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Estimation of agricultural resource inequality in India using Lorenz curve and Gini coefficient approach

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A B S T R A C T

This study explored inequality of agricultural resources among states in India using the Lorenz curve and Gini coefficient. The shape of the Lorenz Curve shows inequality in operational holding, livestock population, irrigation and per capital income at current prices (2012–2013) among states in the country. Irrigation inequality was highest with Gini-coefficient value of 0.66 followed by 0.6 for agricultural landholding size. Livestock inequality had a value of 0.54 whereas per capita income at current prices (2012–2013) reported the least inequality among states with a Gin coefficient value of 0.2.

Introduction

Agriculture is the primary source of livelihood for 58 per cent of India's population. Area under agriculture production is estimated to be about 157.35 million hectare hence not surprising the country wields the second largest agricultural land next to United States globally (India Brand Equity Foundation, 2014). Also, World Bank data shows that about 60.3 percent of India's land area is agricultural land. The bank defines agricultural land as "share of land area that is arable, under permanent crops, and under permanent pastures. All the 15 major climates are found in India and the country also possess 45 of the 60 soil types in the

world. The country has the world largest livestock population and irrigated area, 512.05 million numbers and 57 million hectare respectively (Government of India, 2012, 2014).

Notwithstanding the aforementioned standards of the country in terms of agriculture, the most recent Rangarajan expert group report in 2014 indicates, India is home to more than 363 million poor (260.5 million of them in rural and 102.5 million in urban areas). The number of poor in the country according to the report is more than the overall population of the 18 countries in West Africa combined. The

proportion of the population below the poverty line in India is 29.5 percent with majority of the poor (72%) in rural areas (Rangarajan, 2014).

Poverty eradication has been one of the major objectives of the development process in India. Government of India has designed from time to time, different poverty alleviation programmes to widen the income-earning opportunities for the rural poor. The results are encouraging even though the percentage of population below the poverty line is declining at a modest pace. Official statistics show that poverty measured in terms of headcount ratio (HCR) declined from 54.9% in 1973-74 to 29.5% in 2011-12, (Rangarajan, 2014), but the pace of poverty reduction over the past decade has been slow. The period of rapid growth and poverty reduction (2004–9) also witnessed a rise in inequality, with the Gini index rising from about 0.27 in rural and 0.35 in urban India in 2004/05 to about 0.28 and 0.37, respectively, in 2009/10. Moreover, rural-urban as well as regional inequality also increased during this period (Anand *et al.,* 2014).

The importance of agriculture to reduction of the number of poor below the poverty line cannot be underestimated in government enormous effort to push chunk of the populace above poverty line as the country's development soars. Expansion of agricultural productivity in farming sector can lead to a faster rate of poverty alleviation, by raising the incomes of rural producers and reduction of food expenditure, and thus reduces income inequality (World Bank, 2008).

Commenting on the importance of agriculture, the 2008 World Development Report observed that GDP growth originating in agriculture is about four times more effective in reducing poverty than GDP growth of other sectors (World Bank, 2008). For agricultural household, the capacity to buy is the capacity to produce but production and productivity depends on the amount of resource used in production. Access to productive resources such as land, water, and other inputs are keys to higher levels of agricultural incomes and poverty alleviation (IHDS, 2003). In addition to increase crop production and consequential family incomes, improved irrigation access can significantly contributes to rural poverty reduction within a region (Chambers 1988; Barker *et al.,* 2000)

The Government of India believes that growth in agricultural production and productivity is needed to raise rural incomes to tackle the rural poverty. This is because, enhancing agricultural productivity contributes to industrial growth by providing cheap labour, meet the food and raw material needs, capital investment, foreign exchange and markets for manufactured consumer goods. The government also realizes that enhancing agricultural productivity coupled with access to productive resources such as land, water, livestock and other inputs are one of the best road map to higher levels of agricultural incomes among the poor.

In light of the aforementioned reasons, this study is therefore designed to study the extent to which major agricultural resources are equal or unequal among different states of the country.

Materials and Methods

Data type and source

Secondary data used for the analysis were from the following government sites and databases.

