7
Per capita income (per day)	222.9	167.0	248.7	186.4

SD: Standard deviation, OFC: Other field crops, HWR: High water risk, LWR: Low water risk farmers. However, LWR farmers getting fairly greater income from nonfarm activities compare to their counter partners.

In addition, to a descriptive comparison of income variation among selected four groups, researcher used independent sample t-test to measure the significances of means income variation among different income sources by each group. As results depicted in Table 3 annual paddy income showed highly significant means difference between groups. In other words, annual paddy income has recorded significantly different means between head-end and tail-end as well as HWR and LWR farmers. Beside, annual farm income too depicted significant mean differences among all four groups. In both groups: Head verses tail and HWR verses LWR, have showed insignificant means variation with respect to annual nonfarm income per household.

The study further found that the annual per capita income between head-end versus tail-end and HWR versus LWR has reported significant means difference. According to the effect size analysis which is an objective and standardized measure of the magnitude of the observed effect, paddy income has recorded large effect for mean differences between head- and tail farmers. In the case of HWR and LWR models, total farm income has recorded medium effect on mean difference as the values are closed to 0.3.

5.2. Gini income inequality indices

The per capita net income inequality indices of selected farmer households under four models are presented in Table 4. The results show that income inequality indices in all the models are high among numerous income sources. Intra disparity is highly recorded under livestock production as a few farmers were involved in livestock farming. The business income within the group also has measured high Gini coefficient in all the models reflecting substantial income variation from business within the same group. Inter disparity of annual net earnings from OFC and perennial crops have depicted significantly high Gini coefficients in all four groups.

However, the main variable in this study which is the net earnings from paddy had the lowest Gini values within the selected four groups. It indicates that intra disparity is at moderate level with respect to annual net earnings from paddy farming in all the selected models. The Gini coefficients for total annual net income in all the models have showed 0.47 and above indicating relatively high-income disparity compare to national level figures (national level GI is 0.36). However, intra disparity (between the groups) is substantially high as measured Gini indices values are greater than 0.5 for entire income sources. Furthermore, in the combines' analysis for all farmer models (total sample) the estimated Gini coefficient for annual total income is 0.512 and it is higher than the national level Gini-inequality index.

Table 3: Mean income comparison among groups independent sample t-tests

Income sources by groups	T-ratio	Sig (2-tail)	Effect size
Head-and and tail-end			
Income farm paddy (Rs/HH/Year)	9.003	0.000	0.404
Total farm income (Rs/HH/Year)	4.816	0.000	0.110
Total nonfarm income (Rs/HH/Year)	0.430	0.667	0.021
Total income (Rs/HH/Year)	1.275	0.203	0.026
Per capita income (Rs/Day)	3.465	0.001	0.167
High water risk and low water risk			
Income farm paddy (Rs/HH/Year)	5.678	0.000	0.268
Total farm income (Rs/HH/Year)	6.114	0.000	0.286
Total nonfarm income (Rs/HH/Year)	0.130	0.897	0.021
Total income (Rs/HH/Year)	3.233	0.001	0.156
Per capita income (Rs/Day)	2.487	0.058	0.072

An effect size (r) is an objective and standardized measure of the magnitude of the observed effect. As per Cohen (1988, 1992)
r=0.1: Small effect, r=0.3: Medium effect, r=0.5: Large effect

5.3. Contribution of income sources to overall income inequality – head-end and tail-end farmers

Table 5 examines the contribution of the income sources to overall income inequality in head-end and tail-end farmers. As shown in Table 5 it reveals that incomes from paddy farming and paid employment in farm and nonfarm sectors have accounted for the largest and equal share of total income with 36%. However, paid employment contributed 38.2% to total income inequality while paddy income contributed 23.6% to total income inequality. OFC income, on the other hand, also shows significant impact on total income inequality. In tail-end region, income from paid farm and nonfarm employment accounted for the largest share of total income with 40.6% and contributed 31.2% to total income inequality. Second highest share to total income has shown by OFC income while it has highest contribution to total income inequality. Income from paddy accounted for 23.8% of the total income,

Table 4: Gini inequality indices for sampled households among selected four groups

