RESEARCH REPORT

113

Applying the Gini Coefficient to Measure Inequality of Water Use in the Olifants River Water Management Area, South Africa

James Cullis and Barbara van Koppen

International Water Management Institute

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Cover photographs (clockwise from left):

- Woman gathering water from stream in Sekororo area (photo credit: Dominique Rollin)
- Bulshoek Weir (photo credit: James Cullis)
- Large-scale flood irrigation (photo credit: Mike Shand)
- Irrigated sugarcane (photo credit: Nico Rossouw)

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Contents

Summary

The present study explores the application of the Gini Coefficient, which has hitherto only been used for income and land distribution, to quantify the distribution of water resources. The tool is tested in the water-stressed Olifants Water Management Area, in South Africa. Using readily available information on water use registrations, water use estimates, and census data, two versions of the Gini Coefficient are calculated. The first measures the distribution of the allocation of direct water use in rural areas and was estimated at 0.96 in the study area. In other words, 99.5 percent of the rural households are entitled to use only 5 percent of the available water. The second version calculates the distribution of the indirect benefits of water use in the form of direct employment. This is shown to have a Gini Coefficient of 0.64.

Using the Gini Coefficient an assessment was also made of the impacts of different policy scenarios. It was found that by more than doubling the amount of water used by rural households from the current 225 cubic meters per household per annum (m^3/hh/annum) to 610 m^3/hh/annum, which would enable each household to meet its basic human needs of 50 litres/person/day and irrigate 1,000 square meters (m^2), would reduce the Gini Coefficient significantly. Yet, this would only require the large-scale registered users to reduce their current irrigation water use entitlement by 6 percent or the largest ten users to reduce their use by 20 percent each.

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Introduction

"Equitable access to water, or to the benefits derived from using water, is critical to eradicating poverty and promoting growth. This is particularly important in South Africa, which is still facing significant inequalities in access to and use of water." (DWAF 2005)

Rationale

This report introduces an indicator for measuring the distribution of water use in an area. The proposed indicator is an application of the Gini Coefficient, which is traditionally used for measuring income and land distribution. For the purposes of this study, the Olifants Water Management Area (WMA) has been selected as a test case to explore the potential for developing the indicator. The Olifants WMA has been identified as one of the first catchments in South Africa to undergo a process of compulsory licensing due to the stressed nature of the water resources in the WMA as well as the pressing need to address the current inequities in water allocation and the sharing of benefits. It is important to note that this case study is used simply to indicate the potential to apply the Gini Coefficient to measure the distribution in water use. The study shows that there is potential to apply the Gini Coefficient to measure the distribution in actual water use as well as the benefits of water use. It is, however, recommended that more in-depth studies are conducted to develop this concept further and to address some of the issues raised in this report before the Water Gini Coefficient is employed as a tool for ensuring more equitable access to water and to the benefits of water use in an area.

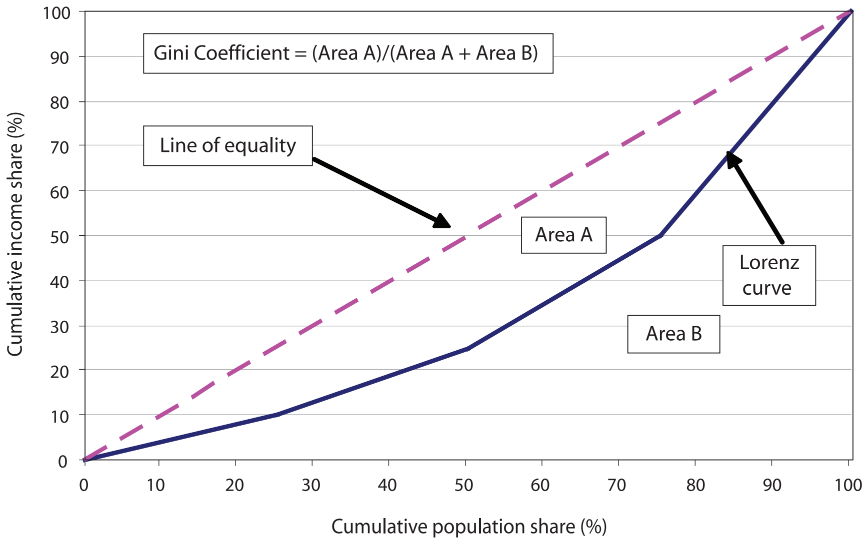
The Gini Coefficient

The Gini Coefficient is one of the most commonly used indicators for measuring distribution. It is traditionally applied to the measurement of income inequality, but has also been applied to measure land inequality. As yet, it has not been applied to measure water use inequality. The Gini Coefficient is calculated from un-ordered size data as the "relative mean difference", i.e., the mean difference between every possible pair of individuals, divided by the mean size and is defined as follows (Gini 1912; quoted in Litchfield 1999):

$$Gini = \frac{1}{2n^2\bar{y}} \sum_{i=1}^{n} \sum_{j=1}^{n} |y_i - y_j|$$

The Gini Coefficient can be displayed graphically as a plot of the distribution of the size fractions of ordered individuals. This is

FIGURE 1.
Graphical example of the Lorenz curve and Gini Coefficient.



termed the Lorenz curve and is shown in Figure 1.

In a perfectly equal society the Lorenz curve would plot as a straight line. This is termed the line of equality. In most cases, however, the Lorenz curve plots below this line of equality, showing the inequality in the distribution of income, land or, now, water between members of a community. In the example shown in Figure 1 the poorest 50 percent of the population account for only 25 percent of the total income of all individuals in the area, while the richest 20 percent account for 50 percent of the total income. The Gini Coefficient is calculated as the ratio of the area between this Lorenz curve and the line of equality (Area A) and the total triangular area under the line of equality (Area A + B). The closer to 1, the more unequal is the distribution of income, and the closer to 0, the more equal is the distribution of income.