- ➤ Agriculture Census, 2010–11, Ministry of Agriculture, Government of India

- ➤ 19th livestock census, 2012, Ministry of agriculture department of animal husbandry, dairying and fisheries, Government of India.

- ➤ Directorate of Economics and Statistics, Ministry of Agriculture.

- ➤ Government of India (2014).State-wise Per Capita Income and Gross Domestic Product at current prices. Retrieved from *http://pib.nic.in/ archieve/others/2013/dec/d20131217 03.pdf* on 28/03/2015

Analytical techniques

In this study, the element chosen to be measured in the context of the conventional understanding of economic inequality is the agricultural resources among states. Inequality represents only the value judgment of the absence of a homogeneous distribution of resources. Lorenz curve and Gini-coefficient can be used for describing the objective measures of inequality, as they are the main inequality measure employed in literature.

The main feature of the objective measures of inequality is that they are characterized by the use of statistical and mathematical tools for the estimation of inequality (dispersion) among a set of individuals. Measurement of inequality helps us to further understand the nature and effects of inequality. For understanding the phenomenon of inequality, understanding the correct way to measure inequality is fundamental.

Lorenz curve

The Lorenz Curve is a tool used to represent wealth distributions as proposed by Lorenz (1905); it tells us which proportion of total wealth is in the hands of a given percentage of population. However, instead of ending up with income shares, the Lorenz Curve relates the cumulative proportion of income to the cumulative proportion of individuals. The shape of the Lorenz Curve is therefore a good visual indicator of how much inequality there is in an income distribution. Inequality measurement is an important factor in economy that indicates weather benefits of the growth have been concentrated or "trickled down" sufficiently to the society.

The Lorenz Curve is obtained as follows:

The *X*-axis records the cumulative proportion of population ranked by income (wealth) level. Its range is therefore (0, 1). The *Y*-axis records the cumulative proportion of income for a given proportion of population, i.e. the income (wealth) share calculated by taking the cumulated income of a given share of the population, divided by the total income Y, as follows:

$$L\left(\frac{k}{n}\right) = \sum_{i}^{k} y_i$$

Where

k =1……………n is the position of each state in the wealth distribution;
i=1……………k is the position of each state in the wealth distribution
P……………… is the total number of states in the distribution
y $_i$ …………… is the wealth of the *i*[th] state in the distribution

$\Sigma_i^k y_i$ ………….is the cumulated wealth up to the kth individual

It is obvious that $\Sigma_i^k y_i$ ranges between 0, for k=0, and *Y*, for *k = n*, therefore the equation value Ranges between 0 and 1.

A 45° line represents absolute equality and the Lorenz curve represents the current distribution of the income, as the Lorenz curve reaches farther away from the 45° line more inequality dominates the distribution. The Lorenz curve performs as the natural instrument for graphically depicting the Gini coefficient.

The Gini-coefficient

Attributed to Gini (1912), is by far the most widely used measure of inequality; the reason for this may be the fact that it is a straight forward, easy to understand and not at all complicated to calculate. Another reason for its popularity can be attributed to the availability of inequality datasets, particularly the one of Deininger and Squire (1996). Its value ranges from 0 to 1, (Although it is commonly multiplied by 100 in empirical studies) being 0 the value of perfect equality and 1 of maximum inequality (i.e. one individual holds all the income or wealth and the rest hold no income or wealth). Another advantage of the Gini- coefficient is that it can be easily represented in the Lorenz (1905) graph for a graphical, more intuitive, description, as it represents the ratio of the difference between the line of absolute equality and the Lorenz curve which represents the income (wealth) distribution among population quintiles.

