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Assessing health risk using regional mappings based on local perceptions: A comparative study of three different hazards

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ABSTRACT
Usually risk assessment falls within the competence of "hard sciences" through environmental and epidemiological measurements, evaluations, and modeling. Even if these approaches bring accurate assessment and evaluation of environmental processes, the perception of local inhabitants is often excluded or at least relegated to second place. Evaluation of human vulnerabilities and capacities to face such hazards requires us to understand the perceptions of the population exposed. Three case studies (Lao, Tunisia, and Ecuador) are presented where we applied a perception-based regional mapping, a mapping tool based on local perceptions, for assessing the connection between land uses and health issues. A selection of the results collected on these three study areas show that the perception of local inhabitants provides a good spatial representation of the different contaminations observed locally, with a good consistency with external data. It also indicates for a certain number of cases that the contamination extends far beyond the simulated radius and impacts peripheral areas. Beyond the analysis of such a method (methodological bias, spatial representation bias, *etc.*), the objective is to combine our results with epidemiological measurement.

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risk assessment; perception-based regional mapping; local inhabitant; methodological bias

Introduction

While human societies remain exposed to natural hazards, anthropogenic dynamics have dramatically increased the exposure to human-originated hazards. Meanwhile, vulnerabilities to such hazards can be managed, controlled, or reduced thanks to public policies, through environmental control, sanitation, and medical infrastructures and practices (Becerra 2012). However, assessing such vulnerabilities faces difficulties. According to Di Mauro and Bouchon (2009) the analysis of vulnerability is limited to assessing deaths or potential economic damages, which obstruct the understanding of the complexity of territorial vulnerability. Besides the evaluation of hazards themselves through environmental (Zheng *et al.* 2013; Smouni *et al.* 2010; Ribolzi *et al.* 2011; Lavazzo *et al.* 2012; Houdart *et al.* 2005; Altaweel and Watanabe 2012) and epidemiological measurements (Khan *et al.* 2013;

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Mahmood and Naseem Malik 2014), evaluations and modeling (Ghorbel *et al.* 2010), evaluating human vulnerabilities and capacities to face such hazards requires to understand the perceptions of the population exposed. These perceptions condition the local acknowledgement of such dangers but also the differences among the concerned public stakeholders and population for such an evaluation (Becerra *et al.* 2013, 2014). The goal of these researches is to better understand how a human-originated contamination is perceived by local stakeholders. For instance, participatory rural appraisals (PRAs) are one of the most known and prominent package of community-based participatory tools used within the nongovernmental organization (NGO) and social science community (Chambers 1994; Loader and Amartiya 1999; Olivier de Sardan 2003), including mental spatial representation. However, the non-combination with spatial references (*i.e.*, a factual map) implies noncomparable results. Along with other participatory mapping methods (Nackoney *et al.* 2013; Norris 2014), we integrate results into geographic information systems (GIS).

Our approach to such an evaluation goes through a spatial representation of the corresponding hazards, along other constraints people may consider. Using perception-based regional mapping (PBRM), we have assessed three mapped evaluations at the regional level in three different sites in three different countries (Lao PDR, Tunisia and Ecuador), each one corresponding to three different contaminations (tropical diseases, heavy metals and petrol). The interest of the PBRM method lies in the confrontation to other sources and the combination with other data. More importantly, it provides in a short period of field time a large-scale meta-analysis of (1) variables first better than data, (2) local actors' variables better than expert ones, and (3) local perceived hierarchy for territorial issues dealing with health, environment, or agriculture. Usually, one can get this only through an *ex post* series of field missions collecting data, which means a high cost.

This work tends to present these results and compare them in order to establish the efficiency of such a method for different contaminations and different social and environmental conditions. This article does not pretend to exhaustively present all the information we collected but presents a selected overview of these results for a broader perspective.

Methods and materials

Local stakeholders and inhabitants' perception of risks is essential and is treated by various methods such as questionnaire survey related to exposure to pesticide and adoption of self-protective behavior (Remoundou *et al.* 2015) or related to perception of drought impacts on socioeconomic activities and environment (Udmale *et al.* 2014). Both studies use an interesting and relevant methodology based on descriptive statistics to assess stakeholders' and local inhabitants' perceptions, but do not allow a precise geographical representation of these contaminations. The wide range of space perception from different actors in relation to different needs leads to diversifying the source and the input mode of these data (Laaribi 2000); the PBRM is part of it.

