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# Water and Poverty in Rural China: Developing an Instrument to Assess the Multiple Dimensions of Water and Poverty

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**Abstract**

This paper describes the theoretical foundations and development of a multidimensional, water-focused, thematic indicator of rural poverty: The Water, Economy, Investment and Learning Assessment Indicator (WEILAI). The WEILAI approach was specifically designed for application in rural China, to support poverty alleviation project planning, monitoring and evaluation, as well as targeting and prioritization. WEILAI builds primarily on the basic needs framework of poverty alleviation (Hicks and Streeten, 1979, Streeten et al., 1981, Hicks, 1979), and on the methodological structure of the Water Poverty Index (Sullivan, 2002), to provide a proxy measure of an area's poverty, by assessing eight key poverty sectors, with a strong focus on the components of water-poverty. The WEILAI approach was piloted and implemented in 534 households in China's mountainous southwest. This paper describes the indicator construction, weighting schemes, methodology, field sites, and statistical validation of the results. In addition, we discuss feedback from in-country project staff, and the likely utility of the tool for project planning, monitoring and evaluation support. The paper concludes with a discussion of WEILAI's overall utility and ongoing development.

**Keywords:** Asia, China, indicators, rural poverty, water, assessment.

# 1. INTRODUCTION

This article introduces the Water, Economy, Investment, Learning and Assessment Indicator (WEILAI) a new tool developed for multidimensional poverty assessment in rural China. Weilai (未来) means "future" in Mandarin, illustrating how the tool has been designed specifically in this instance for application in rural China. This initiative was largely demand-based, as monitoring and evaluation (M&E) for most poverty alleviation projects remains inadequate - especially in the eyes of donors. With regard to poverty reduction, it is crucial that a given project can be evaluated, both against itself and other projects. This is critical not only for the project at hand, but for the continuous process of iterative improvement which is central to the project cycle and rural poverty-reduction generally. At present, M&E tools are too reliant on quantitative measurement and generally limited in scope (often based on a few, economically-oriented, or consumption-oriented, indicators).

Project monitoring and evaluation are fundamental to poverty alleviation efforts since donors, planners, governments and beneficiaries alike want objective data which testify to a given project's performance. WEILAI is designed to support planning, monitoring, reporting and evaluation at the project level in rural China, so that all parties involved have a readily understandable, standardized, visual tool with which to examine key dimensions, and to enable comparisons between projects or areas. WEILAI quickly reveals which sectors may be most in need of further investment, and therefore can also be used for targeting and prioritization.

Specifically, WEILAI is a thematic indicator, a collection of composite indicators, or components, presented together, but not aggregated together. There are eight components, the: Water Resources Component (1WR), Water Access Component (2WA), Water Resource Management Capacity Component (3WRMC), Sanitation Component (4S), Education Component (5E), Health & Hygiene Component (6HH), Food Security Component (7FS) and the Environment Component (8E). Each of WEILAI's eight components, is based on three (to five) subcomponents which are in turn derived from multiple sources of data. WEILAI can be calculated before project implementation (project planning), for baseline surveys, and also for midterm review (project monitoring), or for project completion reports (project evaluation). The intervals between implementations (suggested at about three to four years) allow for the measurement of temporal processes in action across all eight components. While WEILAI is a highly useful tool, it, like all indicators, provides only a proxy measure of reality and has a number of limitations. Thus, any policy decisions, planning or interventions based on WEILAI should be complemented by additional in-depth examinations of the data upon which WEILAI is based to ensure that context specificity is properly taken into account.

In this paper, the theoretical foundations for WEILAI's construction and the justification for its usefulness are discussed followed by a discussion of rural poverty in China, the research field sites, and a detailed account of the methodology used to develop the WEILAI questionnaire, administer the survey and collect data in the field. The analysis and computation of the data collected and a variety of statistical tests and frameworks for validating WEILAI's structure and calculation are addressed, followed by an examination of what this initial iteration of WEILAI reveals about the tool itself, the field sites and the dangers of using WEILAI (or any indicator) incorrectly. The paper closes with a discussion of future directions for WEILAI and ongoing research to refine and upscale the methodology.

## 2. WATER, RURAL POVERTY, BASIC NEEDS AND WEILAI

In most areas of the world, water is central to poverty, and thus its provision is central to poverty alleviation, which is why this paper begins with a brief discussion of how water and poverty are interconnected. As water demand increases globally and competition among water users shifts to new modalities, water-scarcity continues to negatively affect the rural poor (Hanjra et al., 2009, UN/WWAP, 2009), a problem which will be exacerbated by changes to the frequency and duration of precipitation brought on by climate change (Sullivan and Meigh, 2005). In spite of efforts to control population growth, increasing demand from cities, peri-urban areas, as well as rural industry, compound the problem as multiple users, inside and outside the rural domain compete over water (Cleveringa et al., 2009, Showers, 2002). There exists a mass of literature which examines the interlinkages between water and poverty , yet little of this work focuses the discussion through a pro-rural-poor lens (an exception is the recent work of Cleveringa et al., 2009). The main reason for this is the complexity of the problem.

Water-scarcity cannot be measured by examining physical water reserves or inflows/outflows, abstraction/recharge balances alone, since it is the qualitative, socioeconomic and political factors which in fact have the greatest impact on water-scarcity in most places (UN/WWAP, 2003). Indeed, the socioeconomic impacts are likely to become increasingly important as the effects of climate change on water resources become more severe (Vörösmarty et al., 2000). To measure water-poverty, one must look beyond the availability of the physical resource itself and examine how water is used, managed and shared (see: Sullivan, 2002). These quick observations serve to highlight the role of water as a factor influencing poverty. Hence, to better understand poverty alleviation strategies, the basic needs of the poor must also be investigated. Determining what these needs are, and where the shortfalls lie, inevitably requires measurement.

Most measures of poverty are still based primarily on assessments of income which can be highly problematic, especially in a rural context since the rural poor's incomes are so notoriously difficult to measure in monetary terms. Moreover, measuring changes to income alone cannot provide an adequate indication of development progress (Hicks and Streeten, 1979, Streeten et al., 1981, Hicks, 1979, Sen, 2000). Income-based measures of poverty can also mask local-level poverty disparities, and do not reflect the multidimensional nature of poverty itself (Bourguignon and Chakravarty, 2003).

While much of this discussion on the multiple dimensions of poverty can relate to the characteristics of urban and rural poverty, this research focuses solely on rural poverty. With regard to less developed nations, poverty can be simply defined as a situation in which human beings basic needs are not being met. The basic needs approach holds that poverty is best reduced when the basic needs of the poor are addressed (Streeten et al., 1981, Hicks and Streeten, 1979, Hicks, 1979) which, much like the concept of a using a multidimensional method for measuring poverty, suggests that focusing solely on increasing income is not alone sufficient for long-term poverty reduction. The basic needs perspective focuses on the poor's essential needs, most obviously: food, water, sanitation, health/healthcare, shelter and education (Streeten et al., 1981, Hicks and Streeten, 1979, Hicks, 1979).

WEILAI builds largely on the basic needs framework, as well as Sen's (1984, Sen, 2000) entitlements work, to address some of the fundamental characteristics of rural poverty. Moreover, because water is central to rural livelihoods, poverty and poverty alleviation, and crosscuts all of the Millennium Development Goals, WEILAI measures the key elements of water-poverty, after Sullivan's (2002) Water Poverty Index (WPI). Theoretical framework of the WPI (Sullivan, 2002) is founded largely on the entitlements approach of Sen, and the sustainable livelihoods analytical framework of Scoones (1998)and is based on a Multicriteria framework as used in the Human Development Index. This focuses on people's access to livelihood assets (natural resources and social support systems), and suggests that the poor can be empowered by helping to enhance their capacity to utilize the resources available to them, while improving access to those assets (IFAD, 2001, Sen, 2000, Sen, 1984). "To redress any kind of poverty, access to these capital types must be redistributed more equitably" (Sullivan et al., 2003, p.193), and beneficiaries capacity to use them productively must be enhanced (especially the case where and when water resources are scarce).

