9. Index of sustainable functionality: Application in Urat Front Banner

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9.1 Introduction

The functionality of sustainable societies is a pressing notion; sustainability has, indeed, become a quintessential example of what is wrong, but at the same time embodies an ultimate practicality since it is literally meaningless unless it can be repaired. As such, it is firmly rooted in the present (Bell & Morse 2008) and in characterising its measurability one could begin investigating what is required to survive on the planet. Sustainability is an example of a paradigm recognisable from what some see as the contradictory word to sustainable growth. Paradigms are vital in that they are philosophical and theoretical frameworks within which "theories, laws and generalisations [are derived]" (Bell & Morse 2008). According to Bell and Morse (2008) the broadest spectrum of the sustainable component within the sustainability paradigm implies, and dates back to the Brundtland Report, that whatever is done now will not detriment future generations (UN 1987). However, the clear-cut definition of sustainability, and what it encompasses varies depending upon "who is using it and in what context" (Bell & Morse 2008).

In short, this chapter does not specifically focus on wetland sustainability or restoration science – it is interlinked via geography and aspects of the science and statistical data presented in previous chapters. It provides a brief look at the design of an index of sustainable functionality (ISF) model (Imberger et al. 2007; Mills et al. 2005; Cirella & Tao 2008) based on a multi-criteria analysis study of Urat Front Banner, Inner Mongolia. The research's

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standpoint delineates key sustainability ideas for a novel ISF formulation (Cirella & Zerbe 2014a) and, simply put, extends methodological inter-linking ideologies. Some key points from (Cirella & Zerbe 2014b) that have been identified for ISF integration include:

- uncertainty and sustainability governance, which relates to the precautionary principle and the uncertainties that come about from pathways of why we are where we are and what our carrying capacity as a species is on the planet;
- definitional concerns, noting Daly's (2006) utility- versus throughput-based notions and illustrations on a broadened spectral-view of sustainability;
- characterising measurability and natural capital, which reports on the developments of intergenerational equity concerns and conflicts between differing perspectives via constraints and thresholds; and
- measuring sustainability towards an indicator-based system, which reveals the requisite to optimise data via the use of an indicator-based system via multi-dimensional categorisation.

9.2 ISF background

The ISF of Urat Front Banner is implemented using a matrix-based model. The aim is to calculate over a 20-year period, from 1990 to 2010 in five-year blocks, Urat Front Banner's societal sustainable functionality and promote sustainable principles amongst its citizens and local authority, so it can better comprehend required action towards a sustainable way of living. The definitional status of sustainability is examined in quantitative and qualitative terms and calculated using a multi-criteria assessment. This is based on operations research in which the application uses analytical methods to help make better decisions for optimal, or near-optimal, solutions to problems. Methodology expands across a geographic domain where the related sustainability is the level of functionality within the measured area. Theoretical analysis is tested and comprised of primary research concepts, in which preliminary steps are predefined by integrating notions from previous ISF studies in betterment of formulation and

mathematical controls. Triple bottom line (TBL) parameters and capital, defined as all goods that can be used in the production of other goods and services, play a key role in the definition of the methodological approach. All components of society, that being individual, community, from small business to conglomerate, and, even nation-state must ensure their actions are conducive to maintaining the life support systems that surround them (Mills et al. 2005). Hence, there is a niche for multi-faceted tools that can measure and monitor how well varying orders of life matchup against contemporary scientific standards. Many varieties of quantitative and qualitative methods of sustainability continue to be developed in an effort to transform the concept of sustainability into practical application. Key index-based examples within the scope of sustainability can be found in Table 1.

Table 1 – Key examples of sustainability-based indices based on data type.

Quantitative data type methodologies	Qualitative data type methodologies
Index for sustainable economic welfare (Daly & Cobb 1989)	Assessing the sustainability of societal initiatives and proposing agendas for change (Devuyst 1999)
Ecological footprint (Rees 1992)	Gross national happiness (Royal Government of Bhutan 1999)
Genuine progress indicator (Redefining Progress 1995)	Significance and sustainability model (Gibson et al. 2001)
Millennium development goals (UN 2000)	Quality-of-life index (Economist Intelligence Unit 2005)
Environmental performance index (preceded from the Environmental sustainability index) (Esty et al. 2005)	Happy planet index (New Economics Foundation 2006)
Living planet index (WWF 2005)	Global peace index (Institute for Economics and Peace 2007)
Index of sustainable functionality (Imberger et al. 2007)	Sustainable project appraisal routine (Arup 2008)
n-bottom line sustainability concept and performance approach (Foliente et al. 2007)	Structured analytical process for assessing measured sustainability (IUCN 2008)
Human development report (preceded from the 1990 Human development index) (UNDP 2010)	

