To which extent is vitality of rural regions a geospatial variable?

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SUMMARY

In the context of studying and detecting variations in vitality, vulnerability and versatility in rural regions, a dilemma exists with regard to the geospatial nature of the concept ‚vitality'. Development studies usually characterize vitality by a number of statistical and descriptive indicators, which are on the one hand connected to either individuals or groups of individuals, and on the other hand to features of objects or clusters of such features and objects. Whilst such indicators tend to rely on regular government repositories and on proxies generated from open geospatial resources, it is not meaningful to associate one pixel, point or polygon with a given value to represent vitality, because there is a strong dynamic and discretionary human and social component, which is not necessarily fixed to one location. Based on both socio-economic and geospatial data collection followed by a conceptual reflection in case studies in Germany, Spain, Poland and Japan, we reach the conclusion that vitality can best be approached as a quasi-geospatial variable. This means that one can indeed distinct degrees of vitality based on geospatial differences, but one cannot derive a particular value of vitality for one specific location. The implication of this notion is that a map showing grades and quantitative values of vitality is not necessarily significant for spatial planning. Instead, one still needs to understand the non-spatial degree and variability of vitality in its spatial context to generate feasible spatial development plans. In simple terms, an empty school building is not an indicator of negative vitality because of its location and spatial features, but because of its lack of social activity needed to generate a vital socio-spatial environment.

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1. INTRODUCTION

Land managers are tasked to optimize the use of land, by appropriately allocating and distributing land use and assigning rights, restrictions and responsibilities to land. These tasks should typically support broader processes of development, including rural development. The goal of rural development is in essence ensuring that people living in rural regions have adequate working and living conditions, such that they can obtain an adequate quality of life standard, similar and equivalent to other parts of the country (Lu and de Vries, 2022). Making decisions on this standard of life depends however on norms and values on what such a standard may be. In other words, the development of rural development plans depends on the collection of appropriate data and indicators related to people, built-up structures, access and dependencies on infrastructures and facilities and general contextual conditions, including environment, livability, greenness, water, etc. Many of such indicators are either based on attributes of individual people (such as age, education level, type of employment, ownership rights) or to bio-physical features and characteristics (such as locations of buildings, topography, soil type, temperature distribution, vegetation type per location). These descriptive indicators are usually part and derived by standard publicly accessible and authentic repositories, such as civil and commerce registers, topographic, soil and land use, land cover databases, demographic and socio-economic statistics. Additionally, open (geospatial and non-geospatial) data sources, either through voluntary (geographic) information, such as openstreetmap, or through commercial companies, such as google earth engine, can contribute to the collection and comparison on estimating the degrees of rurality and rural vitality.

There are however several problems when assembling and integrating these various data sources. Besides the existing heterogeneity in spatio-temporal and semantic quality of the respective data sources, there is also a fundamental epistemological problem, namely, can one detect and attribute a spatio-temporal value to something which is inherently social or human, discretionary and possibly irrational. Although vitality, and the variation of vitality is a useful concept to discuss and explain the problems of rural regions, is it also a meaningful concept in a spatial and temporal sense. In other words, can one pinpoint a value of vitality to a single pixel, point or polygon if its variation and its dynamic is fundamentally rooted in human behavior, values and interactions? And, ultimately, if one still qualifies pixels, points or polygons as more or less vital, to which extent are the derived rural development policies still significant or appropriate? This article addresses this fundamental question by first discussing

the theoretical concept of vitality. Then, we present how this concept relates to similar concpets, such as vulnerability, versatility and resilience. From the research on the how this concpets is practically translated into indicators we present how one can collect data on vitality. The following section discusses to which extent the vitality indicators aare fundamentally spatial and to which extent one can therfore derive vitality assessments through geospatial tools. The final seciton concludes on the main research quesiton and discusses a nubmer of recommendations for follow up research.

