

Identifying rural food deserts: Methodological considerations for food environment interventions

Alexandre Lebel, PhD,^{1,2} David Noreau, MSc,^{1,3} Lucie Tremblay, RDN, MSc,⁴ Céline Oberlé, MSc,¹ Maurie Girard-Gadreau, MSc,¹ Mathieu Duguay, MSc,¹ Jason P. Block, MD, PhD⁵

ABSTRACT

OBJECTIVES: Food insecurity is an important public health issue and affects 13% of Canadian households. It is associated with poor accessibility to fresh, diverse and affordable food products. However, measurement of the food environment is challenging in rural settings since the proximity of food supply sources is unevenly distributed. The objective of this study was to develop a methodology to identify food deserts in rural environments.

METHODS: In-store evaluations of 25 food products were performed for all food stores located in four contiguous rural counties in Quebec. The quality of food products was estimated using four indices: freshness, affordability, diversity and the relative availability. Road network distance between all residences to the closest food store with a favourable score on the four dimensions was mapped to identify residential clusters located in deprived communities without reasonable access to a “good” food source. The result was compared with the food desert parameters proposed by the US Department of Agriculture (USDA), as well as with the perceptions of a group of regional stakeholders.

RESULTS: When food quality was considered, food deserts appeared more prevalent than when only the USDA definition was used. Objective measurements of the food environment matched stakeholders’ perceptions.

CONCLUSION: Food stores’ characteristics are different in rural areas and require an in-store estimation to identify potential rural food deserts. The objective measurements of the food environment combined with the field knowledge of stakeholders may help to shape stronger arguments to gain the support of decision-makers to develop relevant interventions.

KEY WORDS: Social environment; geography; food supply; food insecurity

La traduction du résumé se trouve à la fin de l'article.

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Adequate nutrition is fundamental from infancy until adult life and is among the most important determinants of health.^{1–3} Healthy dietary choices are associated with a higher life expectancy; unhealthy choices are associated with substantial comorbidities, including obesity, diabetes and other chronic diseases.^{4,5} While individual dietary behaviours remain important,⁶ there is an increasing interest in ecological approaches to improving nutrition, including access to healthy foods.^{7,8} Promotional interventions for healthy eating are essential, but it is widely recognized that such interventions are more efficient when healthy choices are facilitated by enhanced accessibility to a variety of nutritious foods at a reasonable price.⁹ If such accessibility is unevenly distributed among regions or between demographic subgroups, health determinant disparities may emerge,¹⁰ including food insecurity.¹¹ Food insecurity occurs when all members of a household do not have reliable access to food in sufficient quantity and quality to maintain an active and healthy lifestyle.¹²

In 2012, 13% of Canadian households experienced food insecurity,⁵ which is similar to the 14.5% observed in the US.⁴ In 2012, all the 10 counties in the Health Region of Chaudière-Appalaches (HR-CA), a mainly rural administrative region in the province of Quebec with approximately 400,000 people, perceived food insecurity as a priority area for policy action.¹³ According to

regional HR-CA stakeholders, most production of fresh food is oriented to the market outside the region. In order to develop context-specific interventions, the Regional Public Health Authority (RPHA-CA) planned to characterize the food supply offered and its accessibility in the Authority’s Action Plan 2013–2018.¹⁴

Various methods to measure accessibility to the food environment have been developed during the last decade. The use of geographic information systems (GIS) as a tool for

Author Affiliations

1. Graduate School of Land Management and Regional Planning, Laval University, Québec, QC
2. Evaluation Platform on Obesity Prevention, Quebec’s Heart and Lung Institute, Laval University, Québec, QC
3. Ministère des Affaires municipales et de l’Occupation du territoire, Québec, QC
4. Regional Public Health Authority, Chaudière-Appalaches, Ste-Marie de Beauce, QC
5. Obesity Prevention Program, Department of Population Medicine, Harvard Medical School, Harvard Pilgrim Health Care Institute, Boston, MA, USA

Correspondence: Alexandre Lebel, PhD, Graduate School of Land Management and Regional Planning, Laval University, Pavillon Félix-Antoine-Savard, Office 1616, 2325, allée des Bibliothèques, Québec, QC G1V 0A6, Tel: 418-656-7685, E-mail: alexandre.lebel@esad.ulaval.ca

