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ORIGINAL ARTICLE

Assessing local-scale inclusive wealth: a case study of Sado Island, Japan

Yuki Yoshida[1] · Hirotaka Matsuda[1] · Kensuke Fukushi[1] · Shinya Ikeda[2] · Shunsuke Managi[2] · Kazuhiko Takeuchi[1]

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Abstract

Present trends of urbanization are accompanied by increasing demographic and economic shrinkage of rural regions. In countries such as Japan, these rural regions trail behind metropolitan counterparts according to GDP, the conventional measure used to guide governmental policies. Yet, past research suggests that these regions may be undervalued. Further, the Inclusive Wealth Index (IWI), largely only used at the national level, may be able to capture aspects previously missed. As such, our study attempts to highlight the wealth of rural regions by comparing the inclusive wealth of Sado Island and Japan between 1990 and 2014. Minor methodological modifications were made according to data availability at the local level and to improve the accuracy of human capital estimations. Results captured the ongoing shrinkage of Sado and demonstrate the distinct potential of the IWI as a stock measure. Sado's per capita wealth was about 10% lower than the national averages, but its natural capital was about threefold national averages. Supplementary estimations of the natural capital of fisheries and cultivated forests suggest that inclusion of additional factors in the evaluation would further increase the relative valuation of rural regions. We discuss implications of our estimations for wellbeing, and conclude with a critical appraisal of the IWI calculation towards policy implementation of the index.

Keywords Sustainable development · Wellbeing · Socio-ecological production landscapes and seascapes · Satoyama–satoumi · Rural–urban disparity

Abbreviations

FAO	Food and Agriculture Organization of the United Nations
IWI	Inclusive wealth index
IWR	Inclusive wealth report
GDP	Gross domestic product
GIAHS	Globally Important Agricultural Heritage Site
GPI	Genuine progress indicator
GRP	Gross regional product
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan
MIC	Ministry of Internal Affairs and Communications of Japan
MOE	Ministry of the Environment, Government of Japan
NTFB	Non-timber forest benefits
OECD	Organisation for Economic Co-operation and Development
PIM	Perpetual inventory method
UN DESA	United Nations Department of Social and Economic Affairs
UNEP	United Nations Environment Programme
UNU-IHDP	United Nations University/International Human Dimensions Programme on Global Environmental Change
USD	United States Dollar

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✉ Yuki Yoshida
yukiyoshida@sustainability.k.u-tokyo.ac.jp

[1] The University of Tokyo, Environmental Studies Building 784, 5-1-5 Kashiwanoha, Kashiwa 277-8563, Japan

[2] Kyushu University, Fukuoka, Japan

Introduction

Rural regions around the world are increasingly challenged by depopulation and aging. While the majority of urbanization in the world is accompanied by rural depopulation (United Nations Department of Social and Economic Affairs (UN DESA) Population Division 2014), the proportion of this depopulation is greatest in Japan, where the rural population is projected to decline by 71% before 2050 (National Institute of Population and Social Security Research 2013). The country, and particularly its rural regions, also leads the world in the aging of its population (Organisation for Economic Co-operation and Development (OECD) 2016; United Nations 2017). Beginning with the postwar era of rapid economic growth, demographic changes due to constant flows of Japan's working age population into urban centers have continued to widen rural–urban, economic and demographic disparities (Feldhoff 2013; Matanle and Sato 2010). In terms of economic output, disparities between Japan's metropolitan and rural regions should come as no surprise (Feldhoff 2013; Hayashi 2015; Matanle and Sato 2010).

Yet from an alternative perspective, "rural areas are the main sustention of urban spots and therefore the guarantors of national prosperity" (de los Ríos et al. 2016, p. 86). Multiple lines of research suggest that there may be more to rural regions than seen through gross domestic product (GDP), the conventional proxy measure of wellbeing (Donovan and Halpern 2002). Research linking GDP to wellbeing has had mixed results. For example, one study found that per capita GDP explained only 18% of variance in household income, and that household income was a better indicator of resident experiences and wellbeing than GDP (Diener et al. 2013). At the same time, self-reports of wellbeing do not necessarily correspond with standards of living implicated by either measure (Davey et al. 2009). In fact, some studies report on the malaises of urbanization that outweigh economic output (Berry and Okulicz-Kozaryn 2011; Knight and Gunatilaka 2010; Winters and Li 2016). In developed countries, i.e. countries with less rural–urban disparity, rural residents report greater subjective wellbeing than residents of urban areas (Berry and Okulicz-Kozaryn 2009; Morrison and Weckroth 2017; Requena 2016).

Aspects of rural regions that transcend conventional policy-making indicators are increasingly documented. Works building on the concept of ecosystem services (Daily 1997; Gómez-Baggethun et al. 2010) highlight the importance of the natural environment. More recently, scholars illustrated the importance of socio-ecological production landscapes and seascapes in Japan using the narrative of ecosystem benefits to human wellbeing (Japan Satoyama Satoumi Assessment 2010). Also known as satoyama–satoumi landscapes, these regions are characterized by mosaic-like mixtures of different land uses that provide habitat for diverse flora and fauna (Duraiappah et al. 2012). In one such region, home-grown foods and foods received as gifts constituted considerable portions of the diet; residents purchased a mere quarter to a third of their food (Kamiyama et al. 2016). In another study at the national level, residents of agricultural areas received on average 16% of their food from non-market sources (Saito et al. 2018). The multifunctionality of such landscapes contributes to the wellbeing of residents and resilience of the community (Schippers et al. 2014). However, non-market goods and community networks go undetected by conventional evaluations of a society.

The use of GDP (or gross regional product; GRP)—the value of all goods and services produced within a country (or region)—as an indicator of societal wellbeing has been long disputed (Sustainable Development Commission 2003). Critiques include its inability to account for externalities, defensive expenditures or distribution, as well as overt focus on production and growth (Price et al. 2010; Stiglitz et al. 2009) despite the negative impacts of focusing on material acquisitions (Kasser 2002). Policies designed to enhance societal performance with a sole focus on GDP are likely to overlook and jeopardize aspects of rural regions that are beneficial, even critical to residents and society at large. Indeed, ongoing demographic and economic shrinkage of rural regions pose a grave threat to satoyama–satoumi landscapes that require manual labor for maintenance (Takeuchi et al. 2016).

How then, might we assess a society's progress? Of particular interest is the natural environment, since its use and state has been missing from national accounts (Dasgupta 2007). Fortunately, many "beyond GDP" indicators have been developed in recent decades to replace or supplement GDP. One example, the genuine progress indicator (GPI) integrates aspects missed by GDP such as environmental conditions, cost of living, and income distribution (Anielski and Rowe 1999), and has demonstrated certain strengths of rural areas in Japan (Hayashi 2015). Yet like other such alternatives, the GPI is a flow indicator and does not address the potential wellbeing of future generations. This study has thus selected the Inclusive Wealth Index (IWI) for its ability to address an often-overlooked aspect of societal wellbeing—its sustainability.

The IWI was developed in light of the definition of sustainable development as "a pattern of societal development along which intergenerational wellbeing does not decline" (United Nations University International Human Dimensions Programme on Global Environmental Change (UNU-IHDP) and United Nations Environment Programme (UNEP) 2014, p. 201). Its biggest strength is that it directly assesses produced, human, and natural capitals (stock). Rather than measure the yearly output (flow) of an economy, the IWI assesses its capital assets, i.e. the productive base for present and future wellbeing (Arrow et al. 2003; Price et al.

2010). In other words, the IWI is unique in its theoretically founded pertinence to resilience and development across time (Polasky et al. 2015; Walker 2005).

Moreover, the IWI is relatively new and has not been applied at the local level. To date, most empirical studies have focused on national comparisons. Japan was initially noted as depicting "the most favorable situation" for being the only country which showed an increase in per capita natural capital and wealth (1990–2008; UNU-IHDP and UNEP 2012, p. 55). However, a methodological revision resulted in a decrease in subsequent estimates of Japan's per capita natural capital (UNU-IHDP and UNEP 2014). Indeed, developers of the IWI are the first to admit that it is work in progress. We thus extend ongoing efforts to apply the IWI at sub-national levels, so far limited to prefectural and state levels (Ikeda et al. 2017; Yamaguchi et al. 2015; Mumford 2012), to the local level, where results can be readily verified with contextual characteristics.

The main aim of this paper is to highlight unique attributes of rural regions that may be missed by GDP. To this end, we estimate the local-level inclusive wealth of Sado, a rural region in Japan, and compare it with nation-level results. As described in the following section, the methodology approximates that used in the second and latest Inclusive Wealth Report (IWR2014) by the developers of the IWI (UNU-IHDP and UNEP 2014). Minor modifications were made to improve the accuracy of human capital estimations and according to data availability. Results are shown as comparisons of nation and local-level wealth over time, by capital, and per capita, and supplemented with additional estimations of natural capital of fisheries and cultivated forests. Discussions focus on the implications of the estimations on wellbeing as well as appropriateness of the IWI for our objective. We conclude the paper with opportunities for future research and a summary of our main findings.