2. THEORY OF VITALITY

2.1 Notions of Vitality

Vitality is a boundary concept which interconnects several scientific domains and epistemologies (de Vries et al., 2022). Li et al. (2019) posit that changes in rural vitality are the manifestation of an economic transition, namely from an '*agrarian to the urban-industrial economy, and further on to the knowledge economy*'. The implication of this transition is not only economical (i.e. the need to support the development of new economic opportunities, diversification and entrepreneurship), but also the development of new social capital (i.e. new skills and networks to operate effectively in new types of economies). This notion is also relevant for developing strategies for rural development (de Vries, 2018b). Makkonen and Kahila (2021) argue furthermore that in the context of rural development a 'rural vitality policy' transforms the conventional focus on competitiveness of rural (mostly agrarian) firms and enterprises to a more holistic one, which includes issues, such as attractive living environments, communality and the well-being of residents. Lehtonen (2021) connects the issue of vitality to social migration and depopulation and argues that the closing of basic facilities, such as schools, is both an effect and a trigger of depopulation and therefore both directly and indirectly an indicator of social vitality. (Wangdi, 2022) links vitality of rural communitires to social happiness and sustainability, expressed by *trust more in neighbors, share stronger family relationships, are safe from violence, donates time and money to community activities, and do more volunteering services*. Lamb (2022) places rurality and rural vitality in an historical, archeological and cultural context, argueing that the ancient Maya civilizations indeed had variations in degrees of rurality and rural vitality, which are not so much rooted in either rural-urban dichotomies, spatial built-up or density differences or commoner-elite inequalities, but more in complexities of people's daily lifes of living outside city boundary. These complexities include people's relationships, identities and personalities. The implication of the conceptual findings is that the variation of rural vitality is not necessarily socially or spatially discrete, but rather fuzzy, overlapping, fluid, and dynamic in both time and space. As Lamb (2022) argues '*spatial distinctions may not "objectively" exist, yet people do practice and experience them*'.

2.2 Vitality, vulnerability and versatility

In a previous publication we argued that vitality of rural regions relates conceptually to versatility on the one hand and vulnerability on the other hand (de Vries et al., 2022). In the context of rural development, the three concepts shed a different light on the manner in which rural citizens are able to cope with the challenges which both nature and fellow humans or social institutions pose in a rural environment. (de Vries, 2018a) discusses the issue of rural vitality in terms of versatility of rural villagers and argues that those who have a high degree of self-consciousness and a sense of pride in the village, will also have a positive image about their village, which creates a capacity to be versatile and resilient. It will result in some form of local and regional identity, whereby it becomes easier to engage people in local activities and whereby citizens activate each other and are being activated mutually. Vitality and versatility are this closed interconnected, although for each one can create their own indicators as a measure for rural development. Similarly, vitality is linked to vulnerability. Vulnerability is indeed a complex concept with multiple aspects and dimensions, including social, economic, historical, and political vulnerability. Vulnerability is very much a spatial variable if it clearly relates to potential hazards which are spatially induced. Yet, vulnerable situations may also occur because of inadequate governance processes or human conflicts. These may not necessarily spatially determined. Regardless of the spatial nature, the link to vitality is obvious. If a rural village is vital, it also has to capacity to engage people actively in preparing against hazards, as a result of which the location will be less vulnerable.

2.3 Vitality and resilience

In addition to the relation of vitality to vulnerability and versatility there is a close relation of vitality to resilience. There exists a broad literature base on the issue of resilience, which is both clarifying as well as confusing. Sharifi (2016), for example, compares 36 community resilience assessment tools which all differ in objective and measuring instruments and collective indicators, yet share the goal to detect spatio-temporal and/or socio-human-community variations in resilience. Many of such tools have limited degrees of success in terms of practical use in development planning, and their indicators often fail to rely on bottom-up implementation plans. Resilience is more or less the opposite of vulnerability, whilst related to vitality in the sense that it relies on the internal (often community) capacity to organize social action.

