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Abstract

Measuring sustainability is an integral part of decision-making processes in order to promote sustainable development. The present paper focuses on sustainability indicators as these are measured on local level and explores two main issues: firstly, the subjective measurement of indicators focusing especially on social dimensions of sustainability, secondly, the incorporation of local perceptions in sustainability assessments. These two issues are explored in the Asopos River basin in Greece, an area where significant environmental degradation has been observed in the past decades and is also under financial pressure due to the on-going national recession. A large-scale research study was conducted measuring environmental, economic and social indicators while, at a second stage, a model was developed, estimating new indicators that incorporate local communities' perceptions on what they considered as important for their area. The results of the study reveal that the most important indicators for the sustainable development of the area, according to locals' perceptions, are environmental quality as well as quality of life. By contrast, trust in local and central institutions and also local enterprises were not considered as important by locals. These results illustrate the importance of combining global and national scale assessment with locally focused social measurements of sustainability in order to better understand what is important for local communities prior to embarking on public policy planning.

Keywords: environmental degradation, water contamination, industrial zones, participatory measurement, Greece

1. Introduction

It is now widely accepted that in order to manage the complex pressures that socio-economic and environmental systems face it is essential that public policies are designed based on the principles of sustainable development (Ascher 2007; Allen et al., 2017). A variety of indicators have been proposed in order to reflect the different dimensions of the term sustainability (Valentin and Spangenberg 2000) while there is extensive discussion regarding the scale of measurement. In this context, there are different approaches in measuring sustainability on different scales, such as in the context of an organisation (Keeble et al. 2003; Dissanayake et al. 2015; Urbanski and Leal Filho, 2015; Myllyviita et al. 2017), on a national level (Distaso 2007; Dahl 2012; van Beynen et al. 2017) or focused on specific localities (Valentin and Spangenberg, 2000; Tanquay et al., 2010; Shen et al. 2011).

Local measurements of sustainability have recently proven to be an important part of sustainability assessments for researchers and practitioners (eg. Winther, 2016; Arnes et al. 2018). Their significance lies on two main issues: a) they can facilitate decision-makers to plan public policies tailored to tackle specific local challenges by incorporating perceptions of local stakeholders (Wiek and Binder 2005; La Rovere et al. 2010; O'Faircheallaigh 2010; Vilei 2011). For this reason such measurements can often result from bottom-up processes involving a variety of local stakeholders such as local professionals, Non-Governmental Organisations and residents (Bell and Morse 2003; Wallis et al. 2010; Vilei, 2011; Turcu et al. 2013; Marzo-Navarro et al., 2015; Arnes et al. 2019) in order to determine the level of importance of indicators on a local level

(Mickwitz and Melanen 2009; O'Ryan and Pereira 2015), but also how sustainability is perceived by different social groups (Wynveen 2015); b) Secondly, local and participatory measurements of sustainability allow researchers and practitioners to measure indicators which are otherwise very difficult to be assessed and for this reason there is often a disproportionate representation of the different aspects of sustainability (Ness et al., 2007), with environmental indicators being the most frequently used Moldan et al. 2012). Social indicators of sustainability are equally important and there is a growing body of literature highlighting additional aspects of social sustainability that need to be taken into consideration (Hicks et al. 2016; Carlsen 2017) including subjective measurements (Carlsen 2017) such as human wellbeing and quality of life. These subjective measurements reflect the reality that sustainability means different things to different entities depending on the locality where it is measured (Wallis et al. 2010) and thus it can be a concept socially constructed (Onduru and Preez 2010)

Taking into consideration the above, the aim of the present paper is to explore the use of subjective sustainability indicators in order to improve our understanding of local sustainability focusing on a specific environmentally degraded area in Greece, the Asopos river. In particular, the paper will explore two main issues:

a) the measurement of social sustainability indicators in a subjective way and

b) the incorporation of local communities' perceptions in sustainability assessments

These two issues were explored in the area of the Asopos River, situated in East-Central Greece (Figure 1). The specific area was considered an appropriate case study as it faces long-term problems of environmental degradation but also financial insecurity. In total, the river has a length of 57km, with its spring in central Greece being surrounded mainly by agricultural land. However, along its path the river passes through the area of *Inofita*, where numerous industries have been established in the past 60 years, several of them considered as high polluters (Botsou et al. 2011), with occasional discharges of untreated waste directly into the river being recorded. As a result, certain parts of the river, especially the area near the industrial estates and towards the coast, are highly contaminated (Panagopoulos et al. 2015; Matiatos 2016; Sazakli et al. 2016). This has led to significant environmentally induced stigmatization (Skouloudis et al. 2016). Considering the historic environmental degradation in the area, it is crucial that new policies are planned and implemented aiming to reduce environmental harmful actions, but also to secure employment and economic stability. The collection of data in order to assess sustainability indicators in a participatory way was considered a key step in developing new public policies in this direction.

2. Methods

2.1. Data collection

Local stakeholders were initially consulted in order to identify the most important indicators according to their perceptions. This was achieved through personal interviews and focus groups. A list of indicators as proposed in the literature (Allen et al. 2017) were discussed during these interviews and, based on the results of the qualitative analysis, it was decided to assess specific indicators divided in the three main categories of environmental, economic and social. Due to the aims of the study, significant emphasis was given to the measurement of social aspects of sustainability in the research area.

Environmental indicators: Levels of environmental quality in the sustainability model were estimated through the analysis of samples of surface and ground water in the area. Surface water samples were collected from 18 sampling stations along the river, both in the wet and dry season, whereas groundwater was sampled in a single campaign from 9 wells in the vicinity of the river. All water samples were analysed for Cr (VI and total) and other heavy metals by Atomic Absorption Spectrometry and for nutrient ions by Ion Chromatography, following standard or widely accepted methods. Among the new indicators, only those denoting environmental degradation were used and the initial raw data of these indicators (available in Table A3, in the Appendix) were further analysed and re-calculated in a 4-point ordinal scale in order to be comparable with the rest of the socio-economic factors measured, which were either binary or ordinal. The new environmental indicators were calculated taking into consideration current regulations in European countries of acceptable environmental quality levels with the value of 1 representing 'very bad' environmental quality and the value of 4 representing 'very good' environmental quality. These new indicators were used in order to estimate the total Sustainability Index (SI) for the research area.

Economic indicators: Economic data were drawn from the database of the local Prefecture Chamber where all commercial enterprises of the prefecture are registered. At the time of the project, the registry comprised of 1700 enterprises. Environmental impact for each of these enterprises was assessed through a 0-2 rating scale - relying on the classification of economic activities (NACE) - where '0' signifies low, '1' medium and '2' high environmental impact. Likewise, organizational size was proxied through a binary (0-1) variable, where zero indicates a small- or medium-sized enterprise while one signifies a large business entity (Table 1).

Social indicators: Social indicators were measured through a large social survey with the distribution of a structured questionnaire to the local population. The questionnaire was distributed to 22 local communities, living around the river or communities which have been influenced directly or indirectly from the contamination of surface and underground water. According to the latest national census (data available from the Hellenic Statistical Authority), the total sampling frame in the area was approximately 30,000 individuals and the final questionnaires collected were 861. Sample characteristics were checked in relation to the demographics of the actual population to ensure it is representative. The social indicators selected to be measured in the area were based on the results of the focus groups and the relevant literature and included social trust, institutional trust, social networks, quality of life, public engagement and feeling of safety, all measured on 10-point Likert scale or binary (0/1) questions (Table 1).

These sustainability indicators were measured after the area was divided in three larger regions based on key economic activities: a) The west region which includes mainly agricultural land and several Small-Medium-Enterprises (SMEs); b) The industrial area (central) consisting of all villages in or at the border of the industrial zone of Inofita and Schimatari; c) the coastal region (East) where mainly SMEs exist, with a strong focus on tourist and recreational activities due to their proximity to the sea. The heterogeneity of the area allowed us to observe differences in perceptions between the three areas, but also for the area as a whole.

[Insert Figure 1 here]

2.2 Data Analysis

2.2.1 Statistical Methods

2.2.1.1 Exploratory Factor Analysis (EFA)

Due to the large amount of (social, economic and environmental) indicators we proceeded in data reduction through the use of Exploratory Factor Analysis (EFA). As a result, social indicators were clustered in four new factors (social trust, institutional trust, social networks and quality of life), economic indicators were clustered in one final factor and environmental indicators were divided in two new factors (see Table 1). The EFA was conducted with the use of statistical program SPSS v.21.0 (IBM Corp. Released, 2012). The descriptive statistics of all indicators measured are presented in Table 1.