WEILAI's eight components attempt to simplify the complexity inherent in rural poverty while keeping water, which is central to both poverty and poverty alleviation, in focus. The theoretical understanding of water-poverty, poverty and poverty alleviation outlined above, in combination with the context for which WEILAI is designed (rural China), together provide the justification for the selection of WEILAI's components and their subcomponents. The following list provides a brief explanation and rationale for each of WEILAI's subcomponents, illustrated in Table 3 **1WR**: This component evaluates the water supply from the HH's primary water source which they use for domestic and limited agricultural use (that is, close to the HH). 1WR provides an indirect measure of the probable reliability of water supply and water quality the HH uses, as well as a rough gauge of whether water quality is improving or worsening.

**2WA:** Even if water is available, and even in great supply, this alone does not ensure that access to that water is equitable. Throughout the less developed world, women and minorities often suffer the most from a lack of equitable access to water. 2WA measures the average HH's access to water resources by measuring the time needed to collect water, which in turn is largely a function of the distance to the water source and the time spent collecting it. HH wealth is also assessed because it can provide a buffer to temporary water-stress.

**3WRMC:** This component complements 1WR and 2WA by gauging the capacity of HHs to effectively and efficiently manage their water resources - both for HH consumption and agriculture. Water User Groups (WUG) can provide the structure and framework for improved Water Resources Management (WRM), but a minimum level of capacity is still required of the WUG members. This capacity is largely determined by education and training. In this way, 3WRMC provides an indication of the likely capacity for effective WRM.

**4S:** Improved water supply best serves its beneficiaries when complemented with concomitant improvements to sanitation facilities. The actual type of toilet facilities a HH uses (if any) provides a highly useful proxy of the overall quality of their sanitation.

**5E:** The returns to investments in rural education for poverty alleviation initiatives are some of the highest (Fan et al., 2002). Rural incomes are also tied to education and skills. 5E measures children's access to education by measuring the distances children walk to school and the quality of education their schools probably provide.

**6HH:** The links between adequate sanitation, health and hygiene, education and even income are clearly established in the literature and the availability of affordable healthcare is a reliable development and welfare indicator. 6HH measures the existence of clinics, number of doctors/nurses per capita and affordability of health services, in order to gauge the availability and affordability of healthcare (6HH also measures the capacity for, and practice of, good hygiene).

**7FS:** Lack of food security presents a serious hurdle for poverty reduction initiatives. 7FS is measured by examining and combining the area of arable land available to the average HH, whether the HH can afford to sell more produce than it consumes, and the household's exhibition of the coping mechanisms one would expect under conditions of food quality or quantity deficiencies .

**8E**: This component gauges the extent of environmental degradation around the areas surveyed, since most rural communities rely heavily on the natural resource base for their livelihoods. Soil erosion and fluctuating populations of wildlife provide good proxy measures of environmental degradation, or improvement. A measure of the general status of an area's environment provides a useful indication of possible present, and future, hindrances to development, agriculture and health.

## 3. RURAL CHINA AND THE STUDY AREA

As a nation, China's poverty alleviation success story is unparalleled globally as far as the number of people who have been lifted out of severe poverty and the speed with which this was achieved. From roughly 1978 to 1999, the annual real GDP/per capita in China increased from ¥792 to ¥3,631 according to one estimate (based on 1990 prices, see: Fu, 2004). In spite of the significant differences in poverty estimates for China based on recently updated figures, even the adjusted estimates (Chen and Ravallion, 2008) make it clear that China's poverty alleviation success has been significant, to say the least.

Most of the poverty reduction which took place over the last 25 years in China was in large part due to the very low base present at the start of the period. The years between 1966 and 1976), impacted heavily on China's cultural, educational and scientific progress, but at the same time, did bring significant benefits for the rural poor: chief among them improvements to rural healthcare and access to education. By 1978-1979, the country was ripe for thepoverty alleviation measures facilitated by Deng Xiaoping's pro-market reforms, and associated dissolution of the farming collectives . Specifically, by targeting the most easily accessible and fertile agricultural lands first (especially the coastal regions), from 1980-1985 approximately half of China's famous poverty reduction gains were achieved (Piazza and Liang, 1998, Ravallion and Chen, 2007). However, a consequence of this success was that those rural regions which were relatively isolated to begin with and, geographically-speaking, not as conducive to rapid poverty reduction, were essentially left behind.

Presently, many of these regions are still being left behind; a fact confirmed by the increase in rates of extreme rural poverty in some areas, between 1998 to 2001 (Shen, 2005). It is not surprising then that the country's mountainous southwest is home to the majority of China's rural poor. It was for this reason that WEILAI was developed and implemented in the Guangxi Zhuang Autonomous Region ("Guangxi Province" prior to 1958, hereafter referred to as "Guangxi"). *[Figure 1 here]*

Guangxi is located in southern China just north of the Golf of Tonkin, sharing its south-western border with Vietnam (small map in Figure 1). Approximately 41 per cent of Guangxi is covered in natural forests and the region is typified by Karst (carbonate) topography. While seemingly rich in water resources, thanks to the Karst topography surface water supplies are actually relatively scarce and fertile soils are not abundant. Many of the rural poor in Guangxi live in isolated, "resource-deficient areas" (Piazza and Liang, 1998: 255) with poor education, substandard healthcare, limited arable land with low agricultural productivity and a relative shortage of quality roads limiting their access to cities and markets (Shen, 2005, ADB, 2004). The focus of the pilot study presented here is the IFAD-supported West-Guangxi Poverty Alleviation Project area, covering approximately 15,400km³ of mostly mountainous Karst, with elevations up to 2,000m. The project's beneficiaries include 1.3 million people, in 260,000 households (HH), living in 10,590 Natural Villages (NV) in 74 Townships in 10 counties (IFAD, 2000). Temperatures for the project region range between 17-20ºC with average yearly rainfall of 1,300-1,500mm, 80 per cent of which falls during May to September (IFAD, 2000). The local climate is punctuated regularly by droughts in the spring and fall, and floods in the summer.

This research was carried out in eight Administrative Villages[1] (AV) in four counties: TianDeng, LeYe, NaPo and TianLin (see Figure 1: IFAD project counties in blue, and field-site counties labelled in English). The field sites were chosen in consultation with Guangxi province Project Management Office (PMO) staff to provide a variety of topographies, altitudes, climates and soil types, while keeping the populations relatively consistent. See Table 1 for more details. *[Table 1 here]*

## 4. METHODOLOGY

In order to capture the elements of water-poverty, the backbone of the WEILAI questionnaire was initially based on the WPI questionnaire (Sullivan et al., 2002, Appendix 2.4) which was then significantly augmented to acquire data for all eight of WEILAI's components, and to tailor the questions to represent the situation in rural China. Care was taken to word and order the WEILAI questionnaire in such a way as to minimize leading questions and other factors which result in unwanted participant bias. During consultation sessions with PMO staff, the questionnaire was reviewed question-by-question to resolve issues of question wording, structure, intention and translation. Further fine-tuning resulted from pre-testing and piloting the questionnaire. The primary

[1] A simple breakdown of the administrative regions in China is: Central Government – Province – County – Township – Administrative Village – Natural Village (a Natural Village consisting of anywhere from a few, to dozens of households. An Administrative Village is a collection of Natural Villages).

development, research and field work for WEILAI were conducted in 2007 (Cohen, 2007a, Cohen, 2007b).