Inequality in South Africa

In South Africa the Gini Coefficient for income increased from 0.60 in 1995 to 0.64 in 2001 (UNDP 2003). This inequality has been attributed to a number of factors. These include weak access to basic services by the poor, unemployment and underemployment, low economic growth rates and the weakening employment generation capacity of the current growth path, environmental degradation, HIV/AIDS and an inadequate social security system (UNDP 2003).

Inequality with respect to land in South Africa is even worse. This is very much the result of the territorial and institutional segregation policies of the past, where the black majority were forced onto 13 percent of the land until 1994.

The inequality of access to land has been translated into inequality in access to water, as access to water is often related to land resources. In addition, the white minority obtained access to a high level of water-related services such as domestic water supplies, and water supplies for irrigation, mining and industrial use, while large sections of the black community had little or no access to even basic services. As a result, the black population in South Africa suffered under a double deprivation in relation to water: lack of water services was compounded by a lack of access to water for economic purposes, including irrigated agriculture (Schreiner and Naidoo 2001).

Addressing these past, and current, imbalances in the access to water and the use of water for domestic and commercial purposes is now the primary focus of the Water Allocation Reform programme in South Africa (DWAF 2005). A measure of the inequality of water use, such as that proposed in this paper, will be very useful in terms of quantifying the current situation, identifying areas of greatest concern, testing the impact of various proposed policy initiatives, and tracking the progress of these policies when implemented.

Inequality versus Inequity

It is important to note that the Gini Coefficient measures *equality* and not *equity*. Equality is defined as the state of being equal, while equity refers to the quality of being fair and impartial[1]. It is true that equality can be an important component of equity, but the relationship between equity and equality depends very much on the interpretation of the above definitions. The debate over what constitutes equity in terms of water resource allocations and use is essential if we are to develop ways of implementing integrated water resources management. It is particularly significant in South Africa, where the Water Allocation Reform programme is striving to develop ways of giving practical meaning to the aims of the National Water Act, particularly with regards to redressing the inequities of the past. This report does not attempt to address this issue, but merely presents a potential way of measuring the *equality* of water use entitlements and use and the *equality* of certain derived benefits of water use (i.e., employment). How this can be translated into measures of equity should be the subject of further development of this tool and other monitoring and evaluation tools.

Water Use Data

Unfortunately, there is no database available of actual water use in South Africa. The availability and reliability of data presents a challenge to applying the Gini Coefficient. This, however, is a problem faced by all monitoring and evaluation tools. Despite this, it is possible to make some initial calculations using the data that are available and to consider the possible implications of the reliability of those data where necessary. Two data sources are used for this initial assessment of the potential to apply the Gini Coefficient to water allocation. The data used are the record of registered water use in the Water Use Authorization and Registration Management System (WARMS) and the estimated water demands developed for the National Water Resource Strategy (NWRS) (DWAF 2004) and refined in the relevant Internal Strategic Perspective (ISP).

The National Water Act (NWA) requires that all water use in excess of Schedule One[2] be registered with the Department of Water Affairs and Forestry (DWAF). These data are captured in the Water Use Authorization and Registration Management System (WARMS). The primary objective of WARMS is to serve as a billing system for the collection of water user charges by the DWAF. As a result, there are a number of concerns with regards to the accuracy of the data captured in WARMS. The database is currently undergoing a verification and validation process in certain catchments, including the Olifants WMA. This will take some time to address concerns such as identifying users who no longer exist or have either over- or under-registered their water use due to the financial implications. Registered water use is recorded in WARMS in terms of the type of user, the location of use, the water use sector, the nature of the source and the authorized volume, which

[1] South African Pocket Oxford Dictionary, 3rd Edition, 2002.

[2] Schedule One is defined in the NWA as water used for reasonable domestic purposes, small gardening not intended for commercial purposes, and the watering of livestock (excluding feedlots).

is assumed to be equal to the actual use for the purposes of this case study.

It is hoped that the DWAF will look to develop a more comprehensive database of actual water use, based on the validation and verification process of the WARMS database as well as through the assimilation of data on water use recorded by the local municipalities as part of the Water Services Development Plans (WSDP). The section, *The Gini Coefficient for Registered Water Uses in the Olifants WMA,* discusses the application of the Gini Coefficient to registered uses only. The section, *The Gini Coefficient for All Rural Water Uses in the Olifants WMA*, estimates the Gini Coefficient for all water uses.

The Gini Coefficient for Registered Water Uses in the Olifants WMA

Registered Water Uses in WARMS and Water Inequality

The registered water use, as recorded in the WARMS for the Olifants WMA, is given in terms of the type of user (or "customer" as they are referred to in WARMS) and the sector of use in Table 1 and Table 2, respectively.

The key consideration when attempting to calculate the Gini Coefficient to measure the inequality of water use in a catchment is the definition of the agent or water user (i.e., the x-axis) and the unit for measuring the water use (i.e., the y-axis).

The simplest way to calculate a water use Gini Coefficient would be to base it on the registered volumes in WARMS and consider each registration as an individual water use agent. This, however, ignores the fact that each record of registration is unique in terms of the user, the use type and the location of use and as a result a single user may have a number of different registration records[3]. To obtain a better measure of the inequality of

TABLE 1.
Registered abstraction of water by user customer type (July 2005).

Customer type	Registered amount		Percentage	
	Number	Volume (Mm^3/a)	Number (%)	Volume (%)
Company	1,919	514	41.0	33.2
Individual	2,648	439	56.6	28.3
National Department	26	13	0.6	0.8
Provincial Department	5	0	0.1	0.0
Water Services Provider	25	183	0.5	11.8
Water User Association	55	400	1.2	25.8
Total	4,678	1,550	100.0	100.0

[3] As of July 2005 there were 4,647 records of registered water use in WARMS, but only 1,782 individual users (or customers).