The ISF captures components of subject complexities and acknowledges balances within its systems. Focusing upon societal assessment, typical ISF

theory taps into the notion of business accounting in which a TBL approach intertwines the relationship between environmental, social and economic paradigms (Elkington 1998). The ISF differs from other methodologies as it has been formulated on a different definitional basis of sustainability. Unlike the Brundtland Report (1987), it examines the assessment of need as problematic, not as a fact but as an understanding or interpretation. The ISF overcomes this subjectivity in defining need by focusing on the present level of functionality of a system, under consideration, to indicate longevity instead of sustainability as a state or as a future point of reality (Kristiana 2009). It is in this concept that this research aspires and encapsulates continuity with other ISF-based research via a novel design and pilot study in northern China. It utilised available electronically-formulated data, and interlinked varying interdisciplinary management approaches and procedural techniques.

9.3 ISF procedural steps

The ISF geographic work is site specific and has been adapted from a number of key scientific sources and technical reports (Imberger et al. 2007; Cirella & Tao 2008; Brown & Imberger 2006; Mills et al. 2005; Kristiana 2009). The ISF framework illustrates a bottom-up approach and encompasses seven steps (Figure 1), it is theoretical and founded within the scope of a decision-aiding technique for sustainability assessment.

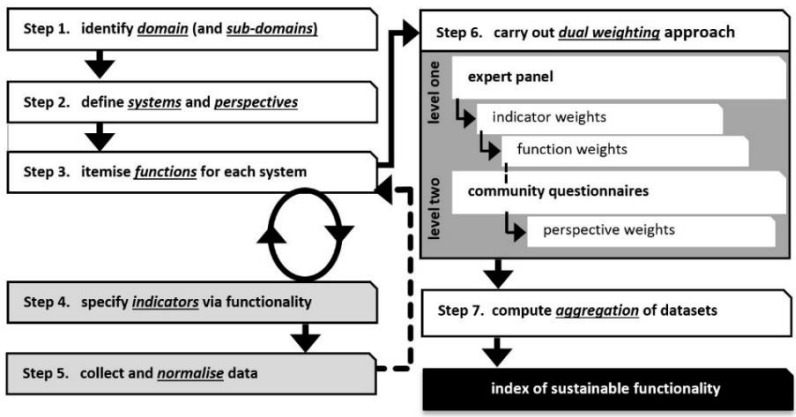

Figure 1 – ISF framework adapted from Imberger et al. (2007) and Cirella and Tao (2008).

In terms of validation, the assessment of data is mostly analytical with some parts qualitative in nature. Levels of notation, specifically functions and indicators, were selected to best suit the application via the available period permitted within the area, potential for dataset collection, expertise within the area and previous research experience and practice. The ISF formulation of Urat Front Banner has been modified from previous studies and will be briefly explained in a sequential step-by-step order. It can be reviewed in detail by reviewing (Cirella & Zerbe 2014a). The ISF equation, Eq. (1), is defined for the model. For reference purposes, associated variables are labelled throughout the procedural steps and illustrated via a list of variables in Table 2.

$$\mathrm{ISF} = \sum_{j=1}^{J^i} \sum_{k=1}^{K^i} \left[(W_{\beta} W_{\flat})^{\psi} W^{\phi} \left\{ \sum_{l=1}^{L^i_{jk}} \frac{1}{M(\lambda^i_{jkl})} \sum_{m=1}^{M(\lambda^i_{jkl})} \left(I^i_{jklm} \right) \right\} \right] \qquad \text{Eq. (1)}$$

Table 2 – Defined variables used for the ISF formulation of Urat Front Banner (Imberger et al. 2007; Cirella & Tao 2008)

Definition		Variable
i	=	sub-domain
j	=	perspective
k	=	system
l	=	function
L	=	number of functions in the matrix element (j, k)
I	=	indicator
M	=	normalised indicator
λ	=	defined indicator range
W	=	weight
ψ	=	expert panel
ϕ	=	community questionnaire
n	=	total number
r	=	rank level
$\flat$	=	averaged indicator
β	=	averaged function
σ	=	averaged perspective

9.3.1 Step 1. Identify domain (and sub-domains)

The domain (D) can be broadly identified as the subject whose sustainability is being assessed. It sets the resolution of the ISF and we define N sub-domains (D^i, where $i = 1, N$) as a focused or proxy-like aspect of the domain. For this study, the domain is the geographic area of Urat Front Banner, Inner Mongolia and its sub-domains are the nine counties within the banner (Figure 2). Located in the southwest corner of the League of Bayannur, Urat Front Banner is one of seven administrative sub-divisions. It is situated on the northern bank of the Yellow River where the Hetao Irrigation District drains into Wuliangsuhai Lake. It has a total area of 7,476 km^2 and in 2010 approximately 341,600 inhabitants (Bayannur Government 2013). Population statistics show a huge influx of people between 1990 and 1995 and an almost static population since then. Table 3 illustrates this fact, labelled with numerated variables of each sub-domain (D^i), or county.