There are several ways to calculate the Gini coefficient; by referring the most customary method for calculating the Gini coefficient based on the Lorenz curve, the Gini coefficient can be calculated as the ratio of the area between the Lorenz curve and the absolute equality line, divided over the total area under the 45° line,

$$Gini = \frac{Concentration\ Area(A)}{Maximum\ Concentration\ area(A+B)}$$

$$Gini = \frac{A}{(A+B)}$$

Since, A+B equals 0.5(Area of equality triangle), the Gini - coefficient will be:

$$Gini = \frac{A}{0.5} \quad or \quad Gini = 1 - 2B$$

Result and Discussion

Land is the fundamental means of production in an agrarian society without which no agricultural production can take place. An understanding of the pattern of operational holdings distribution of land among states is, therefore, of central importance to assist the process of planning and targeting of poverty reduction. The 2010-11 census data depicts that only five states hold more than 50% of operational holdings of the country. Rajasthan, Maharashtra, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh have the highest share of operational holdings. Rajasthan state takes the lion share and Chandigarh has the smallest, 21,136,000 (13.25%) and 1000(0.0006%) hectares of operational holdings respectively. Except in Uttar Pradesh and Madhya Pradesh, the high operational land holding states have low percentage of the population below the poverty line of 29.5% which is the country's average poverty line. This outcome agrees with Melkamu and Bannor (2015), who reported that a hectare increase in land size will result in 8.9% probability of a person not being poor in Chencha district of Ethiopia. That is to say, land ownership

inequality is one factor that creates low and insecure incomes for the rural poor which have impact on saving and future investment to get out of poverty.

The shape of the Lorenz Curve for operational land holding depicts more dispersed or greater variability among states on land holding. In the figure 1 above, the Lorenz curve is farther away from the line of equality (45° line), indicating of high inequality dominates the distribution of land holding in the country. The Gini-coefficient result (0.6) also shows it is very far from 0 which indicates above average inequality in land distribution. Thus, Gini coefficient value shows existence of skewed distribution of land holding and few states hold major land holdings and the rest states hold few land holdings.

Livestock is capital assets produced in the past and contributing to future product output. In India livestock is the source of food, income, employment and foreign exchange hence has potential key role in reducing rural poverty. For low income producers, livestock can serve as a store of wealth; provide draught power and organic fertilizer for crop production. Livestock sector in its bid to help rural poor recently introduced technology which is applicable for landless households. This land-saving technology is alternative solution for household income poverty alleviation. However, when we see the distribution of livestock in the country it follows operational holdings and disproportionately distributed.

A state wise distribution of livestock population shows that, Uttar Pradesh, Rajasthan, Andhra Pradesh, Madhya Pradesh, Bihar and Maharashtra, have greater proportion of livestock population. These five states have more than 55% share

of countries total livestock holding. Surprisingly, the countries 90% livestock population is accumulated only in 14 states. Uttar Pradesh is home for maximum livestock population having more than 6.5 million livestock and Goa has only 145,853 livestock population minimum over all states.

The Lorenz curve drawn to see how livestock wealth is distributed among states shows the existence skewed distribution. Gin-coefficient value of 0.54 also approves the existence of inequality in livestock population distribution in the country.

Recently farm household income depends more on water than land. Whereas land was the primary resource affecting agricultural production in the early decades of the twentieth century, access to irrigation has taken on increasing importance in recent decades. Improved access to irrigation infrastructure will increase crop yield, agricultural production and farm income within a region.

Uttar Pradesh, Rajasthan, Madhya Pradesh, Punjab and Andhra Pradesh have larger operational holdings and high irrigation, so they are the generally acknowledged as the heart of Indian agricultural progress. These five states own more than 56% of irrigated area of the country and more than 90% of irrigated land found in only 11 states. Uttar Pradesh takes the lion share having 21.5% share and Goa has 0.015% share in irrigated land coverage.

Empirical studies also suggest that irrigation has positive impacts on agricultural production and the reduction of poverty in rural area. The above table also supports positive contribution of irrigation on poverty reduction even though Uttar Pradesh with the highest irrigation facility has 39.8% of

the state population below poverty line. Nevertheless Punjab, Andhra Pradesh and Rajasthan states have less population below the poverty line than country average.

Lorenz curve drawn to see irrigated area distribution among states, magnify existence of big difference in irrigation distribution among states. The curve clearly depicts existence of high inequality in irrigation among states in the country. The Gini-coefficient value of 0.66 also supports the skewed distribution hence livestock inequality.