Model	Paddy	OFC	Perennial	Livestock	Total farm	Employment	Business	Total nonfarm	Total
Head	0.279 (0.020)	0.696 (0.025)	0.587 (0.037)	0.969 (0.000)	0.283 (0.017)	0.624 (0.024)	0.964 (0.018)	0.613 (0.027)	0.501 (0.014)
Tail	0.370 (0.017)	0.690 (0.034)	0.438 (0.022)	0.980 (0.00)	0.412 (0.028)	0.502 (0.027)	0.908 (0.024)	0.433 (0.026)	0.468 (0.019)
HWR	0.366 (0.020)	0.638 (0.024)	0.427 (0.043)	0.953 (0.016)	0.351 (0.018)	0.573 (0.028)	0.932 (0.011)	0.549 (0.026)	0.482 (0.017)
LWR	0.305 (0.011)	0.701 (0.024)	0.582 (0.036)	-	0.352 (0.023)	0.566 (0.029)	0.947 (0.056)	0.051 (0.026)	0.503 (0.014)
Pooled sample	0.658 (0.014)	0.698 (0.021)	0.530 (0.029)	0.976 (0.000)	0.656 (0.015)	0.572 (0.019)	0.945 (0.015)	0.538 (0.018)	0.512 (0.011)

Based on net income Rs/HH/Year, figures in the parentheses representing standard errors. HWR: High water risk, LWR: Low water risk

Table 5: Relative and absolute contribution - head-end and tail-end farmers

Income source	Coefficient of concentration	Income share	Relative contribution	Absolute contribution
Head-end				
Paddy	0.3247	0.364	0.236	0.118
Other field crops	0.6827	0.174	0.238	0.119
Perennial crops	0.6356	0.054	0.068	0.034
Livestock	0.9776	0.004	0.008	0.004
Employment (F&N)	0.5240	0.366	0.382	0.192
Business	0.907	0.038	0.068	0.034
Total	-	1.000	1.00	0.501
Tail-end				
Paddy	0.353	0.238	0.179	0.084
Other field crops	0.674	0.246	0.353	0.165
Perennial crops	0.415	0.056	0.049	0.023
Livestock	0.980	0.008	0.017	0.008
Employment	0.361	0.406	0.312	0.146
Business	0.912	0.046	0.090	0.042
Total	-	1.000	1.00	0.468

but it has contributed 17.9% to total income inequality in tail-end section. It evident that within the tail-end farmers income from paddy farming does not much variation compare to the head-end farmers.

5.4. Contribution of income sources to overall income inequality – HWR and LWR farmers

Table 6 examines the contribution of the income sources to total income disparity in HWR and LWR farmers. According to Gini estimations, paddy income and employment income contributed equal share (37%) to total annual income and accounted 30.1% and 35.9% of total inequality in HWR farmers, respectively. The results are expected as divergence of access to irrigation water with water risk situation between head-end and tail-end farmers within the same reservoir would be very high. On the other hand, in rural areas access to paid job is not easy task and it may highly vary among households with their education background.

The results were rather different in LWR model as OFC accounted 38% of total inequality although it has contributed 27.3% to total income. This is expected because income from OFC much varies from farmer to farmer since they have cultivated a different type of market-oriented crops in the dry season. Further, employment income (both farm and non-farm) contributed 39.1% of the total income and accounted for 35.9% of total income inequality.

5.5. Contribution of income sources to overall income inequality – pooled sample

Tables 7 and 8 examine the important part of the study which is the inter income disparity (between the groups) among head-enders and tail-enders. It reveals that inter income disparity is substantial level as estimated Gini coefficient is 0.512 for total sample. It is 42% greater than the national level Gini estimation. Farm and nonfarm paid employment contributed 38.4% of the total income and accounted for 34.9% of inter income inequality between head-end and tail-end farmers. This is expected result since the study covered rural areas and they have unequal access to paid employment due to their diverse socioeconomic background. It is an impotent highlight that more than 57% income of pooled sample is mainly depending on agriculture. Paddy and OFC jointly contributed 51.2% of the total

Table 6: Relative and absolute contribution of income inequality – LWR and HWR farmers

Income source	Coefficient of concentration	Income share	Relative contribution	Absolute contribution
HWR				
Paddy	0.389	0.372	0.301	0.145
OFC	0.589	0.136	0.166	0.080
Perennial crops	0.503	0.043	0.045	0.022
Livestock	0.965	0.012	0.023	0.011
Employment	0.960	0.377	0.359	0.173
Business	0.880	0.058	0.106	0.051
Total	-	1.000	1.000	0.482
LWR				
Paddy	0.282	0.243	0.135	0.068
OFC	0.699	0.273	0.380	0.191
Perennial crops	0.606	0.066	0.078	0.039
Livestock	-	-		-
Employment	0.463	0.391	0.359	0.181
Business	0.960	0.025	0.048	0.024
Total	-	1.000	1.000	0.503

OFC: Other field crops, HWR: High water risk, LWR: Low water risk income and accounted 50.4% of total inequality among pooled sample. Beside, perennial crops and livestock together contributed to 12.1% to the total income and accounted for 7.3% for total income inequality between head-end and tail-end farmers.