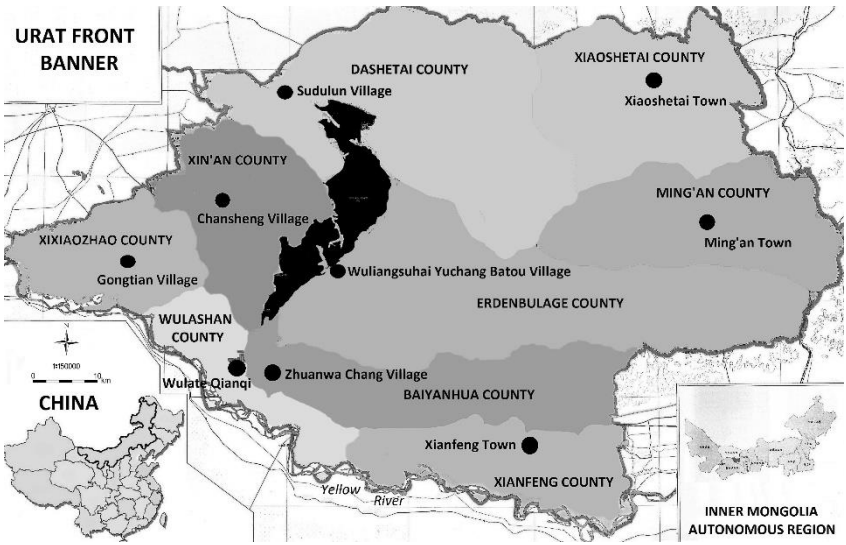

Figure 2 – The ISF domain is based on the political map of Urat Front Banner, Inner Mongolia and sub-domains correspond to its nine counties. Circles relate to a town or village, within each county, where a community questionnaire and qualitative findings were conducted (Cirella & Zerbe 2014a). Map is digitised from Wulate Qianqi Government (2012).

Historically, Urat Front Banner, since the Qin Dynasty, has been a key military station. The Hetao plain lands have acted, and continue to act, as one of the natural northern frontier regions for China. The banner has historical linkages and a strong ethnical heritage with Mongolian culture. The topography is divided between (1) fertile land around the Hetao Irrigation District and Wuliangsuhai Lake and (2) mountainous areas in the north. Key agricultural production includes wheat, sunflower (oil), melon, apple pear, tomatoes and livestock (Wulate Qianqi Government (2012), see Chapter 2 for further details on the geography of the area).

Table 3 – Population statistics of Urat Front Banner and its nine counties with labelled domain (D) and sub-domain (D^i) numerated variables (Wulate Qianqi Government 2012).

Domain (D) andSub-domains (D^i)	1990	1995	2000	2005	2010
(D) Urat Front Banner	115800	338900	330800	334000	341600
(D^1) Wulashan County	30600	105300	107500	126900	154700
(D^2) Erdenbulage County	5900	12400	11600	10800	10900
(D^3) Dashetai County	10600	46100	45300	43200	39900
(D^4) Xin'an County	12100	49500	48900	46700	41500
(D^5) Baiyanhua County	7600	13400	12300	12100	11900
(D^6) Xixiaozhao County	13600	31100	29300	26900	24300
(D^7) Xianfeng County	18600	43500	41000	36500	32700
(D^8) Ming'an County	11300	26400	24600	21400	17500
(D^9) Xiaoshetai County	5500	11200	10300	9500	8200

9.3.2 Step 2. Define systems and perspectives

For each sub-domain (D^i), we may define K^i systems S_k^i, $k = 1, K^i$. There are five systems defined, that is (1) the ecological system which is the natural environment including its components, functions and interactions; (2) the community system which is the formal and informal interactions between people, institutions and governance structures; (3) the individual system which means all human individuals who have an impact through physical and non-physical needs and attributes; (4) the economic system that is the production, distribution and consumption of traded goods and services by

individuals and industry; and (5) the built system as the components which are non-living and constructed.

Perspectives are cross-referenced with systems which are intra- or inter-domain based viewpoints (Brown & Imberger 2006). They are defined as J^i perspectives P_j^i, $j = 1$, J^i for each sub-domain (D^i). Imberger et al. (2007) annotate that this index convention configures the matrix (j, k) with J^i persperctives and K^i systems for each of the employed sub-domains. Perspectives are often influenced by the domain and are the basis for selecting functions when determining measurement.