Following a pilot trial in a village in Tuokan Township, training sessions were held in each of the four counties with project staff who would subsequently administer the WEILAI survey themselves or train other staff to do so. A systematic sampling method was employed due to its relative simplicity (Schofield, 2006), and in order to ensure that PMOs could reliably employ it. In most AVs beneficiaries do not have high levels of Mandarin speaking/comprehension ability so the survey was usually administered in the local dialect (language). This required enumerators to translate the questions from Mandarin as they administered the questionnaire (which may have introduced some observer bias). In all, 534 HHs were surveyed across 71 Natural Villages.

The survey team[2] visited AVs which had been identified for sampling in order to conduct semi-structured interviews with relevant key informants, , inspect water-related infrastructure, schools, clinics, agricultural fields/paddies, and to take Global Positioning System readings. These data (Table 2) was used to calculate some of WEILAI's subcomponents and helped validate the discerning ability of WEILAI's indicator values with respect to providing an accurate reflection of conditions on the ground.

*[Table 2 here]*

## 5. RESULTS

[2] The survey team consisted of staff from TianDeng County, TuoKan Township and Province PMOs, as well as two research assistants (both graduate students studying Agricultural-Economics at Guangxi University), and the project leader (lead author).

This section describes the steps taken to calculate WEILAI. Initially, the key questions to be considered were:

- How many components would be most appropriate to best capture the overall construct WEILAI seeks to measure (i.e., water-focused rural poverty in China)?
- How much variation do different subcomponent weighting schemes introduce?
- should the eight WEILAI components be aggregated to form a composite index, or should they be displayed individually as parts of a thematic index.

Before data analysis, all variables were reviewed for outliers[3] and missing data[4]. From observations, it appears that many of the problems identified were the result of enumerator error, and could have been reduced via lengthier training sessions and multiple trial runs. The collected data are represented on a variety of scales, (e.g., percentage reporting "yes", distance travelled in meters, "bad/poor/good" and so forth); hence, to make comparisons of the WEILAI scores possible across space and time, the data were normalized. A 0-100 scale was used, 100 representing the high, or positive value, and 0 the minimum value. Data were examined via box-plots, with outliers removed as appropriate before the normalization formula was applied. A standard formula for this data normalisation process (to facilitate aggregation of the indicators) was used throughout for the sake of consistency, simplicity and replicability:

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[3] Extreme outliers were identified visually using histograms and/or scatter plots

[4] In the statistical analysis, missing data were ignored rather than trying to take next neighbours, or average values. The interested reader is advised to check the appendices of the IFAD Technical Report on WEILAI for more detailed information on missing data. The appendices are available online at the following URL: http://operations.ifad.org/c/document_library/get_file?p_l_id=10266&folderId=100543&name=DLFE-1611.pdf

$x_i - x_{min} / x_{max}-x_{min}$ [Equation 1: Normalization Formula]

Where:

$x_i$ is the value of a HH response for a given question

$x_{min}$ the minimum value for that set of responses, and

$x_{max}-x_{min}$ the difference between the maximum for the set and the minimum (with minor variations depending on the range and outliers for a given question).

This is the same approach used in the development of many indices, including the Human Development Index (UNDP, 2006: 393) and the WPI. Once data were normalized they were visually inspected via histograms to ensure that the data used for the subcomponents were normally distributed. This is a crucial, but often overlooked, step needed to fulfil the assumptions of a Factor Analysis (described below), and is especially critical when creating any kind of measure to make comparisons between groups (see: Nunnally and Bernstein, 1994).

More generally, transparency should be a key element in indicator construction and presentation. Without it, subjective, "expert" choices are hidden and calculations based upon them cloaked from scrutiny. The appendices of the WEILAI Report[5] detail WEILAI's construction and calculation in an effort to avoid the pitfall many indicators make of becoming "black boxes" where the data, weights and calculations are essentially hidden (Molle and Mollinga, 2003: 534). Moreover, by being upfront about the

[5] The appendices of the WEILAI Report (full report available on request) are available online at: http://operations.ifad.org/c/document_library/get_file?p_l_id=10266&folderId=100543&name=DLFE-1611.pdf

construction and calculations others will be more likely, and more easily, be able to implement WEILAI themselves, or adjust the methodology for different contexts.

## (a) Using Factor Analysis to validate the WEILAI structure

Factor Analysis is a powerful tool for creating and validating composite indicators (Saisana et al., 2005, Saisana and Tarantola, 2002). A Confirmatory Factor Analysis (as opposed to an Exploratory Factor Analysis) extracts a specified number of components, determined a priori, based on a theoretical framework, in a way which maximizes the amount of variance explained in the larger dataset. A Factor Analysis also shows how much total variance a given subcomponent is responsible for in each component, which ideally validates the theoretically-based groupings of subcomponents under their respective components. This approach provides a means of statistically validating the choice of eight indicators in WEILAI. Confirmatory Factor Analysis was performed to illustrate how the 29 WEILAI subcomponents can be best described within eight components, consistent with the basic theoretical framework and the results of stakeholder consultations.

By obtaining quantitative validation and to establish the optimal number of components needed to capture a measure of water-focused rural poverty which WEILAI purports to measure. In the case of WEILAI, this would be achieved if the Confirmatory Factor Analysis showed that eight components explain a sufficient amount of variance in the collected dataset.

For this purpose, all 29 WEILAI subcomponents were converted to *z-scores*. Table 3 illustrates this approach, and shows that all 29 WEILAI subcomponents have an extraction value over 0.5. This represents the amount of variance attributed to each subcomponent that is included in the dataset based on the eight factors. The higher this number is, the less error variance is being contributed to the total variance by a given subcomponent (if lower than 0.5 that subcomponent would most likely be doing more harm than good). On the basis of this analysis, where the mean Extraction Value is 0.705, and no subcomponents fall below 0.5, none of the 29 subcomponents were removed from WEILAI's final calculation.

*[Table 3 here]*

Variance is a measure of the dispersion of the sum of squared standard deviations from the mean value of all data points. In the context of a Factor Analysis, the explained variance helps to indicate the degree to which one can predict an overall score, based on a given number of factors. 70.48 % of the cumulative variance produced by the 29 WEILAI subcomponents can be explained by the first eight components, all of which have an eigenvalue greater than 0.9, which quantitatively supports the use of eight components in WEILAI.

(b) Calculating WEILAI at the administrative village level

All WEILAI subcomponents and components are based on data collected from the household questionnaire and key informant interviews.

D these were combined using the formula:

$$WEILAIComponent = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i}$$

[Equation 2: WEILAI Aggregation Formula]

Where the ***WEILAI Component*** is the value on each of the eight WEILAI components for any given area (for example, an Autonomous Village), **Xi** is the subcomponent **i** (that is, one of the 29 subcomponents), and **wi** is the weighting applied to that subcomponent (for example, 0.333 for one of three equally weighted subcomponents).

The calculated WEILAI component values are displayed in Table 4 and in Figure 2, where they are grouped by township since one would expect geographically close AVs to have similar WEILAI scores. An octagon radar graph format was used so AVs can be easily compared to each other. For each location, the data points indicate the WEILAI component scores, with 100 as the best possible score and 0 the worst.