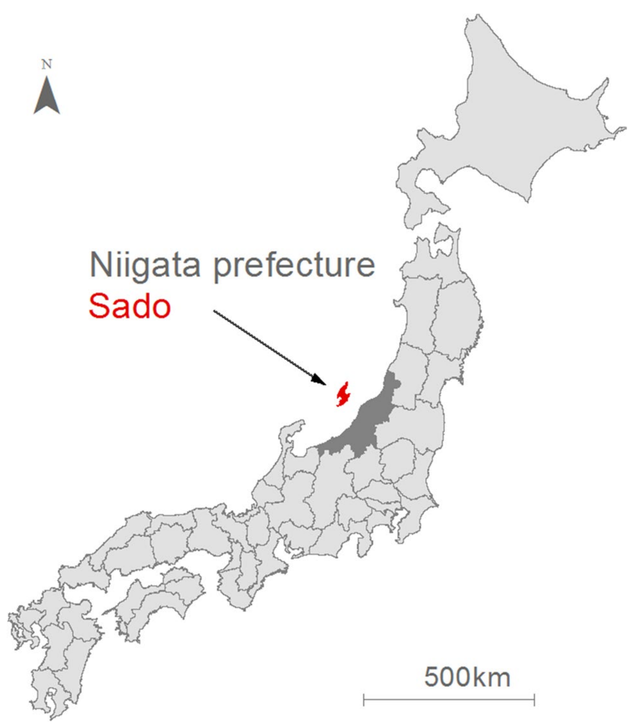

Fig. 1 Sado and the main islands of Japan

Methodology

Study area

Our study area is Sado, a city in Niigata prefecture of Japan that formed when 10 municipalities on Sado Island merged in 2004. With a 280.9 km coastline and land area of 855.7 km^2, the island is the biggest remote island in the country after Okinawa mainland, and located about 55 km from the main island of Japan (Fig. 1). In other words, Sado's regulatory boundary is geographical, rendering it convenient for data collection and verification. Further, Sado exemplifies the traditional rural landscapes that cover 40% (Ministry of the Environment (MOE), Government of Japan 2016) to 67% (Fukamachi 2016) of Japan. The island epitomizes many positive attributes likely not captured by conventional indicators, as well as the demographic transition seen across rural Japan.

Historical heritage and biological diversity contributed to the formal recognition of Sado's socio-ecological production landscapes and seascapes as a Globally Important Agricultural Heritage Site (GIAHS) for the harmonious coexistence of humans and nature. The socio-cultural and ecological wealth that characterize Sado is inseparable from residents' wellbeing (Takeuchi et al. 2016), and understood to contribute to the intergenerational, inclusive wealth of Sado residents. However, much of this wealth is intangible and missed by conventional parameters of a society. Further, the remoteness that helped to preserve Sado's cultural and biological diversity, as well as lack of a university and job opportunities, have cumulated in a serious decline and aging of the population (Fig. 2). The grave extent of such threats to sustainability on the island adds to the societal and academic significance of Sado's sustainable development. Demographic trends of rural depopulation and aging are particularly advanced in islands and other remote regions, but projected for the rest of the country (OECD 2016) (Fig. 2) as well as globally (UN DESA Population Division 2014). While preexisting research illustrates ongoing and anticipated challenges of this situation (Kinsella and Phillips 2005; Bloom et al. 2011; Age International 2015), they do not often quantify or assess the situation in economic terms and within the broader socio-ecological context. We proceed with the premise that understanding the inclusive wealth

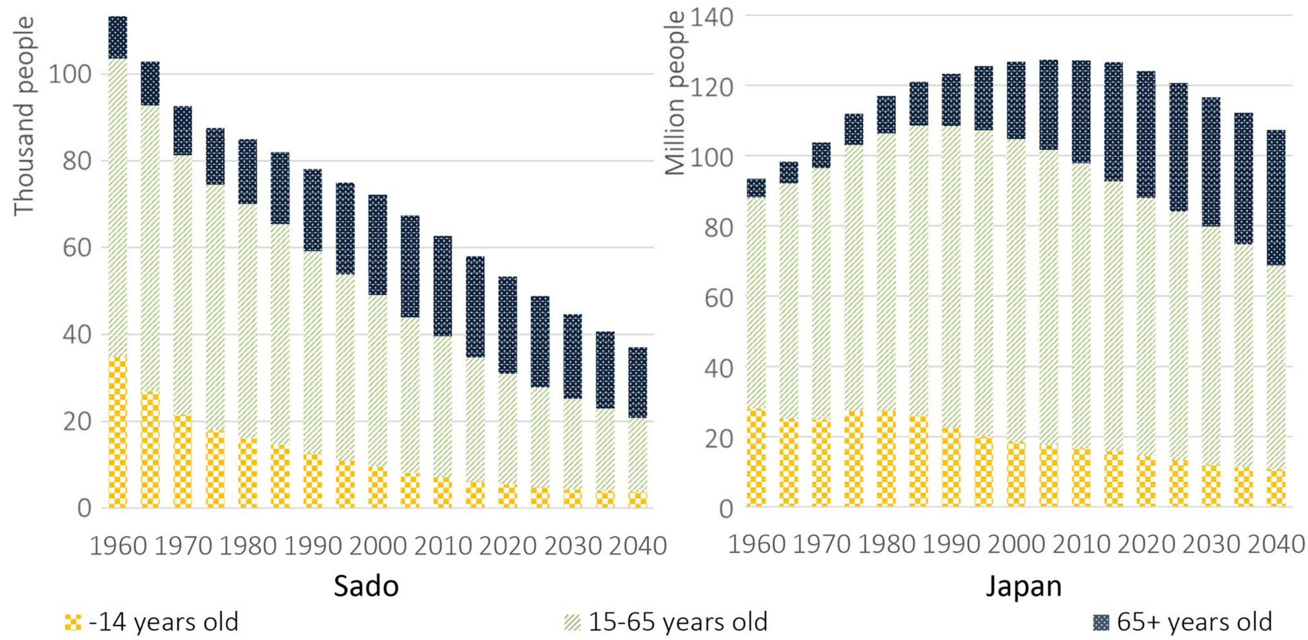

Fig. 2 Projected population of Sado and Japan (1960–2040). Data: National Institute of Population and Social Security Research 2013

of Sado will offer currently unavailable, policy-relevant insights for the sustainable development of Sado and other rural regions of Japan.

Calculating inclusive wealth

Inclusive wealth is the sum of produced, human, and natural capitals. The estimation method described below is an adaptive replication of the IWR2014 (UNU-IHDP and UNEP 2014). The approach taken for additional estimations of natural capital are described in the following section. Data sources are presented in Table 1, and details are available as supplementary material.

Produced capital

Produced capital was estimated by setting an estimate of the initial capital. This perpetual inventory method (PIM) assumes a steady-state economy with a constant capital-output ratio (k):

$$k = (I/Y)/(\delta + \gamma)$$

where I is gross investment, Y is output of the economy, δ is the depreciation rate, and γ is the steady-state growth rate. This capital-output ratio is multiplied by the initial output of the economy (Y_0) to estimate the initial capital (K_0), which forms the basis of the PIM. The wealth of the economy (K_t) in year t is estimated using the following function, where I_j is the investment of year j.

$$K_r = (1 - \delta)^t K_0 + \sum_{j=1}^{t} I_j (1 - \delta)^{t-j}$$

Human capital

Human capital is a product of educational attainment (Term I), working population (Term II), and shadow price of an individual (Term III). The shadow price was derived from the expected working life and average compensation per person. Total human capital wealth (HCW) is as follows:

$$\mathrm{HCW}_{(t)} = \underbrace{e^{(\mathrm{Edu}_{(t)} \cdot \rho)}}_{\mathrm{TermI}} \cdot \underbrace{P_{s+\mathrm{Edu}_{(t)}}}_{\mathrm{TermII}} \cdot \underbrace{\int_0^{T_{(t)}} \bar{r} \cdot e^{-\delta \cdot t} \mathrm{d}t}_{\mathrm{TermIII}}$$

where Edu is years of educational attainment, ρ is the interest rate of education, P is total population, s is the starting age of formal education, T is a worker's expected working life, r is compensation per person, and δ is the discount rate. This method assumes sufficient competition in the labor market for the marginal productivity of a unit of human capital to equal its shadow price and real wage. The shadow price of a unit of human capital ($\mathrm{SP}_{\mathrm{HC}}$; Term III) is thus equivalent to r divided by the amount of human capital per worker (Term I) (Arrow et al. 2012).

$$\text{Term III} = \mathrm{SP}_{\mathrm{HC}} = \frac{\bar{r}}{e^{\mathrm{Edu}(t) \cdot \delta} \cdot \delta} \cdot \left(1 - e^{-\delta \cdot T_{(t)}} \cdot \mathrm{AverageWorkerAge}_{(t)}\right)$$