There are various ways to visually present spatial variation in resilience. One example is resilience maps (https://resiliencymaps.org/). This project ‘aims to put local maps detailing potential hazards as well shelter zones in the hands of (San Francisco) residents. The maps are made with OpenStreetMap and available offline. Another example is the resilient land mapping tool (https://maps.tnc.org/resilientland/), which is ’a proposed conservation network of representative climate-resilient sites designed to sustain biodiversity and ecological functions into the future under a changing climate’. A third example concerns the resiliecne

Atlas (https://www.resilienceatlas.org). The resilience Atlas is' an interactive analytical tool for building (1) understanding of the extent and severity of some of the key stressors and shocks that are affecting rural livelihoods, production systems, and ecosystems in the Sahel, Horn of Africa and South and Southeast Asia; and (2) insights into the ways that different types of wealth and assets (i.e., natural capital, human capital, social capital, financial capital and manufactured capital) – and combinations among these – impact resilience in particular contexts'. According to their site the Atlas *was created by integrating and analyzing more than 12 terabytes of data from over 60 of the best available datasets related to resilience, and summarizing the output in the form of easy to understand maps that can shift focus from regional to national and, where the availability and resolution of the data permit, to local scales*. These practical examples of resilience maps seem to map locations or areas of vulnerability instead of spatial variations in resilience. Nevertheless, they generate a kind of dashboard with multiple scalable indicators which can each be turned off and on, in order to visualize the spatial variations.

3. DATA COLLECTION ON VITALITY

As human activities are considered as an essential component of rural vitality, rural vitality is considered a practical outcome human interactions within social, economic, infrastructure, environment and institutional dimensions. The logic of measuring is then that indicators in each of dimensions collectively determine the vitality of a rural town. The life of the rural population largely depends on the social and economic dimensions. The use of spatial data and geostatistical data are crucial to measure rural vitality. Vitality can be measured spatially in terms of the spatial distribution of activities, settlement layout and patterns, land use, building forms, built-up densities and communication network. Geostatistical data like road and rail network are a measure of accessibility, similarly data on public utility services like schools, hospitals, cultural center, supermarkets are a measure of availability of basic needs. Facilities like electricity, water, sewage, waste disposal and internet connectivity as a measure of affordability.

Comparison of measure of development of rural settlements with regard to population, economic activity and basic facilities with the national average help assess the rural vitality in the rural regions. Attributes are measured based on the current state and the developments over time using a matrix (Kaye-Blake et al., 2019). The result shows that rural areas which are accessible and closer to bigger cities perform better in terms of the socio-economic dimensions as compared to the one's in the remote areas. experience higher population growth. Night time light intensities have been widely used for detection of electric lighting in the settlements. They can be used as economic proxies as they are indicators of industrial activity and occupancy of the building (Lehnert et al., 2022). To measure rural vitality requires availability of geospatial, statistical and geostatistical time series datasets as listed in Table 1.

Type of Data	Contents	Methods
Geospatial data	Road network	Extraction from VIR images

	Building footprints with height	Medium resolution satellite images (Sentinel 1&2) with DEM, Global human settlement layer (GHSL)
	Land use	Image classification from satellite / Orthophoto
	Administrative boundaries	Vector data (State geospatial portal)
	Irrigated areas/ cultivated areas	Classification from satellite /orthophoto
	Population	Geospatial web portals
	Digital Elevation model (DEM)	Remote sensing
	Health centres / clinics/ Hospitals	Geospatial web portals
	Soil Map	Classification of RS data
	Energy Map	Geospatial goeportals
	Source of water	Geospatial geoportals
	Shopping complex	Openstreet extract (OSM) / Geospatial geoportals
	Education and culture	Openstreet extract (OSM) / Geospatial geoportals
	Points of interest	Openstreet extract (OSM) / Geospatial geoportals
Secondary data	Housing price data (including names of neighborhood and their price)	Statistical publication / geoportals
	Local businesses	Statistical publication / geoportals
	Recruitment information / labor information	Statistical publications

Table 1. Type of datasets and methods

As part of the MSc thesis on calculating the resilience of Selected indicators for measuring Vitality, Vulnerability and Versatility (3 Vrut) on the basis of the Infrastructure, Institutional and Economic dimensions and giving them weights in order to calculate a resilience index. Indicators are measured with the help of classification of orthophotos with 40 cm resolution and geostatistical data collected from government and private web portals The list of selected indicators as a measure of vitality are shown in Table 2.