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spatial analysis is one approach.¹⁵ It involves mapping food establishments across a region, measuring spatial access to these facilities,¹⁶ and determining the association with individual dietary and other health behaviours.¹⁵ The popularity of GIS in public health studies has generated a great number of food access measures and methods. In some cases, differing methods of characterizing food access could provide different results and associations. Some studies have focused on a specific food source, such as fast food restaurants or convenience stores, others aimed to describe and compare accessibility between neighbourhoods or regions. A review of these studies has demonstrated evidence for disparities in food access, income and race^{17,18} and has shown an impressive heterogeneity in measurements,¹⁹ which are not always comparable. Findings from other high-income countries have been sparse and equivocal.²⁰ The most common measurements rely on either density of food sources per square/area or physical proximity in road distance network.²¹ These studies have been particularly useful in identifying problematic areas and have been closely linked to the notion of food deserts.²² Food deserts are typically defined as “poor urban areas, where residents cannot buy affordable, healthy food”.^{23,24}

The majority of studies aiming to measure the food environment focus on higher density urban environments, using measurements that are perhaps unsuitable for less dense and more scarcely populated regions.^{25,26} The concept of a food desert is contested regarding rural environments since it is expected that rural dwellers always have access to motorized transport and that they maximize shopping efficiency by making large-volume shopping trips.²⁷ Yet, low-income or elderly rural residents may not have access to safe and reliable transportation, which may lead to low shopping frequency.²⁸ In effect, rural households with fewer resources may be constrained, the long distances and less frequent trips to their primary food store reducing the regularity of healthy food availability at home. Aside from the issue of physical distance between individuals and resources, this situation makes the food desert phenomenon similar to that for low-income urban residents, i.e., healthy food is difficult to reach and is often more expensive.²⁹ However, the measurement of the food environment remains challenging in rural settings, since both population and food supply sources are unevenly distributed in these territories. Few studies address this problem and may be responsible for mischaracterizing food deserts.³⁰ For example, according to desk top information, the US Department of Agriculture (USDA) defines a food desert as a “low-income tract in which at least 500 people or 33 percent of the population live more than 1 mile (in urban areas) or more than 10 miles or 16 km (in rural areas) from the nearest supermarket, supercenter, or large grocery store”.³¹ Such a definition may limit the identification of rural food deserts because of three important shortcomings: it does not consider the relative geographic distribution between households and food supply sources; it only considers large food sources that are often nonexistent in rural communities; and it overlooks the quality of what is offered within food sources. With the increasing proportion of low-income and elderly people in rural areas, the access to fresh, diverse and affordable food products becomes a critical issue, and more precise measurements are needed to identify potential food deserts in rural areas.^{10,30}

The objective of this study was to build a methodology to describe the food environment in a rural area. A specific description of the food environment is more likely to identify potential food deserts and may provide an opportunity for stakeholders to develop intersectoral interventions and policies to address the current food insecurity problem³² currently perceived in the HR-CA.

METHODS

We developed objective ecologic measurements to assess the regional food environment using a mixed methodology approach, grounded in the closely linked concepts of food security and food deserts. Food security rests on four pillars: food availability, access, utilization and stability.¹¹ The food desert concept has been typically operationalized in three ways: problems with food accessibility, problems with food affordability and problems with food availability.³³ Food utilization and stability have typically been the domain of individuals and are not considered to be ecologic measurements. Accessibility describes whether an individual has physical access to food retailers selling healthy items. Affordability relates to the cost of food within these retailers. Availability indicates the relative diversity of food choices available in the food retail economy of a particular neighborhood.

We constructed ecologic measures of the food environment in three steps: 1) modelling the ecumene, a wide concept essentially referring to the area inhabited by human society,³⁴ 2) assessing food store quality; and 3) identifying potential food deserts. Geographic information was validated directly in the field. Inter-rater statistics were computed for in-store observations. Final results were compared with the food desert parameters proposed by the USDA, as well as with the perceptions of a group of regional stakeholders involved in the Regional Food Security Committee.