Table 1 Data

		Variable	Data availability	Japan	Sado
Produced capital		Investment (I)	1986–2016	Gross fixed capital formation National Accounts for Japan (Cabinet Office 2017a)	Gross fixed capital formation National Accounts for Japan [extrapolated by economic output] (Cabinet Office 2017a)
		Economic output (Y)	1986–2014	National Accounts for Japan (Cabinet Office 2017a)	Municipal Accounts for Sado (Niigata Prefecture 2015)
		Depreciation (δ)	1986–2009	5.2% (Feenstra et al. 2015)	
		Growth rate (γ)	1995–2004	3.5%	2.9%
				(The World Bank Group 2017)	
Human capital		Years of education (Edu)	1990, 2000, 2010	School level completed by individuals 15 years old and above Population Census (MIC Statistics Bureau 2017)	
		Interest rate of education (ρ)	–	8.5% (UNU-IHDP and UNEP 2014)	
		Discount rate (δ)	–	8.5% (UNU-IHDP and UNEP 2014)	
		Population (P)	1990–2014	Population by age Population Census (MIC Statistics Bureau 2017)	
		Starting age of education (s)	–	6 years old	
		Average wage (r)	1990–2014	41,826 USD/year National Accounts for Japan (Cabinet Office 2017a)	37,484 USD/year Municipal Accounts for Sado
		Labor participation rate (A)	1985, 1990, 1995, 2000, 2005, 2010, 2015	Population Census (MIC Statistics Bureau 2017)	
Natural capital	Cropland/pastureland	Area harvested (A)	Japan: 1990–2014 Sado: 2006–2014	(FAO 2016)	Data from local JA
		Produce quantity (Q)			
		Produce price (P)			
		Rental rate	–	(Narayanan et al. 2012)	
		Discount rate (r)	–	5%	
		Planning horizon	–	Infinity	
		Cropland area (CLA)	1990–2014	Area survey (MAFF 2017a)	
		Pasture area	1990–2014	(MAFF 2010; Tawaratsumida 2015)	1947 ha Public grazing lands, data from local JA
	Forestland	Volume of growing stock	Japan: 1990, 1995, 2002, 2007, 2012 Sado: 2003–2014	Forest and Forestry White Paper (MAFF Forestry Agency 2017)	Data from Niigata Prefecture Division of Conservation
		Commercially available timber	1995, 2000, 2005	87% for East Asia (FAO 2006)	
		Timber price		153 USD/m^3	159 USD/m^3
			Japan: 2002–2013 Prefecture: 2002–2014	Lumber production and market prices by species Statistical survey of timber prices (MAFF 2017b)	
		Timber rental rate		28.6%	29.9%
			2005, 2010, 2015	Number of forestry management entities by land area *Census of Agriculture and Forestry* (MAFF 2017c)	
			2002–2008, 2013	Revenue and expenditure by land area of forestry management entities Statistical survey of forestry management (MAFF 2017d)	

Table 1 (continued)

	Variable	Data availability	Japan	Sado
	Value of NTFB (P)	–	2091 USD/ha/year Temperate and boreal forests (van der Ploeg and de Groot 2010)	
	Forest area (Q)	Japan: 1990, 1995, 2002, 2007, 2012 Sado: 2003–2014	Forest and Forestry White Paper (MAFF Forestry Agency 2017)	Data from Niigata Prefecture Division of Conservation
	Accessible forest (r)	–	10% of forest area (UNU-IHDP and UNEP 2014; The World Bank 2006)	
	Discount rate (δ)	–	5% (UNU-IHDP and UNEP 2014; The World Bank 2006)	
Fisheries	Fisheries rental rate		16,971 USD/ton	37,172 USD/ton
		2008, 2012	Number of fishery management entities by management type Fisheries Census (MAFF 2017e)	
		2008, 2013	Revenue and expenditure from fishing, by management type and method of fisheries entity, Survey on fisheries management (MAFF 2017f)	
		2008, 2014		Production value by species, Gross fisheries output (MAFF 2017g)
	Fisheries catch by weight	Japan: 1990–2014 Sado: 2004–2014	Statistical survey of marine fisheries production (MAFF 2017h)	
		1996–2013		Niigata Prefecture Statistical Yearbook (Niigata Prefectural Government 2017)
		1992–2004		Fisheries production statistic (Hokuriku Regional Agricultural Administration Office 1993, 1994, 1995, 1997, 1999, 2000, 2001, 2004, 2006)
Deflator		1990–2014	For GDP and by industry	
			National Accounts for Japan (Cabinet Office 2017a)	Prefectural Accounts for Niigata (Cabinet Office 2017b)
Exchange rate		2005	110.218 JPY/USD (Antweiler 2018)	

Missing data were linearly extrapolated/interpolated

Data on Sado before its merger as one city in 2004 is an aggregation of the 10 original municipalities

FAO Food and Agriculture Organization of the United Nations, *FY* fiscal year, *GDP* gross domestic product, *JPY* Japanese yen, *MAFF* ministry of agriculture, forestry and fisheries of Japan, *MIC* ministry of internal affairs and communications of Japan, *NTFB* non-timber forest benefits, *USD* United States dollars

Further, expected working life (T) was from the completion of education until retirement, and derived using the following estimate of the average age of retirement (AAR).

$$T = \mathrm{AAR} = \frac{\sum_{k=9}^{17} (5k)\left(A^{y-5}_{5(k-1)} - A^{y}_{5k}\right)}{\sum_{k=9}^{17} \left(A^{y-5}_{5(k-1)} - A^{y}_{5k}\right)}$$

A^{y}_{j} is the labor participation rate of age group j in year y (Keese 2007). Provided the population is constant across time and age group, the above is the arithmetic weighted mean of the rate of withdrawal from each cohort of the work force every 5 years. It assumes that no one retires before the age of 40, and that no one in the work force is older than 85 [assumptions also used by Ikeda and Nakamura (2017)].

Natural capital

Cropland Cropland wealth (WCL) is based on an estimated rental price per hectare. The rental price of crop k in year j was estimated by dividing the total quantity (Q), price (P) and rental rate (R) of crops produced by harvest area (A).

The discounted rental price was averaged across time to arrive at the unit value of cropland area (CLA).

$$\mathrm{WCL} = \frac{1}{\mathrm{years}} \sum_{j=1}^{\mathrm{years}} \left(\sum_{t=1}^{\infty} \frac{\frac{1}{A} \sum_{k=1}^{x} R_k P_{jk} Q_{jk}}{(1+r)^t} \right) \cdot \mathrm{CLA}_J$$

Pastureland As in prior works, the difficulty of identifying the exact area of pastureland involved in producing livestock-related services was circumvented by assuming equal perhectare rents to that of cropland.

Forest resources Our initial calculations were limited to natural forests and omitted cultivated forests as produced capital (UNU-IHDP and UNEP 2014). Additional estimates for cultivated forests are made in a later section.

Timber Timber wealth is the volume of commercially available timber in a given year, multiplied by price and rental rate averaged across time (Bolt et al. 2002).

$$\text{Rental rate} = \frac{\text{Market Price} - \text{Production Cost}}{\text{Market Price}}$$

Non-timber forest benefits The wealth of non-timber forest benefits (NTFB) was calculated as follows, where P is the estimated value of NTFB per hectare, Q is the area of non-cultivated forest land of which r is the accessible portion, δ is the discount rate, and t, time (Ikeda and Nakamura 2017; UNU-IHDP and UNEP 2014).

$$\mathrm{NTFB}_t = \int_t^T P_t \cdot (Q_t \cdot r_t) \cdot e^{-\delta \cdot t} \mathrm{d}t = Q_t \cdot r_t \cdot \sum_{t=0}^{\infty} \frac{P_t}{(1+\delta)^t}$$

Results

Results portray the shrinking demographics of Sado that forerun national trends. They also mirror relative sizes of the economy. Yet, the relative size of per capita natural capital stands out regarding implications for the region's wellbeing. All results are in constant 2005 prices.

Overall trends

In aggregate terms, human capital dominates inclusive wealth at both scales (Fig. 3). Human, produced, and natural capital comprise on average 70%, 28%, and 2% of total wealth in Sado, and 72%, 28%, and 0.6% of national wealth, respectively. The relative proportions are comparable to IWR2014 averages for higher income countries (64%, 24%, and 12%; 1990–2010), in which human capital is more prominent than in world averages of 54%, 18%, and 28%.

Overall, it is evident that increases in wealth are largely attributable to produced capital, and that decreases are largely due to the downward pull of human capital, particularly for Sado (Fig. 4). This trend is also seen in the small peak of Sado's wealth in 2000 (31.2 billion USD), followed by a gradual decline to 27.3 billion USD in 2014 (Fig. 3). Growth in produced capital outweighs population decline in early years, but trends in later years are largely determined by the declining human capital.

Total wealth increased by 16% in Japan while decreasing by 9% in Sado (Fig. 4). Again, the contrast may be attributed to Sado's 24% decline in human capital; changes in produced capital were of comparable proportions. Despite Japan's 7% increase in human capital during the study period, annual changes steadily decreased to a net negative in more recent years, reflecting demographic trends in Fig. 2. Natural

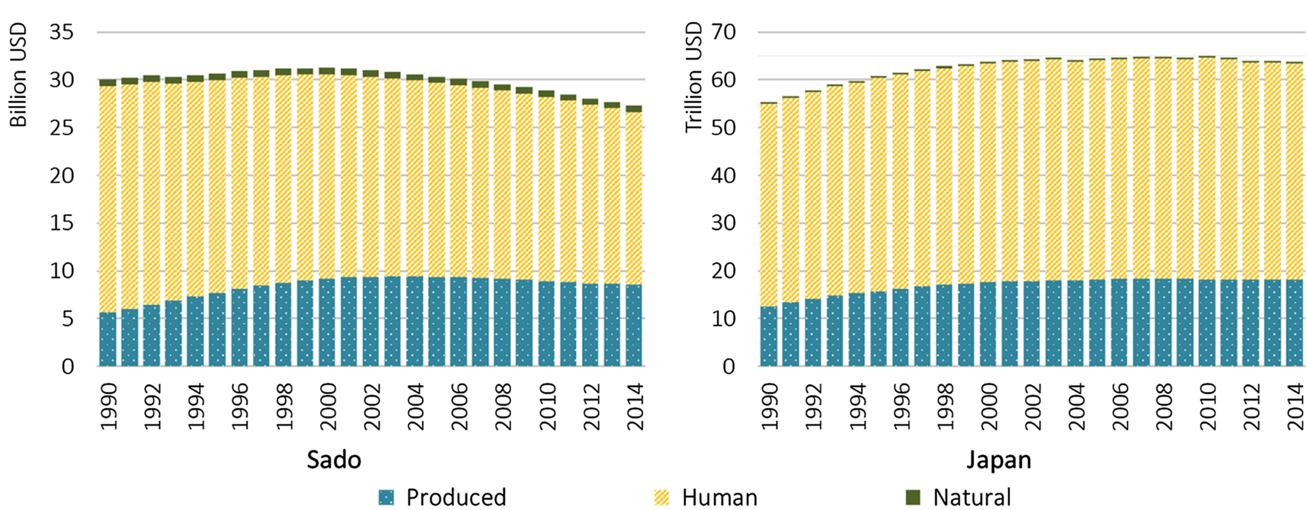

Fig. 3 Inclusive wealth of Sado and Japan (1990–2014)