*[Table 4 –and- Figure 2 here]*

(c) Examining the effects of different weighting schemes

To investigate regional variation, individual WEILAI scores for each location can be combined to generate the composite WEILAI value for a region (i.e., by aggregating the component values into one number). In such a calculation, assigning equal weightings would be, arguably, just as legitimate as attempting to define different weightings by way of expert consensus (Feitelson and Chenoweth, 2002, Molle and Mollinga, 2003) depending on the rationale for doing so. The effects different component weightings have on the composite WEILAI scores can be analyzed by way of a Sensitivity Analysis, which can also be used to analyze the degree of error variance the subcomponents and components contribute to the index score. Such an analysis[6] can also be used to examine the relative sensitivity of an indicator's subcomponents and components to different weighting schemes.

However, it is the authors' opinion that WEILAI's eight components should not be aggregated to form a composite index, as done in the Water Poverty Index or Human Development Index. In the case of WEILAI, such a process would reduce the validity of the measure, due to the large number of variables used to construct the 8 components. Rather, WEILAI's components should be examined individually. So too, if policy decisions are to be made based upon them, the subcomponents should be examined as well as the data upon which they are built. Hence, WEILAI is a thematic indicator and not a composite indicator. The Sensitivity Analysis helps defend this position by examining the ways in which WEILAI could be aggregated, which subcomponents and components have the strongest effect on the aggregate scores and, importantly, the uncertainty which different weighting schemes[7] inevitably introduce into a composite WEILAI score.

[6] Ideally, a Sensitivity Analysis could be performed using a predictor value. Census data could theoretically be used, but at this writing, up-to-date, accessible data at an appropriate scale are not available.

[7] The Sensitivity Analysis could be done using a Monte Carlo-like technique in which weighting combinations with weighting values as low as 0.01 are randomly selected from a distribution of possible weights (Saisana and Tarantola, 2002). However, the analysis here, using weighting values as low as 0.1, sufficiently illustrates the wide range of variability different weighting schemes introduce.

To illustrate the level of uncertainty associated with the application of weightings to the WEILAI scores, Figure 3 shows the variability in the final WEILAI scores resulting from the application of a selection of different weightings to each of the eight AVs.[8] The different possible combinations of weightings illustrated here are constrained by the condition that each component's weight could not fall below 0.1 (that is, every possible weighting combination using 0.1 as the lowest divisor, yields a set of 46 weighting combinations). *[Figure 3 here]*

From Figure 3 it can be seen that the variability of the WEILAI scores differs significantly both across weighting combinations, and by AV. Feitelson and Chenoweth (2002: 268) provide one interpretation of the dilemma: "Using a collective expert judgment to determine the weightings of a multidimensional index results in an index that is subject to the value judgments and cultural biases of those who created it, while arbitrarily adopting an equal weighting for all components of an index is a de facto weighting in itself that is no less problematic". Arguably, the former (i.e., the effects of cultural bias, etc.) is a more serious a problem than the latter. While we recognise these methodological challenges, we believe that using an expert weighting approach is advantageous since it builds confidence in the potential users of the tool in Southern China, and since their inputs (as local experts) were incorporated into the final assessment approach. As a result, for this initial iteration of WEILAI, the expert weightings scores are used only to aggregate the subcomponents used to calculate each of the WEILAI component scores, but no attempt is made to generate an overall composite

[8] If the figure is viewed in black & white, the reader should keep in mind that it is the variability, not the differences between AV's, which is of note.

WEILAI score (either weighted or unweighted).

### (d) Aggregating WEILAI to the Township level

In the context of current institutional arrangements in much of China, measurements of performance are sometimes more relevant at the township (and county) scale, rather than at the village scale. To generate values for such an administrative level, it is possible to aggregate the WEILAI component values calculated for each AV on the basis of demographic variation. Specifically, the total population of both AVs sampled in a given township[9] was calculated and then the WEILAI values were aggregated based on each AV's percentage of that total population. Thus the AV component scores in Table 4 were aggregated to yield the township level component scores, displayed graphically in Figure 4 (i.e., the values for each Township are based on the combination of the values of two AVs in that township). As has been discussed throughout, the more one aggregates indicator values the more resolution is lost, but for the purpose of generating cost-effective policy tools at an appropriate scale, this may be an inevitable trade-off. Hopefully the discussion above has demonstrated this. *[Figure 4 here]*

## 6. DISCUSSION

[9] In this first iteration of WEILAI two AVs were surveyed in each of the four Townships which have similar popualtions. With regard to the degree to which aggregated WEILAI values from AVs will reflect conditions in their Townships, future users will have to determine the confidence interval most appropriate for their work when deciding how many AVs need be surveyed to capture enough data to represent the population of the Township in question.

The WEILAI approach provides a powerful tool for supporting decisions about project planning, monitoring and evaluation, targeting, reporting and the prioritization of development initiatives (big or small). Much like the WPI, WEILAI simplifies a complex reality making it readily intelligible in the form of graphs and tables of values so policymakers, planners, donors, government officials, stakeholders and beneficiaries alike can quickly identify which areas and sectors may be most in need of assistance. Yet, it must be recalled that like many other approaches which attempt to understand complexity, WEILAI is, necessarily, an imperfect tool and caution must be exercised when using it for any purpose which will affect people's lives.

At this stage, it is important to step back and revisit the results of this research, to understand in more detail, what WEILAI can and cannot reveal[10]. With respect to this initial study, based on the WEILAI values calculated for each Township (Figure 4), it is immediately clear that at the township-level JinJie is most in need of assistance relative to the others. When we dig deeper we see that the AVs of MengYang, PinLi and XiHua warrant closer inspection based on their WEILAI scores. If one were particularly concerned about a specific sector, such as Water Resources, then MengYang and NongMin AVs would be highlighted. Yet, as will be seen in the discussion below, it is crucial to more closely inspect all the WEILAI values, not just the relatively low ones. This point is understood more clearly by examining one of the townships with the highest WEILAI scores overall, XinHua, and comparing this more explicitly with other examples; in so doing, we can better understand the importance of looking behind WEILAI's numbers (or any indicator for that matter).

[10] For the following discussion, the reader is advised to consult Figure 2 for an overview of WEILAI values at the AV level, and Figure 4 for an overview of WEILAI values at the Township level.

To illustrate this, we examine Xi Hua and two other AVs, GuiLi and NaShe. Data referred to in this section can be seen in Table 3, where explanations of subcomponents are provided. Both GuiLi and NaShe diversified their agricultural holdings more extensively than any other AV (Table 2, “Main Crops”) and both areas profit from the sale of cash crops (e.g, GuiLi’s organic tea is exported to Singapore). In both cases, these two AVs are able to increase HH incomes through improved yields and cash crops, largely due to the subtropical climate, altitude and their access to relatively good land and water resources (Table 1). However, the higher farm revenues and accompanying reductions in local poverty observed in XinHua are largely due to their ability to efficiently and effectively manage their land and water resources (that is, farmer’s capital assets).

WEILAI accurately captures XinHua’s success, but to see why, we must look behind the component values to the subcomponents which reveal the human capacity element.[11]

GuiLi and NaShe’s water source (sub1.1)[12] and water quality (sub1.2) scores (82.80, 61.81 and 65.36, 58.49 respectively) are relatively high (with 100 being the best achievable score), indicating a reliable, quality supply of water, and good access to it, for both domestic and limited agricultural use. Behind NaShe’s high Food Security score (75.39) is a high arable land score (sub7.1 = 84.64) demonstrating that the land capital is sufficient (assuming good soil quality). While GuiLi’s arable land score is low (sub7.1 = 30.91), we can venture that their land management practices are likely efficient and effective since their erosion score is relatively high (sub8.1 = 65.49), indicating a low

[11] The data itself can be found in the appendices of the WEILAI Report (URL provided above).
[12] Note: “sub” refers to “subcomponent”

incidence of erosion. More importantly, neither GuiLi nor NaShe exhibit the coping strategies (i.e., consuming smaller quantities of food, or foods of lower quality) one would expect from a region suffering from food insecurity (scoring very high, 99.01 and 100 respectively, on sub7.3).