[Insert Table 1 here]

2.2.1.2 Structural Equation Modeling

A total Sustainability Index (SI) was estimated by exploring the impact of the measured factors derived from EFA on the index. Hence, in order to test the influence of the latter latent variables on the SI, we fitted Structural Equation Models (SEMs) (Bollen 1989), testing the conceptual model that was initially hypothesized. The SEM models were estimated with the use of the AMOS software (Arbuckle, 2006). The model was tested by utilizing the complete data collected on citizens residing in the wider area of the Asopos river and the corresponding environmental and economic indicators (Model A). In addition, we fitted the model by breaking down the data with respect to the three geographical regions. In doing this, we re-ran the analyses for the data collected in the western region (Model B), eastern region (Model C) and finally the industrial zone (Model D).

2.2.1.3 Normalization of Indicators and incorporation of locals' opinion

After the initial measurement of the sustainability indicators (i.e. the latent factor scores from SEM analysis), we normalized the derived scores so that the numbers of the different indicators were presented in a similar scale. A large variety of such normalization methods exist. We opted for range normalization, restricting scores into interval [0, 1], by utilizing the following transform on factor scores x:

$$\text{Range normalized score} = \frac{x - x_{\min}}{x_{\max} - x_{\min}}.$$

where $x_{\min}$, $x_{\max}$ the minimum and maximum factor scores for each latent variable.

This allows for comparable magnitudes of the original factor scores among the various latent factors (see Salvati and Zitti 2009; Liu, 2014; Shen and Guo 2014) for applications of similar normalization methodology). Although the normalization method has the disadvantage of losing some information of the original variable, especially as regards to outliers, it facilitates the comparison of factor scores measured in a similar scale.

In order to incorporate local perceptions in the indicators' measurement, participants were asked to state how important certain economic, environmental and social factors are for the sustainable development of their community. All indicators' weights were measured on a 10-point Likert scale. Then the original factor scores were re-calculated taking into consideration the importance (weights) of each of the latent structures according to the local community. In order to do this, we suitably re-adjusted weights ranging in the discrete interval [0, 1] with a 0.1 increment and interpreted in percentage terms (see also Salvati and Zitti 2009). This has a meaningful interpretation since the weighting variables have been measured on a 10-point Likert scale. Hence, a normalized weight of 0.5 for an indicator is considered of average importance, whereas a 0 weight implies that the specific indicator is negligible.

In the final step, the different indicators were re-calculated by the multiplicative scheme:

[new indicator] = [weight%] x [normalized indicator],

where the weights are treated as reduction factors, adjusting for the (non)importance of each indicator (see Liu 2014 for a similar application).

2.2.1.4 Sensitivity analysis

At a final stage, a deterministic sensitivity analysis was performed in order to provide quantitative measurable results regarding the magnitude of impact of the 7 latent factors measuring the importance of sustainability indicators according to citizens' perceptions. Sensitivity analysis is commonly employed as a secondary method, subsequent to modeling (Saltelli et al., 2004) in order to determine which of the model's inputs contribute most to the variability of the dependent variable(s) (Hamby 1994). Conceptually, among the most common approaches of sensitivity analysis is to repeatedly vary one parameter of an explanatory variable at a time while holding the others fixed at a medium value (e.g. median, Yu et al. 1991). Usually, one parameter is increased or decreased by a given percentage while all other parameters remain fixed. This way we are able to obtain a quantification of the change in the output of the model. The estimates from the best selected model for the overall data, (i.e. average sustainability indicators) obtained from the path analysis, were used for the sensitivity analysis taking into consideration the importance of each of the latent indicators according to the local community (see section 2.3.1.3). By applying a deterministic sensitivity analysis we explored the effect of each particular sustainability indicator. This consists of utilizing distinct values for each important covariate as identified by the predictive model, while holding the rest of the indicators' parameters fixed at their median. Specifically, through the analysis we explored whether the same set of parameters appear to be influential in discriminating between acceptable and unacceptable model results for thresholds set at the 5th, 25th, 50th, 75th, and 95th percentile for each parameter.

3. Results

3.1 Measuring the impact of social, economic and environmental indicators on sustainability

In order to test for the association between the SI and the hypothesized latent constructs, and also for the derivation of the SI for each one of the three regions we utilized a total of 7 latent predictors, performing SEM analysis, that is described analytically in the following paragraphs.

Thus, in order to test the influence of the predictor variables on the SI latent construct, we performed a total of 4 SEM analyses, one including the data from the total area and three including data from the three sub-regions. The path diagrams obtained by the fit of our models are shown in Figures 2-5. The single-headed arrows in the path diagrams imply a direction of assumed causal influence while the numerical values next to each arrow represent standardised regression weights of the corresponding item on the SI. The statistical significance of each weight is also indicated. For reasons of clarity, the loadings of non-statistically significant paths are not reported and the particular arrow is marked with a dashed arrow line. The regression weights of the observed items on each of the latent indicators are shown in Table A1 (Appendix).

Figure 2 depicts the standardized regression coefficients and their significances of the full model (Model A). Most of the latent constructs have a significant effect on the SI, with the exception of the [ENVIRONMENTAL INDICATOR B]. A marginal significance is also observed for the [ECONOMIC INDICATOR] ($p<0.1$).

[Insert Figures 2 and 3 here]

In the western region of the Asopos river, the results are similar to Model A with regard to the social indicators, however, we observe important differences with respect to the [ECONOMIC] and the [ENVIRONMENTAL] indicators.

In Model C, utilizing data of the eastern region, three out of the four social indicators are significant predictors excluding [SOCIAL NETWORKS], whereas from the economic and environmental indicators only the effects of the [ENVIRONMENTAL A] indicator are marginally important.

[Insert Figures 4 and 5 here]

Finally, the SEM results for model D (Industrial region) are the most distinguishable among the comparable models, since most of the social indicators are non-significant and the SI is mostly connected with the economic and environmental indicators.

3.2. Measuring sustainability in the research area

Latent factor weights obtained from the fitted SEM models were subsequently used for deriving a measure of sustainability (SI) for each respondent, included in the complete dataset and the subpopulations of the three regions under investigation. Table 2 summarizes the SIs in the form of average SI ($\overline{SI}$) and the corresponding 95% confidence intervals. Higher levels of SI are given for the eastern region ($\overline{SI}$=1.41), whereas the lowest levels are those found for the industrial region ($\overline{SI}$=1.26).

[Insert Table 2 here]

3.3 Estimating new sustainability indicators based on local perceptions

Local communities' perceptions regarding the importance of the different indicators were measured on a 10-point Likert scale. The most important sustainability indicators for locals were 'employment' (7.87) followed by 'environmental quality' (7.81), 'quality of life' (7.43) and the existence of local enterprises (7.4). Other indicators measured were the existence of social trust and reciprocity (7.31), the engagement of the local community in decision-making (7.16), the existence of local enterprises and their Corporate Social Responsibility initiatives (6.99) and social networks (6.91). Trust in institutions was considered as the least important aspect of sustainability by locals (5.31).

After incorporating citizens' perceptions, new scores were calculated presented in Table 3 showing the new indicators for each factor measured and the level of change of the indicator compared to the initial one.

[Insert Table 3 here]

The new calculations reveal what sustainability consists of according to the local population. When looking, for example, at the economic activity in the area it is clear that the number of industries in the area and their activities are not as important indicators compared to other elements of sustainability. Quality of life and indicators of environmental quality are more important in the coastal areas compared to the other two regions. The table also reveals the low importance of institutional trust in all regions.

3.4 Sensitivity analysis

The results obtained from the conducted sensitivity analysis are summarized in the following tables (Tables 4 and 5). In Table 4, the sensitivity analysis results are presented for each sustainability indicator. Sensitivity was checked by varying the parameter value of each covariate one at a time while keeping the rest of parameters fixed at their median value (50% percentile). The obtained values were calculated for the minimum 5th, 25th, 75th, 95th percentiles, and the maximum values of each indicator, as they were determined by the distribution of their weighted scores, after adjusting for the citizens' perceptions.

