Mapping and modeling local food capacity in British Columbia

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Abstract

Interest in local food security has increased in the last decade, stemming from concerns surrounding environmental sustainability, small scale agriculture, community food security, and disaster preparedness. Promotions for consumption of locally produced foods have come from activists, non-governmental organizations, as well as some academic and government research and policy. The goal of this paper is to develop a predictive model for the agricultural self-sufficiency index in the province of British Columbia. To meet this goal, we develop a self-sufficiency index for each Local Health Area in the province, and create a predictive model based on capital investment in regional agriculture. Our predictive model allows for estimation of regional scale self-sufficiency without reliance on regional landuse or nutrition data; however, residual spatial autocorrelation must be accounted for through alternative spatial regression models. The methods developed will be a useful tool for researchers and government officials interested in agriculture, nutrition, and food security, as well as a first step towards more advanced modeling of current local food capacity and future potential.

Background and Relevance

Agriculture is a globally significant land use, and has considerable impact on economic systems, the natural environment, and human health (Rounsevell et al., 2003). Scientists and planners are increasingly required to consider and predict agricultural output based on local variation agricultural practices, ecological variables, climate change, and disaster management scenarios (Basso, Ritchie, Pierce, Braga, & Jones, 2001; Chakir, 2009; Feenstra, 1997; Lobell & Christopher, 2007). Methods to empirically assess local food production and consumption (i.e., local food capacity) are under-developed, hindering the ability of policy makers to effect innovative local food security policy (Rideout, Seed, & Ostry, 2006; Rounsevell, Annetts, Audsley, Mayr, & Reginster, 2003). There is demand for regional agricultural production estimates that allow for mapping of the spatial variation in agricultural productivity. While assessing local-scale agricultural capacity directly is possible, this requires the development and integration of multiple databases that can be time-consuming and costly to develop. The goal of this paper is to use more readily available data to develop a predictive model for the theoretical capacity of local scale agricultural in British Columbia. To meet this goal, we integrate previously developed map-based data on local scale food production and population-level food consumption estimates to estimate the theoretical ability for a local region to meet local food needs (Morrison, Nelson, & Ostry, 2011a, 2011b). We refer to this ratio as the self-sufficiency index. We create a predictive model using capital investment in regional agriculture and amount of cropland as covariates.

Methods and Data

The relationship between food production to food consumption provides us with a theoretical estimate the local food capacity of a region (Duxbury & Welch, 1999; Peters, 2009; Vancouver Food Policy Council, 2009). The SSI can also be used as a proxy to assess import-reliance, as regions must be importing at least *1-SSI%* of their foods. This information allows us to assess noteworthy spatial patterns in food capacity.

The SSI exhibits spatial heterogeneity, and we begin by performing descriptive mapping and cluster analysis to assess spatial patterns. We develop a simple regression model with two covariates; while additional covariates may potentially improve model fit, they increase the data requirements to utilize the model. Minimizing covariates is useful as long as a reasonable model fit can be achieved. Ordinary least squares regression (OLS) requires data to be independent with normally distributed zero-mean errors. The self-sufficiency index and the residuals from a linear regression both have significant spatial correlation in their data structure. To address this, we develop a conditional autoregressive (CAR) model to explore the relationship between the SSI and regional agricultural capital investments. This model incorporates the residual spatial dependence and avoids biased parameter estimates. We operate in a Bayesian framework, which benefits from a fully random effects model, treating all model parameters as random variables with distributions, rather than estimating a single fixed value (Banerjee, Carlin, & Gelfand, 2004). We investigate the impacts of neighbourhood definitions (as defined within the autoregressive model) on our model.

Results and Conclusions

Our conditional autogressive model accounts for residual spatial autocorrelation and allows for unbiased parameter estimation. Model assessment suggests good model fit with two covariates, suggesting that local scale capacity is highly influenced by regional capital investment and amount of regional cropland.

Our descriptive mapping of the SSI informs us on the high level of regionalization in the local food systems, as well as a strong provincial focus on the production of meat and dairy over fruits and vegetables. Regionalization on a food group basis is a negative finding for local food security, as no one region has sufficient variety in nutrients to make up a complete local diet.

The development of self-sufficiency models that are not based on agriculture or nutrition data, but rather on easily accessible farm financial statistics, may allow for estimates of local food capacity while bypassing the labour-intensive process of estimating local scale food production and consumption. The significant correlated relationship between invested farm capital and agricultural self-sufficiency suggests that local investment in agricultural could translate to increased food security at the local scale.

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