For XinHua township, WEILAI reveals high levels of adult education (sub3.3b scores of 62.89 and 59.56) and Mandarin speaking ability (sub3.3a scores of 75.78 and 63.07). Moreover, XinHua's Health & Hygiene score is also high (70.53), illustrating the well-known interlinkages between improved education and health. In the case of the other 2 AVs, capacity is illustrated by participation in water management programmes. In GuiLi, 69 per cent of HHs, participated in water management/use programs, while for NaShe, the figure reached 85 per cent. (sub3.2). From this, one can posit that their natural resources endowment, coupled with their high level of capacity and knowhow enables them to use their capital-assets to produce higher yields of staple and cash crops. Resulting profits reinforce such behaviours and alleviate some of the region's poverty, most clearly illustrated in the case of XinHua, where household wealth scores (sub2.3b = 48.19 and 81.98) are by far the highest of any Township. This finding supports empirical research from many parts of the world, including other areas of China, which suggests (Fan et al., 2002), that it is *human capacity*, largely dictated by education (formal and skills training), which allows people to make the most of their resources and capital assets.

XinHua Township's future, however, may not be as promising. WEILAI accurately identifies XinHua's two weakest sectors: Sanitation (= 20.84) and (school) Education (= 28.88). These sectors will likely have a negative overall influence on the area if unimproved. Fortunately, the low Sanitation scores should rise as many of the soon to be completed biogas facilities for XinHua come on line. For GuiLi, however, the Education scores, , are worrying, although the student-teacher ratio is acceptable there, whereas NaShe is the worst of all AVs on this measure. In this case, this is thought to result from the distances schoolchildren walk to school (NaShe = 2km, GuiLi = 1.7km on average, information captured in sub5.1),and the time taken to get there. Given that NaShe's NVs are spread across mountain peaks at high altitudes (~1,035m) the time it takes NaShe's schoolchildren to get to school is significantly longer than their counterparts in GuiLi (though the distances appear comparable). Although this is not captured in WEILAI - importantly, the township's poor education scores are.

The information WEILAI brings to light, and the likely relationships involved, are largely comparable with the literature on poverty in rural China. Moreover, the WEILAI values for Guangxi were seen to be accurate reflections of reality by PMO staff (Zhang, 2008). The discussion also makes it clear that while WEILAI component scores for a township, or an AV, provide a good proxy measure of poverty by sector, the explanations lie in the subcomponents and the data upon which they are based. These figures in turn can help policy makers get to the roots of why some places are more successful than others. Since all indicators simplify reality it is of crucial importance to attempt to evaluate what that reality actually is, and what the causal connections may be, before taking policy decisions which will affect people's lives and livelihoods.

While the calculation of WEILAI can help to target attention to specific weaknesses and strengths, in-field follow-up should be used to confirm and clarify the legitimacy of the findings, and relevance of their implications. This is the only responsible way to unravel the interconnecting drivers of human wellbeing, and any possible attribution gaps that may exist.

As discussed, WEILAI's focus is primarily on key welfare and poverty sectors, and the components of water-poverty; other assessment tools can be used to examine additional constructs, such as access to markets, roads, access to credit, the state of rural financial institutions, etc. Donors already have Management Information Systems and established tools for M&E within these systems. However, these tools are often limited in scope and should therefore be augmented with other, more holistic, context-based tools. WEILAI is one such tool for rural China, but it should be seen as part of a suite of tools, rather than a single solution.

It is difficult to estimate what WEILAI might cost the average project per implementation since the costs per HH survey vary. In Guangxi, costs range around USD 3.50 per questionnaire with additional costs for the survey team's transportation. With respect to time, given the closed response format of most of the questions, it took approximately 15 minutes to administer each WEILAI questionnaire.

Beyond the potential costs of administering WEILAI is the arguably more important question of whether or not the local capacity exists to properly administer the survey or analyse the data. This will differ greatly by area, but the training sessions and the types of information collected do not require a great deal of capacity, and there is much potential for such approaches to be digitised and facilitated through the use of software (Moglia et al, 2008)

## 7. CONCLUSIONS AND WAYS FORWARD

WEILAI answers the calls for interdisciplinary approaches which blend socioeconomic and biophysical realities (Sullivan and Meigh, 2007, Falkenmark, 2007), within geographical frameworks (Vörösmarty et al., 2005), providing a better understanding of the interactions between water, poverty and development. The theoretical underpinnings, development, methodology, statistical testing and calculation of WEILAI are described in as transparent a manner as space allows; this is done not only to avoid reinforcing the "culture of expertism" (as Jain, 2003:7 has termed it) that surrounds indicators, but also to make the implementation of WEILAI as straightforward as possible so others might benefit from using it.[13]

The conclusion of this research is that the WEILAI approach clearly demonstrates its power to differentiate among AVs and allows comparisons to be made across both AVs and townships. With regard to the robustness of the tool, arguably more important than the analysis above are the opinions of those who would use WEILAI: according to the M&E Officer at the Guangxi Administration Center of Foreign Funded Projects for Agriculture, "WEILAI makes comments on our project in a very objective way, [the]

[13] Detailed descriptions of WEILAI's calculation can be found in the appendices of the WEILAI Report which is available online (URL provided above) or by contacting the lead author directly.

eight components in WEILAI are very good indicators to evaluate poverty, [and] the methodology adopted in WEILAI is very good, practical and worth disseminating" (Zhang, 2008).

As touched on above, WEILAI could prove especially useful to development organizations if calculated before project implementation, for baseline surveys and midterm reviews, and for project completion reports (of course WEILAI's temporal utility will have to be determined in step with future research). In addition, WEILAI can be used as a rapid appraisal tool for local-level poverty assessment in rural areas where a focus on water resources is considered crucial.

This research describes the first iteration of WEILAI. As such, there are certainly improvements to the tool and methodology which can be made. In general, it would be worthwhile to try and reduce the number of sub-components included in the analysis, With this in mind, in the future development of WEILAI, given the focus on basic needs, the next generation of the tool may attempt to blend 1WR and 2WA since access to water is arguably more important than the state of the resource (with respect to the poorest of the poor) and because measuring water quality with subjective tools is incredibly challenging (in any context). Additionally, it was found that the label "Health and Hygiene" was somewhat misleading. "Hygiene" conjures up "sanitation" in the minds of many experts; thus, the next version may need to clarify this. On a more micro level, valuing whether a HH or area is a net consumer or producer of farm products can only be accomplished if the context is accounted for (given this constraint, it is likely advisable to remove or replace sub7.2). More generally, it would be useful to explicitly incorporate and measure gender equality and land tenure/access.

Presently, the 0-100 scale used in WEILAI is relative, based on the range of values across the baseline measured and established in this research. Another approach under investigation is that of setting threshold levels to the 0-100 scale (Cleveringa, 2007). Indeed, with subsequent implementations, and consultation with domestic and international experts, an absolute range could potentially be created for rural China. With this absolute range established, threshold values would help donors and governments understand what type of interventions/assistance might be most appropriate by sector and by area (ranging the spectrum from, for example, outright food aid to initiatives to promote village-managed microcredit).