From the sensitivity analysis it is clear that the higher levels of sensitivity are due to the indicators of Social Networks (SN), Environmental Quality B (ENI B), and the Quality of Life (QL). On the other hand, the SI was found to be less sensitive to changes of the Economic indicator (ECI), Environmental Quality B (ENI A) and Institutional Trust (IT). These results are also verified by Table 5, presenting the corresponding percentages of the reduction in the SI levels (for a visual representation of the sensitivity analysis results see also Figures A1 and A2 in the Appendix). For instance, inspection of Table 5 (see also Figure A1) reveals that the SI is very sensitive to the reduction of the levels of social networks and the levels of environmental indicator B (-37.2% and 57.1 of SI reduction when SN and ENI B indicators are to be found at their lower levels, respectively). According to the results the SI is more robust to an increase of the levels of the latter indicators, with a 16.29% and 10.86% increase in its levels when maximizing the values of SN and ENI B, respectively.

Another indicator on which the SI exhibits sensitivity to is Quality of Life (QL). By increasing or decreasing the specific indicator at its maximum or minimum level a

18.56% reduction can be achieved or an increase by 17.42% for the SI. The SI is also less robust to the changes in the environmental indicator A, and Social Trust but is extremely robust to the changes of the Economic Indicator, as shown by the results of Table 5. The only exception is when the level of the specific indicator is varied at its maximum value, where a moderate 6.78% increase in the SI is achieved. Finally, the indicator of Institutional Trust is also relatively un-important for the final SI, especially when it is reduced.

A general conclusion derived from the sensitivity analysis results is that the SI is more sensitive to the decrease of the most dominant indicators rather than their increase.

[Insert Tables 4 and 5 here]

4. Discussion

The indicators and the final sustainability index estimated in this study revealed several interesting findings. Regarding the total index of sustainability, it was noted that the region facing the most severe problem of environmental degradation, the industrial area, was also the one with the lowest levels of sustainability. When the research area was divided in three sub-regions it became evident that the level of importance of the different sets of indicators for the SI varied significantly. Economic indicators were more important in the west and the industrial regions, environmental indicators were more important in the industrial region and social indicators were more important in the East region. Previous scholars have highlighted the importance of measuring sustainability on a local level and the usefulness and limitations of such measurements (Brugmann 1997; Holman 2009; Mascarenhas et al. 2010). Our study reveals that even when sustainability is measured on a local scale there are variations between communities in the context of the same geographical location verifying previous findings that certain aspects of sustainability can be social constructed (Onduru and Preez 2010).

The study also focused on the importance of social aspects of sustainability. Although social sustainability is increasingly recognized as an important aspect of sustainable development, it is at the same time one of the weakest elements to determine (Lehtonen 2004; Bostrom 2012). Based on developments in the social and environmental science literature (Selman 2001; Pretty 2003) as well as the findings of our pre-survey, we decided to include indicators which are less frequently measured as sustainability indices, such as trust and networks along with more commonly used ones, such as quality of life. All these indicators have been gaining support by scholars as useful indices capturing sustainability levels (Ooi et al. 2014). Our results reveal that such indicators are of high importance for the SI estimation, a fact that highlights that it is essential to include indicators influenced from the social capital literature (Putnam, 2000; Coleman, 1990) when measuring sustainability (Weingaertner and Moberg, 2011; Rogers et al. 2013).

A final aim of the study was to assess the importance of the different sustainability indicators based on individuals' perceptions. Employment was the most important indicator for the sustainable development of the area, according to locals, followed by environmental quality. Both of these findings were expected as they refer to the two most important problems in the area, the current recession and the long-term environmental degradation. It is interesting to note that institutional trust was the least important aspect for respondents. Levels of institutional trust in Greece are traditionally very low, especially towards governmental actors (Jones et al. 2008). This is due to historical and political reasons and they have been further influenced by the current recession in the country where increased taxes have impacted on households, leading to the escalation of social inequality (Matsaganis and Leventi 2014).

When using these perceptions to weigh sustainability indicators significant changes in the initial estimations were observed. We would like to focus on three main issues: First, institutional trust was the indicator with the highest reduction in all areas and was also the parameter with the lowest initial levels. From this finding it is evident that individuals are no longer relying on these institutions to have an important role in improving the level of sustainability in the area. This is a finding which complicates potential actions to be taken in any future decision-making in the context of public policies. As the main institutions to manage public issues are governmental (both local and central government) this is a barrier for which policy makers need to consider a way to overcome. This is because in order to design and implement effective public policies it is crucial that the level of trust in the relevant institutions increases. Second, the importance of economic aspects, as measured in our study, was very limited considering the current financial situation. This leads us to our third point, that other parameters seem to have come to 'fill the gap' of the low trust in institutions and the disappointing role of local enterprises for locals in terms of what individuals consider as important for the sustainable development in their area. These indicators are the 'good quality of the natural environment' and the 'quality of life for individuals', followed by some of the other social indicators. This outcome is confirmed by the sensitivity analysis of the study, suggesting that for a more immediate and direct effect on sustainability levels these are the indicators that will have a stronger impact.

Due to the importance of these additional social indicators for sustainability, a question arises regarding the most appropriate means to measure them, especially considering the option of using subjective or objective measurement tools. The importance of subjective measurements has been identified by previous studies, especially when these refer to issues such as wellbeing (Engelbrecht 2009) and quality of life (Petrosillo et al. 2013). In the present study, we decided to measure social indicators through a structured questionnaire capturing 'subjective' local perceptions. The use of the specific research approach allowed us to measure indicators that are not usually incorporated in sustainability studies, as relevant data are often unavailable. We do however recognize a limitation at this point regarding the subjective measurement of social aspects of sustainability. The lack of a counterfactual study with less local community inspired level of analysis in order to explore whether there are differences is lacking at the moment in this study. Thus, we would like to underline here the importance of taking local perceptions into consideration when trying to use sustainability indicators for the solution of local problems such as the promotion of local social equality. These findings should be seen in parallel with additional studies focusing on global assessments of sustainability and also objective measurement of local sustainability indicators. Furthermore, the interaction of society with the environment is a very complex system (Lehtonen 2004). The indicators and framework proposed here are in no way an exhaustive framework. The indicators used are site-specific, with a significant focus on social aspects. Secondly, the use of subjective perceptions in order to weigh indicators can have certain drawbacks (Bohringer and Jochem 2007; Singh et al. 2009) as it may not provide reliable and accurate weights.

Despite these limitations, the results of this study are very useful also on a local level assisting practitioners and researchers working in the area, and other areas with similar problems, to understand local community perceptions for sustainability in areas facing low environmental quality due to industrial activities. The Asopos river area is a unique case study in Greece as the area has faced persistent environmental degradation problems through the years (Panagopoulos et al. 2014; Davila et al., 2017, Proikaki et al. 2018). Furthermore, the Greek economic crises has affected a variety of aspects in the economic, social and environmental sphere (Halkos and Bousinakis 2017). This paper provides a first glance on the views of local communities regarding what sustainable development means to them in the context of the current economic recession (Hyz and Karamanis 2017). While governmental actors are seeking solutions to move out of the recession (Papatheodorou and Pappas 2017) our study provides significant evidence which indicate that certain socio-economic issues, such as networks and institutional trust, should be the primary focus of new policies designed to re-develop the area considering both environmental quality targets but also socio-economic issues of equitable governance.

5. Conclusion

In conclusion, the present study aimed to explore two main issues: the subjective measurement of social sustainability indicators and the incorporation of local communities' perceptions in sustainability measurements. Key findings of the study were that according to locals' perceptions most important sustainability indicators for the Asopos area were environmental quality and individual's quality of life. Furthermore, when sustainability indicators were 'weighted' by the public, 'quality of the natural environment' and the 'personal quality of life' were more important compared to other measures, such as the level of employment and local enterprises.

The importance of these results lies on two main issues. Firstly, we highlight the role of additional indicators which can be crucial in measuring sustainability, such as the level of trust, networks and quality of life. We would also like to underline that certain aspects of sustainability are socially constructed and local scale studies need to be combined with macro level assessments for a holistic measurement of sustainability. Secondly, the study provides significant evidence on ways to improve the current situation in the environmentally degraded area of the Asopos river. One of the most important findings is the very low level of institutional trust and, on contrary, the high level of informal social network. This finding reveals a potential important obstacle in improving sustainability in the area-the low levels of trust- but also a potential strong element the existence of informal networks. Thus, future policy solutions in the area could be use these informal networks in order to increase public engagement in sustainability-related initiatives.