TABLE 2.
Registered abstraction of water by sector (July 2005).

Water use sector	Registered amount		Percentage	
	Number	Volume (Mm³/a)	Number (%)	Volume (%)
Agriculture: Aquaculture	14	30	0.3	1.9
Agriculture: Irrigation	4,095	1,197	87.5	77.2
Agriculture: Watering Livestock	225	3	4.8	0.2
Industry (non-urban)	68	115	1.5	7.4
Industry (urban)	62	18	1.3	1.1
Mining	71	46	1.5	3.0
Recreation	3	0	0.1	0.0
Schedule One[1]	31	1	0.7	0.1
Water Supply Service	109	140	2.3	9.0
Total	4,678	1,550	100.0	100.0

Note: [1] The use of Schedule One is not reliably captured in WARMS as there is no financial incentive to register this type of use. The few uses of Schedule One that are registered in WARMS are, in most cases, a result of the water use originally being registered, incorrectly, as agricultural water use.

water use, all the records of registration for a single customer were grouped together before determining the water use Gini Coefficient. The registered water users were then ordered according to the total authorized volume, plotted in the Lorenz curve and the water use Gini Coefficient for registered water use was calculated.

The inequality of the registered water use for each sector is shown graphically in Figure 2, where the water use agent is considered to be the registered user or customer. The water use Gini Coefficient of the registered water use in each sector is given in Table 3.

The water use Gini Coefficients shown in Table 3 only give an indication of how the

FIGURE 2.
Distribution of registered water use for all sectors and users: Olifants WMA.

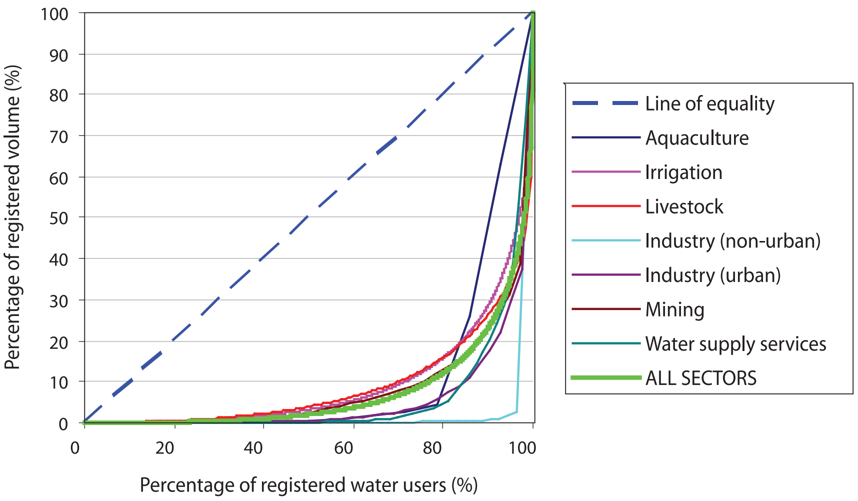


TABLE 3.
Equality of registered water use for all sectors and users: Olifants WMA.

Water use sector	Number of registered users	Registered volume (Mm^3/a)	Average volume (Mm^3/a)	Water use Gini Coefficient
Agriculture: Aquaculture	14	30	2.12	0.79
Agriculture: Irrigation	1,489	1,197	0.80	0.81
Agriculture: Watering Livestock	182	3	0.02	0.82
Industry (non-urban)	53	115	2.17	0.96
Industry (urban)	42	18	0.42	0.89
Mining	37	46	1.26	0.84
Water Supply Service	63	140	2.22	0.88
ALL SECTORS[1]	1,782	1,549	0.87	0.85

Note: [1] This number is not equal to the sum of the number of users registered in each individual section as some users have registered their water use in more than one sector.

registered water use is divided up between the registered users.

It is important to note that registered water users tend to use larger quantities of water than the small-scale water users who are not required to register. It may be the case that all the registered water users have an equal allocation of water, but that the registered water users only represent a small percentage of the total population of the catchment. This would result in a relatively low (i.e., more equal) Gini Coefficient of the registered water use, but a highly unequal distribution of water use over the whole catchment. For this reason it is important to expand the calculation of the water use Gini Coefficient to include the households that do not have a registered water use in WARMS. This is done in the section, *The Gini Coefficient for All Rural Water Uses in the Olifants WMA*, by including the estimated water use by rural households.

A second concern with the water use Gini Coefficients shown in Table 3 is that the registered water users are not all the same. They include individuals, companies, water user associations, water service providers and government departments. There are two significant concerns with regards to this. The first is that while registered water use has been grouped by customer name, this does not necessarily group the registered water use of individuals who may have separate registrations under different individual or company names. This has the potential to increase the inequality of the registered water use, but is a problem that is very difficult to address without a detailed investigation of the institutional structures in the catchment. Second, the larger commercial users tend to make significant contributions to the local economy, both in terms of direct employment and contribution to Gross Domestic Product (GDP). In addition, these companies, particularly in the agricultural sector, tend to have long value chains as they are usually service buyers. The result of this is that the benefit of registered water use extends beyond the individual or company who holds the registration. This issue can be addressed by taking into account the benefits of the registered water use and this has been done in terms of direct employment in agriculture and mining in the section, *The Gini Coefficient for Benefits of Water Use in the Olifants WMA*.

