# Spatial and Social Equity Index for Equity Based Resource Allocation

Arif WISMADI
ITC International Institute for Geo-Information Science and Earth Observation
Hengelosestraat 99
P.O. Box 6
7500 AA Enschede
The Netherlands
Fax: +31 (0)53 4874575
E-mail: wismadi@itc.nl

Prof. Dr. Ir. M.F.A.M. van Maarseveen
ITC International Institute for Geo-Information Science and Earth Observation
Hengelosestraat 99
P.O. Box 6
7500 AA Enschede
The Netherlands
Fax: +31 (0)53 4874575
E-mail: maarseveen@itc.nl

Mark BRUSSEL
Lecturer
ITC International Institute for Geo-Information Science and Earth Observation,
Hengelosestraat 99
P.O. Box 6
7500 AA Enschede
The Netherlands
Fax: +31 (0)53 4874575
E-mail: brussel@itc.nl

**Abstract:** Equity based resource allocation under budget-constrained schemes always deal with priority targeting. This mechanism requires the use of equity measurement as important input for the decision-making process. Available equity measures such as the Gini Index more focus on equality measurement, which also disregards spatial features. It is therefore insufficient to determine priority setting for spatially targeted intervention policies. This paper aims to propose a new equity-based resources allocation framework. To support this framework we developed formal GIS method for evaluating Spatial and Social Equity. We combined both measures of dispersion and measure of entropy as well as by taking into account geographic features of the location. In specific, the objective of this paper was to investigate the effect of spatial feature in preference modeling for resources allocation to the spatial equity and social equity. Given the possible target-based equity-oriented measures (goal, relative and absolute equity benchmarks), we developed several corresponding mathematical programming formulations for preference modeling. Sensitivity analysis of each formulation to spatial and social equity measures (poverty incident, intensity, prosperity, and equality) explains the effect of spatial features in preference modeling to the social and spatial equity.

***Key Words:*** *spatial equity, social equity, measurement, resources allocation*

## 1. INTRODUCTION

In 1968, a theory of social equity was developed and put forward as the “third pillar” for public administration, with same status as ‘economy’ and ‘efficiency’ as value or principles to which public administration should adhere (Frederickson, 1990). Social equity implies fair access to resources and livelihood. Social equity and government productivity are both concerned with the final output of public activities. Without criteria for measuring social equity, public official will be unable to use this criterion for decision-making.

Evaluating social equity of the distribution of public service may face infinite number of pattern (Chitwood, 1974). These patterns relate with the problem of allocating service among citizen differing in numerous characteristics, e.g., age, health, wealth, sex, geographic location, etc. By including social-economic groups and geographic locations, equity measurement should taken into account both ‘spatial equity’ (equitable distribution of services over regions) and ‘social equity’ (distribution of services over social-economic groups).

To implement the concept of equity, the accurate notion of “equity” is required to delimit implementation of the concept for practical context. Several notions such as equality, equity, justice, solidarity, and redistribution are possible to have linked concept, all of them relate to governmental interventionism. (Garcia-Valinas et. al, 2008) provided some practical definitions of those principles. The concept of “equality” means the absence of discrimination, segregation, or privileges among people. Therefore, everybody deserves the same treatment. In an economic perspective, it means that incomes would be shared in a homogenous way. Moreover, government would have to contribute to reduce the strong income differences.

The notion of ‘equity’ has come to replace the more radical notion of ‘equality’, which means something like ‘equality of individual opportunity’. In other word, ‘equity’ only entails a minimum ‘floor’, which ensures the same opportunities in the beginning, while the ‘equality’ would be a ‘floor’ as wall as a ‘ceiling’(Garcia-Valinas et. al, 2008). That is, in term of ‘equality’ not only poor people should be less poor but the rich ones should also be less rich. Our research focused on the ‘equity’ principle, however notion ‘equality’ will still also useful for explaining the equity issues. With the equity concept, the measurement includes properties of both, the groups ‘under’ and ‘above’ the ‘floor’. In poverty measurement, the ‘floor’ is known as ‘poverty line’.

Social equity implies fair access to resources and livelihood. Social equity also reflects a principle that each citizen regardless of economic statuses or personal traits deserves and has a right to be given fair treatment by the political system, giving special attention to the needs of weak and vulnerable populations (Chitwood, 1974). In the context of resource allocation, social equity refers to a bundle of rights and duties of government, collective, and/or individuals, which are applied to protect weak and vulnerable populations (e.g. poor group) in society (Cai, 2007). With the growing number of pro-poor programs and increasing attention to methodological development, beside inequality, many researchers have introduced other properties of poverty measurement such as poverty incidence and poverty intensity or severity. The ‘poverty incidence’ is one of the property measurements for the the group under the ‘floor’. It means proportion of people who lives under poverty lines-or below the ‘floor’. The poverty intensity or severity means how severe people who live under poverty line.

For evaluating social equity, the comparison includes more than two individuals or groups in the society. System of inequality measurement for only two individual is simple and effective with pair-wise comparison. However, the pair-wise comparison becomes nearly useless to measure the inequality across more than two units (Portnov and Felsenstein, 2005).

Max Lorenz already noticed the computational problems associated with multi-group comparison of income inequality in 1905. He formulated; to represent the actual inter-group income distribution as a ‘line’, plotting “along one axis cumulated percents of the population from poorest to richest, and along the other axis the percent of the total wealth held by these percents of the populations”. With an unequal distribution, the curves will always begin and end in the same points as with an equal distribution, but they will be bent in the middle; and the rule of interpretation will be, as the bow is bent, concentration [of incomes] increases

(Portnov and Felsenstein, 2005).

Furthermore, Corrado Gini moved Lorenz's ideas a step further, suggesting a simple and easy comprehensible measure of inequality known as the Gini coefficient. Mathematically, the Gini coefficient is calculated as the arithmetic average of the absolute value of differences between all pairs of incomes, divided by the average income. The coefficient takes on values between 0 and 1, with zero interpreted as perfect equality. Albeit it is widely used, inequality alone is not applicable in equity analysis, which requires a minimum line (e.g. poverty line) in the measurement.

Limitation of certain inequality-index pushes the development of other measurement such as Williamson index, Theil index, Atkinson index, Hoover and Coulter coefficients. In general a variety of additional inequality measurements may fall into two classes: "measures of dispersion" or "measures of entropy" (Portnov and Felsenstein, 2005). Measures of dispersion or defined as measures of variation by (Kluge 1999 in Portnov and Felsenstein, 2005) is calculated based on how far each element is from some measure of central tendency (average) (e.g. Coefficient of Variation, Williamson Index). While measures of entropy or defined as measure of deprivation by (Kluge 1999 in Portnov and Felsenstein, 2005) is a measure of the disorder of a system: a state of order (low entropy) to a state of maximum disorder (high entropy) (Conceição and Galbraith, 2000). It also means inequality is "order" and that equality is "disorder" (e.g. Gini Index, Atkinson Index, Theil Redundancy Index). In the case of Lorenz or Gini Index calculation, if each element has same value, it does not necessary to put every element in order (e.g. from the poorest to the richest) to do the calculation. With Gini index, this "disorder" distribution will result index of zero (0) or maximum equality. The graphical representation of the 'disorder' in Lorenz Curve is straight line. This illustration demonstrates that the measure of entropy can be analyzed with a graphical representation of curve, such as Gini Index with Lorenz Curve.

The graphical representation of a curve is one of the most common ways to evaluate the differences between distributional patterns. This graphical method, which employs curves analysis, enables us to compare distributional patterns. Comparison between two curves, so-called dominance analysis, helps us to evaluate and rank two distributional patterns in terms of the pro-poorness level. The development policy or program is pro-poor if the distribution of benefit mitigates inequalities and facilitates income and employment generation for the poor. As a graphical method, Lorenz Curve enables us to compare and rank two distribution patterns in term of level of inequality. With Lorenz curve, the straight curve indicates lower inequality that the bent one. In an evaluation of poverty alleviation program, those two curves might come from two set of policies applied in a region on different periods.

Beside 'inequality' measurement, for poverty alleviation program decision maker need other properties of poverty measurement (e.g. poverty incidence and intensity). To fulfill this need, a number of graphical methods has been developed, such as the TIP curve (Three Is of Poverty: Incidence, Intensity and Inequality) by (Jenkins and Lambret, 1999), CDF (Cumulative Distribution Function) Curve and Pen's Parade (Pen, 1971). With those methods, we can obtain values of not only 'equality' but also other properties of poverty measurement from a distribution pattern. Combination of properties helps us to evaluate comprehensively the changes of a distribution pattern due to poverty alleviation programs. Those current methods are useful to evaluate multi-properties measure of poverty. However none of those methods aims specifically for measuring properties derived from 'equity' concept.