Finally, although the study is site-specific and locally focused it describes an approach that can be replicated in other sites in the world where assessments for sustainability are conducted and researchers and practitioners would like to incorporate the views of locals in their decisions. It highlights that, along the traditional assessment of sustainability indicators, researchers and practitioners can use local perceptions in order to identify the importance of specific indicators of sustainability in a certain geographical context. This can assist in setting new policy directions in reaching sustainable development goals on a local level.

References

Allen C, Nejdawi R, El-Baba J, Hamati K, Metternicht G, Wiedmann T. 2017. Indicator-based assessments of progress towards the sustainable development goals (SDGs): a case study from the Arab region. Sustain Sci, 1296: 975-989.

Arbuckle JL. 2006. Amos 7.0 User's Guide. Chicago, IL: SPSS.

Arnes E, Astier M, Gonzalez OM, Diaz-Ambrona CGH. 2018. Participatory evaluation of food and nutritional security through sustainability indicators in a highland peasant system in Guatemala. Agroecol Sust Food, 43(5): 482-513.

Ascher W. 2007. Policy sciences contributions to analysis to promote sustainability. Sustain Sci 2(2): 141-149.

Bell S, Morse S. 2013. Measuring Sustainability: Learning from Doing. Earthscan, London.

Blancas FJ, Lozano-Oyola M, Gonzalez M, Guerrero FM, Caballero R. 2011. How to use sustainability indicators for tourism planning: The case of rural tourism in Andalusia (Spain), Sci Total Environ, 412-413 (15): 28-45.

Bohringer C, Jochem PEP. 2007. Measuring the immeasurable-A survey of sustainability indices, Ecol Econ, 63: 1-8.

Bollen KA. 1989. Structural equations with latent variables. New York: Wiley-Interscience.

Bostrom M. 2012. A missing pillar? Challenges in theorizing and practicing social sustainability: introduction to the special issue. Sustainability: Science, Practice and Policy, 8(1)

Botsou F, Karagoergis AP, Dassenakis E, Scoullos M. 2011. Assessment of heavy metal contamination and mineral magnetic characterization of the Asopos river sediments (central Greece). Marine Pollution Bulletin. 62: 547-563.

Brugmann J. 2007. Is there a method in our measurement? The use of indicators in local sustainable development planning. Local Environment The International Journal of Justice and Sustainability. 2, 59-72.

Carlsen L. 2017. Happiness as a sustainability factor. The world happiness index: a posetic-based data analysis. Sustain Sci, doi: https://doi.org/10.1007/s11625-017-0482-9

Coleman JS. 1990. *Foundations of Social Theory*. Belknap Press of Harvard University Press, Cambridge, MACostanza R., Fisher B., Ali S., Beer C., Bond L., Boumans R., Danigelis N.L., Dickinson J., Elliott C., Farley J., Gayer D.E., MacDonald Glenn L., Hudspeth T., Mahoney D., McCahill L., McIntosh B., Reed B., Rizvi A.T., Snapp R. (2007) Quality of life: An approach integrating opportunities, human needs and subjective well-being. Ecol Econ, 61: 267-276.

Dahl AL. 2012. Achievements and gaps in indicators for sustainability. Ecol Indic, 17: 14-19.

Davila OG, Koundouri P, Pantelidis T, Papandreou A. 2017. Do agents characteristics affect their valuation of common pool resources? A full preference ranking analysis for the value of sustainable river basin management, Sci. Total Environ, 575: 1462-1469

Dissanayake N, Xia B, Wu P. 2015. Measuring Sustainability performance within the Australian energy industry. Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate, pp 135-143.

Distaso A. 2007. Well-being and/or quality of life in EU countries through a multidimensional index of sustainability. Ecol Econ, 64: 163-180.

Engelbrecht H-J. 2009. Natural capital, subjective well-being, and the new welfare economics of sustainability: some evidence from cross-country regressions. Ecol Econ, 69: 380-388.

Fernandez-Sanchez G., Rodriguez-Lopez F. 2010. A methodology to identify sustainability indicators in construction project management-Application to infrastructure projects in Spain. Ecol Indic, 10(6): 1193-1201.

Fraser EDG, Dougil AJ, Mabee WE, Reed M, McAlpine P. 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowererment and sustainable environmental management. Journal Environ Manage, 78(2): 114-127.

Grunblatt J, Alessa L. 2017. Role of perception in determining adaptive capacity: communities adapting to environmental change, Sustain Sci, 12: 3-13.

Halkos G, Bousinakis D. 2017. The effect of stress and dissatisfaction on employees during crisis. Economic Analysis and Policy, 55: 25-34.

Hamby DM. 1994. A review of techniques for parameter sensitivity analysis of environmental models. Environ Monit Assess 32: 135-154.

Hara K, Kumazawa T, Kimura M, Tsuda K. 2016. Participatory approach in vision setting: emerging initiatives in local municipalities in Japan. Sustain Sci, 11: 493-503.

Hicks CC, Levine A, Agrawal A, Basurto X, Breslow SJ, Carothers C, Charnley S, Coulthard S, Dolsak N, Donatuto J, Garcia-Quijano C, Mascia MB, Norman K, Poe MR, Satterfield T, Martin KS, Levin PS. 2016. Engage key social concepts for sustainability. Science, 352: 6281, 38-40.

Holman N. 2009. Incorporating local sustainability indicators into structures of local governance: a review of the literature. The International Journal of Justice and Sustainability. 14: 365-375.

Hyz A, Karamanis K. 2017. The role of the creative industries in regional development during the economic cycle: case of the region of Epirus, Greece. Int. J. Entrepreneurship Innovation Management, 21(3): 170-184

IBM Corp. Released. 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.

Jones N, Malesios C, Iosifides T, Sophoulis CM. 2008. Social capital in Greece: Measurement and comparative perspectives. South Eur. Soc. Politics.13 (2: 175-193

Keeble JJ, Topiol S, Berkeley S. 2003. Using indicators to measure sustainability performance at a Corporate and Project Level. J Bus Ethics, 44: 149-158.

King MF, Reno VF, Novo EMLM. 2014. The concept, dimensions and methods of assessment of human well-being within a socioecological context: A literature review, Soc Indic Res, 116: 681-698.

Krueger AB, Stone AA. 2014. Progress in measuring subjective well-being. Science, 346: 42-34.

La Rovere EL, Soares JB, Oliveira LB, Lauria T. 2010. Sustainable expansion of electricity sector: Sustainability indicators as an instrument to support decision making. Renew Sust Energ Rev, 14: 422-429.

Lehtonen M. 2004. The environmental-social interface of sustainable development: capabilities, social capital institutions. Ecol Econ, 199-214.

Liu G. 2014. Development of a general sustainability indicator for renewable energy systems: A review. Renew Sust Energ Rev, 31: 611-621.

Marzo-Navarro M, Pedraja-Iglesias M, Vinzon L. 2015. Sustainability indicators of rural tourism from the perspective of the residents. An International Journal of Tourism Space, Place and Environment, 17(4): 586-602.

Mascarenhas A, Coelho P, Subtil E, Ramos TB. 2010. The role of common local indicators in regional sustainability assessment. Ecol Indic. 10: 646-656.

Matiatos I. 2016. Nitrate source identification in groundwater of multiple land-use areas by combining isotopes and multivariate statistical analysis: A case study of Asopos basin (Central Greece), Sci. Total Environ, 541: 802-814.

Matsaganis M, Leventi C. 2014. Poverty and inequality during the great recession in Greece. Polit Stud Rev, 12: 209-223.

Mickwitz P, Melanen M. 2009. The role of co-operation between academia and policymakers for the development and use of sustainability indicators – a case from the Finnish Kymenlaakso Region. J Clean Prod. 17: 1086-1100.

Moldan B, Janouskova S, Hak T. 2012. How to understand and measure environmental sustainability: indicators and targets. Ecol Indic, 17: 4-13.

Myllyviita T, Antikainen R, Leskinen P. 2017. Sustainability assessment tools-their complehensiveness and utilization in company-level sustainability assessments in Finland. Int J Sust Dev World, 24(3): 236-247.