Perception-based regional mapping

The PBRM method is based on interviews of pairs of local people (Tables 1–3), supported by a map of the concerned area on which tracing paper is set. The four main steps of PBRM method are presented in Figure 1. For an exhaustive description of

Table 1. Distribution of interviewees according to their professions and official positions (Lao PDR).

		Main present or past activity (%)				Gender (%)	
PBRM Lao	Mean age	Public officers	Traders	Farmers	Employees	Women	Men
Territory	44.6	22.5	28.5	49.0	0.0	33.9	66.1
Health	49.2	12.0	28.0	60.0	0.0	49.1	50.9

Table 2. Distribution of interviewees according to their professions and official positions (Tunisia).

		Main present or past activity (%)				Gender (%)	
PBRM Tunisia	Mean age	Public officers	Traders	Farmers	Retired people	Women	Men
Health	49.8	42.3	11.5	19.2	23.1	15.4	84.6

Table 3. Distribution of interviewees according to their professions and official positions (Ecuador).

		Main present or past activity (%)				Gender (%)	
PBRM Ecuador	Mean age	Public officers	Traders	Farmers	Employees	Women	Men
Territory	44.9	37.5	7.8	23.1	31.6	30.9	69.1

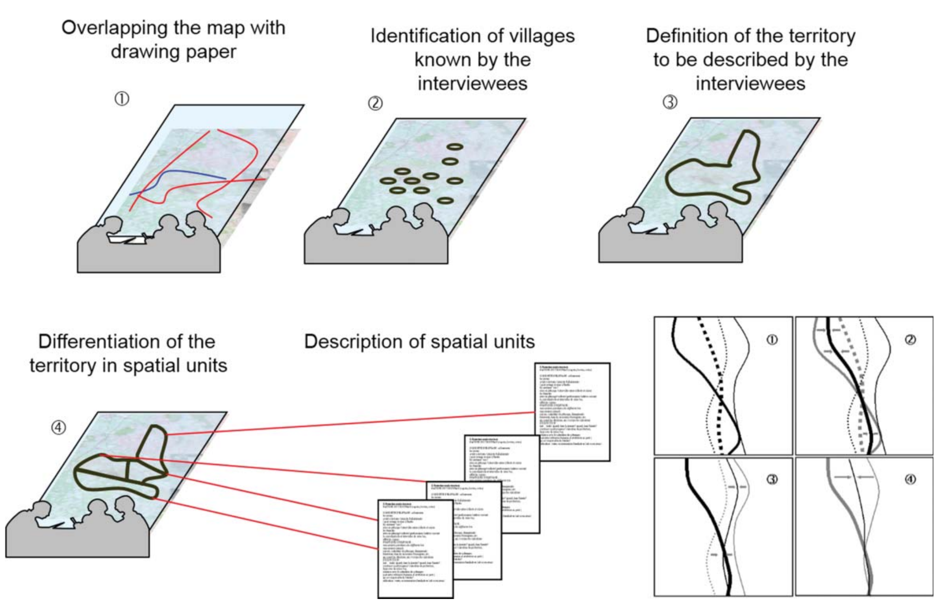

Figure 1. The different steps of the PBRM process (Saqalli *et al.* 2009).

the methodology (preparation of the interview, synthesis and formalization of the results) we refer the reader to Saqalli *et al.* (2015).

A series of maps is therefore obtained, combined, and analyzed through a GIS. All of the GIS operations were performed using ArcMap 10.1. Each map is geolocalized (Lao PDR–WGS 1984/UTM zone 48 North; Ecuador–WGS 1984/UTM zone 17 south; Tunisia–Lambert Conformal Conic) and all geographic features are included in an attribute table. The advantage of such a method is to obtain the local hierarchy of factors that described the territory according to the sampled population, from which the hazard can be evaluated. Such maps provide the inherent multidisciplinary environment of the concerned population, including local economy, sociology, and environmental constraints that may condition the capacity to face environmental hazards. GIS permits the storage, manipulation, analysis, and mapping of geographically referenced data (Suárez Vega *et al.* 2012) applied to management and planning issues. Because the map is already positioned it also permits the comparison and/or fusion with external data (wind model, hydrographical model, and so on) in order to assess the level of accuracy of perception.

This technique is relevant compared to the others methods (Table 4). Field measure campaigns cover a small study area and the measuring processes are expensive. The objectives are research-oriented but can be combined with the PBRM method in order to validate the

Table 4. Comparing observed investigation methodological tools in the context of Sahelian Niger (Saqalli *et al.* 2009).