Since its initial development and subsequent implementation in rural China, WEILAI was presented to experts at United Nation organizations, conferences and universities in China. Based on the positive feedback received, as well as feedback from technical reviews, there is now ongoing work (supported by an IFAD grant and other funding sources) to build on the WEILAI approach in order to use it in other parts of rural China, India, and possibly other parts of Asia. A more globally applicable tool designed to measure the key components of rural poverty, called the Multidimensional Poverty Assessment Tool (Cohen, forthcoming), is currently being developed based on this research, and have been piloted in China and India in 2009.

WEILAI, though flawed like all indicators, clearly has wide appeal due to its utility as a tool for project planning, monitoring and evaluation support, as well as targeting and prioritizing of interventions. In the end, the main problems which poor, rural communities face in many less developed nations are, at their core, the same: people's basic needs are not being met, which in turn diminishes their capacity to make any real progress. The WEILAI approach described here illustrates that this methodology can help provide a lucid overview of where problems may exist at a local level. WEILAI's application in other parts of the rural China could provide the opportunity for similar insights to be made in other poor, rural locations, just as it has done here for a small piece of Guangxi Province.

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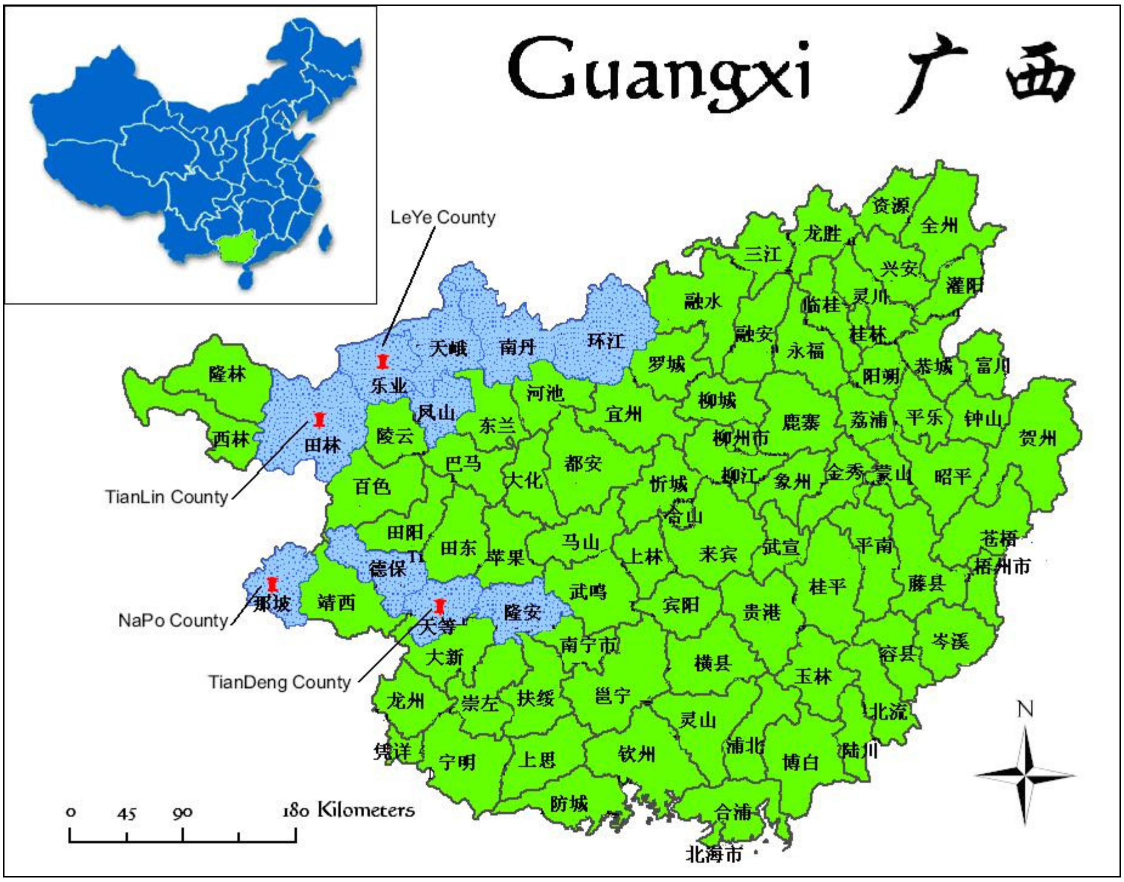


**Figure 1:** West-Guangxi Poverty Alleviation Project: Participating counties
*Source:* Publicly available GIS data

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**Table 1: Physical environment and climate of field sites**

| County | Land Area ($km^2$) | Climate [Mean Temp °C] | Predominate Topography | *Soil Types [source] | Mean Annual Rainfall (mm) | Admin. Village (AV) | **Apx. Elevation (m) |
|---|---|---|---|---|---|---|---|
| Tiang Deng | 1,326 | south-subtrop. [19.5] | 77% Karst ~33% Granite | R & B [S & L] | ~1,460 | MengYang | 316 |
| | | | | | | PinLi | 324 |
| LeYe | 1,896 | subtrop. [16.3] | Mostly Karst | R & Y [L] | 1,100-1,500 | GuiLi | 647 |
| | | | | | | NaShe | 1,035 |
| NaPo | 1,488 | south-subtrop. [20-22] | Mostly Karst | R & Y [mostly L] | ~1,270 | ShangLong | 742 |
| | | | | | | NongMin | 800 |
| TianLin | 1,454 | subtrop. [19] | 90% Karst | R & B [S & L] | 1,200-1,400 | TangHe | 1,195 |
| | | | | | | XiHua | 1,315 |

* Soil Types: ‘R’ = Red, ‘B’ = Brown, ‘Y’ = Yellow | Soil Sources: ‘S’ = Sandstone, ‘L’ = Limestone
**Based on GPS readings taken at field sites (average of recorded elevations if multiple readings taken) margin of error = ~3–40m

*Sources:* IFAD (2000) and data collected by lead author

**Table 2:** Data collected in the field

| Admin Village (AV) | Total Ag. Land in *mu* *(1mu = 0.067 ha)* | Avg. Ag. Land per HH | *Main Crops | **Main HH Water Supply | Water User Group (members) | Main HH Sanitation | Clinic (No. of Nurses) | ***School Supplies/ Teachers Sufficient? | Teachers (per school) | Students (per school) | Students per Teacher (per school) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Na<br>She | 1,200<br>~20,000 f | 4.1<br>69 f | C4, C5, C6,<br>C7, C2 | W1 | 2<br>(5) | >50% = S2 | None<br>(2) | No/No | 5<br>(4 \| 1) | 193<br>(157 \| 36) | 38.6<br>(39.3 \| 36) |
| Gui<br>Li | 9,300<br>~20,000 f | 25.4<br>55.6 f | C5, C4, C6,<br>C1, C3, C8,<br>C9, C7 | W1 | 2<br>(9) | ~50% = S5<br>~50% = S1 | 1<br>(1) | Yes/No | 12 | 260 | 21.7 |
| Nong<br>Min | 670<br>750 f | 2.8<br>3.2 f | C7, C1 | W2 | 9<br>(3) | >50% = S1 | None<br>(2) | No/No | 4<br>(2 \| 2) | 83<br>(37 \| 46) | 20.8<br>(18.5 \| 23) |
| Shang<br>Long | 634<br>~1,000+ f | 3.7<br>5.8 f | C5, C10,<br>C7, C2, C1 | W1 | 1<br>(not in use) | >50% = S3 | 1<br>(2) | † ?/? | 2 | 43 | 21.5 |
| Meng<br>Yang | 920 | 2.2 | C1, C11 | W2 | None | >50% = S2 | None<br>(2) | No/No | 7<br>(3 \| 3 \| 1) | 70<br>(32 \| 17 \| 21) | 10<br>(10.7 \| 5.7 \| 21) |
| Pin<br>Li | 1,826 | 2.9 | C1, C11 | W2 | None | ~50% = S5<br>~50% = S2 | 1<br>(3) | Yes/Yes | 19<br>(18 \| 1) | ~363<br>(333 \| ~30) | 19.1<br>(18.5 \| ~30) |
| Tang<br>He | 2,899 | 9.1 | C1, C2 | W1 | 3<br>(11) | >50% = S3 | 1<br>(1) | Yes/Yes | 8<br>(4 \| 4) | 256<br>(126 \| 130) | 32<br>(31.5 \| 32.5) |
| Xi<br>Hua | 1,554 | 4.5 | C1, C2 | W1 | None | >50% = S3 | 1<br>(1) | Yes/No | 11<br>(5 \| 6) | 191<br>(68 \| 123) | 17.4<br>(13.6 \| 20.5) |