5.6. Inequality of economic conditions

The study measured the cumulative value of assets accumulation by households (consumer durable and production assets). The ownership of capital items is one of the criteria to assess economic condition of farm family.

It was revealed that the inter disparity (between the group) of assets accumulation from durable and production assets were at a higher level among all groups. Between head- and tail farmers the GI for durable assets accumulation and production assets accumulation were 0.634 and 0.695, respectively. This is very worst situation compare to the income disparity. Similar results have shown between HWR and LWR farmers. This is mainly due to not only the number of items owned but also due to quality or values of these items between different water stress groups. The Lorenz curves for pool sample, head-end versus tail-end, HWR versus LWR are presented in figure 1, 2 and 3 respectively.

6. Findings and Conclusions

The study made step wise income analysis as depicted in analytical to identify the net income variation due to uneven access to irrigation water among sample households. Annual paddy income has recorded the highest significant mean difference between high water stress and low water stress groups. The results were not rather surprising and study hypothesized such disparity based on a number of previous literature and empirical evidence. Because, many studies have proven that both extent cultivated and productivity of paddy under high water stress significantly lower than the low water risk farming. Thus, study finding seems consonant to the fact that irrigation inequality leads to discrepancy of household income among irrigation schemes in dry zone of Sri Lanka. Further study reveal that annual net farm income significantly deviation between head versus tail farmers and HWR versus LWR farmers. As paddy income account more than 50% of total farm income, this is also possible outcome of the study. However, nonfarm income does not significant deviation between water stress groups. Per capita annual income also has reported significant mean variation between high water stress and low water stress groups.

As the study hypothesized, it was evident that the uneven access to water highly impact on intra and inter income inequality in the sample households. Intra disparity is highly recorded from livestock and business income. This is expected results because a few households involved such activities. OFC income also depicted high GI within the group due to the variation of extent cultivated and different crops selection by farmers. However, intra disparity of net paddy income was at moderate level among all four groups. This is due to the homogeneity of the same group in the study area being that the respondents are predominantly farmers and will not have much variation in their income. However, even within the same group annual net income disparity is considerably at a higher level as compare to the national level. The inter income disparity (Head versus Tail and HWR versus LWR) also displayed higher values from all income sources. Total income inequality between groups was 0.512%, and it is 42% ahead the national level.

Elsewhere, the author analyzed the decomposition of inequality based on per capita household income by water stress groups. More than 50% intra and inter income inequalities among water stress groups have drawn by farm income. Paddy and OFC income were the largest sources in inter and intra income inequality across the groups. Employment income was the largest source of income inequality between head versus tail and HWR versus LWR farmer models. Second highest source was OFC income and third was paddy income. The variation of employment income is due to many socioeconomic factors. OFC income also varying mainly due to the type of crops, extent owned, selling price, etc. However, income variation from paddy was mainly due to low productivity and low cropping intensity. Cropping intensity and productivity variation associated with unequal access to water within the same group.

The ownership of capital items is one of the criteria to assess economic condition of farm family. It was revealed that the inter disparity (between the group) of assets accumulation from durable and production assets were at a higher level among all groups. Between head and tail farmers the GI for durable assets accumulation and production assets accumulation were 0.634 and 0.695, respectively. This is very worst situation compare to the income disparity. Similar results have shown between HWR and LWR farmers. This is mainly due to not only the number of items owned but also due to quality or values of these items between different water stress groups.