		Remote sensing	Field measure campaigns	PRAs	PBRM
Information sources	Medium	Satellite images	Field observations	Population assembly and interviews	Resource person interviews
	Tools	Image processing and GIS	GIS	None	GIS
	Topics	Land cover, and then biophysics and land use	Biophysics and agro-ecology	All expressed dimensions	All expressed dimensions
Input	Cost	2750 €	5150 €	1330 €	1925 €
	Required time	15 days	30 days	10 days	15 days
	Required expertise	Remote sensing, biophysics, and agro-ecology	Biophysics and agro-ecology	Mainly humanities	Mainly humanities
Output	Semantics	Low	High	High	Very high
	Topology	Low	High	High	Very high
	Spatial resolution	Very high	High	Very low	Low
	Repeatability	High	High	Low	Medium
Study area size		Local to national	Local	Local	Regional
Quality assessment		Field campaigns and data correlations	Repetitions	Crosschecking within village	Crosschecking between maps, with external data
Purpose		Data collection and correlation	Data collection	Variable collection	Variable collection, GIS crossing with various sources
Objective		Science legitimacy, research-oriented for decision support	Science legitimacy, research-oriented	Local legitimacy, action-oriented	Local legitimacy, action-oriented

spatial representation of local stakeholders and inhabitants' perceptions. Satellite imagery covers large areas but is often expensive—if we exclude free satellite images. Plus, remote sensing leads to a necessary field measure campaign because there is no bijective relation between color on an image and the reflectance of an object (one object on the ground may have two distinct spectral signatures, and one spectral signature may correspond with two elements). Overall, PBRM covers large areas—unlike the PRAs method—and it is a low-cost and rapid method. It may be exact in terms of variable collecting and precise topologically; it cannot be precise spatially. Plus, a census of a perceived hazard does not prove the existence and/or extent of this hazard. Despite this, the census tests the adequacy between the existence and/or extent of the real hazard and the perceived hazard.

Study areas

First, the PBRM was applied in Tunisia in the region of Jebel Ressas (36°42′-36°30′ N and 10°06-10°34′ E) (Figure 2), which mean literally "mountain of lead." The Jebel Ressas mining site is located 30 km south of Tunis where Pb and Zn exploitation was conducted for almost 70 years, until 1957. The Jebel Ressas village stands at the foot of the Jebel Ressas Mountain where the Pb–Zn extraction zone was located. It is bordered southward by the former ore processing plant and westward by the treatment dumps. Almost two million tons of treatment wastes were generated by the ore treatment and dumped in three flat-top dumps. The waste materials have a weak cohesion, fine grain size, and are enriched in Pb and Cd (Ghorbel *et al.* 2010, 2012). Next to the western side of the dumps are the farming lands. Dispersion of contamination in the neighborhood has been addressed in order to predict metal contaminated-dust exposure of the population (Ghorbel *et al.* 2010, 2014).

Lao P.D.R. is a mostly a rural country (78% of the population) with poor living standards (Human Development Index ranking 133rd out of 179 countries; Ribolzi *et al.* 2011). We have focused our research on Luang Phabang District and portions of Chômphet and XiengnGeun Districts, which are parts of Luang Phabang Province (20°00′-19°42′N and 101°53-102°26′ E). The studied territory covers around 35*50 km, meaning a territory of 1840 Km^2. The risk of exposure to microbiological contaminants is important and is enhanced by mud.

Last but not least Ecuador, affected by oil contamination, more specifically by polycyclic aromatic hydrocarbons (PAHs) derived from petrochemical activities in the provinces of Orellana and Sucumbíos (77°58′-75°11′ W and 0°39′-1°33′ S). The trial of Chevron in 2011 (formerly Texaco Petroleum Company) facing 30,000 people is the most publicized example.

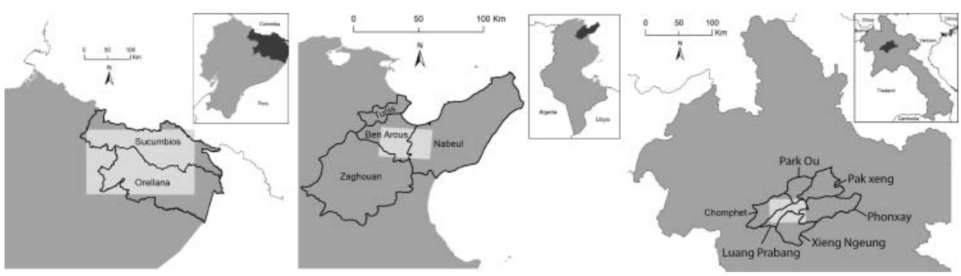

Figure 2. Study areas. From left to right—Ecuador, Tunisia, and Laos.