**Main Crops**
C1 = Corn
C2 = Rice
C3 = Tobacco
C4 = Tea
C5 = Aniseed
C6 = Fir trees
C7 = Mulberry
C8 = Oranges
C9 = Chestnuts
C10= Cassava
C11= Soybean

**Main HH Water Supply**
W1 = Pipe outside HH
W2 = Private Water Tank

**Main HH Sanitation**
S1 = No toilet facilities
S2 = Open Pit Latrine
S3 = Traditional Pit Latrine (enclosed)
S4 = Ventilation Improved Pit Latrine (VIP)
S5 = Latrine connected to Biogas Pit

**Notes:** *Main crops listed in order from most to least in *mu* (lists are not exhaustive; often the same land is used for different crops in the winter, spring and summer)
**Main HH water supply primarily for domestic use, but also for smallscale agriculture around the HH
***Subjective assessment of headmaster/teacher interviewed (teachers level/s of training included in assessment)
**'†'** No teachers available to interview | **'?'** indicates missing or insufficient data | **'f'** = forest land | '~' indicates approximate data

*Source:* Data based on field visits and interviews by lead author with village officials, teachers, nurses and farmers.

**Table 3:** WEILAI Factor Analysis: Communalities & subcomponent descriptions

| Component | Subcomponent Description | Extraction | Component | Subcomponent Description | Extraction |
|---|---|---|---|---|---|
| Water Resources | (1.1) Primary HH water source for HH use & limited HH agricultural use | .874 | Education | (5.1) Children's access to education | .638 |
| | (1.2) HH's subjective assessment of their water quality | .799 | | (5.2) Student/Teacher ratio | .860 |
| | (1.3) How water quality has changed in the last five years | .757 | | (5.3) Teacher's level of training | .866 |
| Water Access | (2.1) Is water affordable if HH were required to pay? | .862 | Health & Hygiene | (6.1a) Access to healthcare | .878 |
| | (2.2a) Distance travelled to collect water (one trip) | .868 | | (6.1b) Affordability of healthcare (WTP) | .660 |
| | (2.2b) Time needed to collect water | .723 | | (6.2) Capacity: Hygiene education | .541 |
| | (2.3a) Percentage of adults living and working outside of the HH | .567 | | (6.3a) Percentage of HHs who treat their drinking water | .763 |
| | (2.3b) HH Wealth assessment based on quantity and type of durable goods HH owns | .587 | | (6.3b) Self-report frequency of illness due to drinking water | .674 |
| Water Resource Management Capacity | (3.1) Existence of a Water User Group in AV and awareness of it | .779 | Food Security | (7.1) Area of arable land HH uses/has access to | .504 |
| | (3.2) HH's participation in any type of water management/use program | .675 | | (7.2) HH is a net food consumer or exporter | .540 |
| | (3.3a) Head of HH's Mandarin speaking ability | .603 | | (7.3) HH reliance on coping strategies for food shortage | .638 |
| | (3.3b) Head of HH's level of education | .690 | Environment* | (8.1) Degree of erosion due to environmental deterioration | .702 |
| Sanitation | (4.1) Type of sanitation facilities (if any) | .769 | | (8.2) Secondary measure of deteriorating environment around HH: Insects | .697 |
| | (4.2) HH perceptions of their sanitation | .630 | | (8.3) Secondary measure of improved environment around HH: Wild animals & wild plants/fungi | .619 |
| | (4.3) HHs access to sanitation | .680 | * that is, an area's natural resource endowment | | |

**Note:** The Extraction Value (i.e., the communality) represents the amount of variance for each subcomponent included in the reproduced dataset using eight factors (i.e., eight components). The higher the extraction value the less error variance is being contributed to the total variance by a given subcomponent (thus, if any value were lower than 0.5 that subcomponent would likely be doing more harm than good, with respect to its contribution to total error variance).

**Table 4:** WEILAI Component scores by AV

| **AV** Administrative Village | **1WR** Water Resources | **2WA** Water Access | **3WRMC** Water Resource Management | **4S** Sanitation | **5E** Education | **6HH** Health & Hygiene | **7FS** Food Security | **8E** Environ-ment |
|---|---|---|---|---|---|---|---|---|
| MengYang | 17.62 | 52.5 | 23.44 | 31.25 | 70.46 | 50.07 | 57.44 | 41.88 |
| PinLi | 28.64 | 18.37 | 26.68 | 39.19 | 76.42 | 67.78 | 61.09 | 34.48 |
| GuiLi | 73.23 | 65.54 | 72.16 | 18.06 | 34.52 | 67.19 | 59.3 | 50.19 |
| NaShe | 59.07 | 60.34 | 58.21 | 23.79 | 22.89 | 74.07 | 75.39 | 52.8 |
| ShangLong | 63.43 | 54.15 | 40.64 | 52.2 | 38.24 | 76.28 | 61.82 | 47.5 |
| NongMin | 20.58 | 53.84 | 48.2 | 69.3 | 82.66 | 74.9 | 65.15 | 16.63 |
| TangHe | 31.47 | 59.92 | 48.24 | 48.1 | 68.22 | 50.24 | 75.04 | 32.23 |
| XiHua | 40.17 | 47.34 | 0 | 41.31 | 77.37 | 42.22 | 64.4 | 40.71 |