Table 4 – Cross-sectional ISF matrix framed between systems (S_k^i) and perspectives (P_j^i), with each (j, k) box corresponding to the 15 questions from the community questionnaire (Cirella & Zerbe 2014a).

		system (S_k^i)				
		ecological	**community**	**individual**	**economic**	**built**
perspective (P_j^i)	**environmental**	**Q1.** How important is it to maintain a range of plants and animals in the countryside or natural reserves within the banner?	**Q4.** How important is it for you that the local government practices responsible environmental management?	**Q7.** How important is it for families or households to reduce their environmental impact?	**Q10.** How important is it to you that companies in the banner minimise their environmental impact?	**Q13.** How important is it to save space for a garden or agriculture by having a smaller house either on your block or within your municipality?
	social	**Q2.** How important are the parks, countryside and river in this banner for your livelihood, recreation and socialising?	**Q5.** How important is the promotion of equality and well-being within this banner's community?	**Q8.** How important is it that banner residents take an active role in the community?	**Q11.** How important is it to you that businesses in the banner pay employees enough to meet their needs?	**Q14.** How important is it to have accessible venues for entertainment in this banner?
	economic	**Q3.** How important do you think green areas are for increasing property prices in this banner?	**Q6.** How important is it for you that the local government supports local businesses?	**Q9.** How important is it to you that individuals contribute their skills to benefit the economy?	**Q12.** How important is the strength of this district/banner's economy to you?	**Q15.** How important to you is the growth of property prices in this banner?

In this study, the three perspectives are centred on the TBL approach that enable comparison on the basis of substance rather than semantics. Table 4 illustrates the matrix for this ISF analysis, which collectively is made up of the considered systems (S_k^i) and perspectives (P_j^i) – with inter-relating

questions for each (j,k) point included from the community questionnaire. The matrix is an engineering viewpoint in that it functions to measure the interaction between elements of functionality (Imberger et al. 2007); it does this by evaluating each system by all the perspectives which allows for integrative sustainability assessment.

9.3.3 Step 3. Itemise functions for each system

The itemisation of functions is the point where the level of sustainability is defined; it is analogous to the notion of strong and weak sustainability. Strong sustainability is when the system can maintain all its functions and weak sustainability is when the system maintains only certain functions of choice (Imberger et al. 2007; Ott et al. 2011 see Chapter 1). This study is restricted to weak sustainability.

Defined functions $F^{i}_{jkl}, = 1, L^{jk}$, where L^{jk} are the number of functions in the matrix element (j,k). Functions define the roles and relationships performed by a specific system carried out from a particular perspective; for this study, 26 functions were selected. A sustainable state is the process when functions within a system are stable and functioning well below a critical stress threshold. It is expected that a system will rapidly degrade once this critical stress threshold is reached, as it can no longer perform its functions (Mills et al. 2005). Functions are itemised for each system by considering the three perspectives defined in Step 2. A systematic matrix of functions is created to ensure that a thorough evaluation of Urat Front Banner is performed, neglecting a minimum level of attributes. Efficiency is improved and complexity reduced as each function is itemised and cross-referenced between a relating system and perspective (Table 5).

9.3.4 Step 4. Specify indicators via functionality

The direct measurement of complex functions the ISF considers is not possible. The ISF measures the performance of functions and systems by identifying indicators via functionality. An indicator provides an indirect measurement of a system; it is only an indication of the health of that system. After a thorough literature review and consultation with local and national experts and stakeholders, 62 indicators were chosen to represent the

functions itemised in Step 3. Utilising Imberger et al.'s (2007) criteria, the selected indicators must:

(1) represent the relating aspect of the function; (2) be scientifically valid; (3) be available over time, and be able to improve and decline over this period; and (4) be comparable to acceptable threshold and target levels.

Table 5 – List and categorised systems (S), perspectives (P), functions (F) and indicators (I) for the ISF of Urat Front Banner (Cirella & Zerbe 2014a).

Ecological system

S	P	F	I	
ecological	environmental	1		**to maintain important ecosystem processes** (I^{iP}) ***sub-indicators***
			1	water quality distributed to the local population — pH, DO_2, P
			2	water quality of the wetlands and water bodies — pH, DO_2, N, P, Cu, Pb
			3	groundwater quality
		2		**to maintain related linkages between biodiversity of plant and animal species in an environment**
			4	% completion of the Inner Mongolia Autonomous Region regional conservation strategy for the Hetao Irrigation Area
		3		**to uphold climate change initiatives**
			5	renewable energy consumption and initiatives within the region
	social	4		**to provide aesthetic and recreational use of nature for the community**
			6	area of green space as a % of total land area of the urban spaces
		5		**to improve the quality of life and an environment beneficial to human health**
			7	safe air quality levels
	economic	6		**the provision of natural aesthetics for economic benefit**
			8	% change in price of a property with a waterfront view, compared to % change in price of a similar property without a view
			9	% change in price of a property next to a green space compared to % change in price of a similar property further from green space
		7		**to provide renewable and non-renewable resources**
			10	renewable resource – annual water consumption trends
			11	non-renewable resource – total fossil fuels value against gross county product within the Urat Front Banner