Modelling the ecumene

A major limitation for the identification of food deserts in rural environments is the need to take into account the enormous variation of the relative geographic distribution between people and resources. In effect, the proximity of food supply sources is disproportionately distributed between households in rural settings, where some people live relatively close to a wide range of food sources and others may have access to only a single store with limited produce, such as a convenience store or a gas station, within 10 or 20 km. In this study, the ecumene was assessed by computing the road network of each household to food establishments in all communities. Communities were defined as municipalities, subsections of municipalities or groups of municipalities in which individuals share common needs and activities. A group of regional stakeholders designated these communities as such while considering attachment or belonging to a community that may influence individuals' travel behaviour.³⁵ The deprivation level of the communities was assessed using the regional weighted deprivation index provided by the Quebec National Public Health Institute using the Canadian census 2006. This index is widely used in Canada and was computed from the communities' mean income, proportion of people without a high school diploma and unemployment rate, and was divided into quintiles.³⁶ A topologic road network database was created using DMTI CanMap Streetfiles 2013 and a GIS (ArcGIS, 10.1).

The Quebec Ministry of Municipal Affairs, Regions and Land Occupancy (MAMROT) provided the municipal property assessment roll of 2010 as well as the civic address and the function of every listed property. We gathered information on all buildings categorized as “food retail”: supermarkets, convenience stores, large general stores (e.g., Walmart) and even gas stations, which often provide a large variety of food products in rural municipalities. All food outlets were mapped and visited to confirm their existence and location. All roads where no food outlets were reported were also visited in order to locate outlets missing from the MAMROT database. Missing outlets ($n = 30$) were removed from the database, and those that were not reported ($n = 43$) were added, thus providing a complete and exhaustive list of 153 food outlets. Six places refused the assessment and were not considered. This validation indicated that the MAMROT data had a positive predictive value of 0.74, which means that it delivered accurate information for 74% of registered food stores three years after its publication in 2010, and a sensitivity of 0.80, which means that 20% of reported food stores in the original data were not observed in the field in 2014.

Assessment of food store quality

In-store evaluations were performed to acquire information on the food affordability and availability. For all visited stores, we categorized 25 food products present in the National Nutritious Food Basket (2008) and distributed among the four groups of Canada’s Food Guide (vegetables and fruit 4, meat and alternatives 10, grain products 6 and milk and alternatives 5) according to availability, freshness and price. The information was used to construct four synthetic indexes: affordability, freshness, diversity and relative availability.

Affordability: The observed price of each food product was subtracted from the regional mean price of the same product. We categorized food as above or below the regional mean.

Freshness: For the vegetables and fruit, a simple qualitative assessment determined whether the product was fresh or not. For products with an expiration date, we considered the product to be fresh if the product had not yet “expired”. A store was considered to be selling fresh food if all products were reported to be fresh.

Diversity: The diversity index was built using an entropy-based formula similar to the land-use mix index.³⁷ It synthesised the importance and availability of each of the four categories of food as shown in Equation 1, where p_i is the proportion of the type of product in one food category and n is the number of food categories ($n = 4$). The denominator \ln_n allows for the calculation of an index bounded between 0 and 1, where 0 qualifies as a store selling a single food product category (no diversity) and 1 indicates a store that has a great number of products (high diversity). The 25% of food stores having the highest scores (fourth quartile) were considered as selling a high diversity of food products.

$$-(\sum_n p_i * \ln p_i) / \ln_n \tag{1}$$

Relative availability: As suggested by Pouliot and Hamelin,³⁸ the shelf space provided for healthy (vegetables and fruit) and unhealthy (sodas and chips) foods was estimated using step count. The ratio of the estimated shelf space for each type allowed for the identification of stores offering more shelf space for healthy than unhealthy products.

Food products quality assessment validation: Using two teams of two observers, we conducted this assessment in two regional counties from October to December of 2013 and another two in October to early December 2014. The observers had been previously trained to look for the right produce and to avoid outliers or inaccurate observations, such as weekly sales and different volumes of product. Inter-rater agreement (Kappa statistics) was computed for all the reported information in a subset of 20 food stores. Most Kappa statistics were above 0.90 (mean 0.92), indicating a very high concordance among observers. However, the freshness of whole wheat bread scored a moderate concordance with a coefficient of 0.57. This indicator was not considered reliable and was removed from the analyses.