The Gini Coefficient for All Rural Water Uses in the Olifants WMA

Estimated Water Use by Rural Households

There are very little data available on the amount of water used by rural households, particularly in cases where they obtain their water directly from the source. As a result the water use of rural households is often estimated based on characteristics of the households such as level of income and access to services. For this case study the estimation of water use of rural households is based on the work done in preparation for the *National Water Resource Strategy* (NWRS)(DWAF 2004). For the NWRS the gross rural water use requirement[4] (gRURo) was calculated for each quaternary catchment based on the following equation:

$$gRURo = \frac{365.25 * 10^{-9} * ((nRCRo * oPORi) + (nRSRo * oRSUi)) + nRIRo}{1 - fRTLo}$$

Where: fRTLo = Portion of total net rural water requirement that is lost during bulk transport and distribution (ranges from 0.1 to 0.3)

oPORi = The rural population

nRCRo = Net per capita water requirement and usually varies between 25 to 50 liters per capita per day (l/c/d)

oRSUi = Number of large stock units

nRSRo = The water consumption per large stock unit is normally in the range 10 to 50 liters per large stock unit per day (l/lsu/d) (smaller animals are adjusted to arrive at an equivalent number of so-called large stock units or LSUs)

nRIRo = Estimated volume of water required for small-scale subsistence irrigation based on the proportion of the rural population dependent on subsistence irrigation schemes.

A national database was developed for the above parameters for each quaternary catchment across the country. This database forms part of the Water Situation Assessment Model (WSAM), which was used to estimate the current and future water requirements of the country for the NWRS[5]. The total estimated rural water use for the Olifants WMA is 74 million cubic meters per annum (Mm^3/a). This is given in terms of the average annual rural water use and is equivalent to 44 Mm^3/a at a 98 percent assurance of supply, which is the figure given in the NWRS.

Inequality of Estimated Water Use by Rural Households

Based on the data from WSAM, a first order estimate of the inequality of water use by rural households can be made by determining the *average* rural water use per household in each quaternary catchment, and then plotting the cumulative rural water use against the cumulative number of households for the whole WMA. This

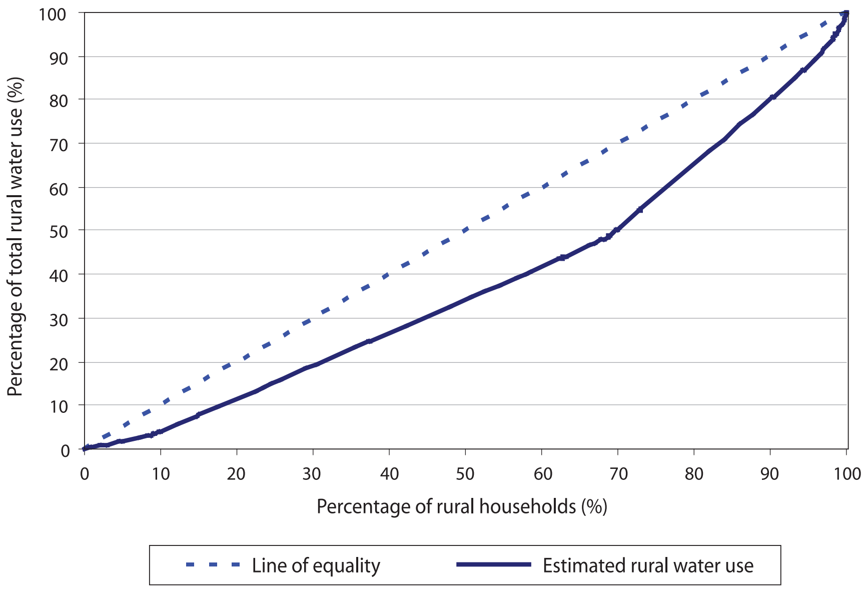
[4] The gross rural water use requirement can be considered to be analogous to an estimation of Basic Human Needs and Schedule One use in the rural areas.

[5] The estimation of rural water use has been updated as part of the ISP process and this data is currently being incorporated into the WSAM database.

is shown graphically in Figure 3. The resultant Gini Coefficient for the estimated rural water use by unregistered users is equal to 0.24.

attempt to apply the Gini Coefficient to measure the total inequality of water use can, however, be made in the rural areas where the registered use

FIGURE 3.
Distribution of estimated household rural water use: Olifants WMA.



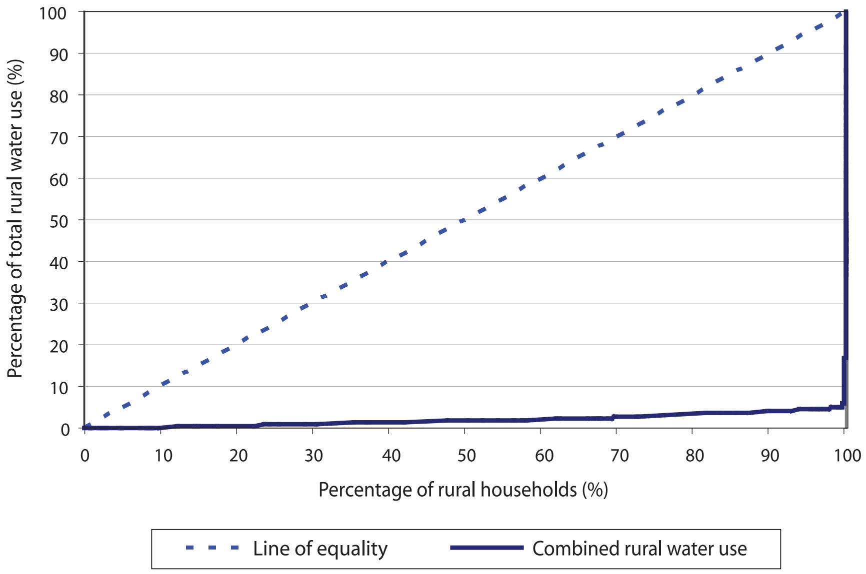
It is important to note that the above plot and the related Gini Coefficient are based only on the estimated average rural water use in each quaternary catchment, and not on individual use. It is most likely that there is a much greater degree of inequality between households within each quaternary catchment. This again highlights the need to develop a national database of actual water use, particularly at the local community or household scale.