Per capita income or income per person is often used as average income. It can also be used as a measure of the wealth of the population of a nation, particularly in comparison to other nations. Per capita income is often used to measure a country's standard of living. This helps the country to know their development status. Countries with more equal distribution of income (as measured for example by the Gini index) experience a greater reduction in the poverty rate for a given increase in per capita income. Generally, increases in per capita income tend to decrease the poverty rate.

The above table shows states vary considerably in per capita income—they varied from □201, 083 in Delhi to □28,317 in Bihar during 2012/13. A comparison of the per capital income at current prices for a total of 32 major states shows, Delhi, Goa, Chandigarh, Sikkim, Puducherry, Haryana, Maharashtra, Tamil Nadu, Uttarakhand, Andaman, Gujarat and Punjab have more than 3.5% share of the country wealth. These ten states share more than 50% of the national wealth. High level of Per capita income is good instrument for poverty alleviation, almost all states, except Chandigarh, have the lowest poverty rate.

The Lorenz curve depicts availability of inequality, as compared to other resource distribution in the country per capita distribution is not much skewed. Generally, the country has relatively low overall inequality in per capita income. The Gini-coefficient (0.2) is also not much far from zero, shows existence of inequality but that inequality in per capital income is not serious like other resources inequality.

Conclusions and Recommendations

Rajasthan, Maharashtra, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh have the highest share of operational holdings. Rajasthan state takes the lion share and Chandigarh has the smallest, 21,136,000 (13.25%) and 1000(0.0006%) hectares of operational holdings respectively. Except in Uttar Pradesh and Madhya Pradesh, the high operational land holding states have low percentage of the population below the poverty line of 29.5% which is the country's average poverty line. The shape of the Lorenz Curve for operational holding depicts of high inequality dominates the distribution of land holding in the country. The Gini-coefficient result (0.6) also shows it is very far from 0 which indicates above average inequality in land distribution.

A state wise distribution of livestock population shows that, Uttar Pradesh, Rajasthan, Andhra Pradesh, Madhya Pradesh, Bihar and Maharashtra, have greater proportion of livestock population. These five states have more than 55% share of countries total livestock holding. The Lorenz curve drawn to see how livestock wealth is distributed among states shows the existence skewed distribution. Gin-coefficient value of 0.54 also approves the existence of very much inequality in livestock population distribution in the country.

Table.1 State-wise area of operational holdings for all social groups
('000 Hectares) (2010–11)

States/UTs	Area	Percentage Share	% of population below Poverty line
Rajasthan	21,136	13.25	21.7
Maharashtra	19,767	12.39	20.0
Uttar Pradesh	17,622	11.04	39.8
Madhya Pradesh	15,836	9.92	44.3
Andhra Pradesh	14,293	8.96	13.7
Other states	70,939	44.44	
			Gini coefficient = 0.6

Source: Authors own computation based on Agriculture Census, 2010–11, Ministry of Agriculture, Government of India

Table.2 State-wise total number of livestock (2012)

States/UTs	Total number of livestock	Percentage Share	% of population below Poverty line
Uttar Pradesh	68,715,147	13.4	39.8
Rajasthan	57,732,204	11.6	21.7
Andhra Pradesh	56,099,407	10.9	11.7
Madhya Pradesh	36,332,627	7.1	44.3
Bihar	32,938,601	6.4	41.3
Maharashtra	32,488,652	6.3	20.0
Other states	228,633,014	44.3	-
			Gini - coefficient = 0.54

Source: Authors own computation based on 19th livestock census in 2012, Ministry of agriculture Department of Animal husbandry, Dairying and Fisheries of Government of India.

Table.3 State-wise total irrigated area ('000 hectare)

States/UTs	Irrigated Area	Percentage Share	% of population below Poverty line
Uttar Pradesh	19353.732	21.5	39.8
Rajasthan	8902.888	9.9	21.7
Madhya Pradesh	8227.505	9.13	44.3
Punjab	7770.881	8.62	11.3
Andhra Pradesh	6784.511	7.53	11.7
Other states	39049.695	43.3	-
			Gini - coefficient = 0.66

Source: Authors own computation based on Directorate of Economics and Statistics, Ministry of Agriculture Data.