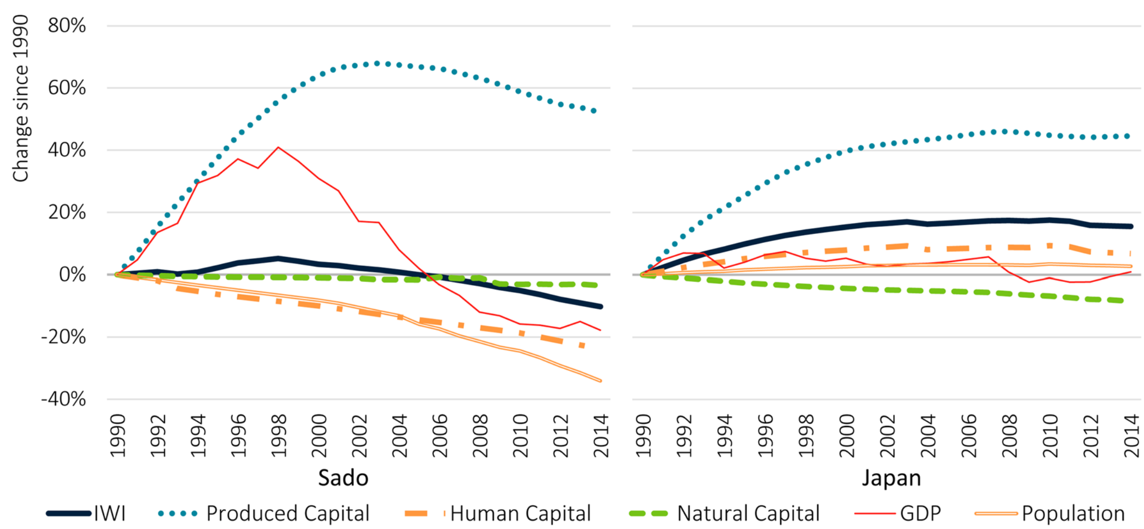

Fig. 4 Changes in inclusive wealth, economic output and population of Sado and Japan from 1990

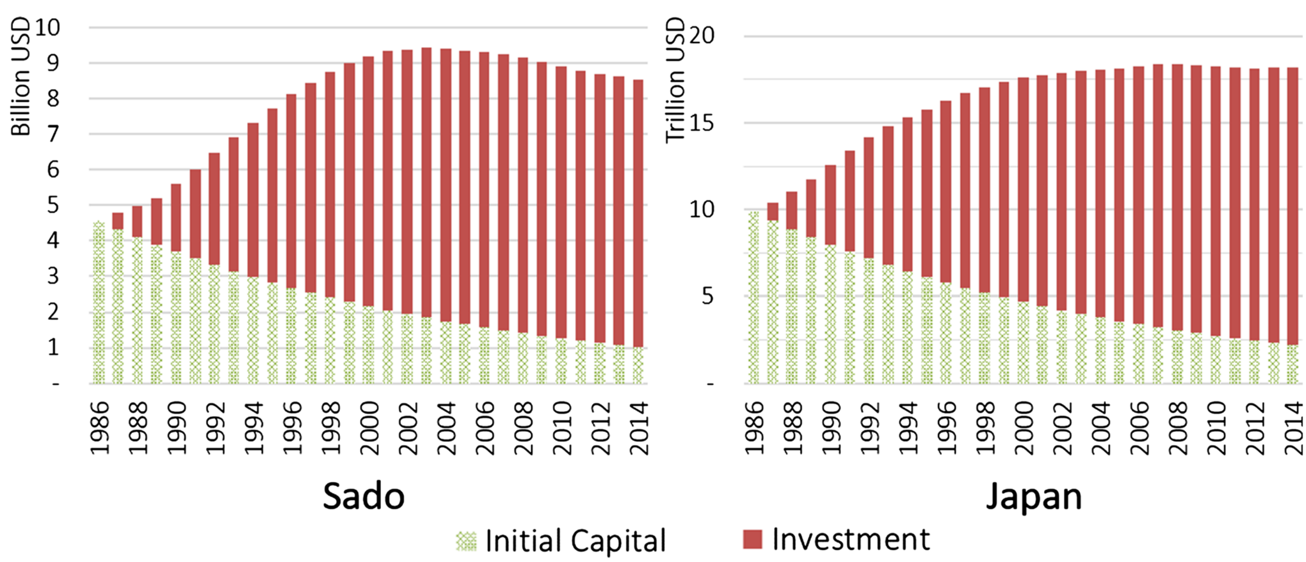

Fig. 5 Produced capital of Sado and Japan (1986–2014)

capital decreased by 6% at the national level and by 2% at the local level. While it bears little impact on overall trends, the fact that trends in natural capital are more positive at the local than national level was not captured by conventional indicators and will be further discussed below.

Constituents of inclusive wealth

Produced capital

Produced capital comprises roughly 28% of wealth at both local and national levels and is notable for its rapid increase in early years. The reason for this is evident in Fig. 5, which depicts the initial capital ($[1\text{-}\delta]^t K_0$) in 1986 and subsequent investment $\left(\sum_{j=1}^{t} I_j (1-\delta)^{t-j}\right)$. Accumulation of investment enables produced capital to increase regardless of fluctuating, or even diminishing economic productivity as measured by GDP (Fig. 4). Nonetheless, continuous depreciation of the initial capital and diminishing investment result in almost consistent decrease of annual change in produced capital at both scales (from 7% to − 1% in Sado, and 6.4 to 0.1% in Japan) (Figs. 4, 5). Annual depreciation is 5% across scales (Table 1); annual changes in investment went

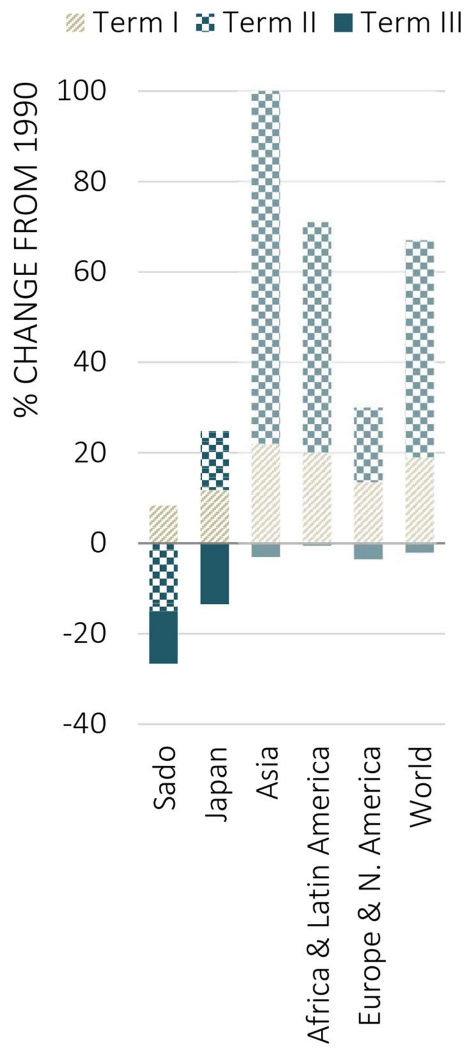

Fig. 6 Changes in the components of human capital (1990–2010). Term I: human capital (education) per person; Term II: educated population; Term III: shadow price per person. Data for four columns on right: UNU-IHDP and UNEP 2014

from 31% to − 0.4% in Sado and 27% to 1% in Japan over the study period (1990–2014).

Human capital

Human wealth is a product of three variables: years of formal education (Term I), size of educated population (Term II), and shadow price per person (Term III). Relative changes in each of these terms for Sado, Japan, and the world (according to IWR2014) between 1990 and 2010 accentuate the characteristic decline in Sado (Fig. 6). The fact that Term I (education) increased less in Europe (15%) and North America (12%) than in other parts of the world (total average 19%) may be explained by the ceiling effect of high preexisting levels of education (UNU-IHDP and UNEP 2014). However, Sado's even lesser increase (8%) may be due to the absence of a university on the island and resulting outflow of young and educated residents. Sado's negative change (− 15%) in Term II (population) is likewise explained by the population decrease of 19.6% between 1990 and 2010 (Fig. 2). Meanwhile, population at the national level was relatively stable, increasing by 4%. Term III (shadow price) is where Sado (− 12%) has fared better than the national level (− 13%). The negative change in Term III is attributable to decreases in the amount of time the average person spends in the labor market (from 22.3 years in 1990 to 19.7 years in 2010 in Sado, and 26.1 years to 23.3 years in Japan). The application of Actual Age of Retirement (*AAR*) in the present study accentuates these changes more than the IWR (UNU-IHDP and UNEP 2014).