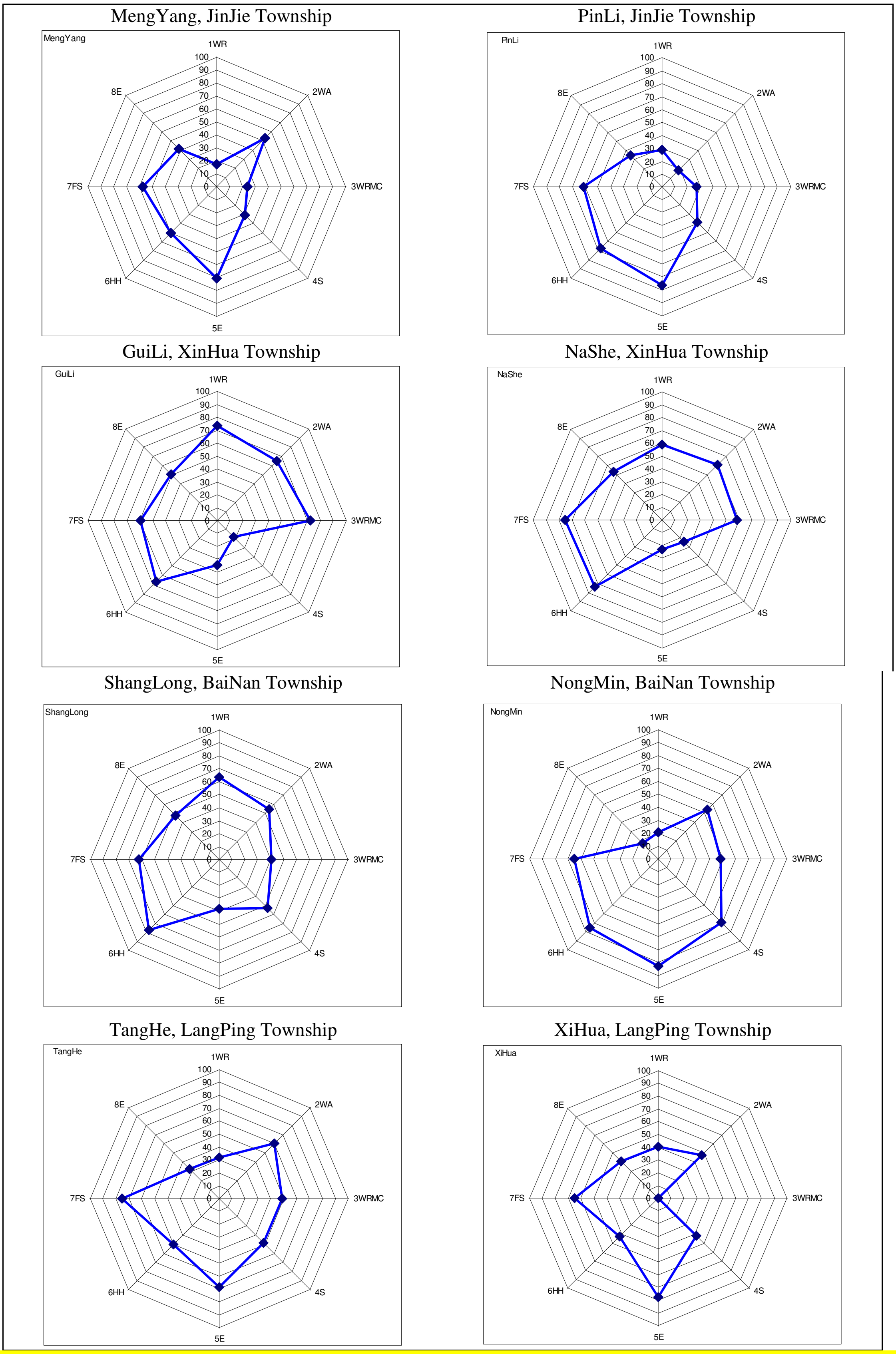


**Figure 2:** WEILAI radar graphs for all eight AVs NEED A KEY TO EXPLAIN AXES

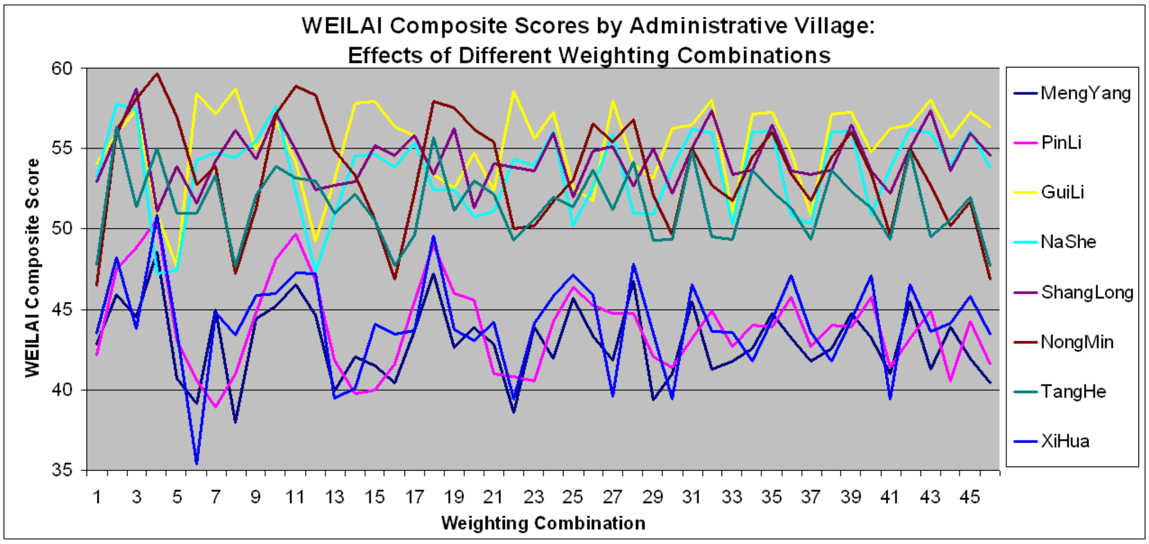


**Figure 3:** WEILAI Composite scores using 46 weighting combinations

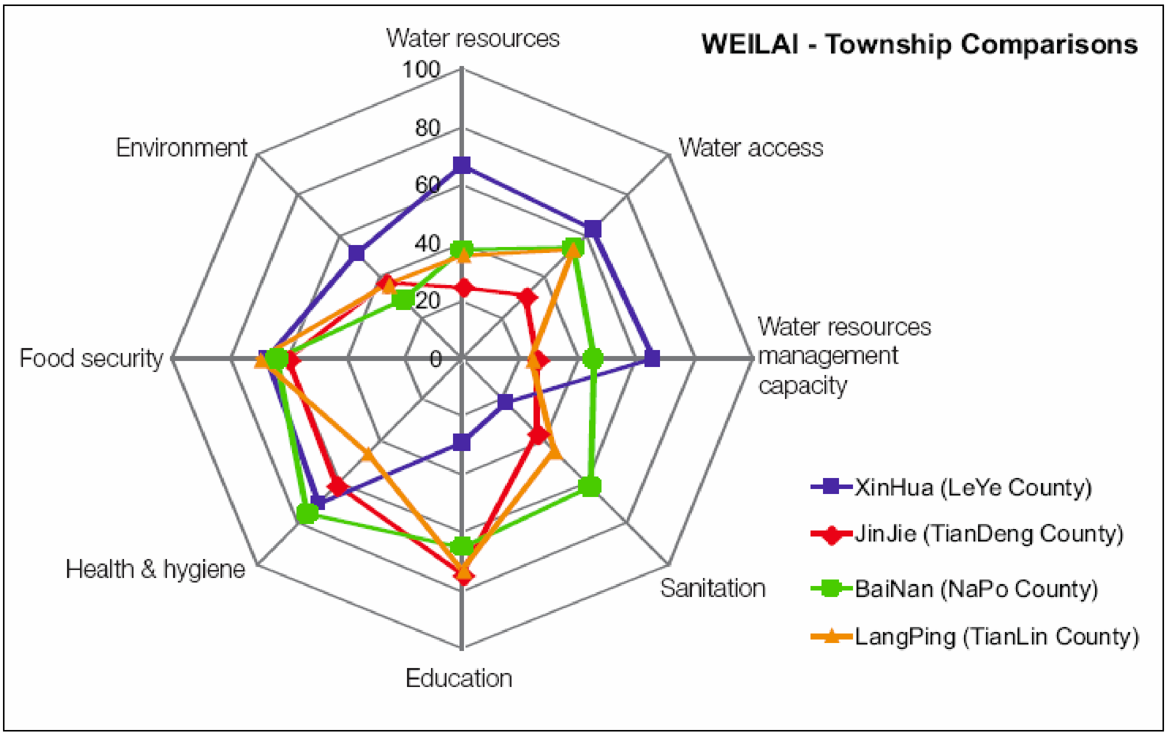


**Figure 4:** Four WEILAI pilot study townships compared through octagon display
Note: In this figure, the further out each data point is from the origin on any axis, the better the situation is on that criteria.