**Table.4** State wise per capita income at current price 2012-2013

| States/UTs	Per Capita Income in □.	Percentage Share	% of population below Poverty line
Delhi	201083	7.89	15.6
Goa	167838	6.59	6.3
Chandigarh	142869	5.61	47.9
Sikkim	142625	5.59	17.8
Puducherry	122652	4.81	7.7
Haryana	108345	4.25	12.5
Maharashtra	107670	4.23	20
Tamil Nadu	98550	3.87	22.4
Uttarakhand	92607	3.63	17.8
Andaman	89748	3.522	6
Gujarat	89668	3.519	27.4
Punjab	88783	3.48	11.3
Other States		43.01	
			Gini - coefficient = 0.2

Source: Authors own based on Government of India (2012-2013). Note:- Goa, Gujarat, Kerala, Mizoram, Chandigarh and Rajasthan data are not available, 2011-12 was used.

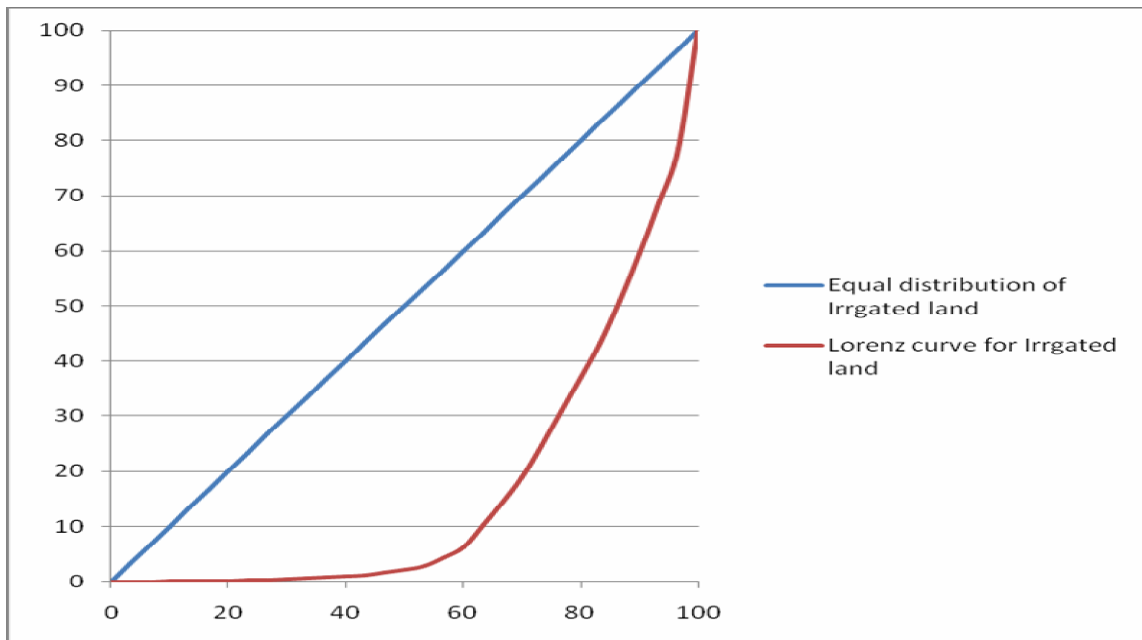**Figure.1** Lorenz curve for operational land holdings in India (2010-11)
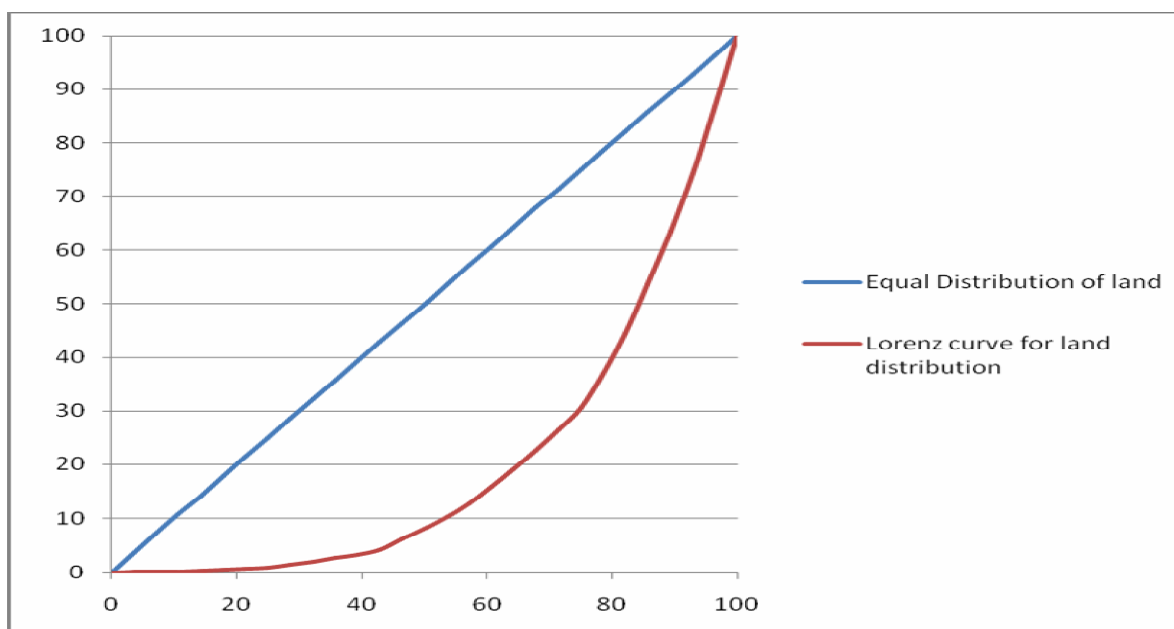
Source: Authors own, 2015