Combined Inequality of Water Use in the Rural Areas

To develop a measure of the overall inequality of water use, it is necessary to combine the water used by registered users and the water used by households. This is complicated in the urban areas by the fact that the majority of water is supplied by water services providers (WSPs) and the number of people or businesses that this water supports is not recorded in WARMS. An

by rural industries such as agriculture, mining and non-urban industries is recorded and can be combined with the estimated use of rural households for Schedule One purposes. One way of doing this is to consider the registered users of water for agriculture, mining and non-urban industry in WARMS as representative of a single rural household and assume that the water use of the remaining rural households is equal to the estimated average rural water use for domestic and subsistence purposes. In terms of calculating the water use Gini Coefficient this is equivalent to combining the distribution of the registered water for the relevant sectors from Figure 2 with the estimated rural water use in Figure 3 in terms of absolute numbers and then calculating the combined water use Gini Coefficient based on the percentage of households and the percentage of the total rural water use. This is shown graphically for the whole of the Olifants WMA in Figure 4 where the water use Gini Coefficient for the estimated actual water use by rural households is equal to 0.96.

FIGURE 4.
Distribution of total rural water use: Olifants WMA.



This indicates a highly inequitable distribution of rural water use in the Olifants WMA. This is reflective of the fact that 1,391 Mm^3/a of water is registered in WARMS to only 1,706 individuals and companies for use in agriculture, mining and non-urban industry. There are, however, approximately 290,000 rural households in the Olifants WMA and the estimated rural water use of these households is only 74 Mm^3/a. Based on these figures, therefore, 99.5 percent of households in the rural area account for the direct use of only 5 percent of the total estimated water use in the rural areas of the catchment. This is significant as it gives an indication of the inequality in control of the water resource in the catchment with a few large users being in control of the vast majority of the resource through the registered water use.

The Gini Coefficient for Benefits of Water Use in the Olifants WMA

One of the key assumptions in the above estimation of the inequality of water use in the rural areas is that only a single household benefits from each registered water user. This may well be the case when considering the inequality in control of the resource, but is clearly not the case when considering the factual distribution of benefits of water use. This is due to the fact that the large commercial users are, in most cases, significant employers of people from the rural areas and service buyers with long value chains that result in multiplier effects in terms of employment and GDP. Hence, the benefits of water use are not only realized by the registered user, but also by those who are employed by these users directly as well as in the wider economy. While the inequality of direct water use is important in terms of the equality of ownership and control of the resource, it is also important to consider expanding the water use Gini Coefficient to take into account the *indirect* benefits of water use for those who benefit from that use without being in control of the use.

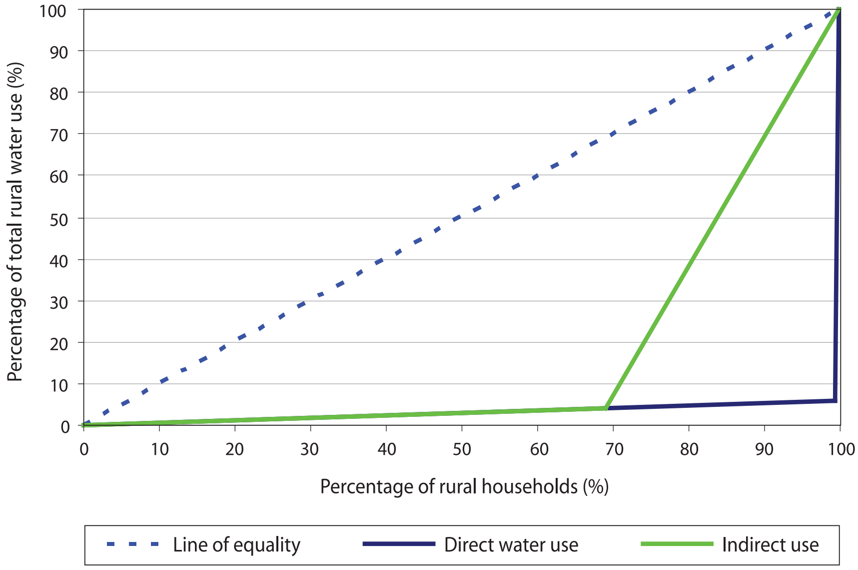
One way to achieve this is to assume that the benefit of the registered water use is shared evenly among all those who are employed directly as a result of that registered water use. Data on the number of people employed as a result of a registered water use are not readily available and is, unfortunately, not captured in the WARMS database. It is therefore necessary to make some assumptions based on average levels of employment in the WMA. A readily available source for this information is the National Population Census. Unfortunately, the industry sectors used in the Census do not distinguish between urban and non-urban industries or between dryland and irrigated agriculture. Therefore, only the total employment in mining and all areas of agriculture can be used to show how the water use Gini Coefficient can be adapted to measure the benefits of water use in addition to measuring inequality in terms of registered water use and direct use by rural households.