Ness B, Urbel-Piirsalu E, Anderberg S, Olsson L. 2007. Categorising tools for sustainability assessment. Ecol Econ, 60: 498-508.

Ooi N, Laing J, Mair J. 2014. Social capital as a heuristic device to explore sociocultural sustainability: a case study of mountain resort tourism in the community of Steamboar Springs, Colorado, USA. J Sustain Tour, 23(3): 417-436.

O Ryan P, Pereira M. 2015. Participatory indicators of sustainability for the salmon industry: The case of Chile. Mar Policy 51: 322-330.

O'Faircheallaigh C. 2010. Public participation and environmental impact assessment: Purposes, implications, and lessons for public policy making. Environ Impact Assess, 30: 19-27

Onduru DD, Du Preez CCC. 2010. Farmers' knowledge and perceptions in assessing tropical dryland agricultural sustainability: Experiences from Mbeere District, Eastern Kenya, Int J Sust Dev World, 15(2): 145-152.

Panagopoulos I, Karayannis A, Kollias K, Papassopi N. 2014. Investigation of potential soil contamination with Cr and Ni in four metal finishing facilities at Asopos industrial areas. J Hazard Mater,. 281

Papatheodorou A, Pappas N. 2017. Economic recession, job vulnerability and tourism decision making: a qualitative comparative analysis, J. Travel Res, 50 (5): 663-677

Petrosillo I, Costanza R, Aretano R, Zccarelli N, Zurlini G. 2013. The use of subjective indicators to assess how natural and social capital support residents' quality of life in a small volcanic island. Ecol Indic, 24: 609-620.

Pretty J. 2003. Social Capital and the Collective Management of Resources. Science 302, 1912-1914.

Proikaki M, Nikolaou I, Jones N, Malesios C, Dimitrakopoulos PG, Evangelinos K. 2018. Community perceptions of local enterprises in environmentally degraded areas. J Behav Exp Econ, 73: 116-124.

Putnam R. 2000. Bowling alone: The collapse and revival of American Community. Simon and Schuster, New York.

Rogers SH, Gardner KH, Carlson CH. 2013. Social capital and walkability as social aspects of sustainability. Sustainability, 5(8): 3473-3483.

Roy R, Weng Chan N, Rainis R. 2014. Rice farming sustainability assessment in Bangladesh, Sustain Sci, 9: 31-44.

Saltelli A., Tarantola S, Campolongo F, Ratto M. 2004. Sensitivity Analysis in Practice. John Wiley and Sons Ltd, Chichester, UK.

Salvati L., Zitti M. 2009. Substitutability and weighting of ecological and economic indicators: Exploring the importance of various components of a synthetic index. Ecol Econ, 68: 1093-1099.

Sazakli E, Siavalas G, Fidaki A, Christanis K, Karapanagioti HK, Leotsinidis M. 2015. Concentrations of persistent organic pollutants and organic matter characteristics as river sediment quality indices. Toxicol Environ Chem, 98(7): 787-799.

Selman P. 2010. Social capital, sustainability and environmental planning. Planning, Theory and Practice, 2,13-30.

Shen LY, Ochoa JJ, Shah MN, Zhang X. 2011. The application of urban sustainability indicators- A comparison between various practices. Habitat Int, 35: 17-29.

Shen L., Guo X. 2014. Spatial quantification and pattern analysis of urban sustainability based on a subjectively weighted indicator model: A case study in the city of Saskatoon, SK, Canada. Appl Geogr, 53: 117-127.

Singh RK, Murty HR, Dikshit AK. 2009. An overview of sustainability assessment methodologies. Ecol Indic, 9(2): 189-212.

Skouloudis A, Jones N, Roumeliotis S, Isaac D, Greig A, Evangelinos K. 2016. Industrial pollution, spatial stigma and economic decline: the case of the Asopos river basin through the lens of local small business owners. J Environ Plann Man, 60(9): 1575-1600.

SPSS Inc. 1999. SPSS Base 10.0 for Windows User's Guide. SPSS Inc., Chicago IL;

Tanguay GA, Rajaonson J, Lefebvre JF, Lanoie P. 2010. Measuring the sustainability of cities: An analysis of the use of local indicators. Ecol Indic, 10(2): 407-418.

Turcu C. 2013. Re-thinking sustainability indicators: local perspectives of urban sustainability. J Environ Plann Man, 56(5): 695-719.

Urbanski M, Leal Filho W. 2015. Measuring Sustainability at universities by means of the Sustainability tracking, assessment and rating system (ASTRA): early findings from STARTS data. Enviro Dev Sustain, 17: 209-220.

Valentin A., Spangenberg J.H., (2000). A guide to community sustainability indicators. Envir Impact Asses, 20: 381-392.

Van Beynen P, Akiwumi FA, Van Beynen K. 2017. A sustainability index for small island developing states. Int J Sust Dev World, 25(2): 99-116.

Vilei S. 2011. Local perceptions of sustainability of farming systems on Leyte, Philippines-divergences and congruencies between different stakeholders. International

Journal of Sustainable Development and World Ecology, 18(4): 291-303.

Wallis AM, Kelly AR, Graymore MLM. 2010. Assessing Sustainability: a technical fix or a means of social learning? Int J Sust Dev World, 17(1): 67-75.

Weingaertner C, Moberg A. 2014. Exploring social sustainability: learning from perspectives on urban development and companies and products, Sustainable Development, 22: 122-133.

Wiek A, Binder C. 2005. Solution spaces for decision-making—a sustainability assessment tool for city-regions. Environ Impact Asses 25:589-608

Yu C, Cheng J-J. and Zielen, A-J. 1991. Sensitivity analysis of the RESRAD, a dose assessment code. Trans. Am. Nuc. Soc., 64: 73-74.

Winther AM. 2016 Community sustainability: a holistic approach to measuring the sustainability of rural communities in Scotland. Int J Sust Dev World, 24(4): 338-351.

Wynveen B.J. 2015. Perceptions of sustainability and sustainable living among non-environmentally motivated individuals. Society and Natural Resources: An international Journal, 28 (12): 1278-1289.

Zagonari F. 2015. Technology improvements and value changes for sustainable happiness: a cross-development analytical model. Sustain Sci, 10: 687-698

Table 1. Descriptive statistics of sustainability indicators

		GEOGRAPHICAL AREA (Mean (St. dev./Frequency)			
Category/Indicator	Variable	TOTAL AREA	West	Industrial	East
ST: Social trust (10-point Likert scale)	Generalised trust	4.5 (2.75)	5.04 (2.95)	4.03 (2.55)	4.2 (2.47)
	Particularised trust	4.37 (2.84)	4.95 (2.97)	3.93 (2.76)	3.95 (2.52)
IT: Institutional trust (10-point Likert scale)	Trust in government	1.08 (1.96)	0.71 (1.69)	1.31 (2.12)	1.44 (2.07)
	Trust local enterprises	3.51 (2.92)	3.05 (2.94)	3.76 (3.06)	3.98 (2.55)
	Trust Local authorities	2.93 (2.71)	2.95 (2.83)	2.82 (2.65)	3.06 (2.59)
	Trust Ministry of Environment	2.01 (2.36)	1.74 (2.29)	2.04 (2.39)	2.49 (2.35)
	Trust Non-Governmental Organisations	3.03 (2.95)	2.98 (3.11)	2.94 (2.92)	3.51 (2.67)
SN: Social networks (Binary yes/no)	Member in NGO	13.1	15.1	13.5	8.5
	Volunteer in NGO	13.5	16.5	13.9	6.9
	Informed of local council decisions	41.5	40.8	45.8	36
	Participation in protests	31.4	28.3	29.5	40.4
	Meeting friends/relatives several times a week	76.9%	79.4%	77.9%	70.1%
QL: Quality of life and	Quality of life	5.14	5.27	4.84	5.35 (2.46)

safety (10-point Likert scale)		(2.73)	(2.79)	(2.81)	
	Satisfaction from the local area	5.81 (2.91)	6.55 (2.85)	5.2 (3.05)	5.3 (2.46)
	Feeling of safety	2.46 (1.06)	2.4 (1.1)	2.45 (1.05)	2.57 (0.97)
Economic Indicator (scale 1-3)	Level of environmental impact of local enterprises	1.48 (0.32)	1.47 (0.14)	1.71 (0.36)	1.17 (0.16)
	Size of local enterprises	1.03 (0.14)	1.00 (0.0)	1.09 (0.23)	1.00 (0.0)
Environmental quality-indicator A (ENVA) (scale 1-4)	NO_3-Underwater	1.86 (0.99)	3.00	1.00	1.00
	Cr(Vi)-Surface water	2.29 (1.48)	4.00	1.00	1.00
	NH_4-Surface water	2.49 (1.35)	1.00	4.00	3.00
	NO_2-Surface water	1.86 (0.99)	3.00	1.00	1.00
Environmental quality-Indicator B (ENVB) (scale 1-4)	Cr total	3.56 (0.83)	4.00	4.00	2.00
	PO_4-Surface water	1.22 (0.41)	1.00	1.00	2.00

Table 2: Average factor scores for SI along with the corresponding 95% confidence intervals in the parentheses.