7. Recommendations and Policy Implications

The main objective of the study was to examine the irrigation inequality impact on household income level. As the study hypothesized, the annual net income from paddy has significantly varied between high water stress and low water stress models. This was due to low productivity as well as low extent cultivated by high water stress farmers. Further study reveal that annual net farm income significantly deviation between head versus tail farmers and HWR versus LWR farmers. However, nonfarm income does not significant deviation between water stress groups. Per capita annual income also has reported significant mean variation between high water stress and low waterstress groups. According to the Gini coefficient, within the same group (intra disparity), the annual net income disparity was at significantly higher level compare to the national figures. The inter income disparity (between groups head versus tail and HWR versus LWR) was also have displayed higher values from all income sources. The estimate Gini coefficient for total income inequality for pooled sample was 0.512, and it was 42% ahead the national level. Elsewhere the author analyzed the decomposition of inequality based on per capita household income by water stress groups. This study found the evidence that more than 50% intra and inter income inequalities among water stress groups have drawn by farm income. Further paddy and OFC were the largest income sources that were adversely affected on deviation of farm income.

Table 7: Contributions of income sources to overall income inequality among pooled sample

Income source	Coefficient of concentration	Income share	Relative contribution	Absolute contribution
Paddy	0.372	0.306	0.223	0.114
Other field crops	0.698	0.206	0.281	0.144
Perennial crops	0.571	0.055	0.061	0.031
Livestock	0.983	0.066	0.012	0.006
Employment	0.466	0.384	0.349	0.179
Business	0.926	0.041	0.074	0.038
Total	-	1.000	1.000	0.512

Table 8: Gini coefficient for assets accumulation inequalities

Model	Type of inequality	Value of cumulative durable assets	Value of cumulative production assets
Head-end	Intra	0.453	0.546
Tail-end	Intra	0.498	0.578
Head and tail	Inter	0.634	0.695
LWR	Intra	0.476	0.498
HWR	Intra	0.501	0.588
LWR and HWR	Inter	0.625	0.689
Pooled	Inter	0.615	0.673