Identification of potential food deserts

Food stores that qualified as affordable and selling fresh, diverse and high-quality food products were selected in the GIS and labeled as “high store”. A road network distance was calculated between each residential building to the closest high store. Residences located above 16 km to a high store³¹ and in most

Table 1. Regional characteristics to identify potential food deserts for the ecumene model and US Department of Agriculture (USDA) criteria

<i>Ecumene model</i>	Robert-Cliche		Etchemins		Beauce-Sartigan		Appalaches		Region	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	Total	%
Population	19,288	14.8%	17,245	13.2%	50,962	39.0%	43,120	33.0%	130,615	100%
Number of residences	6500	14.3%	6850	15.1%	16,727	36.8%	15,323	33.8%	45,400	34.8%
Located in a deprived community	1898	29.2%	4711	68.8%	5021	30.0%	3661	23.9%	15,291	11.7%
Located beyond 16 km of a high store*	181	2.8%	2770	40.4%	3188	19.1%	725	4.7%	6864	5.3%
Located in a potential food desert	24	0.4%	2211	32.3%	2339	14.0%	541	3.5%	5115	3.9%
Mean distance to closest high store*	5.4 km		14.8 km		7.2 km		5.3 km		7.4 km	
Median distance to closest high store*	3.2 km		14.4 km		2.2 km		2.3 km		3.5 km	
<i>USDA criteria</i>	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	Total	%
Population in derived census tract	0	0.0%	3370	31.9%	2462	23.3%	4720	44.7%	10,552	8.1%
Population beyond 16 km supermarket	110	3.9%	196	6.9%	745	26.2%	1797	63.1%	2848	2.2%
Population in potential food desert	0	0.0%	0	0.0%	0	0.0%	686	100%	686	0.5%

* Affordable and selling fresh, diverse and high-quality food products.

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deprived quintile communities were identified as potential food deserts.

Comparison with USDA method and stakeholders' perceptions

We used the USDA method to define potential food deserts.³¹ The methodology was applied by keeping only retailers identified as “supermarkets”. The results were then compared to highlight the differences in the exposed population. All results were presented to the Regional Food Security Committee of Chaudière-Appalaches and collaborators in March 2015. This interdisciplinary committee comprises 17 professionals working in the field of education, public health, agriculture, food banks and other non-government organizations (NGOs) and includes as many other collaborators from various institutions (for a total *n* of close to 40). We obtained their perceptions regarding this representation of the food environment and inquired whether the information matched their knowledge of the region.

RESULTS

All regions have extensive numbers of food establishments; few residences have no access within 16 km. When in-store food affordability, freshness, diversity, quality and relative availability are incorporated, the proportion of residences with poor accessibility varied from 2.8% to 40.4% among regions. When residences located in deprived communities only were considered, accessibility varied from 0.4% to 32.3% among regions (Table 1). The Etchemin region may be particularly vulnerable since the mean distance to reach a high store was 14.8 km; over 68% of the population live in a deprived community. The difference between the mean and the median distance to a high store indicates the importance of the variation within and among regions, and highlights the heterogeneity of local contexts of food environment.

Using the USDA criteria to define rural food deserts led to substantially altered results. For example, Table 1 shows that 5,115 households were living in a potential food desert distributed among all four regions, whereas using USDA criteria this dropped to 686 households located in only one region.

Mapping provided more precision regarding the location of residential clusters located in a deprived community and living further than 16 km from a high store (Figure 1). The map also reveals vulnerable communities that are materially deprived but where accessibility to a good food source relies on only one store.