The Ecuadorian court found that Texaco had "caused extensive damage to the environment, peoples, and indigenous cultures in Ecuador in violation of Ecuadorian law" (Brower and Brown 2014, p 29). There are many ways of contamination: the wind with flaring; the water and the ground, mainly through oil spills. The effects of PAHs on human health are variable. According to Olawoyin *et al.* (2014) they range from mild to severe depending on the concentration and exposure of either an individual toxicant or a mixture of different organic and inorganic toxicants. In these provinces and more generally in Ecuador Pan *et al.* (2010) argue that this contamination has been linked to skin and respiratory irritations, elevated cancer mortality, and spontaneous abortions.

Institutional and practical bias

The elaboration of PBRM generates institutional, administrative, or language biases.

Institutional and main issues bias

As an operational tool, and even in an institutional context where research is a priority, such investigations have the necessity to deal and compose with institutional partners, including local governments or even scientific institutions with their own agenda. As a consequence, several issues are to be raised more because of a collaboration duty than a field-based hypothesis. This may influence the way questions are asked and the fact that interviewees may notice that some issues are more attractive to researchers.

Administrative and public bias

Depending on the country, the objectivity of the interviews is affected by the presence of officials. For instance, in Laos, District Agriculture and Forestry Office (DAFO) officers did facilitate contact with local administrations for preparing interview sessions but were present during interviews inducing consequences on the freedom of speech of the interviewees. In Tunisia, where interviews were assessed after the Revolution, self-auto-censure control of the speech remained among interviewees, especially where crowds of people did surround interview places. Ecuador interviews were clearly the less affected by such a bias.

Language bias

Lao, Arab (along with French), and Spanish were used during interviews in Laos, Tunisia, and Ecuador, respectively. Meanwhile, even though a majority of interviewers were fluent in the local language (4/8 in Laos, 3/5 in Tunisia, 3/4 in Ecuador), senior researchers, who led the team, were usually the poorest speakers. This may have induced some bias in the fluidity of the talks and some losses while rewriting interviews.

Results

Laos, Tunisia, and Ecuador all have in common exposure of the population to contaminants coming from the exploitation of natural resources, which actually drove the interest of environmental scientists on such places: in the region of Luang Phabang (Laos PDR) (Figure 3)

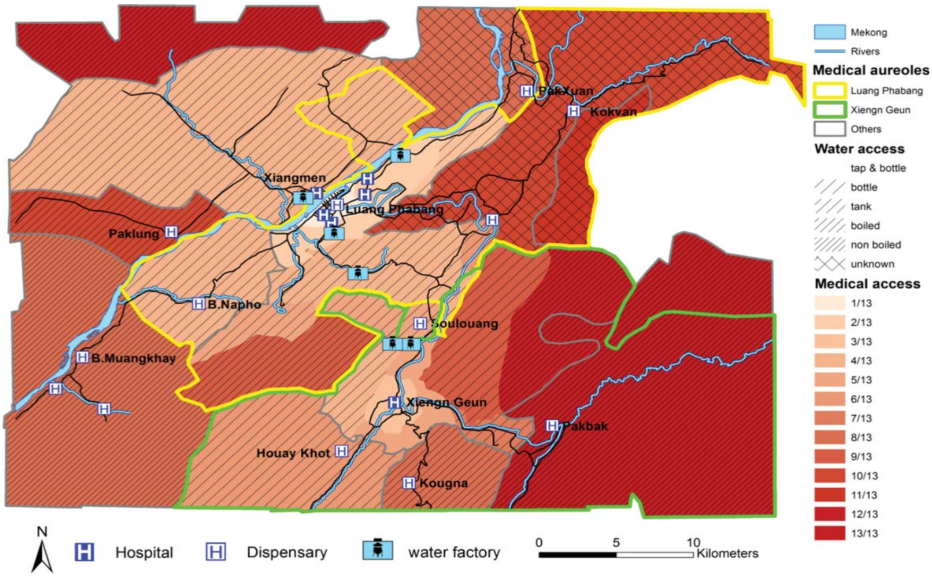

Figure 3. Spatial representation of medical aureoles and medical/water access according to PBRM health interviewees (Lao PDR) (Saqalli *et al.* 2015).