From the 2001 Census it was apparent that there are a total of 54,273 people employed in agriculture in the Olifants WMA and 33,345 employed in mining. As a result, the registered water use by these two sectors (1,276 Mm^3/a) is now taken as being representative of the benefit of water use to 87,618 households in terms of direct employment, in addition to the 1,672 registered users. This benefit will not be shared equally between all households, both, because incomes and benefits greatly vary within one sector and water sectors have different levels of efficiency in terms of the number and type of employment created per cubic meter of water used. Information on the relative efficiencies of different water users is however very difficult to obtain. Therefore, for the purpose of this example it has been assumed that all industries have equal levels of efficiency and as such the total amount of water authorized to these industries is shared evenly between all the people employed in these two sectors. The number of households that are dependant on the estimated rural water use for subsistence purposes (74 Mm^3/a) is now equal to the total number of rural households less the number of people employed in agriculture and mining[6], i.e., approximately 200,710 households. These assumptions enable us to make a rough plot of the distribution of the benefits of water use in terms of employment in the WMA[7] (Figure 5). The water use Gini Coefficient for the beneficial use of water in the rural areas is equal to 0.64, as opposed to 0.96 if only the direct water use is considered.

[6] This assumes that only one member of the household is employed and that their employment satisfies all the direct and indirect water needs of the household.

[7] The fact that the distribution of indirect water use becomes a straight line for the registered users is based on the assumption that each registered user has the same level of efficiency in terms of jobs per cubic meter of water used. This is not necessarily true, but at this stage there is insufficient data to record the relative efficiencies of the individual registered users in the WMA.

FIGURE 5.
Distribution of estimated direct and indirect rural water use: Olifants WMA.

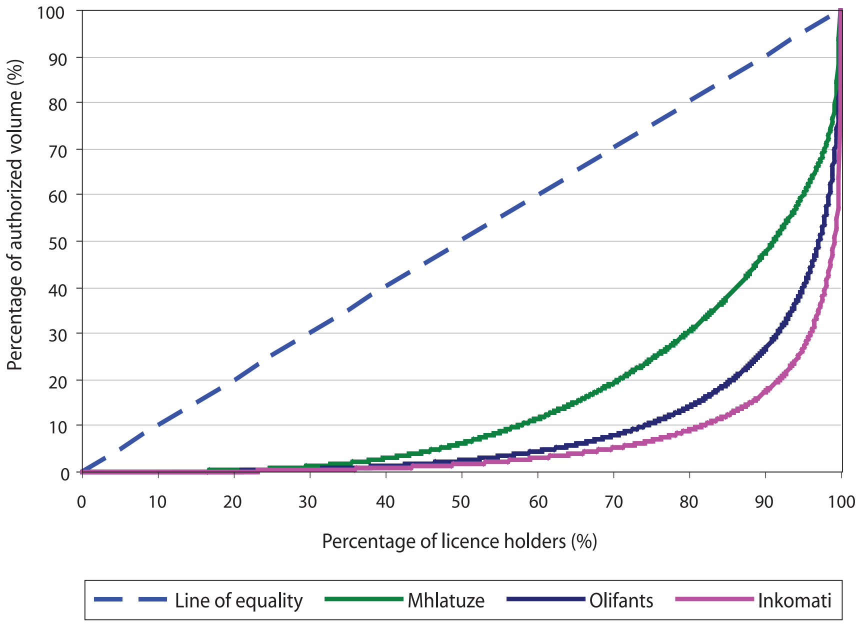


Using the Water Gini Coefficient to Compare Catchments

While the Gini Coefficient is a useful tool to measure the level of inequality in an area, it is most useful in comparing the inequality in one area with that of another area, or of the same area but at a different time. As an example, the water use Gini Coefficient for registered water use has been calculated for two other catchments in South Africa. Figure 6 shows the distribution of registered water use to all users and in all sectors for the Olifants, the Mhlatuze and the Inkomati catchments. The measured Gini Coefficients of the registered water use are 0.85, 0.75, and 0.90, respectively, for the three catchments.

From this it appears that the registered water use is much more equal in the Mhlatuze catchment. However, there are, on average, 438 households per registered user in this catchment while there are only 195 and 112 households per registered user in the Olifants and the Inkomati catchments, respectively. The conclusion from this is that while there is a relatively high degree of equality between the registered users in the catchment, the registered users are only a small portion of the total population, so there is a relatively high level of inequality overall. This highlights the need to include both registered and unregistered uses in calculations.

FIGURE 6.
Distribution of registered water use for three catchments in South Africa.



Using the Water Gini Coefficient to Test Policy Scenarios

One of the proposed uses of a water use Gini Coefficient is to consider the likely impact on inequality for a number of potential policy scenarios. To demonstrate this, two simple policy scenarios are tested for the Olifants WMA using the water use Gini Coefficient. The two scenarios tested are:

1. The revitalization of existing irrigation schemes.
2. The doubling of the amount of water made available to rural households without having to register their use.

Revitalization of Irrigation Schemes

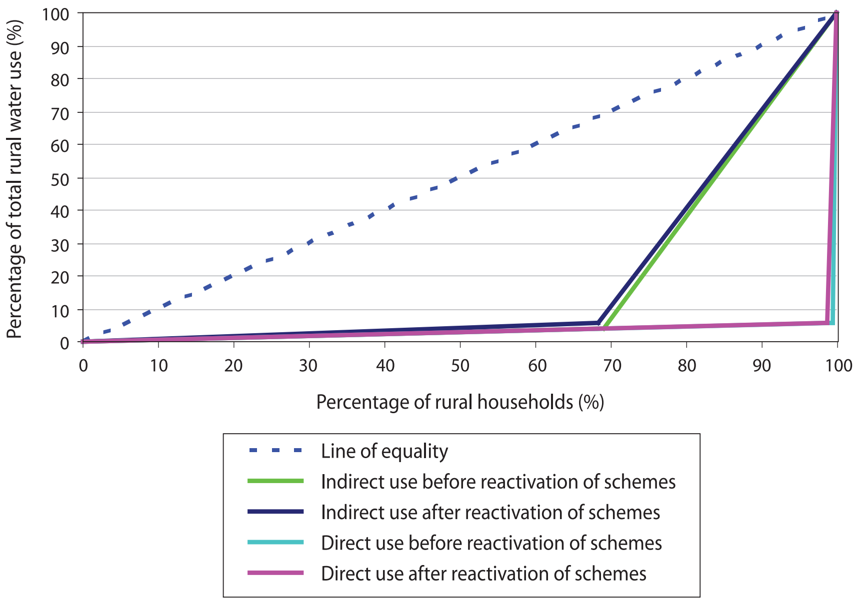
There are currently 68 small irrigation schemes registered in the Department of Land Affairs (DLA) Small Irrigation Scheme Database in the Olifants WMA. Of these schemes only 40 are currently active. The remaining 28 inactive schemes represent approximately 2,480 farms and have a total irrigation demand of 34.3 Mm^3/a. A possible policy scenario for addressing the inequality of water use in the WMA could be to make water available by reducing the allocations to the largest users and using this water to revitalize the inactive schemes to provide livelihood support for rural households and small-scale farmers[8].