With ‘equity’ as extended concept of ‘inequality’, the existence of ‘poverty line’ becomes substantial in the measurement. At the same time, the measurement should look into the changes of distribution pattern not only the group under poverty line but also the group above poverty line. However, since the current graphical methods are more focusing on poverty analysis, they overlook distribution pattern for the group above poverty line. On the other words, the existing method is insufficient to evaluate the impact of distribution to the non-poor groups.

In poverty alleviation program, if the evaluation indicates inequity, a targeted intervention policy is required. The target of intervention should take into account both social and spatial equity issues. The spatially targeted intervention policy is required to provide a fair access to resources and livelihood. As consequences, it is important to implement spatial equity measurement to determine priority setting. (de Smith et. al, 2007) implied the importance to include spatial feature for determining location for spatially targeted intervention policy. The power of location comes not from location itself, but from the linkages or relationships that it establishes — from relative positions rather than absolute ones. Topological properties, including adjacency, connectivity, and containment are some part of fundamental concepts in spatial analysis. Therefore, the analysis should take into account geographic feature of the location.

To set priority for targeted intervention, a preference modeling is required. However, although it is considered important to include spatial feature in a ‘preference modeling’ to determine priority, most of preference modeling disregards spatial feature in their formula.

With respect to provide proper resources allocation and addressing inequality issues, numbers of effort to measure spatial inequality have been done (Alesina and Angeletos, 2005, Omer, 2005, Tsai, 2005 and Druckman and Jackson, 2008). However, most of them implemented inequality measurement such us Gini Index without including spatial feature in the calculation.

Other approach for regional inequality measure is based on measures of dispersion. Williamson Index (WI), for example, is an index for regional inequality measure (Portnov and Felsenstein, 2005). WI implement population weighted coefficient of variation for dispersion measures, however it also does not include geographical or spatial feature in the formula.

Recent works have attempted to include Gini into spatial configuration evaluation. (Druckman and Jackson 2008) incorporated Gini coefficient in spatial context with AR-Gini (Area-based Resources Gini). The A-R Gini is possible to show inequalities in the resources usage of area and increase our understanding of area base inequalities. However, (Tsai, 2005) provided evidence of the limitation of Gini Index in spatial context. He discovered that the Gini is not sensitive to spatial forms, distributions, and configurations.

In spatial analysis field, there are spatial measurement index associated with multi-group comparison so called autocorrelation statistics such as Getis Index G*, Geary’s C, Moran’s Index I. The autocorrelation statistics produce one value (Global Index) indicating types (positive or negative) and degree (strong or weak) auto correlation. In cluster evaluation, Local Index for Spatial Autocorrelation (LISA) is able to indicate the character of spatial local autocorrelation (e.g. high-high: an object with high value surrounded by other objects with high values; as well as low-low, high-low, or low-low). The current formula of autocorrelation statistic is applicable to analyze spatial pattern, however it is not applicable to measure inequity (Tsai, 2005).

With respect on addressing social and spatial equity, based on the advantages and disadvantages of those methods, the purpose of this study was to establish a framework for equity-based resources allocation. In specific, the objective of this paper was to investigate the effect of spatial feature in preference modeling for resources allocation to the spatial equity and social equity.

We combined and expanded the approach for developing Spatial Autocorrelation (sensitive to spatial patterns) and Equity Measurements Index (sensitive to distribution patterns). This combination aims to produce Spatial Equity Index, which useful for determining priority for spatially targeted resources allocation. For developing this spatial equity index, non-spatial aspect of equity measurement (e.g. number of n, level of difference) were combined with spatial feature of geographic phenomena (e.g. location, shape, size, orientation). At the same time, we evaluated the impact of the resource allocation based on goal, relative and absolute equity benchmarks to the changes of social equity.

## 2. MATERIAL AND METHODS

### 2.1 Study Design

We applied preference modeling to set priority targeting for resources allocation. We set two groups of preference modeling to observe the effect of spatial feature in the model to the spatial equity and social equity. The first group was preference modeling with a preference criterion without take into account spatial feature. The second was preference modeling with a preference criterion that include spatial feature in the calculation.

#### 2.1.1. Preference modeling with-out spatial features

A preference criterion is a decision rule based on a difference of ranking between two objects. For comparing objects, we applied linear scale transformation methods to convert the original criterion scores into standardized scores. We used three of the most standardization procedure, those are maximum standardization, interval standardization and goal standardization.

Maximum standardization produces the scores with a linear function between 0 and the highest absolute score. For benefit effect, the absolute highest score is indicated with 1, for a cost effect the lowest score become 1. Following (Sharifi and Herwijnen , 2001) the formulas used for the maximum standardization are presented in Eq. 1 and Eq. 2. Maximum standardization is evidence when the criterion is measured on a ratio scale. The advantage of maximum standardization is that the standardization values are proportional to the original values. A possible disadvantage of maximum standardization is that small differences between the alternatives do not become clearly visible.

Benefit criteria: Eq.1

$$P = \frac{X}{X_{\max}}$$

Cost criteria: Eq.2

$$P = \frac{X_{\min} - X}{X_{\max}} + 1$$

Interval standardization produces the score that normalized with a linear function between absolute lowest score and highest score. In a benefit effect, the absolute highest score is indicated with a 1 and the absolute lowest with a 0. For cost effect, it is the other way around. Following (Sharifi and Herwijnen, 2001) the formulas used for the interval standardization are presented in Eq. 3 and Eq. 4. Interval standardization is evident when a relative scale is used. Depending on the situation, this can be an advantage when we want to exaggerate the differences, but it will be a disadvantage if the differences are only small and not significant.

Benefit criteria: Eq.3

$$P = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

Cost criteria: Eq.4

$$P = -\left( \frac{X - X_{\min}}{X_{\max} - X_{\min}} \right) + 1$$

Goal standardization is similar with interval standardization; however it assigns specific reference point to the highest and lowest values. The reference points are an ideal or goal value and a minimum value. It also defines the range of the values to standardize. A meaningful minimum value is often the score in the no action alternative, or the score of the worst possible alternative. Following (Sharifi and Herwijnen, 2001) the formulas used for the interval standardization are presented in Eq. 5 and Eq. 6. The advantage of this method is that the standardized value have a clear, real meaning independent of the alternatives evaluated.

Benefit criteria: Eq.5

$$P = \frac{X - G_{\min}}{G_{\max} - G_{\min}}$$

Cost criteria: Eq.6

$$P = -\left( \frac{X - G_{\min}}{G_{\max} - G_{\min}} \right) + 1$$

### 2.1.2. Preference modelling with spatial features

To include spatial feature in preference modelling, we extended Moran'I scatter plot formulation by means combining with linear scale transformation methods.

Moran's I can be interpreted as the correlation between variable, X, and the "spatial lag" of X formed by averaging all the values of X for the neighboring polygons. We can then draw a scatter diagram between these two variables (standardized by the standard deviation): **X** and $\mathbf{X_{lag}}$ (or w_X). In specific, we defined the local inequity as $\mathbf{X_{lag} - X}$. Furthermore, to obtain preference criteria we use this local inequity with linear scale transformation methods. Three of standardization procedures, those are maximum standardization; interval standardization and goal standardization were applied.

Goal standardization implies a constraint on location-allocation process. It means the allocation restricted only for the location under poverty line. With spatial lag calculation, we set local benchmark. It means the allocation restricted only for the location below average value of neighbouring units. The expected result was increasing spatial equity within neighbouring groups.

In our preference-modelling, we applied two types of criteria for standardization. For Non–Spatial Preference Modelling, since the input for calculation was actual value (raw data), we applied Cost Criteria to allow the preference for allocation goes to area with lower score. However, since the input for the Spatial Preference Modelling was the gap calculation ($\mathbf{X_{lag} - X}$), we applied Benefit Criteria. It means the allocation goes to the area with wider gap to the benchmark.

In sum, by including different types of preference modelling, standardization method and criteria, we executed six sets of simulation. Table 1 explains those simulations and its characteristics.

In the simulations, we allocated growth of 10% from total value in the initial step. We observed the distribution impact of this allocation to analyse the impact of distribution on both spatial equity and social equity.