(Ribolzi *et al.* 2011), it is the exploitation and paradoxically the spatial restriction of farming and the concentration of the population along rivers that may condition the exposure to bacterial contaminants.

For the Lao case, practically speaking, this "bottled water network" can be seen as a temporary but efficient solution. It represents a "2.0 version" of sanitary networks and an innovation for risk managers. Saqalli *et al.* (2015) explain that, regarding health remediation, the

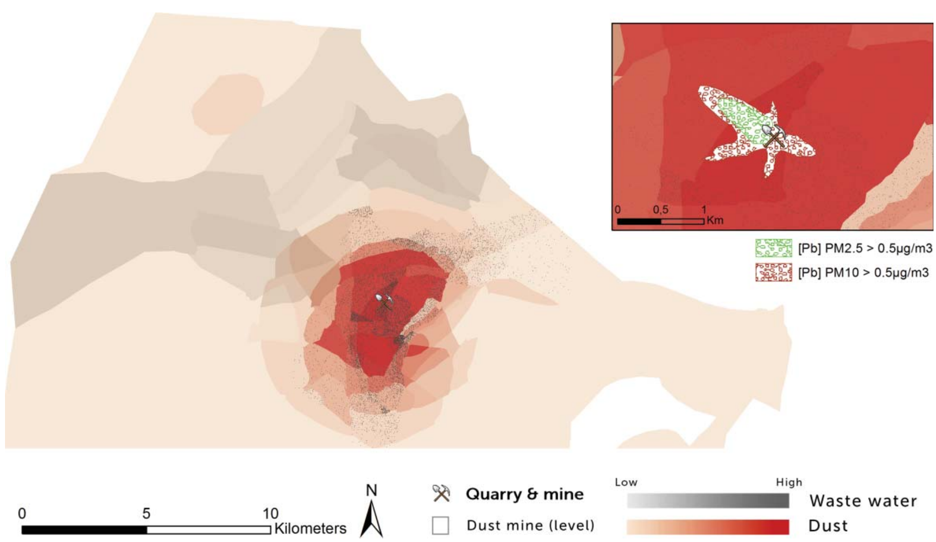

Figure 4. Combination of PBRM and wind model (Tunisia).

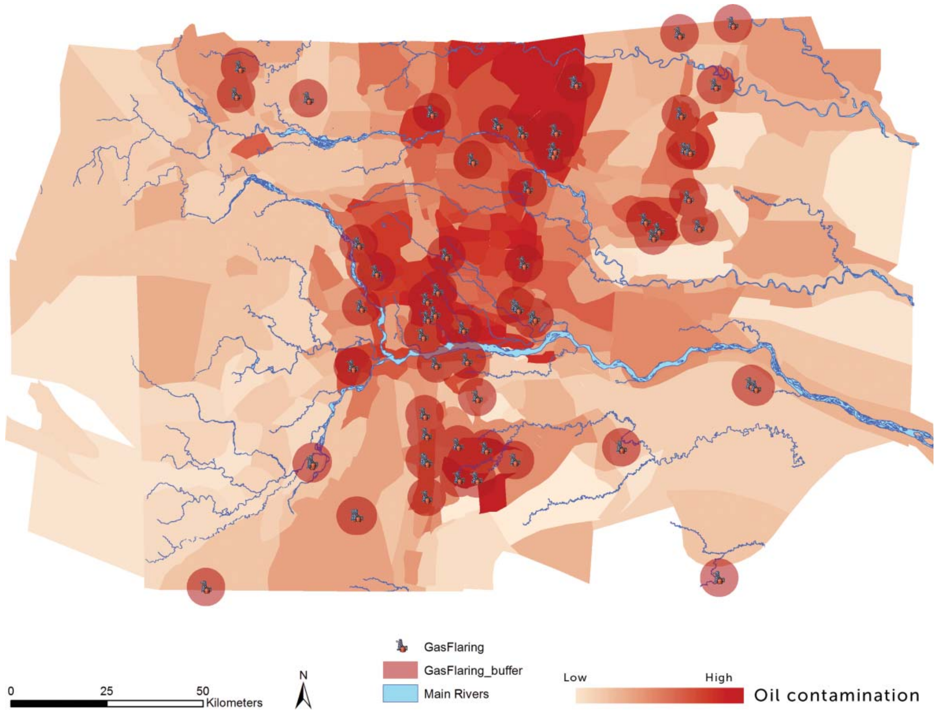

Figure 5. Perception of oil contamination in the provinces of Orellana and Sucumbíos (Ecuador).