Vitality

		double weighting	
	indicator number	weighting	indicator
INFRASTRUCTURE	INF_I10	3	Internet connection/ mobile internet connection/ network coverage
	INF_M10	2	quality of roads
	INF_M30	3	Public institutions (also cultural) --> available, use Examples: Parks, sports facilities, playgrounds, exhibitions, cinema
	INF_M50	2	Schools/ day-care centers
	-	2	Public transport - available/ use
	Total:	12	
INSTITUTIONAL	INS_C30	1	Physiotherapy/ Osteopathy
	INS_C50	4	Basic medical care/ pharmacies
	INS_C40	2	medical specialists
	INS_C60	1	Veterinary care (small/large animals)
	INS_P10	2	schools
	INS_P20	2	facilities for the elderly
	Total:	12	
ECONOMIC	EC_D20	2	Number of tourist beds
	EC_D30	3	Specialty shops in town
	EC_D40	3	Local food market in town (village shop)
	EC_D50	2	Local supply available (bakery, butcher)
	EC_D80	1	Renewable energies in households
	EC_S20	3	Percentage of house & land ownership
	EC_S30	4	Rent index/average sales price in €/m^2
	EC_S40	1	share of second homes
	Total:	19	

Table 2. Indicators for measuring vitality

Some of the publication on measuring vitality using remote sensing-based data and geostatistical data are listed in Table 3.

Publication	Indicator	Use	Method
(Lee and de Vries, 2021)	LULC changes with intense land development	Land Use rights	Detect larger built-up spaces (false colour image) in TS of LU Maps (LU Change)
(Smilka, 2020)	Compactness of Built-up	Land ownership	Population density, Complexity of Land Use (both values given in literature, see source), Area per capita (calculate w/ LU map) distance to puiblic facilities, distance to public transportation, distance to green areas (all 3 w/ distance calculatons in GIS - Data from openStreetMap)
(Sapena et al., 2021)	Compactness (= walkability)	Indicating intensity of factors as Health, Housing, Education, Income, Affordability, Employment, Transportation, and Commuting within a spatial dimension	Classification of LU according to Local Climate Zones (LCZs) (sparsely built, compact mid-rise, open-highrise, bare soil, water ,… (see right) Connect it to prior determined socioeconomic characteristics w/ VSURF (Variable Selection Using Random Forests)
(Avtar et al., 2020)	Vegetation Cover	Biodiversity	NDVI, EVI (Enhanced Vegetation Index), surfac reflectance, land surface temperature (LST), Maximum Entropy algorithm

(Watmough et al., 2019)	Size of building within compound	Poverty in LMICs	LU Map from high-res orthophotos compared to cadastre (parcel sizes)
(Jean et al., 2016)	Economic / human activity	Economic / human activity	Use nighttime imagery for detection of human activity (for more see Publication)

Table 4. Literature on measurement of vitality through remote sensing

Rural towns have their own unique characteristics which may differ from one region to another. Therefore, rural vitality depends on a lot of factors which include location, proximity to large city, size, settlement patterns etc. The most widely used method to map rural vitality is with the help of spatio-temporal satellite images, change analysis can be carried out and mapped to analyze the change in land use and growth of the rural towns on the basis of settlement patterns and direction of growth. A multi criteria decision analysis method of mapping vitality on the basis of several explanatory variables that impact the changes in land use. Mapping the levels of vitality on the basis of the values derived from the indexing of the measured indicators.