**Table 1. Sets of Simulations**

| | SIM1: NSMax | SIM2: NSInt | SIM3: NSGoal | SIM4: QNMax | SIM5: QNInt | SIM6: QNGoal |
|---|---|---|---|---|---|---|
| Groups | Non–Spatial Preference Modelling | | | Spatial Preference Modelling | | |
| Linear scale transformation methods | Maximum | Interval | Goal: poverty line | Maximum | Interval | Goal: 0 |
| Input for Linear scale transformation | **X** | **X** | **X** | Standardized $\mathbf{X_{lag}} - \mathbf{X}$ | Standardized $\mathbf{X_{lag}} - \mathbf{X}$ | Standardized $\mathbf{X_{lag}} - \mathbf{X}$ |
| Location-Allocation Constraint | No location constraint, differences were minimized | No location constraint, differences were exaggerated | Allocation only in locations below poverty line | No location constraint, differences were minimized | No location constraint, differences were exaggerated | Allocation only in locations below average value of neighbouring polygon |
| Weighting | Population | Population | Population | Population | Population | Population |
| Benchmark | Global | Global | Poverty Line | Global (Exclude the area above poverty line) | Global (Include the area above poverty line) | Local |
| Type of Criteria for Standardization | Cost | Cost | Cost | Benefit | Benefit | Benefit |
| Type of Spatial Equity Index for resources allocation priority | Global Non-Spatial Equity Index | Global Non-Spatial Equity Index | Global Non-Spatial Equity Index | *Glocal* Spatial Equity Index | *Global* Spatial Equity Index | Local Spatial Equity Index |

## 2.2. Empirical Case Study

This paper deals with preliminary attempts to empirically testing equity-based resources allocation framework. Since we focused on equity measure which requires minimum poverty line in the evaluation, we applied term and approach of poverty measure for this empirical test.

In this study, we used non-income indicators, instead of income indicators. The non-income indicators are commonly used in poverty measurement with a capability approach (Sen, 1976). According to Sen's 'capability' approach, individuals are considered poor only if they lack the capability to achieve essential functioning. An individual may choose a poor diet in order to indulge some inessential personal weakness. However, if this individual has the capability to achieve the 'adequately nourished' functioning, s/he would not be considered poor. It is the capability that matters.

Deneulin (2008) presented Sen's capability approach for transport infrastructure and mobility in measuring poverty and justice. He provided example that the capability to move around in a particular society strongly depends upon the availability of transport infrastructures and its service. (Grosse et. al. 2008), also applied non-income indicator for pro-poor growth measure. Moreover, (Kakwani, 2008) promoted non-income indicators for pro-poor growth evaluation.

Utilizing the capability approach, we applied the level of mobility as a proxy for non-income indicator. The datasets from Special Province of Yogyakarta, Indonesia in 2005 were used. The study area consists of 439 villages as targets for resources allocation priority.

**2.3 Calculations**

To calculate mobility, the main sub-indicators available in the dataset were speed and transport cost. The speed is a proxy to represent the quality both infrastructure and service. The speed (KM/hrs) was calculated by dividing distance from the village center to facilities with travel time to facilities. The travel cost unit (Rp/KM) was calculated by dividing travel cost to facilities with distance to facilities. Type of facilities for the analysis were education, market, entertainment and administrative centers (Potdes codes: B5R1, B11AR2, B11AR1, B7BR1, B11AR2, and R902)

To determine poverty line, there are two possible approaches. First approach is based on average time available for traveling daily. Second approach is based on average ability to pay. In this research, we focused on mobility with time constraint for traveling, therefore the calculation only based on travel speed and average time for traveling.

Since the priority-targeting unit was the village, we applied poverty line on village level. Villages under poverty line were determined as deprived villages therefore it has high priority. On the other words, people who live in these villages have limited opportunity to mobility therefore should be prioritized.

To set poverty line, the average speed was 25 KM/hr and travel time was 1 hours per person per day. It means the distance of 25 KM was the poverty line for calculation. In the other words, people who were not able to travel above 25 KM due to speed constraint determined by availability of infrastructure and service, were categorized as poor. The assumption for 25 KM/hr was based on survey of expected speed on local road in mountainous area (TRB, 2004). We multiplied possible travel distance with number of household for each village and added up to obtain total number of opportunity to mobility in each village.

Figure 1 summarizes the calculation procedure from raw data into indicators of mobility.

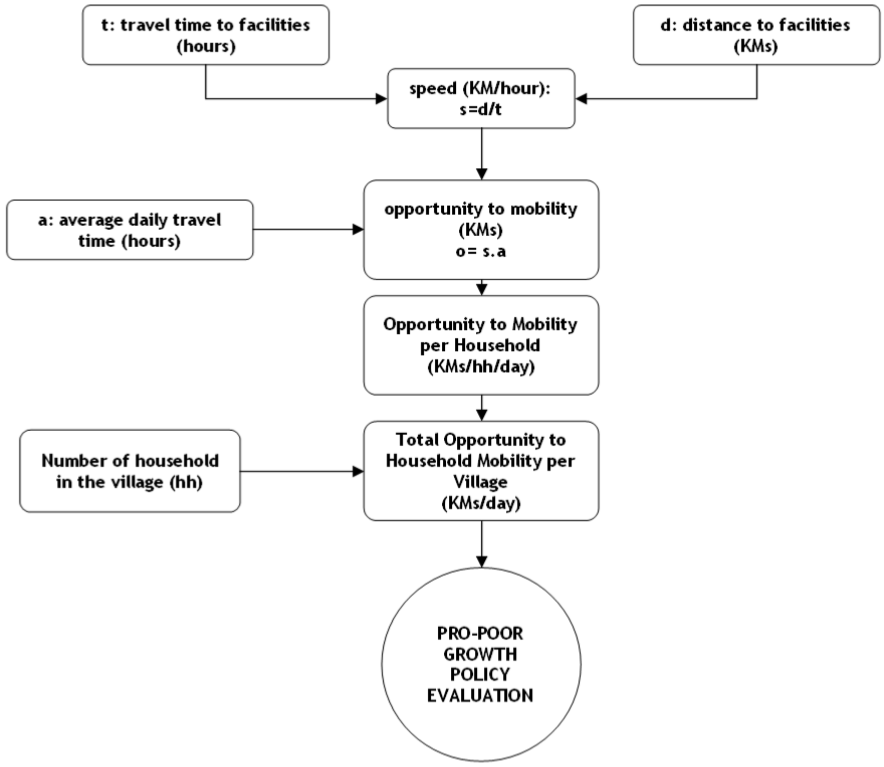


Figure 1 The calculation procedure from raw data into indicators of mobility

## 2.3 Data Analysis

### 2.3.1 Spatial Equity Analysis

To evaluate effect of both preferences modelling with and without spatial feature we applied spatial autocorrelation techniques by allowing exploration of possible spatial structural relationships and spatial equitable patterns of resources allocation. This technique is concerned with the degree to which objects at some place are similar to other objects located nearby. Since it deals simultaneously with both location and attribute information, it is in some situations a powerful, analytic technique (Tsou, 2005).

To implement spatial autocorrelation techniques we applied the existing Moran's I method. Moran's I is a product-moment coefficient analogous to the Pearson correlation coefficient and it is strongly affected by marked joint departures of neighbors from the mean of the studied variable.

The value of Moran's I is positive when nearby objects tend to be similar in attributes; a positive Moran's I suggests an equitable distribution, with Moran's I = 1 as the best equitable distribution. On the contrary, the value of Moran's I is negative when they tend to be more dissimilar than what is normally expected. With respect to spatial equity of a public facility, a negative Moran's I suggests an inequitable distribution, with Moran's I = -1 as the worst equitable distribution. Moran's I = 0 when attribute values are arranged randomly and independently in space (Tsou, 2005).

For each polygon, we calculated based on neighboring polygons with which it shares a border.

A measure were available for each polygon, we mapped to indicate how spatial autocorrelation varies over the study region. Moran's I is most commonly used for this purpose, and the localized version is often referred to as Anselin's LISA. LISA is a direct extension of the Moran Scatter plot, which is often viewed in conjunction with LISA maps

We applied Moran's to analyse the allocation priority as well as the changes of distribution patterns.

### 2.3.2. Social Equity Analysis

To evaluate effect of both preferences modeling with and without spatial feature on social equity we applied graphical method. The graphical method of poverty measurement is a common way to evaluate the distribution of income to the poor and to the rich. These methods apply graphical comparison of curves generated by certain distribution patterns. It useful to compare and rank the distribution patterns from different periods or policies.