Natural capital

For renewable, terrestrial natural capitals, a shadow price is calculated based on historical production, then multiplied by land area. Thus, natural capital is essentially stable when there is little change in land use. In Sado's case, overall natural capital declined by 2% during our study period due to land use changes, particularly of croplands (Fig. 7). However, a 25% reduction in population (Fig. 2) during this time resulted in a 31% increase of per capita natural capital. Meanwhile at the nation-level, population increased by 3%. The overall 8% decline of natural capital was a 11% decrease per person. General trends are nonetheless similar to Sado's, as most of this decline is attributed to decreases in cropland area (pasturelands declined by 34% but comprised less than 3% of natural capital).

Fisheries Understanding that fisheries and secondary nature are essential components of the socio-ecological production landscapes and seascapes of Sado and Japan, we also considered the wealth of fisheries and cultivated forests. Fisheries wealth was included in the IWR2012 for a handful of countries with preexisting marine stock estimates, but omitted in the IWR2014. We have followed the methodology of Sato and colleagues (2015), who used historical data and annual catch as a proxy for marine stock estimates.

In short, our results elucidate why fisheries wealth might have been omitted from the IWR2014. Figure 8 depicts annual changes in the components of per capita natural capital. While terrestrial natural capitals reflect land area, fisheries wealth reflects the annual catch. Despite shadow prices that incorporate longitudinal changes in rental price, volatile fluctuations in Sado's fisheries wealth suggest that the calculation method fails to capture meaningful changes in fisheries stock. The relative stability of nation-level results is alarming in its consistent decrease, but contrasts local-level instability and demonstrates the increased difficulty of stock estimates at smaller scales. Nonetheless, the fact that

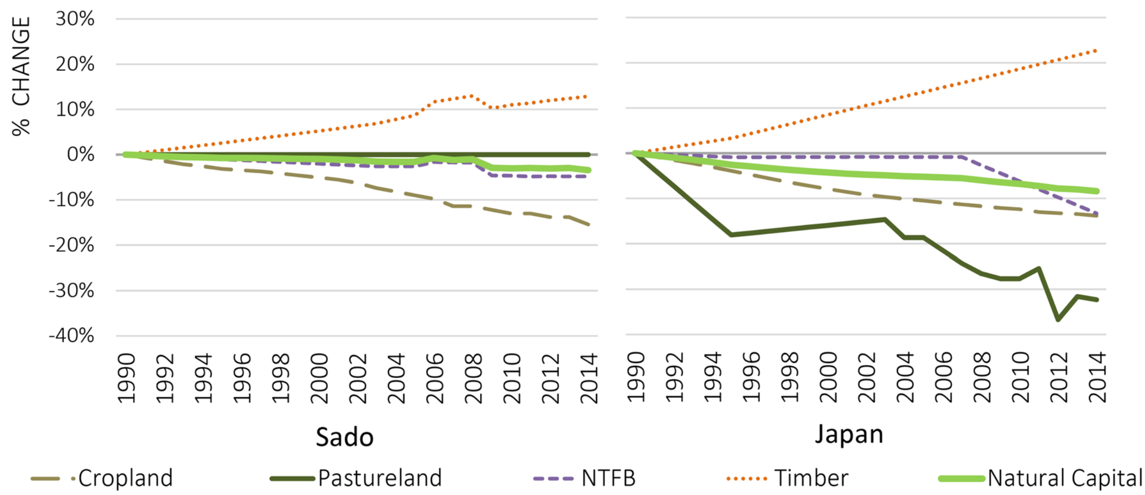

Fig. 7 Changes in natural capital from 1990 baselines of Sado and Japan

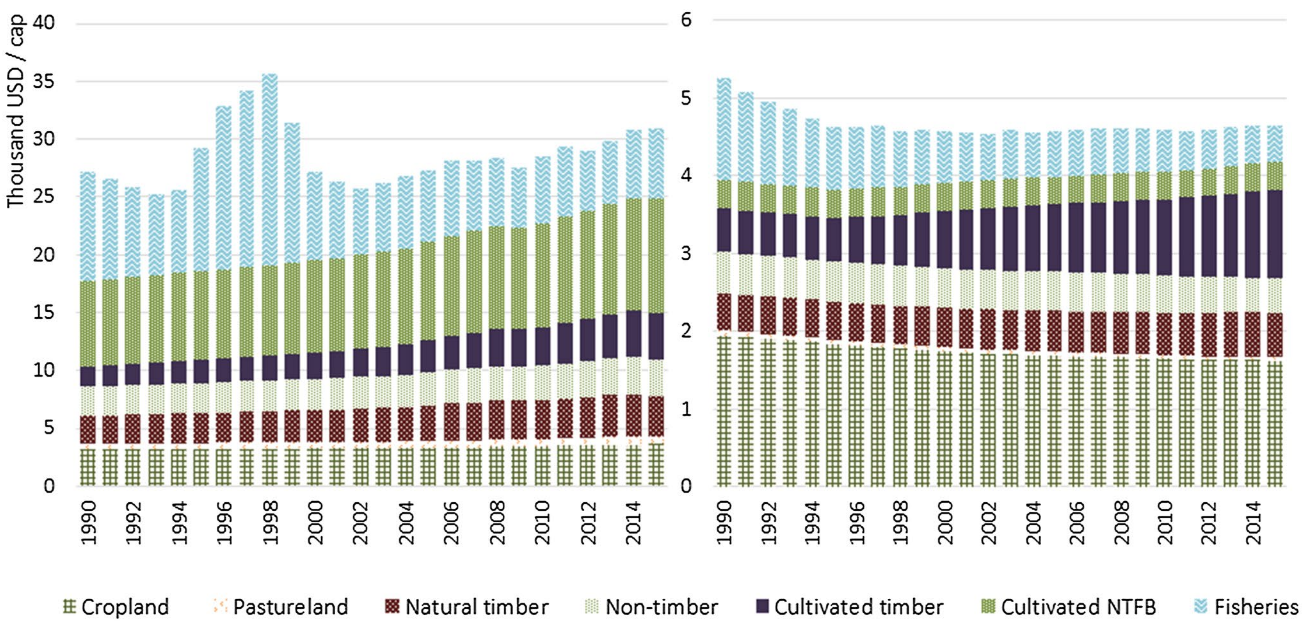

Fig. 8 Per capita natural capita in Sado and Japan (1990–2014), with additional wealth of fisheries and timber and non-timber forest benefits (NTFB) from cultivated forests

fisheries wealth adds another 33% (2009) to 64% (1998) (average: 44%) to Sado's natural capital and 16% (2014) to 30% (1990) (average: 20%) to nation-level natural capital is noteworthy and demands further inquiry.

Cultivated forests Cultivated forests were not considered natural capital in previous works (UNU-IHDP and UNEP 2014), but encompass the majority of Sado's forestland (Fig. 9) and is an integral component of the socio-ecological production landscape. As assumptions on the accessibility of timber (FAO 2006) and NTFB (The World Bank 2006) on forestlands did not specify forest type, we assumed equal accessibility and shadow prices for natural and cultivated forests. The assumption that only 10% of the land is accessible for retrieving ecosystem services likely results in a conservative estimate (Table 1), as all cultivated lands are presumably accessible, but we maintain the assumption for comparability and to accommodate for uncertainty regarding relative shadow prices.

Results directly reflect the proportionate importance of cultivated forestland (Fig. 9). Cultivated forests comprise a large portion of forests throughout Japan but are especially

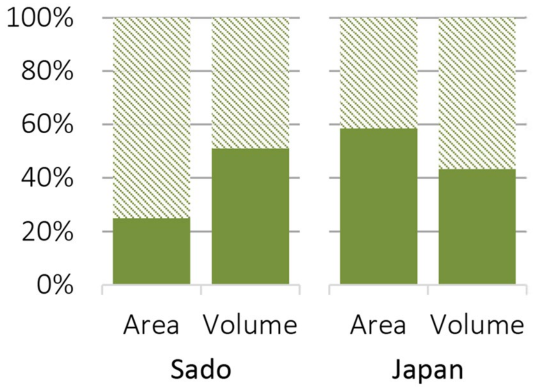

Fig. 9 Area and timber volumes of natural and cultivated forest land in Sado and Japan (1990–2014 average)

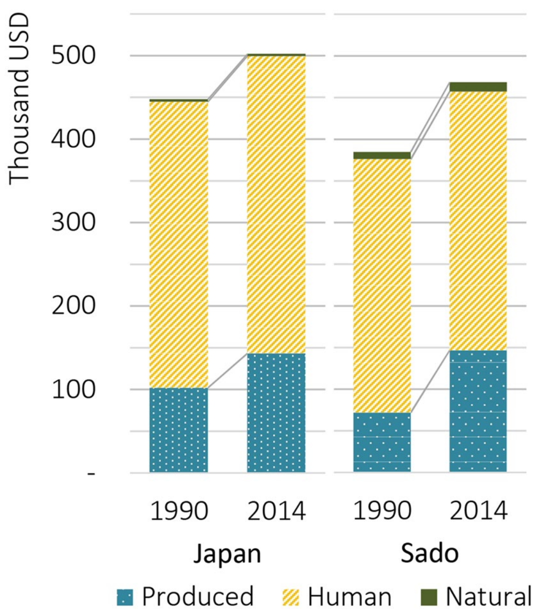

Fig. 10 Per capita inclusive wealth in Sado and Japan (1990 and 2014)

dominant in Sado (Fig. 9). Their addition more than doubles (1990–2014 average: an additional 112%) Sado's terrestrial capital and adds 13% to Japan's terrestrial capital. Also noteworthy is that cultivated forests exhibit more positive trends compared to natural forests. At the local level, timber wealth increased by 13% in natural forests and by 75% in cultivated forests. Respective increases at the national level were 23% and 102%. Meanwhile, natural forest area (the basis of NTFB estimations) decreased, by 5% in Sado and by 13% across Japan. Yet changes were minimal in cultivated forests: 2% and −0.4%, respectively.