	Asopos Region (total area)	Western Region	Eastern Region	Industrial Region
Average SI	1.36	1.39	1.41	1.26
95% CI for SI	(1.31, 1.4)	(1.33, 1.46)	(1.32, 1.49)	(1.19, 1.34)

Table 3. Estimating new indicators incorporating local perceptions for their importance

	TOTAL		WEST		INDUSTRIAL		COASTAL	
	Mean	Reduction %	Mean	Reduction %	Mean	Reduction %	Mean	Reduction %
Social trust	0.32	27.95	0.35	29.97	0.29	26.72	0.31	25.06
Inst. Trust	0.14	41.30	0.12	44.19	0.15	39.64	0.17	39.25
Social networks	0.54	29.35	0.51	31.53	0.54	29.00	0.60	25.90
Quality of life	0.42	20.65	0.47	17.49	0.38	24.47	0.42	21.47
Econ. indicators	0.09	26.70	0.07	24.57	0.15	27.79	0.01	27.63
Env. indicator 1	0.41	19.12	0.81	18.68	0.01	23.18	0.28	21.70
Env. indicator 2	0.56	21.18	0.68	18.68	0.76	23.73	0.01	20.56

Table 4: Sensitivity analysis results of the SI obtained by utilizing the estimates from the best selected path analysis model.

Percentiles	ST	IT	SN	QL	ECI	ENI_A	ENI_B
Min	1.056	1.138	0.841	0.972	1.146	1.027	0.733
5%	1.056	1.138	0.849	0.972	1.146	1.027	0.733
25%	1.088	1.139	1.037	1.075	1.147	1.027	0.781
50%	1.152	1.152	1.152	1.152	1.152	1.152	1.152
75%	1.216	1.169	1.241	1.227	1.155	1.394	1.199
95%	1.300	1.202	1.323	1.307	1.167	1.435	1.292
Max	1.376	1.279	1.376	1.395	1.236	1.435	1.292

Table 5: Percentage of change in the SI estimates due to the changes in the parameter values

Percentiles	ST	IT	SN	QL	ECI	ENI_A	ENI_B
min	-9.057	-1.207	-37.212	-18.567	-0.536	-12.152	-57.123
5%	-9.057	-1.207	-35.719	-18.567	-0.536	-12.150	-57.113
25%	-5.852	-1.129	-11.133	-7.130	-0.396	-12.143	-47.745
75%	5.239	1.425	7.191	6.102	0.279	17.361	3.883
95%	11.405	4.132	12.946	11.886	1.253	19.709	10.862
max	16.287	9.906	16.289	17.425	6.785	19.709	10.862

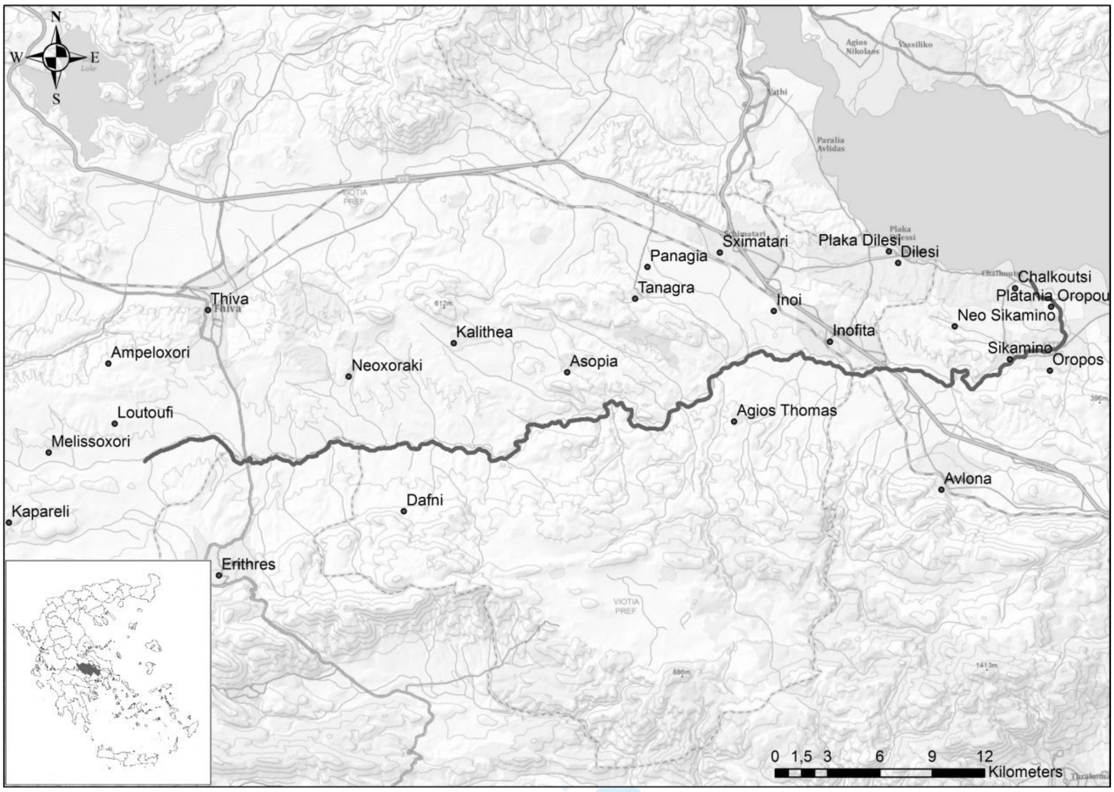


Figure 1. The area of the Asopos river

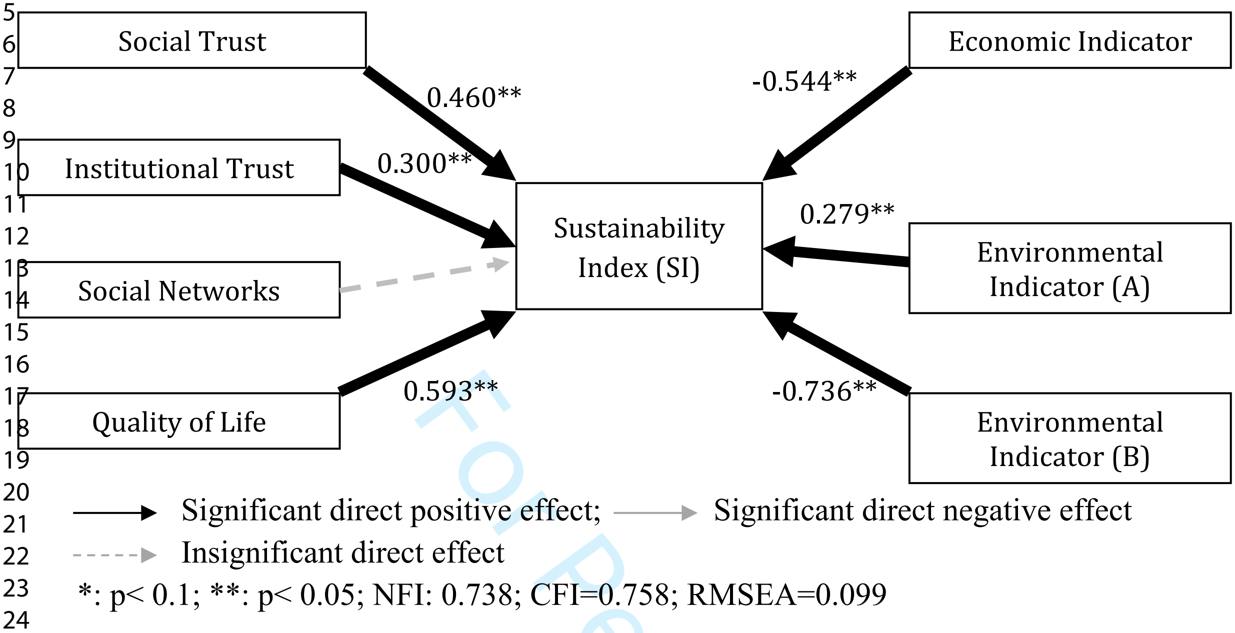


Figure 2. Estimated SEM Model for the Asopos Region (MODEL A)