Aforementioned, current graphical methods for social equity analysis such as Lorenz Curve, The Three I's of Poverty (TIP) Curve, Pen's Parade and Cumulative Distribution Function (CDF) do not satisfy the objective of this research. Lorenz curve has limitation since it only covers inequality analysis. The TIP, Pen's Parade, and CDF provide more properties of poverty measurement (e.g poverty incidence, severity, intensity etc.) however these methods more focus on poor-group analysis (Figure 2).

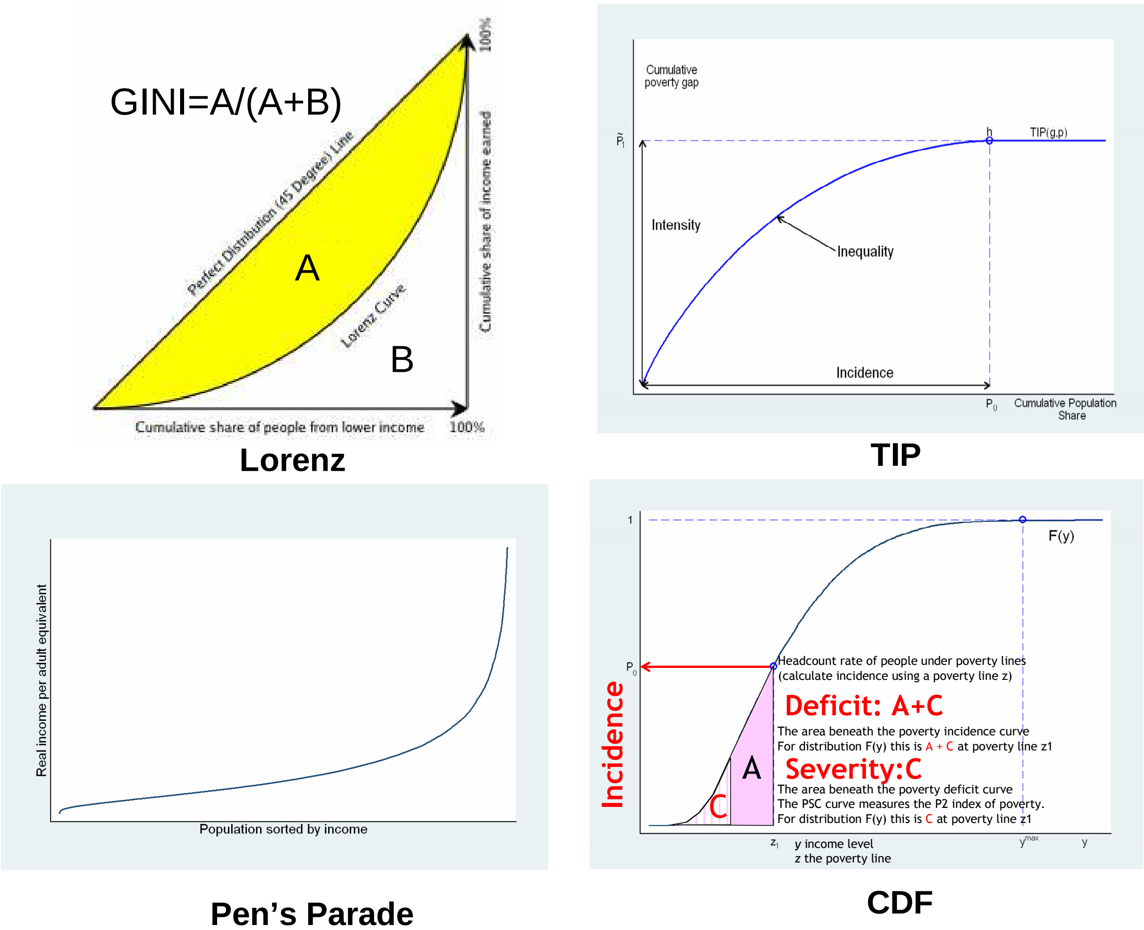


Figure 2. Existing Graphical Methods

The research aims to include non-poor group in the analysis. With the limitation of existing graphical method, we developed W-curve as new graphical method for social equity measurement. We proposed new properties for non-poor group analysis, namely *prosperity*. Therefore, the W-curve consists of poverty incidence, degree severity, degree of prosperity and inequality. Figure 3 explain the properties and its ranges of the values. For degree of severity and prosperity, an alternative measurement can be obtained by dividing value of y axis with x value where y is minimum, without converting it into degree (0 – 90)

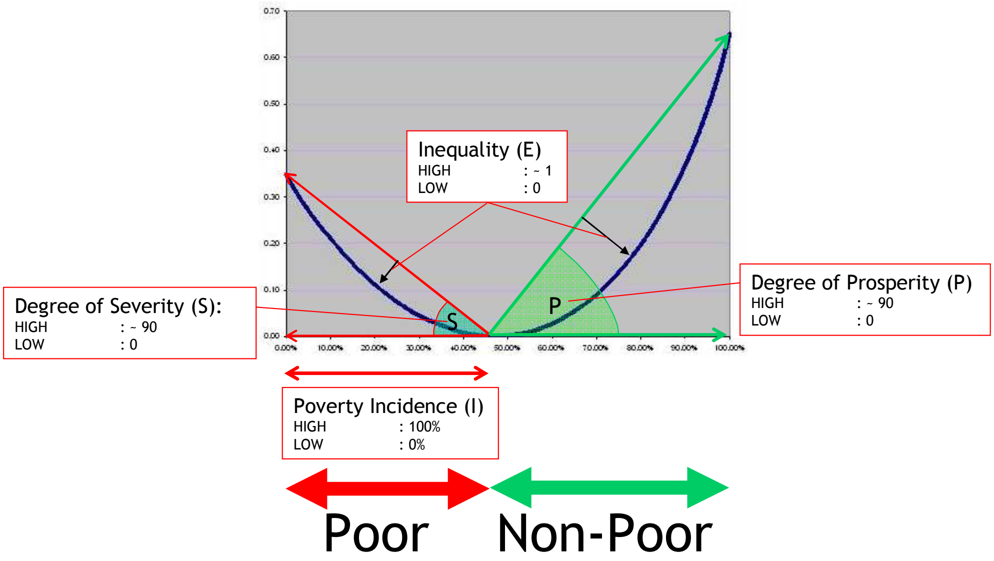


Figure 3. W-Curve

Poverty incident indicates proportion of target group under poverty line. Degree of severity and prosperity indicate the intensity of gap or surplus of poor and non-poor group with the reference of poverty line. Inequality indicates differences of surplus or gap between individual units.

Figure 4.explain the step-by-step procedure to build W-curve.