To provide the water required to reactivate these irrigation schemes, the existing registered users of water for irrigation would have to reduce their current use by less than 3 percent or alternatively the ten largest users (who together account for 372 Mm^3/a) would have to reduce their existing use by 9.2 percent[9]. This assumes that there is no reduction in the employment by these large users. By making this water available to the households on the reactivated irrigation schemes, one would then increase the number of households that benefit directly from the water use by some 2,480 (i.e., one household per farm)[10]. This will alter the distribution of both the direct water use and the benefits of water use in terms of direct employment as shown in Figure 7. For this proposed policy, the water use Gini Coefficient reduces marginally form 0.94 to 0.93 for direct rural water use and from 0.64 to 0.63 for the benefits of water use in the form of direct employment.

Increasing the Amount of Water Made Available to Rural Households

Another possible policy scenario would be to increase the current allocation of water to rural households by increasing the amount that can be taken up under Schedule One, or alternatively through issuing a General Authorization[11]. This assumes that the rural households have the means to take up this additional allocation of

FIGURE 7.
Distribution of rural water use after reactivation of irrigation schemes.



[8] It must be noted that only three of the schemes rated poor water supply/climate as a limiting factor.

[9] The Olifants is, however, already considered to be over-allocated, and as such it is likely that the existing users will need to reduce their use by much more than this simply to correct the existing over-allocation even before additional water can be made available to reactivate the schemes.

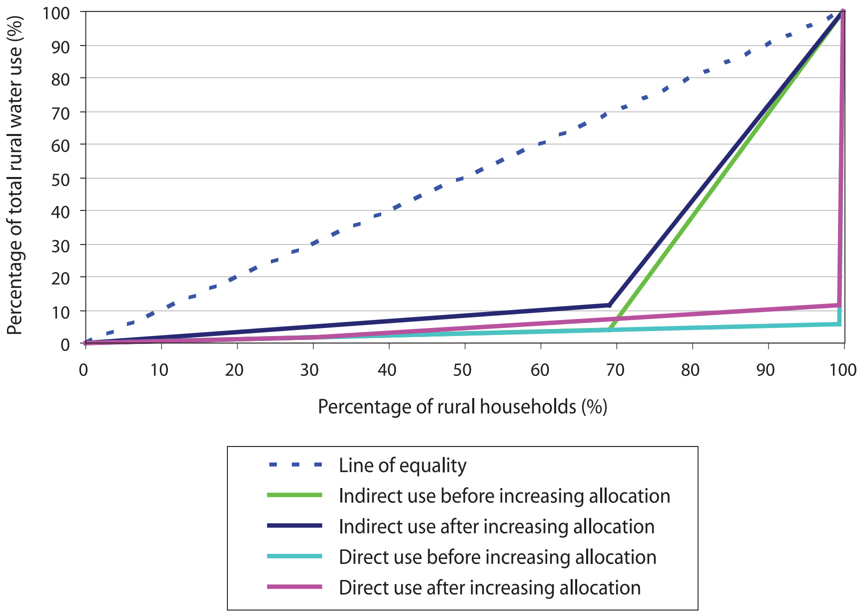
[10] If each of the new users are to be registered, this would require the processing of some 2,480 new licenses, while if allocated in the name of one water user association for each scheme, it would only require 28 new licenses to be issued, one for each irrigation scheme.

[11] General Authorizations are a mechanism whereby any user, or a certain category of user, may abstract or store a limited amount of water for productive purposes without having to apply for a license.

water. In the Olifants WMA the current estimated amount of water that is currently used by rural households under Schedule One is 74 Mm^3/a, which is equivalent to 255 m^3/hh/annum or roughly 116 l/c/d. If the allocation to unemployed households were to be increased to, say, 610 m^3/hh/annum, which would provide each household with 110 m^3/hh/annum for domestic purposes at 50 l/c/d as well as 500 m^3/hh/annum for productive use (which is the equivalent of 1,000 m^2 of irrigated land at an average irrigation demand of 500 millimeters per annum (mm/a)), an additional 71 Mm^3/a of water would have to be made available to unemployed rural households.

To make this additional water available, the existing registered users would have to reduce their current irrigation demand by 6 percent, or alternatively the ten largest users would have to reduce their current demand by 20 percent. Again, this assumes that there is no reduction in the employment by these large users. The potential impact on the distribution of direct water use and the benefits of water use in the rural areas is shown in Figure 8. The water use Gini Coefficient improves from 0.94 to 0.90 for direct rural water use and from 0.65 to 0.58 for the benefits of water use with regards to direct employment.

FIGURE 8.
Distribution of rural water use after increasing the allocation to unemployed households: Olifants WMA.