medical infrastructure density raises as the most noticed criterion for spatial differentiation, to be linked with the accessibility to these medical facilities. Spatial analysis allows the ranking of planning priorities and encourages more the development of communication (road network and bridge construction) rather than sanitary infrastructures. Indeed, health centers are well developed throughout the area, so the accessibility to these center is the main priority.

Around the former mines of lead and cadmium of Jebel Ressas (Tunisia), the signal of the exposure to heavy metals from the treatment waste dumps is mixed with other and more visible exposures (nitrates from intensive farming, dusts from a nearby cement plant) (Figure 4). This area is particular and subject to huge transformations.

The construction of the Tunis ring road (2*3 ways) is planned to cross the study site, reinforcing the suburban character of the place rather than its rural aspect. The PBRM identified several risks related to the rural present (lead mine wastes and dusts, agriculture pollutions in waters) but the issue that was ranked no. 1 by the interviewees was domestic refuse (trash, garbage; in Arabic *zbel*) that is not taken in charge by local authorities. More precisely, local public authorities do have the power and the means of a rural area but do face and are overwhelmed by issues of suburban areas, from which *zbel* is the most prominent. Therefore, PBRM results suggest that beyond mine contamination, suburban issues are the local priority.

As a part of a practical analysis, identification of planning priorities is even more urgent in a context of economic slump. Mains roads are well maintained in the downstream sectors, and regarding sanitary infrastructure there are no sanitary problems. The main challenge is

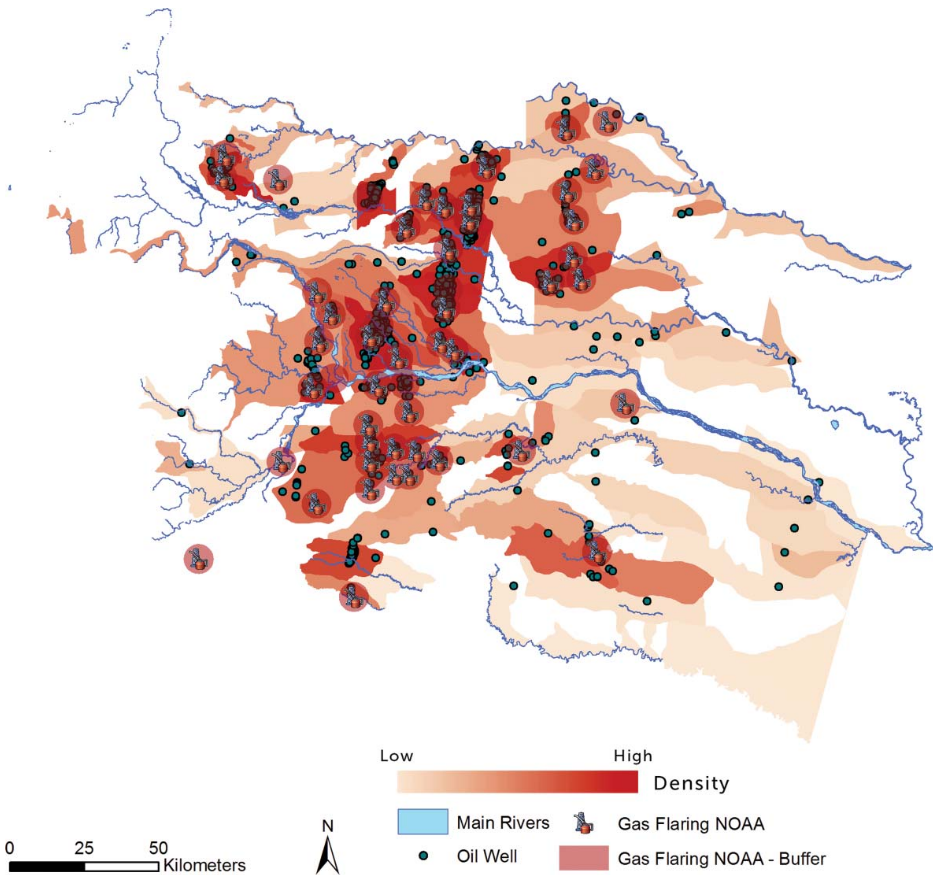

Figure 6. Estimation of oil contaminations based on GIS-data collected within Municipios and Parroquias of the two provinces of Orellana and Sucumbíos.

to tackle the worst sources of pollution in the upstream sectors. Therefore, refuse collection and water purification may be seen as the first priority.