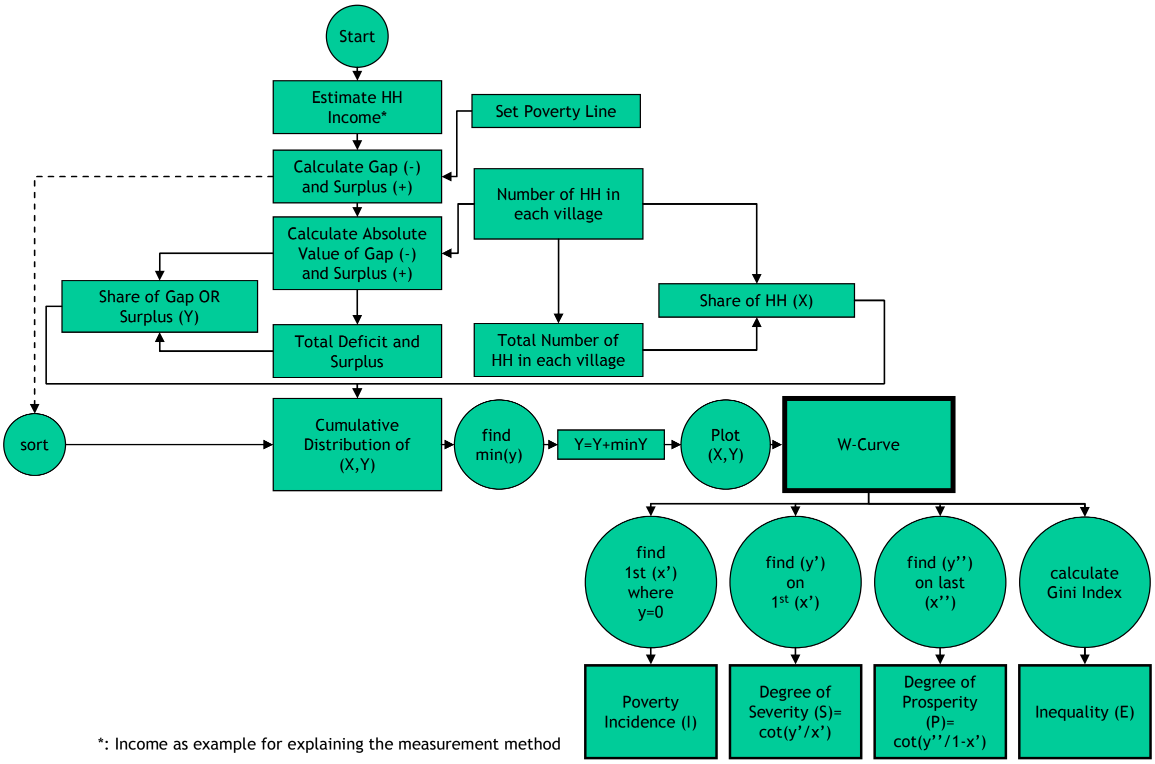


Figure 4. Step-by-step Procedure to build up W-Curve

# 3. RESULTS

## 3.1. Spatial Equity Analysis

We found some variation on spatial distribution impact in our simulations. With Moran's I we found in non-spatial preference modelling with maximum and interval standardization, no changes of Moran's on all simulations. The Moran'I on distribution of initial steps (before simulation: KECKAB), the score of priority allocation (NSMAX), as well as distribution after (NSINT) were identical with I=0.4218. However, with goal standardization we found Moran's I increase on the Allocation Priority (Figure 5 and 8) and decrease on the Distribution after allocation (Figure 5 and 6).

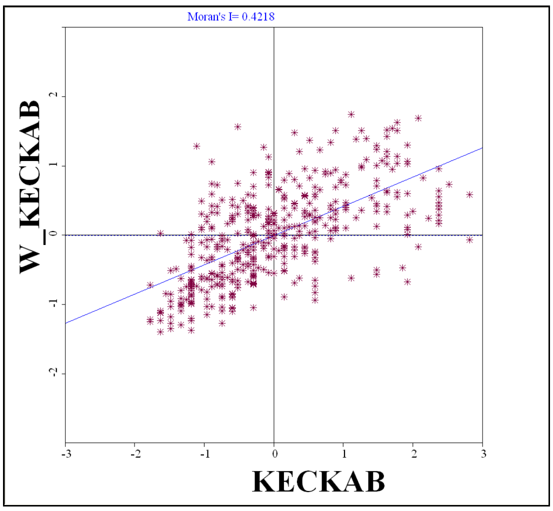

Figure 5. Initial Data before Simulation

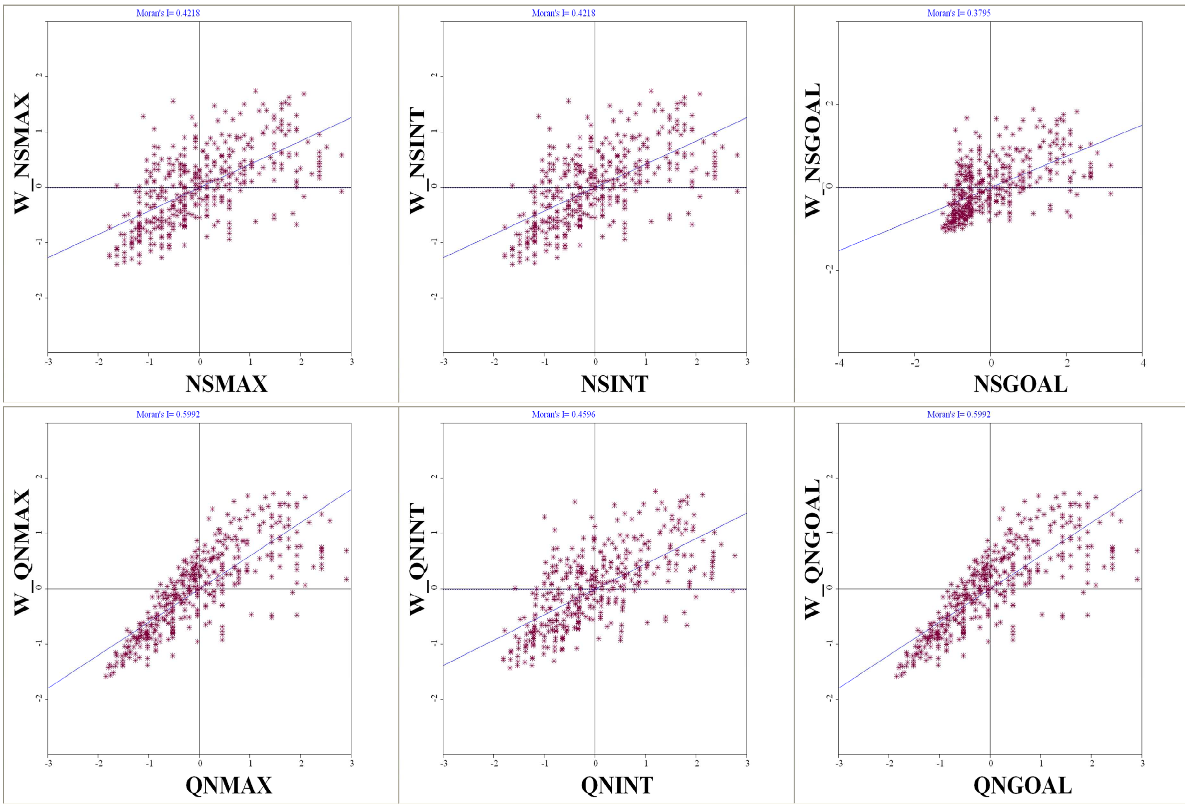


Figure 6. After Simulation

With spatial preference modelling, we found negative autocorrelation on allocation priorities for all standardization methods (PRQNMAX, PRNINT, and PRQNGOAL in Figure 7). The Moran's I also increased on the distribution after allocation. We also found that maximum and goal standardization produce identical Moran's I (PRQNMAX and PRQNGOAL in Figure 7).

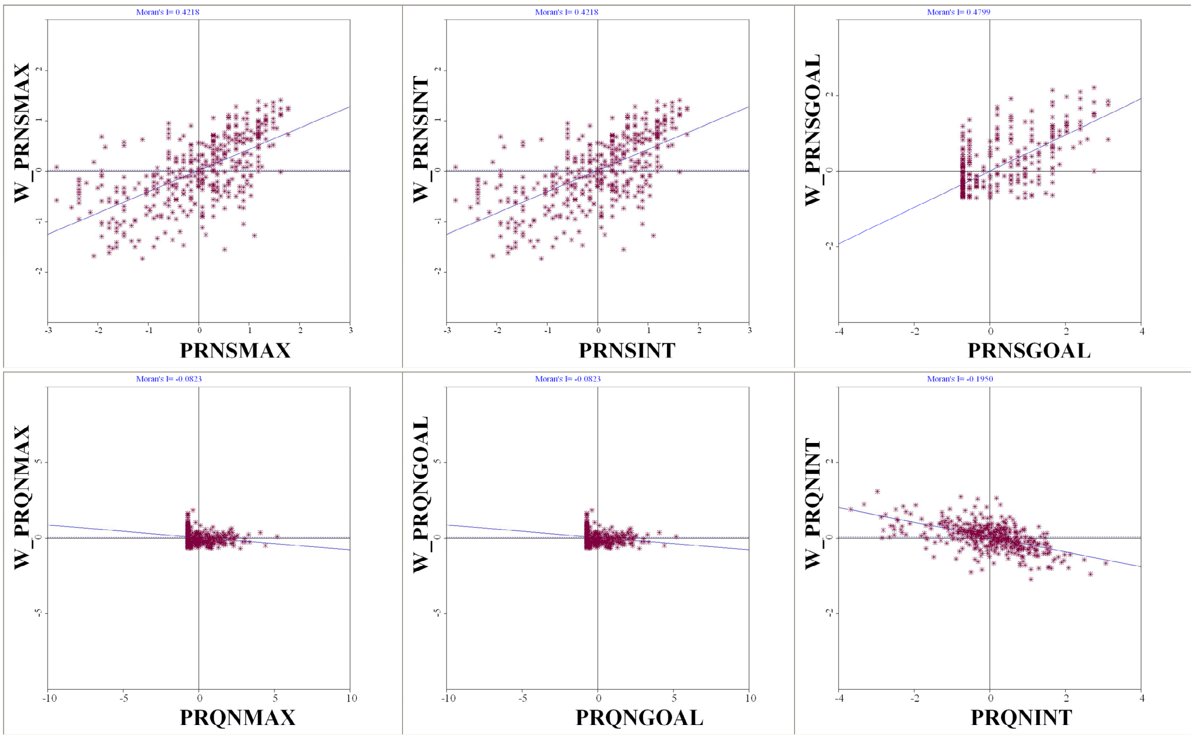


Figure 7. Distribution of allocation preferences in the simulation.