Per capita wealth Trends in per capita wealth differ from overall trends. Per capita wealth increased more for Sado (20%) than for Japan (12%) (Fig. 10). The greatest increase was in produced capital, which increased by 104% in Sado and by 41% in Japan. Human capital follows, with respective increases of 2% and 4%. Finally, natural capital increased by 31% in Sado but decreased by 8% nationally. While divergent trends in population (Fig. 2; 4% increase in Japan, 25% decrease in Sado) explain a great portion of these results, per capita wealth by capital reveal realities not immediately visible at the aggregate level (Fig. 3).

In monetary value, Sado's average wealth is 88% (1990) to 95% (2014) of the national average. As seen in Fig. 10, difference in per capita produced capital is most pronounced, reflecting differing intensities of economic activity largely captured by per capita output (1990–2014 average: Sado $29,696; Japan $35,812). Similarly, the difference in per capita human capital can be attributed to differences in average wage (Sado $37,484; Japan $41,826).

Per capita natural capital is a different story. While small in magnitude, the proportional difference between local and national per capita wealth is largest and expanding, with Sado roughly triple that of Japan [287% (1990) to 417% (2014)] (Fig. 10). This is despite the likely undervaluation of agricultural land at the local level (Sado $19,944; Japan $45,928 per hectare) due to constraints in available data. Rather, the difference can be explained by population density and depopulation, also discussed by Ikeda and Nakamura (2017). There is 0.04 ha of agricultural land per capita in Japan (declining each year by an average of 0.8%), and 0.20 ha per capita in Sado (increasing annually by 0.7%). Forest wealth showed similar trends, with 0.11 ha per person in Japan (increasing at 0.8% per year) and 0.68 ha per person at the local level (increasing at 1.4% per year).

Discussion

Wellbeing implications of the wealth valuation

One finding of this study is that Sado's average wealth was lower than the national average (Fig. 10). As shown above, the main reasons for the 11% gap are differences in the sheer size of economic output and of average wage; Sado was 16% and 10% behind national averages, respectively. However, dollar-value results must be regarded with caution. For one, the monetary unit in this analysis does not take purchasing power into account. Consumer prices in cities of Sado's size average 4% lower than national standards (Regional Difference Index of Prices; Ministry of Internal Affairs and Communications (MIC) Statistics Bureau 2007). Sado being an island requiring surface transportation of goods and services from mainland Japan, prices are comparatively high (1% lower), but still lower than nationwide averages.

Moreover, theoretical works suggest that monetary income may be less important for rural residents (Wirth 1938), and empirical studies substantiate the importance of nonmonetary, reciprocal exchange systems in the rural lifestyle (Kamiyama et al. 2016). For example, local-level data on agricultural production only captured produce in known markets. Yet the portion of crops consumed or given away may be larger for a region such as Sado, resulting in lower valuation of agricultural land. Similarly, communities with active informal networks may have less monetary spending but fresh produce and frequent social interactions. Thus, wellbeing implications of the dollar-value wealth may vary by context; standards of living may be higher than implicated by the relative wages and market purchasing power.

Indeed, the local scale of the present study brings to light specific, known attributes of regions represented by Sado that the IWI has yet to address. This is particularly clear for natural capital. At present, shadow prices are approximated solely by the market value of provisional ecosystem services (with the exception of NTFB, which take prices from empirical studies on ecosystem service valuation). Other attributes that relate to wellbeing and sustainability such as the quality or variety of produce (Jehlička and Daněk 2017; Kamiyama et al. 2016; Kohsaka et al. 2016), regulating, supporting, and cultural ecosystem services (Díaz et al. 2015), and diversity or resilience of landscapes (Wilson 2010) are not currently taken into consideration. Similarly, there is currently no way for local, traditional ecological or cultural knowledge to be accounted for despite their documented relevance to the sustainability of resource (or wealth) management (Comberti et al. 2015; Díaz et al. 2015; Olsson and Folke 2001). Assessment of human capital would also benefit from refinement. Health was integrated in this study as Actual Age of Retirement (2.6 years longer in Sado than Japan). Yet this may be an undervaluation considering the unofficial labor in family farms and businesses, as well as recent findings that farmers live longer and have lower medical costs than non-farmer counterparts (Horiguchi and Genma 2017). Our exploratory valuation of actual working life, cultivated forests and fisheries suggests that inclusion of currently unaccounted aspects is likely to increase the relative valuation of rural regions.

Wellbeing implications of capital ratios

Rural and urban regions differ in the structure of capitals. Monetary valuation of the three capitals enables trade-off analysis and is considered a major strength of the IWI (UNU-IHDP and UNEP 2014). However, the relative importance of the three capitals for wellbeing may differ. There is solid consensus on the positive association of natural capital and wellbeing (Cox et al. 2017; Hadavi 2016; Korpela et al. 2014; Seymour 2016): natural environments benefit happiness, life satisfaction (Biedenweg et al. 2017; MacKerron and Mourato 2013), physical health (de Vries et al. 2003), mental health (Kaplan and Kaplan 1989) and the wellbeing or cohesion and functioning of communities (Holtan et al. 2014; Sullivan et al. 2004; Weinstein et al. 2015). While factors of human and produced capitals such as education (Michalos 2008; Economic and Social Research Council 2014) and income (Kahneman and Deaton 2010) are also known to benefit wellbeing, our results portray natural capital as a defining characteristic of rural regions (Fig. 10). These regions would benefit from governance that sees beyond the conventional focus on economic output and considers the wellbeing implications of abundance in natural capital.

Limitations and future research

The globally applicable methodology is convenient and offers otherwise unavailable, comparative insights, but is constrained to widely available data. The shadow value of human capital is derived from formal schooling and market wages; natural capital is largely dependent on market values of produce. Use of economy-wide variables such as output and investment to quantify produced capital brings practical difficulties of parsing out inter-capital dependencies and double counting. In our case, some data were only available at higher administrative levels and extrapolated or interpolated accordingly (see supplementary material). The downscaling may have affected the accuracy of our results.

As such, applying the index designed for use at the national level has revealed opportunities for future refinement of the index itself, as well as for use in contexts similar to our study area. Our assessment suggests that the restriction of data has limited the IWI's ability to capture assets essential to a society's long-term wellbeing. Data reflecting on-ground realities and verification of the top-down assessment with bottom-up measures of social welfare, such as individual-level questionnaire responses, may help to address this lack of accuracy in shadow price estimates. Non-market production and labor, cultural ecosystem services, and social capital are often context-specific (Eastwood et al. 2016) and largely missed at present. These are suggested as starting focal points of such optimization.

An additional consideration is that values inevitably change according to the socio-cultural and temporal context. While the valuations strive for intertemporal validity by encompassing historical market values and discounting into time horizons of infinity, shadow prices ultimately rely on market prices, and of some period of time. The shadow value of agricultural land is fixed across time, so that changes in agricultural wealth reflect change in land area, rather than consumption. This may be a reasonable approximation of the preferences of individuals represented by available data, but is unable to account for the full extent of an asset's benefits to society or for future changes to preferences (Duraiappah et al. 2014) or external circumstances. Future work to ensure the pertinence of this index to sustainable development may account for physical i.e. planetary limitations to growth in wealth (Dearing et al. 2014). It may also consider (Ascough et al. 2008) and represent (Spiegelhalter et al. 2011) uncertainties in ways accessible to decision makers to better implement the theoretical ideal of shadow prices that represent intergenerational wellbeing.

Conclusion

In light of demographic and economic shrinkage in rural regions around the world, our study attempted to highlight rural regions' unique wealth by comparing the inclusive wealth of Sado Island and Japan between 1990 and 2014. In doing so, we have broadened the knowledgebase of IWI and parallel indicators by newly applying the IWI at the local level and identifying its strengths and weaknesses. We also adapted developments in the estimation of human capital (i.e. work life span), and supplemented natural capital with estimates of cultivated forests and fisheries. Results demonstrate the distinct potential of the IWI as a stock measure. As with per capita GDP, Sado's per capita wealth was lower than national averages, but the difference was 10% and narrowing, compared to the 16% and recently widening difference in per capita GDP. Of the three capitals, human capital was dominant, as previously reported, and captured the ongoing shrinkage of Sado. However, Sado's per capita natural capital was about threefold national averages. Further, findings suggest that current measures undervalue natural capital, and that integration of additional aspects would increase the relative valuation of inclusive wealth in rural regions. In other words, this study affirms past research indicating that rural regions are undervalued, and suggests that development policies consider them as greater assets to society than currently suggested by GDP. Opportunities and focal points for optimizing the methodological approach are also suggested toward the implementation of the index for sustainable development.