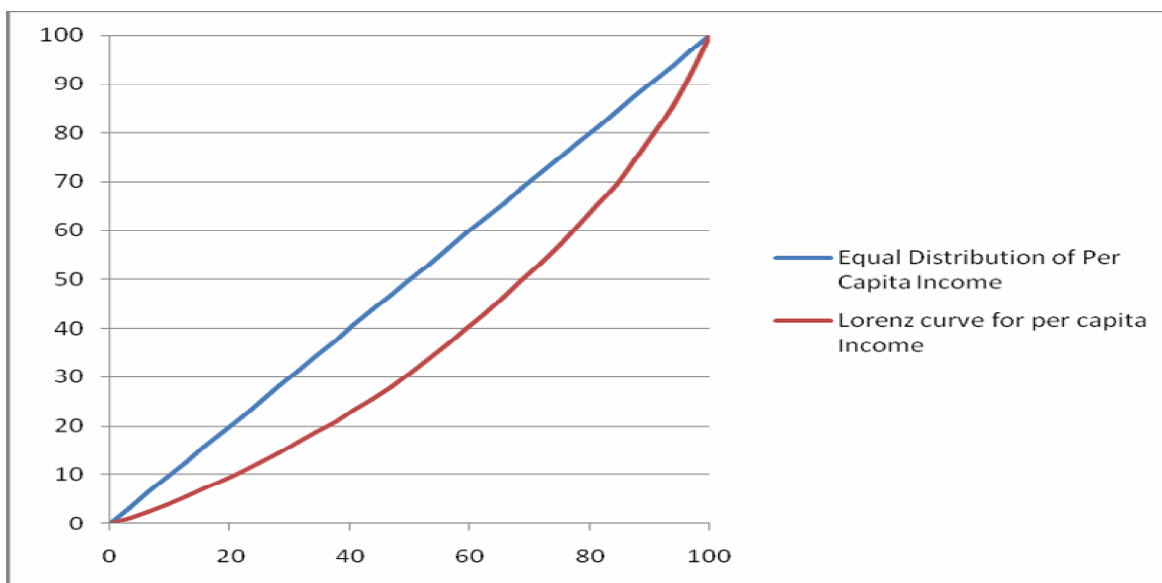**Figure.2** Lorenz curve for state-wise total number of livestock (2012)
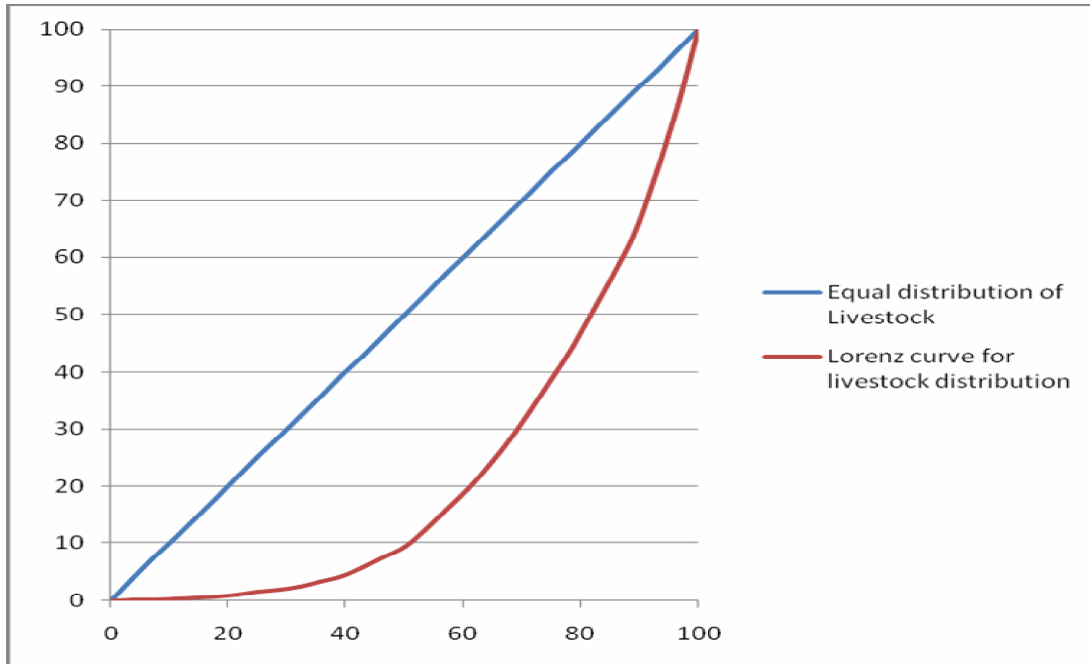
Source: Authors own, 2015