Figure 8 and 9 present the direct extension of the Moran Scatter plot which is viewed as LISA maps and the statistically significant relationship with its neighbors. These maps visualize clearly differences between Non-spatial and Spatial Preference Modelling.

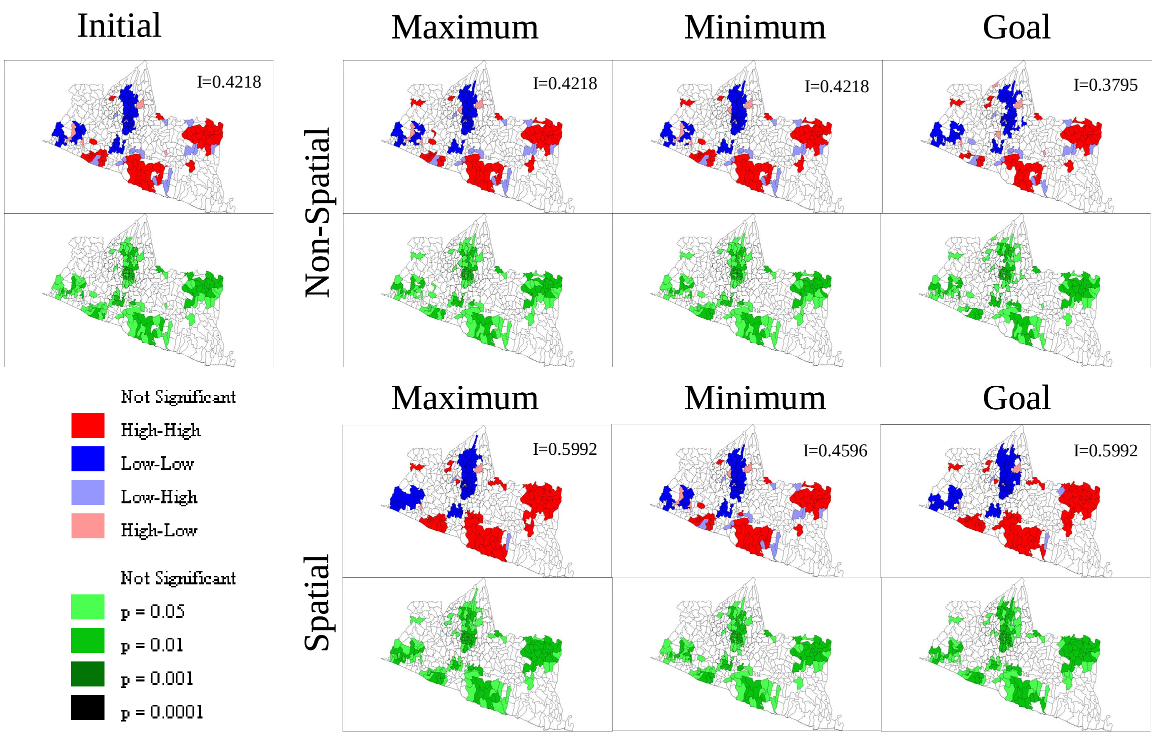


Figure 8 Before and After Simulation

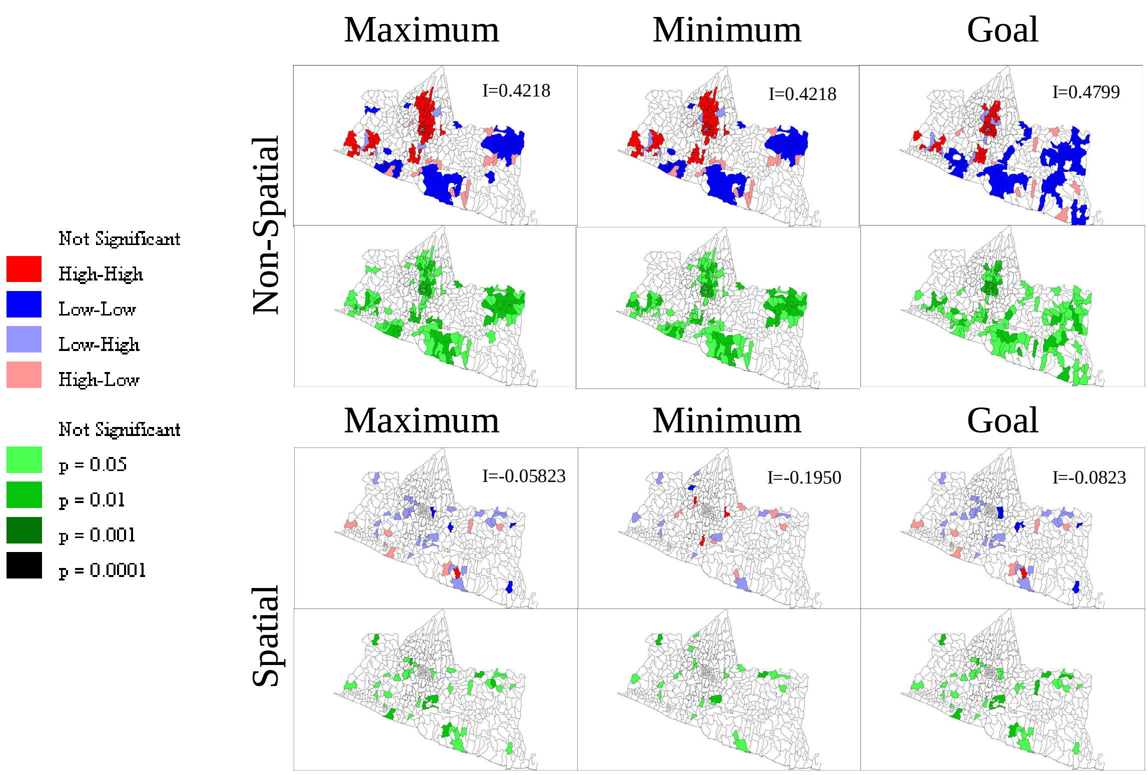


Figure 9 Distribution of Spatial Priority

We also found that spatial priorities of Spatial Preference Modelling were more dispersed than Non–Spatial Preference Modelling (Figure 10).