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References

Age International (2015) Facing the facts: The truth about ageing and development. Age International, London, United Kingdom

Anielski M, Rowe J (1999) The genuine progress indicator—1998 update. Redefining Progress, San Francisco, CA.

Antweiler W (2018) Foreign Currency Units per 1 U.S. Dollar, 1948–2015. http://fx.sauder.ubc.ca/etc/USDpages.pdf. Accessed 22 Feb 2018

Arrow KJ, Dasgupta P, Mäler KG (2003) Evaluating projects and assessing sustainable development in imperfect economies. Environ Resour Econ 26:647–685. https://doi.org/10.1023/B:EARE.0000007353.78828.98

Arrow KJ, Dasgupta P, Goulder LH et al (2012) Sustainability and the measurement of wealth. Environ Dev Econ 17:317–353. https://doi.org/10.1017/S1355770X12000137

Ascough JC, Maier HR, Ravalico JK, Strudley MW (2008) Future research challenges for incorporation of uncertainty in environmental and ecological decision-making. Ecol Modell 219:383–399. https://doi.org/10.1016/j.ecolmodel.2008.07.015

Berry BJL, Okulicz-Kozaryn A (2009) Dissatisfaction with city life: a new look at some old questions. Cities 26:117–124. https://doi.org/10.1016/j.cities.2009.01.005

Berry BJL, Okulicz-Kozaryn A (2011) An urban-rural happiness gradient. Urban Geogr 32:871–883. https://doi.org/10.2747/0272-3638.32.6.871

Biedenweg K, Scott RP, Scott TA (2017) How does engaging with nature relate to life satisfaction? Demonstrating the link between environment-specific social experiences and life satisfaction. J Environ Psychol 50:112–124. https://doi.org/10.1016/j.jenvp.2017.02.002

Bloom DE, Boersch-Supan A, McGee P, Seike A (2011) Population aging: facts, challenges, and responses. Program on the Global Demography of Aging Working Paper Series No. 71.2011. Harvard Center for Population and Development Studies, Boston, MA

Bolt K, Matete M, Clemens M (2002) Manual for calculating adjusted net savings. Environment Department, World Bank, Washington, D.C.

Cabinet Office (2017a) National Accounts. http://www.esri.cao.go.jp/jp/sna/menu.html. Accessed 11 Dec 2017

Cabinet Office (2017b) Prefectural Accounts. In: Gov. Japan. http://www.esri.cao.go.jp/jp/sna/sonota/kenmin/kenmin_top.html. Accessed 11 Dec 2017

Comberti C, Thornton TF, Wylliede Echeverria V, Patterson T (2015) Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. Glob Environ Chang. https://doi.org/10.1016/j.gloenvcha.2015.07.007

Cox DTC, Shanahan DF, Hudson HL et al (2017) Doses of nearby nature simultaneously associated with multiple health benefits. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph14020172

Daily GC (1997) Nature's services. Island Press, Washington, D.C.

Dasgupta P (2007) Economics: a very short introduction. Oxford University Press, Oxford

Davey G, Chen Z, Lau A (2009) "Peace in a thatched hut-that is happiness": subjective wellbeing among peasants in rural China. J Happiness Stud 10:239–252. https://doi.org/10.1007/s10902-007-9078-x

de Vries S, Verheij RA, Groenewegen PP, Spreeuwenberg P (2003) Natural environments—healthy environments? An exploratory analysis of the relationship between greenspace and health. Environ Plan A 35:1717–1731. https://doi.org/10.1068/a35111

Dearing JA, Wang R, Zhang K et al (2014) Safe and just operating spaces for regional social-ecological systems. Glob Environ Chang 28:227–238. https://doi.org/10.1016/j.gloenvcha.2014.06.012
de los Ríos I, Rivera M, García C (2016) Redefining rural prosperity through social learning in the cooperative sector: 25 years of experience from organic agriculture in Spain. Land Use Policy 54:85–94. https://doi.org/10.1016/j.landusepol.2016.02.009
Díaz S, Demissew S, Carabias J et al (2015) The IPBES conceptual framework—connecting nature and people. Curr Opin Environ Sustain 14:1–16. https://doi.org/10.1016/j.cosust.2014.11.002
Diener E, Tay L, Oishi S (2013) Rising income and the subjective well-being of nations. J Environ Psychol 2:267–276. https://doi.org/10.1037/a0030487
Donovan N, Halpern D (2002) Life satisfaction: The state of knowledge and implications for government. Strategy Unit, Cabinet Office, Government of the UK
Duraiappah AK, Nakamura K, Takeuchi K et al (2012) Satoyama–Satoumi Ecosystems and Human Well-Being: Assessing Trends to Rethink a Sustainable Future. Yokohama, Japan
Duraiappah AK, Asah ST, Brondizio ES et al (2014) Managing the mismatches to provide ecosystem services for human well-being: a conceptual framework for understanding the new commons. Curr Opin Environ Sustain 7:94–100. https://doi.org/10.1016/j.cosust.2013.11.031
Eastwood A, Brooker R, Irvine RJ et al (2016) Does nature conservation enhance ecosystem services delivery? Ecosyst Serv 17:152–162. https://doi.org/10.1016/j.ecoser.2015.12.001
Economic and Social Research Council (ESRC) (2014) The wellbeing effect of education. Economic & Social Research Council, Research Councils UK
FAO (2006) Global forest resources assessment 2005. FAO, Rome
FAO (2016) FAO-STAT. http://www.fao.org/faostat/en/#data. Accessed 5 Oct 2017
Feenstra RC, Inklaar R, Timmer MP (2015) The next generation of the penn world table. Am Econ Rev 105:3150–3182. https://doi.org/10.15141/S5J01T. https://ggdc.net/
Feldhoff T (2013) Shrinking communities in Japan: community ownership of assets as a development potential for rural Japan? Urban Des Int 18:99–109. https://doi.org/10.1057/udi.2012.26
Fukamachi K (2016) Sustainability of terraced paddy fields in traditional satoyama landscapes of Japan. J Environ Manag 1–7. https://doi.org/10.1016/j.jenvman.2016.11.061
Gómez-Baggethun E, de Groot R, Lomas PL, Montes C (2010) The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. Ecol Econ 69:1209–1218. https://doi.org/10.1016/j.ecolecon.2009.11.007
Hadavi S (2016) Direct and indirect effects of the physical aspects of the environment on mental well-being. Environ Behav. https://doi.org/10.1177/0013916516679876
Hayashi T (2015) Measuring rural-urban disparity with the genuine progress indicator: a case study in Japan. Ecol Econ 120:260–271. https://doi.org/10.1016/j.ecolecon.2015.11.006
Hokuriku Regional Agricultural Administration Office (1993) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (1994) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (1995) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (1997) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (1999) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (2000) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (2001) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (2004) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Hokuriku Regional Agricultural Administration Office (2006) Niigata gyogyō no ugoki: Niigata ken nōrinsuisan tōkei nenpō (Trends in Niigata fisheries: Niigata prefecture statistical yearbook for agriculture, forestry and fisheries)
Holtan MT, Dieterlen SL, Sullivan WC (2014) Social life under cover: tree canopy and social capital in Baltimore, Maryland. Environ Behav 1–24. https://doi.org/10.1177/0013916513518064
Horiguchi K, Genma M (2017) Secrets behind longevity of farmers: Working hard and living life to the fullest [in Japanese]. https://www.waseda.jp/top/news/topic/52003. Accessed 5 Oct 2017
Ikeda S, Nakamura H (2017) Accounting for inclusive wealth of regions: prefecture-level analysis in Japan during 1990–2010. In: Managi S (ed) The wealth of nations and regions, 1st edn. Routledge, New York, pp 150–185
Ikeda S, Tamaki T, Nakamura H, Managi S (2017) Inclusive wealth of regions: the case of Japan. Sustain Sci. https://doi.org/10.1007/s11625-017-0450-4
Japan Satoyama Satoumi Assessment (2010) Satoyama-Satoumi ecosystems and human well-being: socio-ecological production landscapes of Japan—Summary for decision makers. United Nations University, Tokyo, Japan
Jehlička P, Daněk P (2017) Rendering the actually existing sharing economy visible: home-grown food and the pleasure of sharing. Sociol Ruralis 57:274–296. https://doi.org/10.1111/soru.12160
Kahneman D, Deaton A (2010) High income improves evaluation of life but not emotional well-being. Proc Natl Acad Sci USA 107:16489–16493. https://doi.org/10.1073/pnas.1011492107
Kamiyama C, Hashimoto S, Kohsaka R, Saito O (2016) Non-market food provisioning services via homegardens and communal sharing in satoyama socio-ecological production landscapes on Japan's Noto peninsula. Ecosyst Serv 17:185–196. https://doi.org/10.1016/j.ecoser.2016.01.002
Kaplan R, Kaplan S (1989) The experience of nature: a psychological perspective. Cambridge University Press, Cambridge
Kasser T (2002) Personal well-being. In: The high price of materialism. MIT Press, Cambridge, Massachusetts, pp 5–22
Keese M (2007) A method for calculating the average effective age of retirement. In: OECD. https://www.oecd.org/els/emp/39371923.pdf. Accessed 27 Jun 2017
Kinsella K, Phillips DR (2005) Global aging: the challenge of success. Popul Bull 60:5–42
Knight J, Gunatilaka R (2010) The rural–urban divide in China: income but not happiness? J Dev Stud 46:506–534. https://doi.org/10.1080/00220380903012763