Community system

community	env'tal	8		**to manage the natural environment responsibly through government policy, legislation and services – through public awareness and involvement in environmentally-friendly initiatives**
			12	% of solid waste recycled
			13	% of local government expenditure allocated to green spaces (Urat Front Banner)
			14	% of local government expenditure allocated to sustainable development (Urat Front Banner)
			15	% of wastewater reused
	social	9		**to provide all individuals in society with equitable opportunities and outcomes – via the provision of basic services**
			16	weekly income by gender
			17	number of deaths per year, due to heart disease
			18	% of annual government expenditure allocated to health (Urat Front Banner)
			19	the number of violent and property crimes per 1000 residents
			20	% annual government expenditure allocated to law, order and public safety (Urat Front Banner)
		10		**to promote and encourage a diverse, interconnected and participative society**
			21	equity of political representation
			22	proportion of indigenous Mongolian residents, residents born overseas and Chinese born residents in the League of Bayannur, compared with the rest of Inner Mongolia
			23	% of residents with a high school education
			24	% of annual government expenditure allocated to education and welfare (Urat Front Banner)
			25	% government expenditure allocated to recreation and culture (Urat Front Banner)
	economic	11		**to support business and industry through appropriate, innovative and effective implementation of policy and mgmt strategies by the local govt**
			26	% of annual local government expenditure allocated to economic development
			27	average business satisfaction rating
		12		**to provide a stable social society – via interaction and networks of interaction within the community that are oriented towards, or facilitative to, economic growth and efficiency**
			28	the number of crimes reported per capita
			29	the number of people who own or who have purchased (via mortgage) a home in which they are residing

Individual system

individual	environmental	13	**to maintain an environmentally sustainable lifestyle**
		30	green power consumption as a % of the total residential power consumption
		31	number of people using sustainable transport as a % of total transport use
		32	recycled residential waste as a % of total residential waste
		33	ecological footprint
		14	**to minimise waste output**
		34	total County (industry and household) waste to landfill
		35	proportion of households that participate in recycling
	social	15	**to participate in activities that contribute to the functionality of the social, political and legal system**
		36	voter turnout at local government elections (Urat Front Banner)
		37	public attendance at local government meetings (Urat Front Banner)
		16	**to take personal responsibility for own well-being**
		38	fraction of hospital related separations diagnosed with related tobacco smoking health problems
		39	fraction of hospital related separations diagnosed with related diet-related health problems
		40	emotional well-being
	economic	17	**to develop and provide human resources for production**
		41	the proportion of employed residents relative to the population in the labour force
		42	the proportion of residents with higher education qualifications relative to the employed population
		18	**to consume, save and invest to maintain economic growth and productivity**
		43	proportion of disposable income available for consumption

Economic system

economic	environmental	19	**to minimise adverse impacts of industry on the environment**
		44	total energy use by industry per gross county product within the Urat Front Banner, via use of coal energy
		45	fraction of total energy use by industry that is from renewable sources
		46	industrial solid waste to landfill per gross county product within the Urat Front Banner
		47	fraction of total solid waste by industry that is recycled
	social	20	**to ensure affordability and provision of basic needs**
		48	fraction of working population whose income is over the minimum wage of the State
		21	**to create diversity and opportunity**
		49	gender equality as a deviation from 50% across all industries
		50	occupied job types as fraction of total number of possible job types in the economic System
	economic	22	**to provide accurate measures for all forms of capital which are traded in the Economic System**
		51	to contribute to economic stability and progression towards growth in the Urat Front Banner and Inner Mongolia
		23	**to contribute to stability and progression towards growth in the Urat Front Banner**
		52	county growth rate via the gross county product within the Urat Front Banner
		53	the stochastic diversity of the Urat Front Banner industry mix compared to the Inner Mongolia industry diversity
		54	growth rate of people employed in the Urat Front Banner industries

Built system

built	env'tal	24	**to allow for ecosystem health**
		55	proportion of lots with deep sewerage available
		56	efficiency rating of buildings
	social	25	**to provide serviced land for societal activities**
		57	Urat Front Banner expenditure on street lights
		58	traffic accidents per resident
		59	expenditure on information technology (IT) per person
	economic	26	**to provide a network of tangible assets**
		60	increase in median house prices (i.e. the median house price is the midway point of all the houses sold at market
		61	median home rental prices price over a set period (monthly,yearly, quarterly, etc.))
		62	duration of power outages

9.3.5 Step 5. Collect and normalise data

The functionality, or degree of functioning, of each function is calculated by attributing each function a set of indicators (I^i_{jklm}) and normalising this data ($M(\lambda^i_{jkl})$) from zero to one (Imberger et al. 2007; Cirella & Tao 2008). Any

value below zero will equal zero and any value above one will equal one. The normalisation of indicators is setup between upper and lower functionality limits, which transfer to bounds between zero and one (Kristiana 2009). In operational terms, one is the level at which the system is completely functional, whereas the functional bound of zero indicates dysfunctional (Imberger et al. 2007).