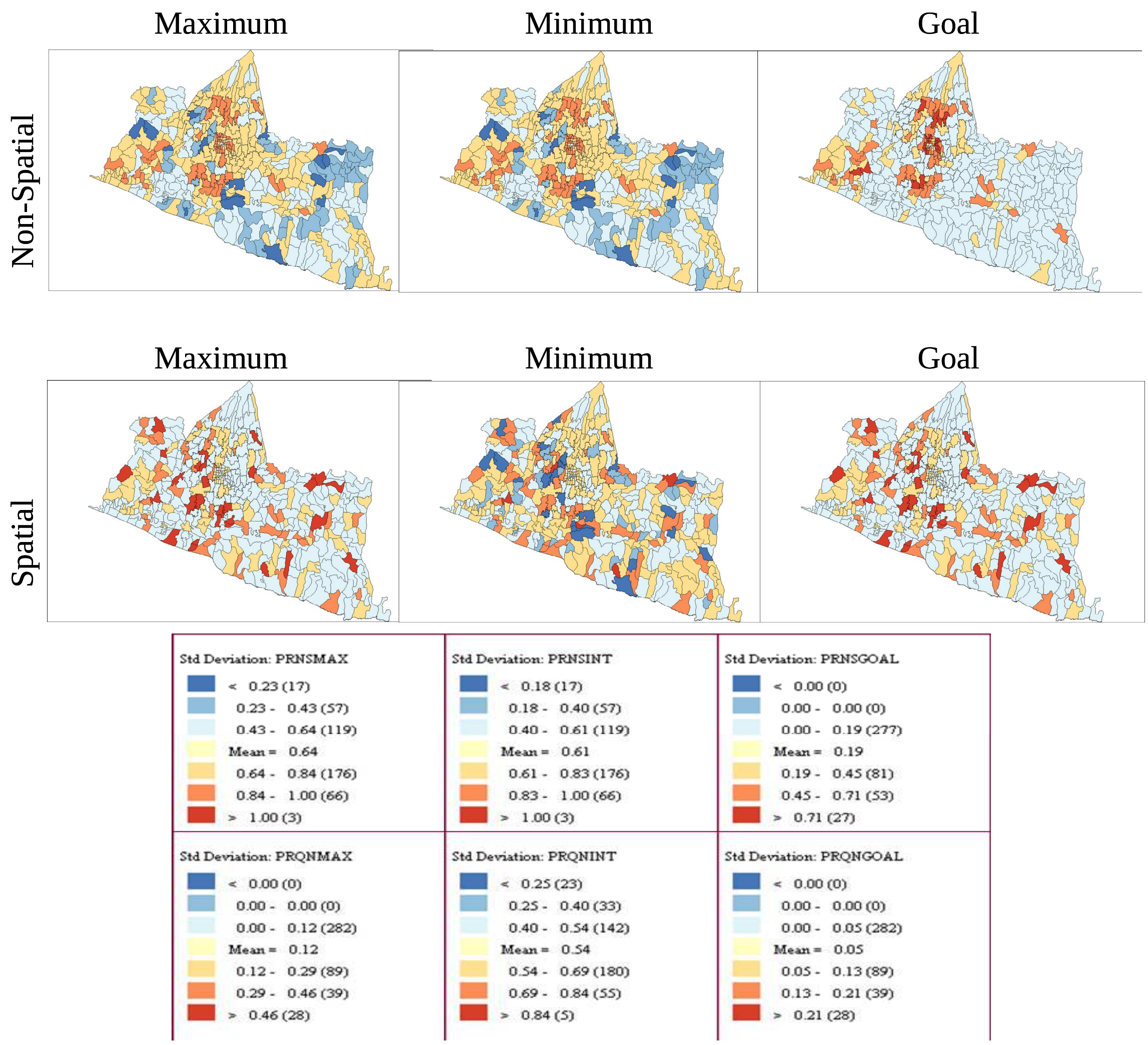


Figure 10. Distribution of Spatial Priority

### 3.2. Social Equity Analysis

We found each simulation produce different impact on the changes on distribution. As the consequences, poverty incidence, poverty severity, prosperity and inequality were also changed.

Figure 11 presents the result of W-Curve analysis. We found that all new simulations tend to shift the bottom of the curve to left side of the graphs. It means poverty incidences reduced. In general, poverty incidence were decreasing, except in simulation on Non-spatial with goal standardization. Poverty severities were also decreasing in all of simulations. Surprisingly, all simulation reduce the prosperity, except simulation on Non-spatial with goal standardization. On both of spatial and non-spatial simulation, we found inequality increased. Table 2 summarizes information from the graphs.

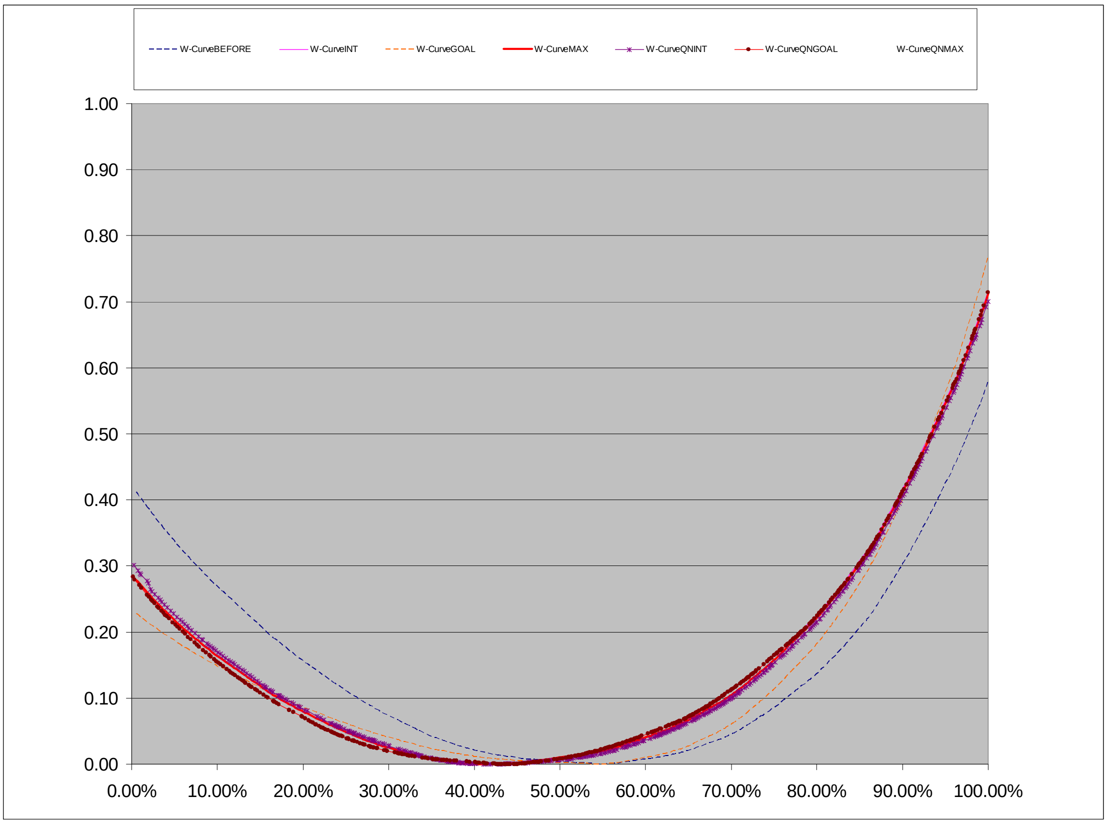


Figure 11. W-Curve results

Table 2 Result on Social Equity Analysis

| | **Before** | **Non Spatial Lag** | | | **Spatial Lag** | | |
|---|---|---|---|---|---|---|---|
| | | **NSMax** | **NSInt** | **NSGoal** | **QNMax** | **QNInt** | **QNGoal** |
| **Incidence** | 55% | 42% | 42% | 55% | 44% | 42% | 44% |
| **Severity** | 0.7487 | 0.6646 | 0.6615 | 0.4168 | 0.6438 | 0.7215 | 0.643754 |
| **Prosperity** | 1.2851 | 1.2296 | 1.2376 | 1.6913 | 1.2758 | 1.2034 | 1.2757 |
| **Inequality** | 0.396894 | 0.428828 | 0.42763 | 0.410402 | 0.428839 | 0.437359 | 0.428839 |

## 4. DISCUSSION

In this study, we propose new framework for equity-based resources allocation. Within this framework, we discover the effect of spatial feature in preference modelling for resources allocation to spatial equity and social equity.

We provide the evidence that by including spatial autocorrelation approach in Spatial Preference Modeling the spatial equity increase. All the simulations, which include spatial relationship, produce allocation priorities that equally distributed in the region. It is indicated by negative Moran’s I values. As the result the spatial equity of new distribution were increased as indicated by increasing Moran’s I value. At the same time, the spatial preference modeling also decreased the poverty incidence and poverty severity.

Surprisingly, almost all of the simulations reduce prosperity. Only Non-Spatial Preference Modeling with goal standardization increased the prosperity. Moreover, inequality also increased in all simulations.

The fact that Maximum and Interval Non-Spatial Preference Modeling will not change the value of Moran’I is in line with the previous finding by (Tsai, 2005). He investigated effect of different intensity with autocorrelation statistic. Our finding provide more useful conclusion that without including spatial feature, both allocation priority and new distribution will be identical with the spatial equity before allocation. On the other words, we should carefully use Moran’s I for spatial equity measurement. The use Moran’s I alone will not satisfy the conclusion on Spatial Equity but still useful to be integrated in a framework for equity measurement.

Result on Non-Spatial Preference Modelling with Goal Standardization was only simulation with highest impact in decreasing severity as well as increasing prosperity and producing lowest inequality. It is understandable since the goal standardization specifically aims to priority target group below poverty line. The fact that the poverty incidence remains same with the initial set (povety incidence =55%) strengthens this argument.

Result on Goal Standardization in Spatial Preference Modelling, which was the only simulation that does not producing the same effect in Non-Spatial Preference Modelling. There are possible reasons. First, the goal comes from Neighbourhood Benchmark. On the other words, the goal is average value within neighbourhood. Therefore, it does not directly addressing the group below poverty line. Second, the range (maximum and minimum) value applied in the Maximum standardization which comes from standardized value is closely with value applied in Goal standardization (0 as goal value). The value of 0 means the objectives were to get new value equal with average of neighboring polygon.