The results of the food environment description were presented to the Regional Food Security Committee of Chaudière-Appalaches (March 20, 2015). Many stakeholders recognized what they generally observed in the communities but were impressed by how many households were located in a potential food desert and by the variety of contexts in which potential food deserts were identified. The presentation inspired many alternative interventions, such as developing a cooperative businesses network, mobile food suppliers or enhancing in-store diversity. Nevertheless, it was clear to the Committee that the structure of the ecumene makes the development of cost-effective solutions challenging, that none of these alternatives would entirely address the perceived food insecurity problem and that intersectoral cooperation among regional stakeholders (e.g., producers, suppliers, NGOs) would be needed. An objective description of

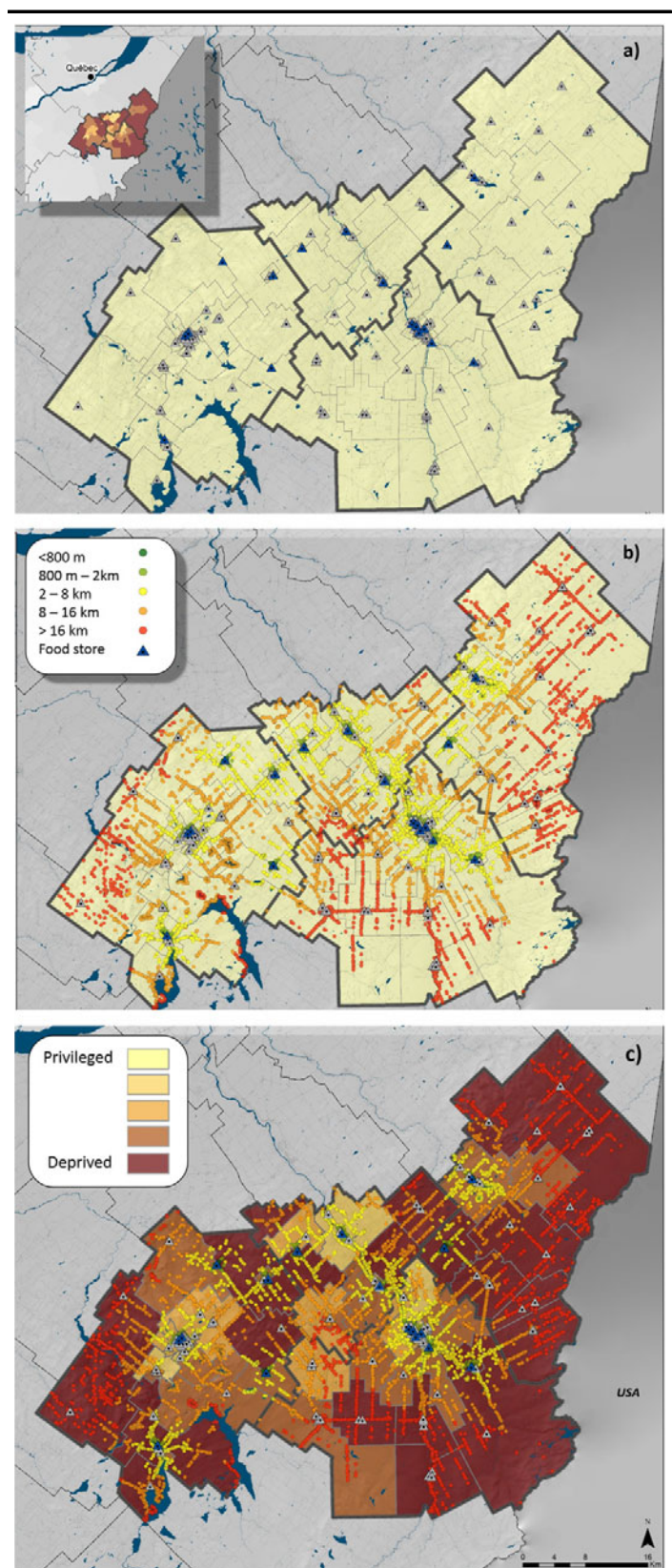


Figure 1. Potential food deserts in four regional counties in Chaudière-Appalaches, Quebec; a) identification of “high stores” (affordable and selling fresh, diverse and high-quality food products); b) residence proximity to high stores; c) deprivation level of communities and potential food deserts

the food environment was seen as a valuable complementary tool and as a first essential step in building the case for decision-makers to develop adapted interventions for the region.