Linear interpolation as an approximation is employed between these two bounds. In five-year intervals dating between 1990 and 2010, data for each indicator for each sub-domain was collected (or period within that range for which data was available). Data collection is sourced from governmental reports and statistics, interviews, technical papers and relating academic literature. Data normalisation is processed in order to aggregate indicators that have different scales and units of measurement.

9.3.6 Step 6. Carry out dual weighting approach

The implementation of weight is where data is put through varying statistical weights before ISF formulation. For the ISF of Urat Front Banner, weighting of data has been used to better reflect community ownership and increase the likeliness of assessment and value (Po et al. 2003). It should be noted that this step is non-compulsory and is based upon the importance of population within the domain.

The weight of the data is determined using the dual weighting approach ($(W_{\beta}W_{\flat})^{\psi}\, W^{\phi}$), first applied via the expert panel and then the community questionnaire. This correlates with Cirella and Tao's (2008) stepladder approach (Figure 3) and demonstrates a logical course of development since experts, in detail, look over the entire stepladder approach and evaluate each function and indicator, while the community, at large, only take the questionnaire that is short and general.

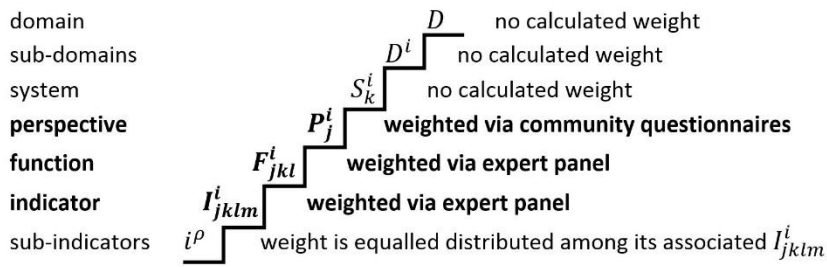

Figure 3 – The ISF stepladder approach from the lowest (i^ρ, I_{jklm}^i) to highest (D) level of notation. Calculated weight, in bold, is at the indicator, function and perspective levels (Cirella & Tao 2008).

For the expert panel, a two rounded Delphi Method of appraisal was implemented (Gordon 1994). Twenty-one experts were, first, weighted calculated indicators ($W_\mathfrak{p}^\psi$), which calculates of indicator-to-function weight and then, functions ($W_\mathfrak{g}^\psi$). For the community questionnaire, one town or village in each of the nine counties was investigated between 29th September and 7th October 2013 (see Figure 2). The questionnaire included 15 questions, in which one question relates to one of ISF matrix (j,k) cross-sections, as shown in Table 4. For each county, 20 questionnaires were completed, with the exception of Wulashan County that had a sample size of 70 and Erdenbulage County that had 30. Within Wulashan County, a larger population size accounted for the extra questionnaires, while Erdenbulage County was inadvertently given more time and resources as the pilot starting point. The total number of questionnaires conducted within Urat Front Banner totalled 240, with a 95 % confidence level accordingly to target population. Specifically, the community questionnaire weighted the ISF perspectives (W^ϕ). This incorporates a community viewpoint by inferring more weight to higher ranked perspectives relative to that system.

The community questionnaire is weighted against the perspective-to-system relationship and completes the dual weighting approach. In addition, supplementary qualitative notes were transcribed, in each of the counties, and appraised by the expert panel members for further harmonisation via the Delphi Method. The notes focused on incorporating a better understanding of intergenerational equity concerns, conflicts between

differing perspectives and harmonisation of concepts of capital and resource productivity as described in Step 2. From a viewpoint of weak sustainability, characterising measurability with experts has proven difficult and an alternative, future-based approach is also considered in Chapter 10.

9.3.7 Step 7. Compute aggregation of datasets

Aggregation uses the calculated percentile weights, or weighted sums, to compute the nine sub-domain county records via the ISF equation, Eq. (1). The ISF of Urat Front Banner is an aggregate of the county records, weighted equally as each county is considered of equal importance. This is a regional view of looking at the banner and, at the county-level, does not take into account geographical size, demographics or land-use. This self-deterministic approach, regionally, is an importance aspect of local sustainability-based thinking.

9.4 ISF analysis

The ISF of Urat Front Banner, calculated according to Eq. (1), can separated its system level (Figure 4) and perspective level (Figure 5), respectively. As these figures illustrate, a varying level of analysis can be achieved via the ISF model. The advantage of this ability is the partitioning of smaller elements and their contribution to the overall, aggregated ISF record.