Kohsaka R, Matsuoka H, Uchiyama Y (2016) Capturing the relationships between local foods and residents: a case in the Noto region, Japan. J Ethn Foods 3:86–92. https://doi.org/10.1016/j.jef.2016.05.001

Korpela K, Borodulin K, Neuvonen M et al (2014) Analyzing the mediators between nature-based outdoor recreation and emotional well-being. J Environ Psychol 37:1–7. https://doi.org/10.1016/j.jenvp.2013.11.003

MacKerron G, Mourato S (2013) Happiness is greater in natural environments. Glob Environ Chang 23:992–1000. https://doi.org/10.1016/j.gloenvcha.2013.03.010

MAFF (2010) Kokyō bokujyō wo meguru jyōsei (Situation regarding public pastures). http://www.maff.go.jp/j/chikusan/sinko/lin/l_siryo/pdf/koukyou.pdf. Accessed 11 Jul 2017

MAFF (2017a) Menseki chōsa (Area survey). http://www.maff.go.jp/j/tokei/kouhyou/sakumotu/menseki/. Accessed 11 Jul 2017

MAFF (2017b) Mokuzai kakaku tōkei chōsa (Statistical Survey of Timber Prices). http://www.maff.go.jp/j/tokei/kouhyou/mokuryu/kakaku/. Accessed 11 Jul 2017

MAFF (2017c) Nōringyō sensasu (Census of Agriculture and Forestry). http://www.maff.go.jp/j/tokei/census/afc/. Accessed 11 Jul 2017

MAFF (2017d) Ringyō keiei tōkei chōsa (Statistical Survey of Forestry Management). http://www.maff.go.jp/j/tokei/kouhyou/rinkei/. Accessed 11 Jul 2017

MAFF (2017e) Gyogyō sensasu (Fisheries Census). http://www.maff.go.jp/j/tokei/census/fc/. Accessed 11 Jul 2017

MAFF (2017f) Gyogyō keiei chōsa (Survey on Fisheries Management). http://www.maff.go.jp/j/tokei/kouhyou/gyokei/. Accessed 11 Jul 2017

MAFF (2017g) Gyogyō sanshutu gaku (Gross fisheries output). http://www.maff.go.jp/j/tokei/kouhyou/gyogyou_seigaku/index.html. Accessed 11 Jul 2017

MAFF (2017h) Kaimen gyogyō seisan tōkei chōsa (Statistical survey of marine fisheries production). http://www.maff.go.jp/j/tokei/kouhyou/kaimen_gyosei/. Accessed 11 Jul 2017

MAFF Forestry Agency (2017) Shinrin / Ringyō hakusho (Forest and Forestry White Paper). http://www.rinya.maff.go.jp/j/kikaku/hakusyo/. Accessed 11 Jul 2017

Matanle P, Sato Y (2010) Coming soon to a city near you! Learning to live "Beyond Growth" in Japan's shrinking regions. Soc Sci Jpn J 13:187–210. https://doi.org/10.1093/ssjj/jyq013

Michalos AC (2008) Education, happiness and wellbeing. Soc Indic Res 87:347–366. https://doi.org/10.1007/s11205-007-9144-0

MIC Statistics Bureau (2007) Statistical survey of national prices. http://www.stat.go.jp/data/zenbutu/2007/index.htm. Accessed 11 Dec 2017

MIC Statistics Bureau (2017) Kokusei chōsa (Population Census). http://www.stat.go.jp/data/kokusei/2015/kekka.htm

MOE (2016) 500 important Satoyama landscapes: Satoyama Landscapes important for biodiversity conservation. http://www.env.go.jp/nature/satoyama/pamph/leaflet0322s.pdf. Accessed 22 Feb 2018 [in Japanese]

Morrison PS, Weckroth M (2017) Human values, subjective wellbeing and the metropolitan region. Reg Stud 1–13. https://doi.org/10.1080/00343404.2017.1331036

Mumford KJ (2012) Measuring inclusive wealth at the state level in the United States. In: UNU-IHDP, UNEP (eds) Inclusive wealth report 2012. Cambridge University Press, Cambridge, pp 69–86

Narayanan G, Aguiar AB, McDougall R (2012) Global trade, assistance, and production: The GTAP 8 data base. Center for Global Trade Analysis, Purdue University

National Institute of Population and Social Security Research (2013) Population projection for Japan by region (March 2013). http://www.ipss.go.jp/pp-shicyoson/j/shicyoson13/t-page.asp. Accessed 5 Oct 2017

Niigata Prefectural Government (2017) Niigata tōkei nenkan (Niigata Prefecture Statistical Yearbook). In: Niigata Prefect. http://www.pref.niigata.lg.jp/tokei/1196871357582.html. Accessed 11 Dec 2017

Niigata Prefecture (2015) Municipal Accounts. http://www.pref.niigata.lg.jp/tokei/1202403638070.html. Accessed 11 Dec 2017

Olsson P, Folke C (2001) Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. Ecosystems 4:85–104. https://doi.org/10.1007/s100210000061

OECD (2016) OECD territorial reviews: Japan 2016. OECD Publishing, Paris

Polasky S, Bryant B, Hawthorne P et al (2015) Inclusive wealth as a metric of sustainable development. Annu Rev Environ Resour 40:150902153650003. https://doi.org/10.1146/annurev-environ-101813-013253

Price R, Durham C, Chan J (2010) GES review of the economics of sustainable development. Government Economic Service and Department for Environment, Food, and Rural Affairs, London

Requena F (2016) Rural-urban living and level of economic development as factors in subjective well-being. Soc Indic Res 128:693–708. https://doi.org/10.1007/s11205-015-1051-1

Saito O, Kamiyama C, Hashimoto S (2018) Non-market food provision and sharing in Japan's socio-ecological production landscapes. Sustainability 10:213. https://doi.org/10.3390/su10010213

Sato M, Sato S, Waki M (2015) Estimation of the inclusive wealth of Japan. Kyoto Institute of Economic Research Discussion Paper No. 1404. Kyoto University, Kyoto (**in Japanese**)

Schippers P, van der Heide CM, Koelewijn HP et al (2014) Landscape diversity enhances the resilience of populations, ecosystems and local economy in rural areas. Landsc Ecol 30:193–202. https://doi.org/10.1007/s10980-014-0136-6

Seymour V (2016) The human–nature relationship and its impact on health: a critical review. Front Public Heal 4:1–12. https://doi.org/10.3389/fpubh.2016.00260

Spiegelhalter D, Pearson M, Short I (2011) Visualizing uncertainty about the future. Science 333:1393–1400. https://doi.org/10.1126/science.1191181

Stiglitz JE, Sen A, Fitoussi J-P (2009) Report by the commission on the measurement of economic performance and social progress. Sustain Dev 12:292. https://doi.org/10.2139/ssrn.1714428

Sullivan WC, Kuo FE, Depooter SF (2004) The fruit of urban nature. Environ Behav 36:678–700

Sustainable Development Commission (2003) Redefining prosperity: resource productivity, economic growth and sustainable development. Sustainable Development Commission, UK

Takeuchi K, Ichikawa K, Elmqvist T (2016) Satoyama landscape as social–ecological system: historical changes and future perspective. Curr Opin Environ Sustain 19:30–39. https://doi.org/10.1016/j.cosust.2015.11.001

Tawaratsumida M (2015) Jōsei hōkoku: Hōboku wo meguru jōsei (Status report: State of grazing(. https://www.naro.affrc.go.jp/nilgs/kenkyukai/files/houboku2015_koen03.pdf. Accessed 11 Jul 2017

The World Bank (2006) Where is the wealth of nations? Measuring Capital for the 21st Century. The World Bank, Washington, D.C.

The World Bank (2017) World development indicators. http://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.MKTP.KD.ZG&country=. Accessed 5 Oct 2017

The World Bank Group (2017) Annual percentage growth rate of GDP at market prices based on constant local currency. In: World Dev. Indic. http://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.MKTP.KD.ZG&country=. Accessed 11 Dec 2017

UN DESA Population Division (2017) World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP/248. New York, NY

UN DESA Population Division (2015) World urbanization prospects: The 2014 revision. ST/ESA/SER.A/366. New York, NY

UNU-IHDP and UNEP (2012) Inclusive wealth report 2012. Measuring progress toward sustainability. Cambridge University Press, Cambridge

UNU-IHDP and UNEP (2014) Inclusive wealth report 2014. Measuring progress toward sustainability. UNU-IHDP, Cambridge

van der Ploeg S, de Groot RS (2010) The TEEB valuation database—a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, Wageningen

Walker B (2005) A resilience approach to integrated assessment. Integr Assess J 5:77–97

Weinstein N, Balmford A, Dehaan CR et al (2015) Seeing community for the trees: the links among contact with natural environments, community cohesion, and crime. Bioscience 65:1141–1153. https://doi.org/10.1093/biosci/biv151

Wilson G (2010) Multifunctional "quality" and rural community resilience. Trans Inst Br Geogr 35:364–381. https://doi.org/10.1111/j.1475-5661.2010.00391.x

Winters JV, Li Y (2016) Urbanisation, natural amenities and subjective well-being: evidence from US counties. Urban Stud 54:1956–1973. https://doi.org/10.1177/0042098016631918

Wirth L (1938) Urbanism as a way of life. Am J Sociol 44:1–24

Yamaguchi R, Sato M, Ueta K (2015) Measuring regional wealth and assessing sustainable development: an application to a disaster-torn region in Japan. Soc Indic Res 124:1–25. https://doi.org/10.1007/s11205-015-1106-3