4. SPATIAL NATURE OF VITALITY

There are several examples in which rurality and partly vitality are mapped. The Thünen Landatlas is a specific example of a rurality map / geodatabase assembling multiple datasets and deriving specific values of rurality for specific municipal administrative units (Steinführer, 2016). The Landatlas makes a spatial difference between rurality by a rurality ranking system based on an aggregate of various indicators. To determine rurality, five indicators are combined into an index by means of a statistical procedure: - settlement density 2013, - share of agricultural and forestry land in total land area 2013, - share of one- and two-family houses in all residential buildings 2013, - regional population potential 2011 (sum of the population in a 50-km radius projected on the 1-km grid of Eurostat with a weighting that decreases proportionally with the linear distance), and - accessibility of major centres (sum of the population of the nearest five major centres in Germany or functional urban centres abroad weighted proportionally with the road distance according to the Federal Institute for Research on Building, Urban Affairs and Spatial Development [data status 2014/2015]). Rurality tends to be more pronounced the lower the settlement density, the higher the proportion of agricultural and forestry land, the higher the proportion of detached and semi-detached houses, the lower the population potential and the poorer the accessibility of major centres (based on www.Landatlas.de). The result is indeed a map of different ruralities for different location and thus a spatial variable rurality. Although the map is insightful to show the distribution of different aspects geospatially, it still leave the question what the specific value of rurality at a particular location really means in spatial terms, as the values are directly related to the administrative governance units, and not necessarily to the spatial networks of

people, which may actually be close to the border of those spatial units or even cross multiple administrative units.

Similarly, for the Netherlands de Voogd and Cuperus (2021) developed the ‘Atlas of disconnected Holland: on outsiders and incumbents’ (in dutch: ‘Atlas van afgehaakt Nederland: over buitenstaanders en gevestigden’). This Atlas shows that there are big differences between people, regions, municipalities and neighbourhoods in the Netherlands. Bustling areas next to shrinking areas, neighbourhoods with people with relatively high social and financial 'capital' next to neighbourhoods with people with relatively low capital. The Atlas shows that the country is unevenly distributed in a complex way. However modest in size and population, the Netherlands is not a homogeneous country. Neither sociologically nor geographically. Certain (groups of) people and certain places have more opportunities and development opportunities and are better represented in politics and society (based on (de Voogd and Cuperus, 2021). Here also, maps of specific indicators show the differences for specific locations geograhically, but do not necessarily show the spatial dynamics causing these differences.

When transforming these insights to the issue of vitality, and taking into acocunt the indicators of the previous seciton, we can indeed provide good arguments that any aggregate value representing vitality of rural regions can generate a map showing the distribution of spatial vitality. The different economic, sociological and anthropological perspectives on vitality have a common view on the relevance of dynamic features and relations. Vitality is not a constant, but it differs in both time and in space and in human interactions and dynamics. Hence, whether spatial vitality has a euclidian location in space is debatable. One needs to rely on other concepts of spatial relations.

5. CONCLUSIONS

The degree to which vitality of rural regions is a spatial variable is to a certain extent a complex issue as there are multiple perspectives possible which are each valid. On the one hand there is the argument that one can indeed discover differences in spatial attributes if one collects data for certain spatial units, either regions or municipal units, or even by using pixels and classifications. The different values indeed provide a visual picture of the spatial differences between certain governance units. The problem is however the reliance on governance units itself. Would one change any of these boundaries, then the results would be different. Moreover, behind the governance units are many spatial relations, interactions and networks which remain unmapped. For a variable such a vitality which is strongly associated with these human variables, it is therefore important to rely on multiple indicators which make these hidden connections and cause-effect relations also visible, because they are crucial for policy making and spatial (usually land) interventions and allocations. Nevertheless, it would still be useful to generate a dashboard which visualizes the spatial variations in all the individual indicators of rural vitality. One can then combine certain indicators and investigate

whether certain causal or spatial relations emerge, which might explain certain variations. Moreover, with pattern recognition and machine learning one could potentially derive these patterns automatically such that individual rural development managers can plan in advance.

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BIOGRAPHICAL NOTES

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