Conclusions

Summary of the Water Use Gini Coefficient

This report has introduced the possibility of applying the Gini Coefficient to measure inequality with regards to water use and the benefits of water use in a catchment. This report has outlined the importance of selecting the water use agent as well as the type of water use in plotting the distribution of water use in an area and calculating the associated water use Gini Coefficient. Two versions of a water use Gini Coefficient have been presented. The first measures the inequality in control of the resource in the form of estimated direct water use. This considers each registered user as a single water use agent under the control of a single household. For this measure of inequality, households without an authorized volume of water have control only over the water that they abstract directly from the resource. Currently there is no record of actual water use in South Africa and therefore the water use of both the registered large users and the rural household, that is necessary to calculate the water use Gini Coefficient, had to be estimated. This has been done by using the registered water use of the large users in the WARMS database and the estimated average rural water use component from the NWRS, which is based on the nature of the rural households and the need for subsistence and livestock farming. A second version of the water use Gini Coefficient measures the inequality of the benefits of water use in terms of direct employment. This measure distributes the benefits of the registered water use among those employed directly in the water-using sectors. At this stage no distinction is made for the relative efficiencies of the different registered users in terms of employment created per cubic meter of water used, as this data is not readily available.

Summary of the Results

It was found that the current allocation of water use entitlements in the Olifants Catchment is highly unequal with 95 percent of the available water being used through licenses that have been registered to only 1,706 (or 0.6%) individuals and companies, while over 99 percent of the rural households are entitled to use less than 5 percent of the available water. The resultant Gini Coefficient for direct water use is 0.96. The distribution of the indirect benefits of water use in the form of employment is much more equal with the allocations to agriculture and mining estimated to contribute to the employment of almost 90,000 individuals. The resultant Gini Coefficient for the indirect benefits of water use is 0.64.

Both versions of the water use Gini Coefficient have been used to demonstrate the potential for employing it to assess the impacts of possible policy scenarios such as reactivating unused irrigation schemes or increasing the water allocated to rural households through expanding the definition of Schedule One or issuing a General Authorization using the Olifants Catchment as a test case. It was found that revitalizing the existing irrigation schemes would only have a marginal influence on the overall Gini Coefficient for both direct and indirect water use. A greater impact could be achieved through increasing the allocation to rural households. An increase in the average allocation to rural households from 225 m^3/hh/annum to 610 m^3/hh/annum, which would enable each household to meet its basic human domestic needs and irrigate 1,000 m^2, would reduce the Gini Coefficients for direct water use and the indirect benefits of water use to 0.90 and 0.58, respectively. This would require the existing users to reduce their current water use entitlement by 6 percent or the ten largest users to reduce their current demand by 20 percent each, but this would have to be done without a reduction in the employment by these large users.

Potential for Measuring Equity

One of the key principles of the NWA is to ensure equity in terms of water use in South Africa. The water use Gini Coefficient does not measure equity, but has the potential to help us to measure this. In this regard it is important to remember that the water use Gini Coefficient is primarily a tool for comparing equality in the distribution of registered and unregistered water use entitlements, direct use, or the indirect benefits of water use. It is therefore important to interpret the significance of the Gini Coefficient in terms of the other characteristics of the catchment when looking to get an indication of the level of equity. These factors could include the level of employment in the catchment, the number of registered water users as a percentage of the total population, the available resources per household, and the land and income inequality. Other issues, which are particularly significant in South Africa, are the race and gender characteristics of the registered users and the beneficiaries of this use. These cannot be accounted for in the calculation of a water use Gini Coefficient.

What is a Good Water Use Gini Coefficient Value?

It is important to note that, as with the link between equality and equity, the decision over what constitutes a good water use Gini Coefficient is dependent on the specific characteristics of the catchment. In some catchments where there is plenty of water and a great demand for water for small-scale users, for example, for agriculture, one would want a relatively low Gini Coefficient (i.e., a more equal distribution of water use entitlements). In other, more urbanized and industrialized catchments it may be more desirable for the bulk of the water to be used by a few large users, such as large industries or water service providers. The latter is most likely to be the case in high-income countries where only a small proportion of the population is active in farming and where people are less dependent on direct water use to support their livelihoods. This would result in a high level of inequality of direct water use and a correspondingly high Gini Coefficient. A political decision would have to be made over whether the benefits can be spread more fairly through a few single large users that have many indirect beneficiaries in terms of making a significant contribution to income and employment in the catchment, or through a number of smaller users with a few indirect beneficiaries. Given the existing inequalities of water use in South Africa, there is significant political pressure to initially move towards the former more equal distribution of direct water use with the ultimate objective of achieving a more equal distribution of the benefits of water use in the long-term.

Equality and equity in terms of water use is often considered to be against the interests of maximizing the efficient use of water. This is an area that needs to be investigated further and by providing a quantitative measure, such as the water use Gini Coefficient, this may be possible. In addition, by taking into account the benefits of water use in terms of employment created, when developing a water use Gini Coefficient, it is possible to bridge this apparent divide between equity, equality and the efficient use of water in a catchment.

Recommendations

In sum, the study shows that there is potential to adapt the Gini Coefficient to measure inequality in actual water use as well as the benefits of water use, and use this as a tool towards achieving equity of water use in a catchment. It is, however, recommended to conduct more in-depth studies to develop this concept further and to address some of the issues raised in this report. Areas that require further focus include the gathering of data on actual water use by both registered users and unregistered rural households, gathering of data on the specific benefits of water use in terms of employment 'efficiency' (i.e., jobs per drop) or economic output (i.e., GDP per drop), developing a better understanding of the definition and practical meaning of equity with regards to water use in South Africa, and more catchment specific case studies to develop a better understanding of the link between inequality of water use, the benefits of water use, and equity under different catchment conditions. If these issues can be addressed then it is clear that the development of a water use Gini Coefficient can become a useful tool for ensuring equity, efficiency and the sustainable use of water.

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