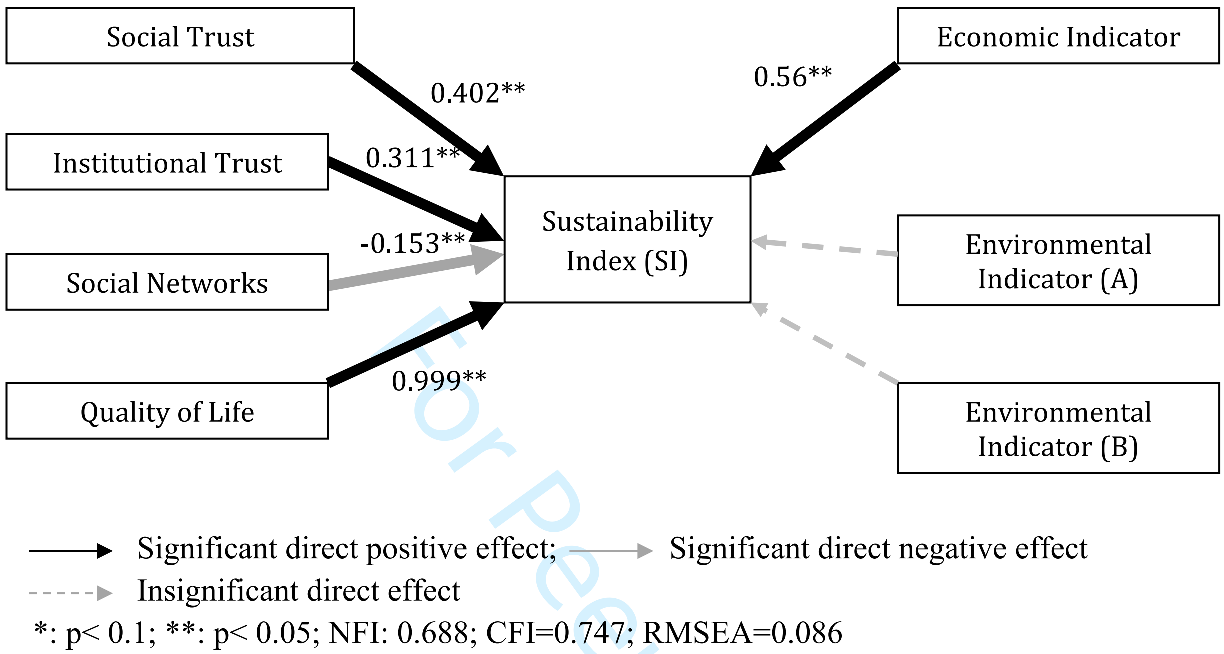
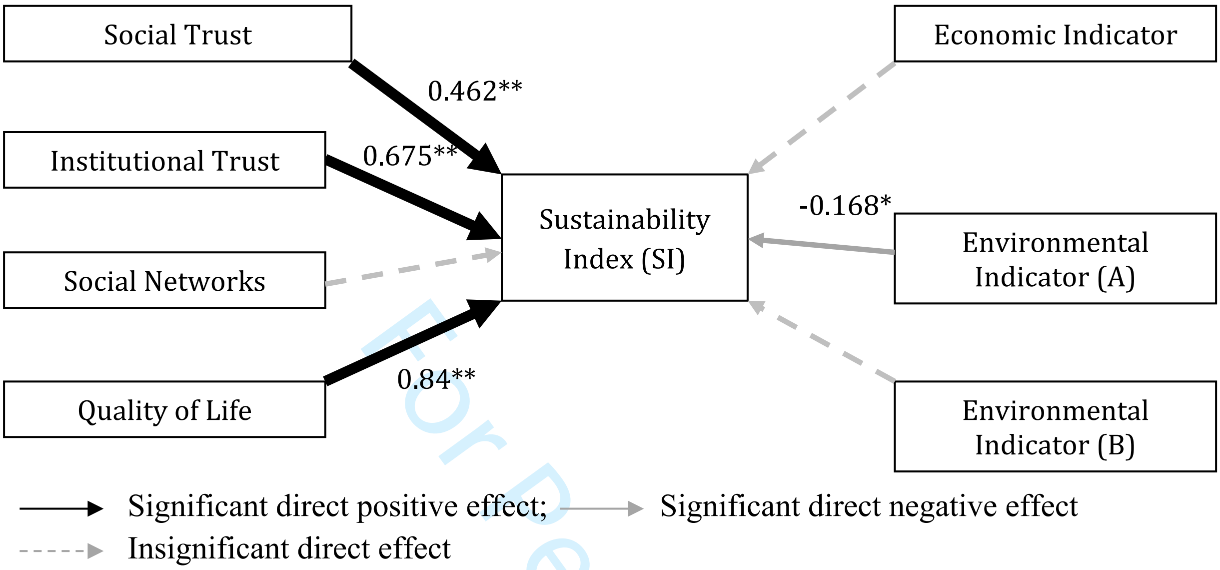
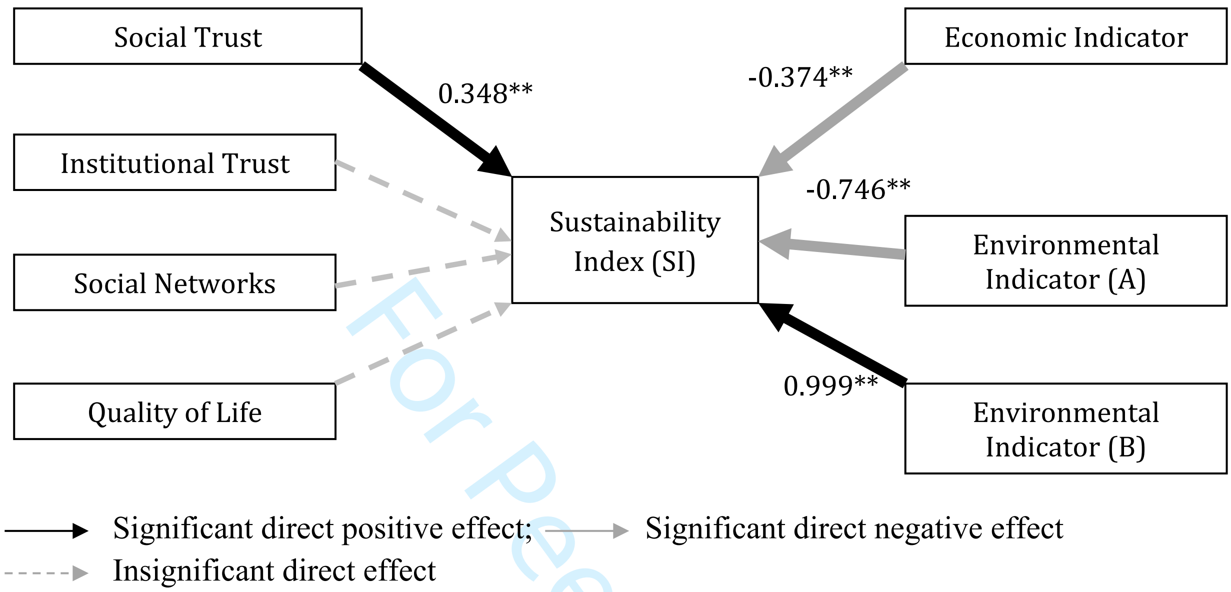


Figure 3. <u>Estimated SEM Model for the Western Region (MODEL B)</u>



*: p< 0.1; **: p< 0.05; NFI: 0.784; CFI=0.806; RMSEA=0.088

Figure 4. <u>Estimated SEM Model for the Eastern Region (MODEL C)</u>



*: p< 0.1; **: p< 0.05; NFI: 0.808; CFI=0.854; RMSEA=0.091

Figure 5. Estimated SEM Model for the Industrial Region (MODEL D)