For the application of Urat Front Banner, the built system shows values that are higher than other systems throughout the selected period; it also shows an increasing trend. The two social-based systems, community and individual, also show slight, consistent increases, the economic system remains mostly linear and the ecological decreases. From an overall systems viewpoint, the performance factors indicate a weak level of sustainable functionality. Important managerial concerns will need to resolve continued signs of rapid degrading natural habitat, resources, ecological balance and, to some degree, socio-economic breakdown. This may correlate with the demographic trend in population in which, basically, has remained the same since 1995. Moreover, in the last decade consistent reservations with a lack of

developmental-boom, parallel with the rest of China, may be cause for concern within the banner.

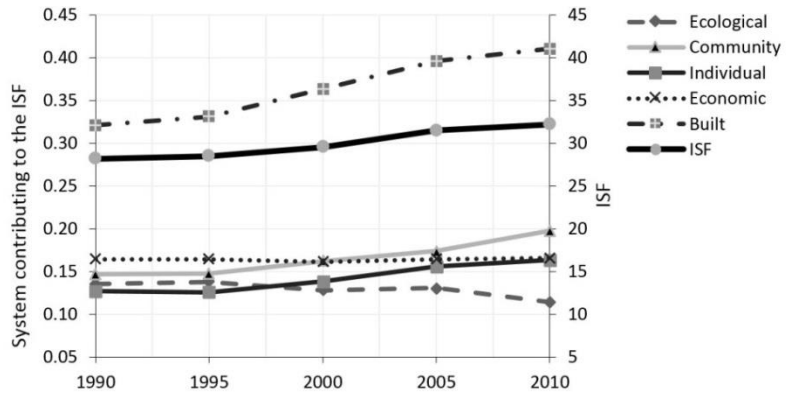

Figure 4 – ISF and system (S_k^i) functionality.

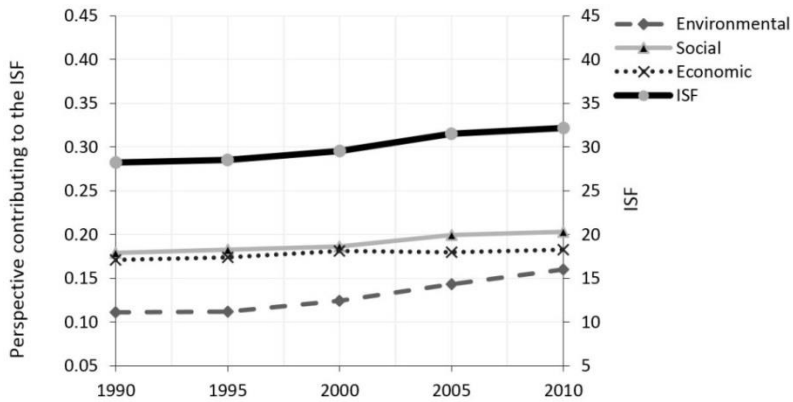

Figure 5 – ISF and perspective (P_j^i) functionality.

From a perspectives viewpoint, the appraisal shows an increasing trend in both environmental and social functionality – with economic remaining, again, constant throughout the selected period. The attentiveness, or yearning, to improve environmental functionality is positive, even though results indicate a reality that is at an insufficient level. Social perspectives are

also positive with an increasing trend that may be reflective of the community and individual systems' results. Economic trends are constant and reflective of the somewhat problematic and impoverished living standards throughout the banner.

A comparative look at the banner's ISF, ecological footprint, gross banner product (GBP) and population has also been calculated (Figure 6). It shows the ISF of Urat Front Banner, composed from its nine counties, has an overall low-intermediate level of sustainable functionality.

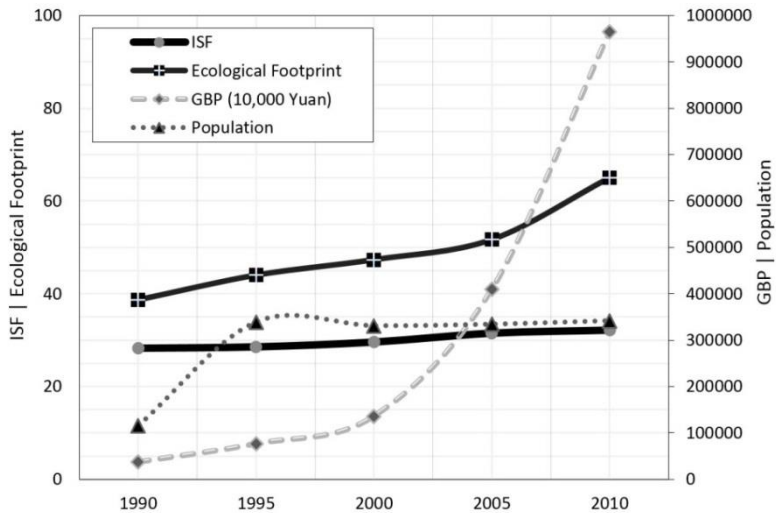

Figure 6 – Urat Front Banner: ISF, ecological footprint (estimated ranked percentage is when 100 % is equal to three planet Earths), GBP per capita and population