Figure.3 Lorenz curve for state-wise total irrigated area

Source: Authors own, 2015

Figure.4 Lorenz curve for state-wise per capita income (2012–2013)

Lorenz curve drawn to see irrigated area distribution among states, magnify existence of big difference in irrigation distribution among states. The curve clearly depicts existence of high inequality in irrigation among states in the country. The Gini-coefficient value of 0.66 also supports the skewed distribution hence irrigation area inequality. Irrigation inequality is the highest among the resource inequality studied by the researchers.

A comparison of the per capital income at current prices for a total of 32 major states shows, Delhi, Goa, Chandigarh, Sikkim, Puducherry, Haryana, Maharashtra, Tamil Nadu, Uttarakhand, Andaman, Gujarat and Punjab are under those who have more than 3.5% share of the country wealth. These ten states share more than 50% of the national wealth. Generally, the country has relatively low overall inequality in per capita income as per the shape of the Lorenz curve. The Gini-coefficient (0.2) is also not much far from zero, shows existence of inequality but that inequality in per capital income is not serious like other resources inequality.

Based on the outcomes, the researchers recommend the following;

I. Government programmes which are targeting increase in agricultural productivity should be encouraged especially in areas that wield low land holdings.

II. Livestock starter pack should be given to groups in villages that show interest and potential especially in states that have low livestock wealth especially the rural poor.

III. Credit facilities should be encouraged for livestock expansion and also market infrastructure for livestock activities should be enhanced by various state governments especially states with low livestock wealth.

IV. Groundwater irrigation should be encouraged in potential agricultural areas but have inadequate irrigation facilities. In addition, water harvesting programmes should be encouraged among farmers who are not having the luxury of canals in their areas of farming.

Expansion of agriculture infrastructure in terms of telecommunication, roads, rail, and market should be encouraged to help decrease the resource inequality and ultimately per capita income inequality between states as the nation soars up in economic development.

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