APPENDIX

Table A1: Standardized regression weights of the observed items on the latent indicators

	Regression weights			
	Model A	**Model B**	**Model C**	**Model D**
SOCIAL TRUST				
Generalised trust	0.911	0.877	0.88	0.991
Particularised trust	0.887	0.913	0.89	0.869
INSTITUTIONAL TRUST				
Trust in government	0.592	0.513	0.589	0.648
Trust local enterprises	0.605	0.573	0.689	0.593
Trust Local authorities	0.663	0.564	0.759	0.741
Trust Ministry of Environment	0.699	0.647	0.599	0.798
Trust Non-Governmental Organisations	0.593	0.541	0.495	0.714
SOCIAL NETWORKS				
Member in NGO	0.94	0.972	0.99	0.892
Volunteer in NGO	0.726	0.747	0.19	0.823
Informed of local council decisions	0.081	0.122	-0.018	0.078
Participation in protests	0.16	0.14	0.068	0.233
Meeting friends/relatives several times a week	-0.106	-0.147	-0.04	-0.03

QUALITY OF LIFE				
Quality of life	0.719	0.644	0.771	0.769
Satisfaction from the local area	0.815	0.846	0.84	0.821
Feeling of safety	0.269	0.097	0.485	0.409
ECONOMIC INDICATOR				
Level of environmental impact of local enterprises	0.99	0.201	0.048	0.881
Size of local enterprises	0.406	0.144	0.99	0.999

The correlations between the various latent predictors are reported in Table A2. Most significant correlations are shown among the social indicators. Correlation between the two environmental constructs is zero, since the two factors comprise of uncorrelated observed items.

Table A2: Pearson's correlation coefficients along with their significance for the latent constructs.

	ST	**IT**	**SN**	**QL**	**ECI**	**ENIA**	**ENIB**
ST	1						
IT	0.236**	1					
SN	-0.105**	-0.039	1				
QL	0.428**	0.32**	-0.115**	1			
ECI	0.011	-0.001	0.042	-0.075*	1		
ENIA	0.176**	-0.094*	-0.042	0.13**	-0.26**	1	
ENIB	0.038	-0.089*	-0.084*	-0.012	0.411**	0	1

(*) correlations are significant at a 5% level of significance; (**) correlations are significant at a 1% level of significance

Table A3. Concentrations of variables related to environmental quality degradation in the research area

ENVIRONMENTAL QUALITY MEASUREMENTS (average values)	GEOGRAPHICAL AREA			
	TOTAL AREA (average value and std deviation)	WEST	CENTRAL	EAST
Groundwater				
NO_3- (mg/L)	76.91 (34.08)	47.9	122.7	60.2
Cr total (µg/L)	38.32 (6.95)	37.9	31.4	50.3

Surface water				
Cr(VI)- (μg/L)	3.09 (2.17)	0.59	4.97	4.98
NH_4 (mg/L)	0.17 (0.04)	0.22	0.13	0.14
NO_2 (mg/L)	0.1 (0.06)	0.05	0.11	0.21
PO_4 (mg/L)	0.24 (0.06)	0.21	0.32	0.18

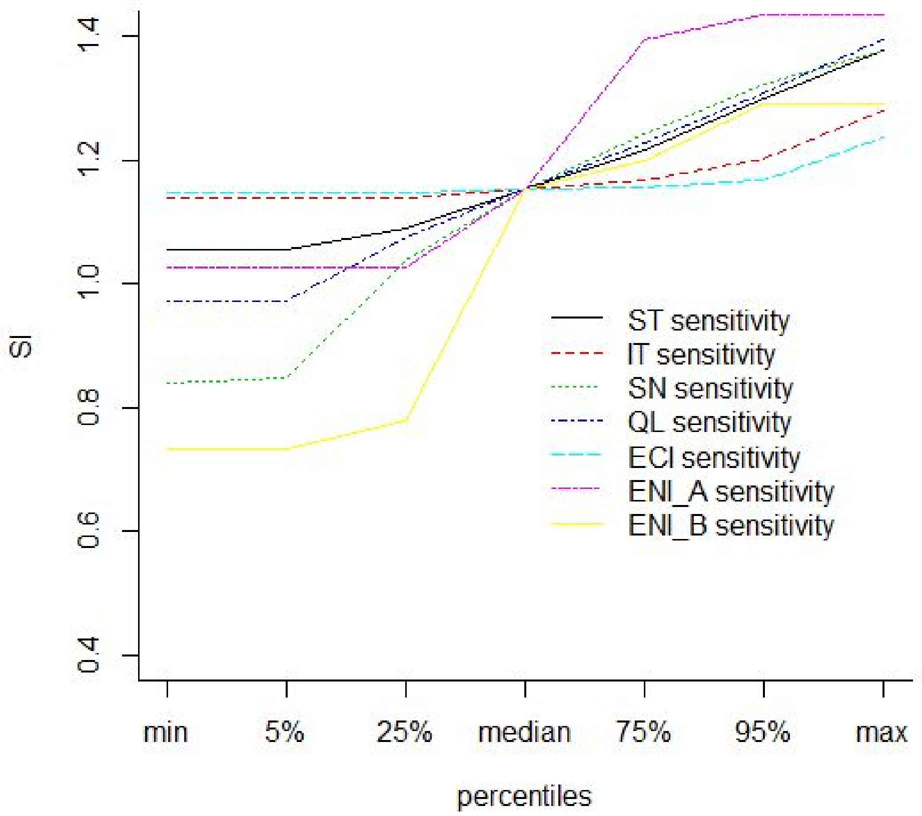


Figure A1: Sensitivity analysis results of SI for the various indicators

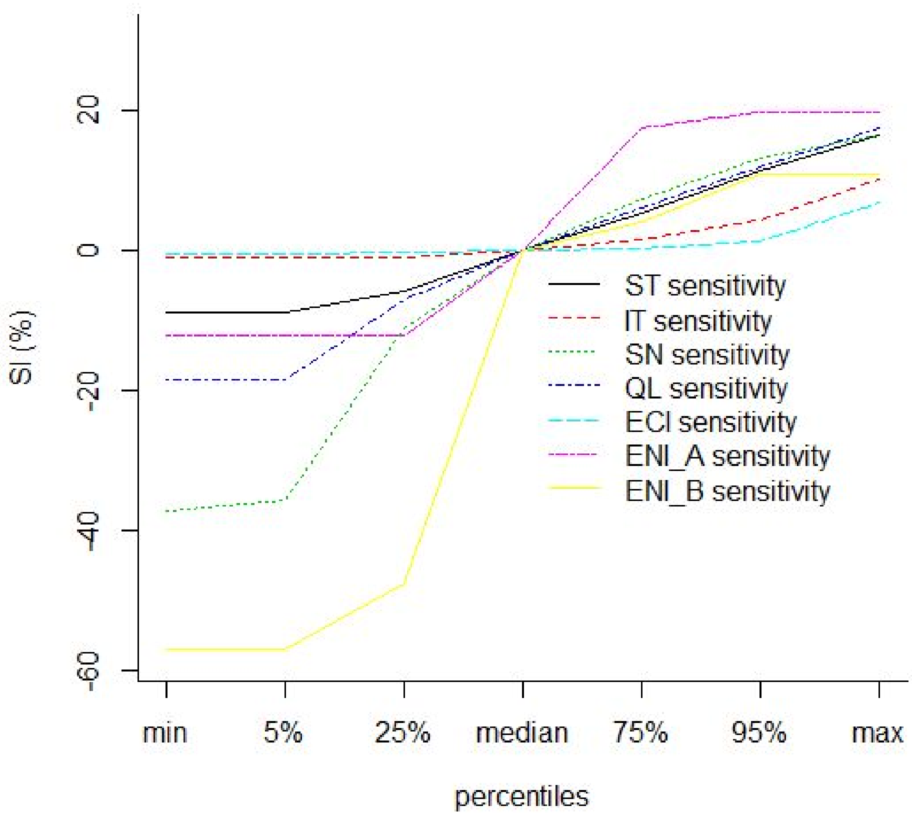


Figure A2: Sensitivity analysis results of SI for the various indicators (% of SI change)