With this limitation, we suggest to perform Goal Standardization in Spatial Preference Modelling using original score instead of standardized value as presented in Moran’s Scatter Plot.

## ACKNOWLEDGEMENTS

The authors would like to thank all the partners of INDF (Indonesian Facility) Project. This publication is the part of research activities in the EVD funded project for establishing new Master of Science Program on Management Infrastructure and Community Development - MICD (http://pipm.pasca.ugm.ac.id). The project is a joint research activity between ITC the Netherlands, PUSTRAL UGM (The Center for Transport and Logistics Studies - Gadjah Mada University) Indonesia, and Keypoint Consultancy BV the Netherlands.

## REFERENCES

BPS. (1996) Potdes, BPS-Statistics Indonesia, Jakarta

BPS. (2000) Potdes, BPS-Statistics Indonesia, Jakarta

BPS. (2006) Potdes, BPS-Statistics Indonesia, Jakarta

Deneulin, Se´Verine. (2008) Beyond individual freedom and agency: structures of living together in the capability approach. In Comim F., Qizilbash M., and Alkire S., (eds) The Capability Approach Concepts, Measures and Applications, Cambridge University Press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Grosse M., Harttgen K., and Klasen S. (2008) Measuring Pro-Poor Growth in Non-Income Dimensions, **World Development Vol. 36, No. 6**, pp. 1021–1047

Jenkins, S. P., and Lambert, P. J. (1997) Three 'I's of Poverty Curves, with an Analysis of UK Poverty Trends, **Oxford Economic Papers, New Series, Vol. 49, No. 3 (Jul., 1997)**, pp. 317-327.

Kakwani N. (2008), Introduction: Multidimensional Poverty Analysis: Conceptual Issues, Empirical Illustrations and Policy Implications, **World Development Vol. 36, No. 6**, pp. 987–991

Portnov B., and Felsenstein D. (2005) Measures of Regional Inequality for Small Countries, pp. 47-62 in Felsenstein D. and Portnov B. (eds) Regional Disparities in Small Countries, Springer, Heidelberg.

Ravallion M. (2004) Pro-Poor Growth: A Primer, World Bank Policy Research Working Paper 3242, March 2004

Sen, A. K. (1976) "Poverty: An Ordinal Approach to Measurement," **Econometrica, Econometric Society**, vol. 44(2), pages 219-31

Slinko I. (2003) The Impact of Fiscal Decentralization on the Budget Revenue Inequality among Municipalities and Growth of Russian, EERC Working Paper Series, EERC Research Network, Russia and CIS, Moscow

Son H., Kakwani N. (2008), Global Estimates of Pro-Poor Growth, **World Development Vol. 36, No. 6**, pp. 1048–1066.

TRB. (2004) Design Speed, Operating Speed, and Posted Speed Practices, TRB's National Cooperative Highway Research Program (NCHRP) Report 504, Transportation Research Board of The National Academies

UNDP. (2008) Malaysia measuring and monitoring poverty and inequality, United Nations Development Programme (UNDP), Malaysia.

World Bank. (2006) World Development Report 2006: Equity and Development, The International Bank for Reconstruction and Development / The World Bank, Washington, D.C.

World Bank. (2008) World Development Report 2008 - Agriculture for Development, The International Bank for Reconstruction and Development / The World Bank, Washington,

D.C.
Frederickson, H.G. (1990), "Public administration and social equity", **Public Administration Review**, **Vol. 50** No.2
Chitwood,S.R. (1974) Social Equity and Social Service Productivity. **Public Administration Review 34** (1), 29-35.
Cai X. (2008), Water stress, water transfer and social equity in Northern China—Implications for policy reforms, **Journal of Environmental Management 87** (2008) 14–25
Goodchild M, Longley P (2007), Geospatial Analysis - a comprehensive guide. 2nd edition © 2006-2008
Omer,I. (2006) Evaluating accessibility using house-level data: A spatial equity perspective. Computers, **Environment and Urban Systems 30 (3)**, 254-274.

Alesina A, Angeletos G (2005), Fairness and Redistribution, The American Economic Review, Vol. 95, No. 4, (Sep., 2005), pp. 960-980, American Economic Association
BPS. (1996) Potdes, BPS-Statistics Indonesia, Jakarta
BPS. (2000) Potdes, BPS-Statistics Indonesia, Jakarta
BPS. (2006) Potdes, BPS-Statistics Indonesia, Jakarta
Cai X. (2008), Water stress, water transfer and social equity in Northern China—Implications for policy reforms, **Journal of Environmental Management 87 (2008)** 14–25
Chitwood,S.R. (1974) Social Equity and Social Service Productivity. **Public Administration Review 34 (1)**, 29-35.
Conceição, P., Galbraith, J. K. (2000), "Constructing Long and Dense Time-Series of Inequality Using the Theil Index," Eastern Economic Journal, 26(1): 61-74.
Deneulin, Se´Verine. (2008) Beyond individual freedom and agency: structures of living together in the capability approach. In Comim F., Qizilbash M., and Alkire S., (eds) The Capability Approach Concepts, Measures and Applications, Cambridge University Press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo
Druckman, A. and T. Jackson (2008). "Measuring resource inequalities: development and application of an area-based Gini coefficient." Ecological Economics, 65(2): 242-252.
Frederickson, H.G. (1990), "Public administration and social equity", **Public Administration Review, Vol. 50 No.2**
Garcia-Valinas M.A., Llera R.F., Targler B., 2005, More Income Equality or Not? An Empirical Analyisis of Individuals Preferences, Working Paper No. 2005-23, Center for Research in Economics, Management and the Arts (CREMA), Basel
Goodchild M, Longley P (2007), Geospatial Analysis - a comprehensive guide. 2nd edition © 2006-2008
Grosse M., Harttgen K., and Klasen S. (2008) Measuring Pro-Poor Growth in Non-Income Dimensions, **World Development Vol. 36, No. 6**, pp. 1021–1047
Jenkins, S. P., and Lambert, P. J. (1997) Three 'I's of Poverty Curves, with an Analysis of UK Poverty Trends, **Oxford Economic Papers, New Series, Vol. 49, No. 3 (Jul., 1997)**, pp. 317-327.
Kakwani N. (2008), Introduction: Multidimensional Poverty Analysis: Conceptual Issues, Empirical Illustrations and Policy Implications, **World Development Vol. 36, No. 6**, pp. 987–991
Omer,I. (2006) Evaluating accessibility using house-level data: A spatial equity perspective. **Computers, Environment and Urban Systems 30 (3)**, 254-274.

Portnov B., and Felsenstein D. (2005) Measures of Regional Inequality for Small Countries, pp. 47-62 in Felsenstein D. and Portnov B. (eds) Regional Disparities in Small Countries, Springer, Heidelberg.

Ravallion M. (2004) Pro-Poor Growth: A Primer, World Bank Policy Research Working Paper 3242, March 2004

Sen, A. K. (1976) "Poverty: An Ordinal Approach to Measurement," **Econometrica, Econometric Society**, vol. 44(2), pages 219-31

Sharifi, A. and M. van Herwijnen, 2001. Spatial Decision Support Systems. International Institute for Geoinformation Science and Earth Observation (ITC) Enschede

Slinko I. (2003) The Impact of Fiscal Decentralization on the Budget Revenue Inequality among Municipalities and Growth of Russian, EERC Working Paper Series, EERC Research Network, Russia and CIS, Moscow

Son H., Kakwani N. (2008), Global Estimates of Pro-Poor Growth, **World Development Vol. 36, No. 6**, pp. 1048–1066.

TRB. (2004) Design Speed, Operating Speed, and Posted Speed Practices, TRB’s National Cooperative Highway Research Program (NCHRP) Report 504, Transportation Research Board of The National Academies

Tsai, YH, 2005, Quantifying Urban Form: Compactness versus 'Sprawl', Urban Study, 42: 141-161

Tsou K.W., Hung Y.T., Chang Y.L, 2005, An accessibility-based integrated measure of relative spatial equity in urban public facilities, Cities, Vol. 22, No. 6, p. 424–435, 2005

UNDP. (2008) Malaysia measuring and monitoring poverty and inequality, United Nations Development Programme (UNDP), Malaysia.

World Bank. (2006) World Development Report 2006: Equity and Development, The International Bank for Reconstruction and Development / The World Bank, Washington, D.C.

World Bank. (2008) World Development Report 2008 - Agriculture for Development, The International Bank for Reconstruction and Development / The World Bank, Washington, D.C.