The record indicates three noticeable zones: (1) the two, isolated mountainous counties of Xiaoshetai County (Photograph 22) and Ming'an County which have slightly a higher ISF bi-decadal average; (2) the three counties that directly encompass Wuliangsuhai Lake of Erdenbulage County (Photograph 23), Dashetai County and Xin'an County which have a slightly lower ISF bi-decadal average; and (3) the four lower counties that are based upon the principal transportation lines in and out of the banner of Xianfeng County, Baiyanhua County, Wulashan County and Xixiaozhao County

(Photograph 24) which have analogous records to the overall banner itself. The ISF of Urat Front Banner shows a stabilised trend that is only slightly increasing over the selected period. The built system is an important aspect of the overall result and depicts the massive attempt from Chinese authorities to input infrastructure and project development into the region. This higher intermediate scoring system has bloated the overall trend from the other four low rating systems.

Comparatively, the ISF shows a much different result from the conventional economic measure of GBP per capita. Over the selected period, the GBP per capita has increased almost exponentially, especially in the last five years of the study, while the ISF only shows a minimum increase in value from 28.2 to 32.2. This indicates the increased flux of monetary growth did not translate into improved sustainable functionality within the domain. An ecological footprint was also conducted (Cirella & Zerbe 2014a) and, comparatively, shows an increase from a little over a one-planet footprint in 1990 to almost a two-planet footprint in 2010. The ISF and the ecological footprint, though calculated in quite different manners, show a general trend of low level of sustenance contrary the GBP per capita.

9.5 Conclusion

The vast amounts of data in compiling index-based research is time consuming and resource intensive. This is common to many quantitative methodologies and the nature of this study is no different. A number of qualitative attempts to investigate the possibility of adding to the dual weighting approach and formulation were investigated. The authors, continue to, suggest that the play of words, or the notion, of a 'quizzical society' is puzzle-like, and unlocking aspects of sustainable functionality exemplar, when trying to improve upon ISF resolution (Davies 2013; Ott et al. 2011). The authors construe that their previous suggestive recommendations remain underdeveloped (Cirella & Zerbe 2014b). In addition, notation development was also thought of as a possibility for improving upon the ISF model, but no concrete solutions have yet been positively tested. From a practical implementation point of view, a vast

amount of metadata opens the record book for management and decision-makers at all levels. A core notion to sustainability indexing incorporates enhanced governance via historical and continual monitoring of records. Better management decisions and strong sustainability directives are future-based objectives that look at societal transitions and pretences for prospective awareness, in which, ISF trends often are not setup to measure. Utilising scenario based judgements, as noted in Chapter 1 and examined in Chapter 10, a subsequent step in sustainable thinking and consciousness towards modernity and its planned development is one such potential alternative.

Key references

Brown, A. & Imberger, J. 2006. The index of sustainable functionality (ISF): A prospective tool for assessing the sustainability of the impact of the World Bank projects. Report. Perth, Western Australia: Centre for Water Research.

Cirella, G.T. & Tao, L. 2008. Measuring sustainability: an application using the index of sustainable functionality in South East Queensland, Australia. The International Journal of Interdisciplinary Social Sciences, 3(8): 231–240.

Cirella, G.T. & Zerbe, S. 2014a. Index of sustainable functionality: Procedural developments and application in Urat Front Banner, Inner Mongolia Autonomous Region. The International Journal of Environmental Sustainability, In press.

Cirella, G.T. & Zerbe, S. 2014b. Quizzical societies: A closer look at sustainability and principles of unlocking its measurability. The International Journal of Science in Society, 5(3): 29–45.

Daly, H.E. 2006. The Future of Sustainability. M. Keiner ed. Dordrecht, The Netherlands: Springer.

Foliente, G., Kearns, A., Maheepala, S., Bai, X. & Barnett, G. 2007. Beyond Triple Bottom Line – Sustainable Cities: CSIRO. In: State of Australian Cities National Conference (SOAC2007). 2007, Adelaide, Australia:

Commonwealth Scientific and Industrial Research Organisation, 28–30 November.

Imberger, J., Mamouni, E.D., Anderson, J., Ng, M., Nicol, S. & Veale, A. 2007. The index of sustainable functionality: a new adaptive, multicriteria measurement of sustainability – application to Western Australia. International Journal of Environment and Sustainable Development, 6(3): 323–355.