HWR: High water risk, LWR: Low water risk

Figure 1: Lorenz curve for head-end and tail-end farmers

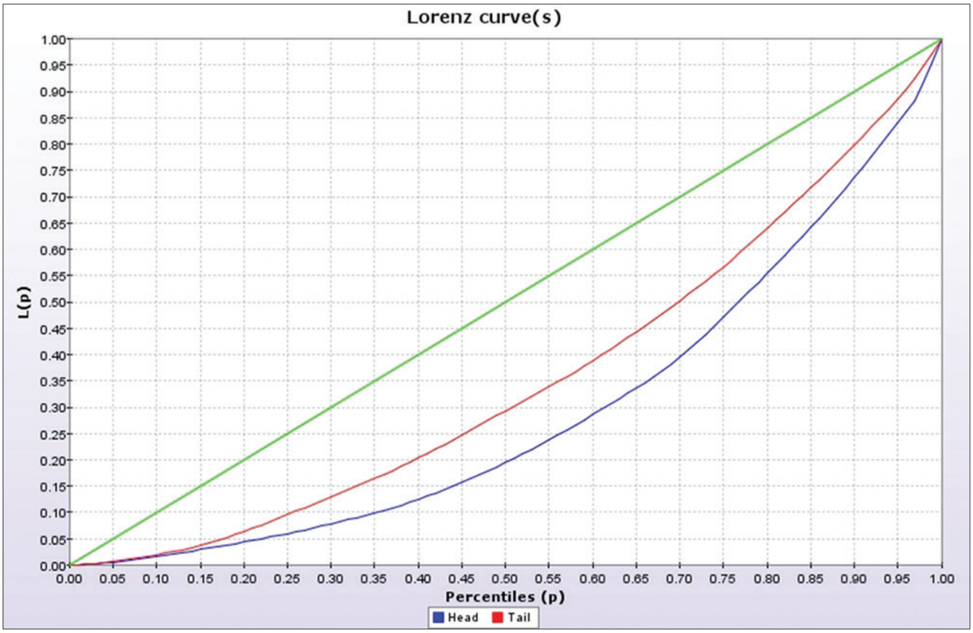
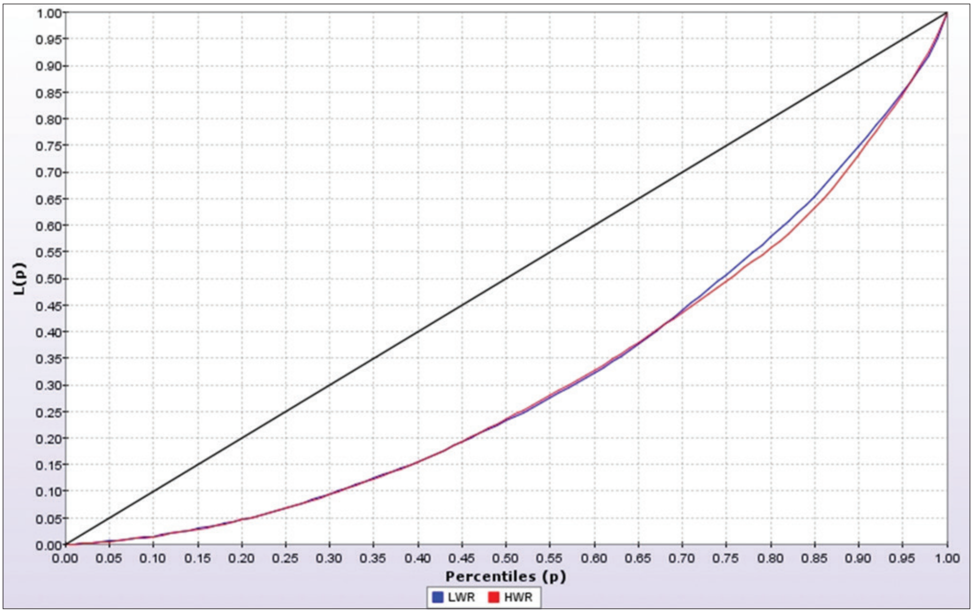
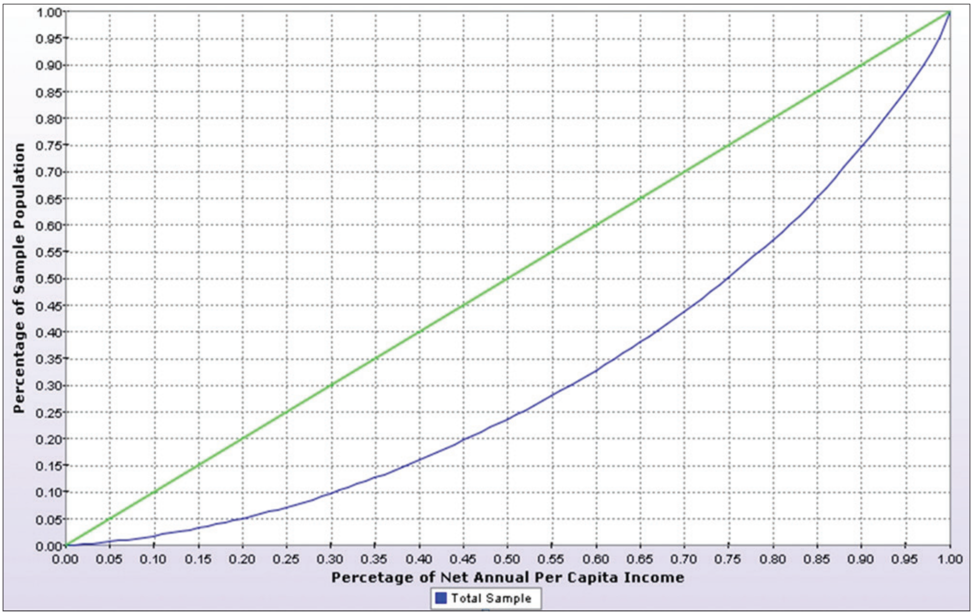


Figure 2: Lorenz curve for high water risk and low water risk farmers



As a single income source, employment income presented highest inequality between the water stress groups. Second highest source was OFC income and third was paddy income. Further, the study found that the significant capital items variation between the groups. Thus, study concluded that there was significant variation of assets accumulation between water stress groups.

Figure 3: Lorenz curve for total sample



The study has drawn forceful and implementable conclusions on income disparity and poverty across major tanks in Sri Lanka. The highest portion of income inequality across different water groups were from farm income, specially paddy and OFC. Efforts to ensure a more equitable distribution of income should, therefore, be made with focus on paddy and OFC cultivation activities among water stress groups. The root cause of this income deviation was cropping intensity and productivity difference due to the divergence of water accessibility across the groups. Thus, policy implementers could focus directly this root cause for solution to income disparity among major tanks in the dry zone of Sri Lanka. According to poverty analysis, presented in this study has shown that tail-end and HWR farmer families were relatively poorer than head-end and LWR farmer families. Thus, state authorities, donor agencies, and NGOs could special attention on those high water stress groups with their poverty alleviation program. Up until now, the state sector poverty alleviation program has been applied common poverty alleviation program without categorize the water groups. However, now, it is time to given special attention on tail-end and HWR farmers in the dry zone of Sri Lanka.

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