DISCUSSION

Knowledge of the food environment is a critical dimension to address when considering the food insecurity problem in the population.³⁹ Because it is particularly challenging to describe the food environment in a rural setting, this study proposes a more precise methodology to identify potential food deserts and has revealed an impressive variety of local contexts. Regional stakeholders in HR-CA recognized this objective measurement as a better complementary tool to their knowledge of the situation than what is usually used and as better contributing to robust arguments directed at decision-makers for facilitating interventions. Regional stakeholders understand the complexity of the food market dynamics and are not looking for a single and easy solution for all vulnerable areas. Although many proposed interventions are known to them, analyzing the food environment by considering the ecumene more closely strengthens the need for intersectoral interventions. Identifying the most vulnerable areas (potential food deserts) may also help to prioritize some areas for intervention or point to the presence of support for initiatives in those areas.

The ecumene model provides a more precise assessment of the food environment and allows the identification of a variety of local contexts, since accessibility to food sources is not constrained by census tract boundaries, as for the USDA criteria. Another benefit of the proposed methodology is its flexibility, as it could easily be transferred to study any rural food environment. Yet food items and thresholds chosen for building each indicator were based on relative measurements specifically in HR-CA and were defined with the help of regional public health authority professionals, including a nutritionist. Consequently, any measurement or threshold proposed in this study should not be considered as an absolute indicator of food-store quality and should be adapted to the area under investigation. Although four synthetic indices (affordability, freshness, diversity and relative availability) are directly associated with the notion of food insecurity, we further recommend validating the thresholds used to identify a good food source with the knowledge of regional stakeholders.

The main limitation of this methodology is that it requires field observation and many data validation procedures. Although these procedures are demanding, our experience has shown that the alternative of using exclusively desk information may be not only less reliable but also misleading for decision-making for at least two reasons: 1) a significant number of errors were found in administrative databases; 2) several nontraditional food sources, such as gas stations, are often the only reachable source of healthy food and must be considered.

Assessment of the food environment in rural areas is methodologically challenging. Nevertheless, in order to provide a relevant complementary tool to stakeholders, we recommend considering field observations and the relative distribution of people and resources (the ecumene) as a necessity, not an option.

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RÉSUMÉ

OBJECTIFS : L'insécurité alimentaire est une problématique de santé publique qui atteint près de 13 % des ménages canadiens. Elle est associée à une faible accessibilité à des produits alimentaires frais, diversifiés et abordables. Cependant, la mesure de l'environnement alimentaire demeure un défi important en milieu rural puisque les sources

d'approvisionnement alimentaire sont distribuées de façon inégale sur le territoire. L'objectif de cette étude était de développer une méthodologie pour identifier les déserts alimentaires potentiels en milieu rural.

MÉTHODES : L'évaluation de 25 produits alimentaires a été réalisée pour tous les magasins d'alimentation de quatre municipalités régionales de comté rurales québécoises. La qualité des produits alimentaires fut estimée par quatre indices : la fraîcheur, l'abordabilité, la diversité et la disponibilité relative. La distance réticulaire entre toutes les résidences et le magasin d'alimentation le plus proche ayant un indice favorable pour les quatre indices fut cartographiée pour localiser les regroupements de résidences localisés dans une communauté défavorisée n'ayant pas un accès à une « bonne » source d'approvisionnement alimentaire. Le résultat fut comparé aux paramètres d'identification d'un désert alimentaire proposés par le USDA, ainsi qu'à la perception d'un groupe d'acteurs régionaux.

RÉSULTATS : Lorsque la qualité de l'alimentation était considérée, la présence de déserts alimentaires potentiels était beaucoup plus importante qu'avec la définition proposée par le USDA. La mesure objective de l'environnement alimentaire concordait avec la perception des acteurs régionaux.

CONCLUSION : Les caractéristiques des magasins d'alimentation sont différentes en milieu rural et nécessitent une évaluation directe pour identifier les déserts alimentaires potentiels. Les mesures objectives de l'environnement alimentaire conjuguées avec les connaissances des acteurs régionaux pourraient contribuer à développer des arguments plus solides pour obtenir le support des décideurs afin d'élaborer des interventions adaptées au milieu.

MOTS CLÉS : environnement social; géographie; approvisionnement alimentaire; insécurité alimentaire