In the Ecuadorian Oriente, the petrol contamination may be paradoxically well-known as a global risk but not as a spatially precise one so that it can be considered now as part of the social landscape, along other social vulnerabilities such as unemployment and insecurity.

The population is aware of contamination problems, on one hand with the desire to do away with oil activities, but on the other hand not to because its maintenance generates wealth and created local employment. Health centers are well developed regarding external data, but the road network is not homogeneous both in quality (asphalted road, track) and in spatial repartition (quasi absence in the South-East–Yasuni Park). The real issue is the water-air-soil quality, which means to tackle the problem (1) upstream, with stringent control releases (gas flare, for instance) (Figure 5) and (2) downstream with the treatment for contaminated water (Figure 6).

In a spirit of water treatment (a major objective of the MONOIL program), PBRM allows locating and giving priority to the main contaminated areas. At last, it allows direct strategies for agricultural production.

For each of the three case studied, the PBRM maps highlight common features:

The environmental hazards we investigated were rarely pointed out by the interviewees as the most important issues:

1. As chronic problems, they are "covered" by individually more vital issues (infrastructures, employment). As problems seen as complex and non-solvable at the individual scale, they are perceived as "beyond the scope" of one person and thereby often neglected.
2. As human-originated and human-affecting issues, there is an obvious correspondence between population densities, sanitary risks related to the investigated hazards, and a relative weakness of the State per capita: for instance, in Lao PDR, there may be more hospitals in high populated areas but actually less infrastructure per capita.

For each study area we can observe a continuous gradation (spatial autocorrelation) in the risk perception, more specifically in Tunisia with concentric aureoles surrounding the quarry and the mine. The higher the distance from the mine site is important; the lower is the gradient of perception to contamination. In Ecuador these perceptions seem to be spatially more scattered. The perception of oil contamination (water, air, or ground) does not highlight a spatial diffusion characterized by contagion in the neighborhood.

Moreover, the linkages between PBRM results and external data show a good consistency. For instance, gas flares (detected by remote sensing data from the National Oceanic and Atmospheric Administration [NOAA]) and oil wells (Figure 6) are located in the areas perceived as the highest level of oil contamination. In Tunisia (Figure 4), a biophysical model has been implemented by Ghorbel *et al.* (2014) describing the extent of contamination because of wind (*i.e.*, the level of lead dust in the air). The contamination surrounds the mine and the quarry (approximatively 1 km width). PBRM results indicates that these dusts extend far beyond the simulated radius and impact the peripheral areas.

Discussion and conclusion

Such a method can be useful for apprehending rapidly the variability of the perception of the risk among the interviewed population, and, confronted with a map of "real risk" of biophysical measurement (Ghorbel and Muñoz 2014), but also the inherent mixture of feelings and perceptions public stakeholders have to deal with. Also, the visualization of spatial differentiations may allow to go beyond the mean sanitary cover until the median sanitary cover. This method can be easily replicated in other countries, regions, and different kinds of environments and socioeconomic contexts. Actually, we should point out that this tool has been used several times in many countries (Brazil 1996, South Africa 1998, France 2003, Niger 2005 and 2006, Tunisia 2008 and 2013, Madagascar 2011, Laos 2012, Ecuador 2013 and 2014) with very heterogeneous interviewees who may have been, depending on the country, mostly illiterates. In terms of priorities, each study site shows different results. There can be no "one size fits all" development strategy. Each country develops its own strategy and tailors it to meet the needs of its local population according to local public assets. The Tunisian site does face a series of "modern" constraints, whose accumulation overwhelm local public capacity of environmental management, while the upper State, or the Tunis city authority do not have any real involvement locally. We then question the balance of power and responsibility between local services and national ones. The Ecuadorian site is a colonized portion of the country whose economy is based on extractivism. All the petrol gains there goes to the upper State, but the latter is well involved in environment issues, unlike local public powers. The question is then the impact of the decentralization process regarding environmental issues. Finally, the Lao case shows the rapid adaptation of a State with new resources (tourism, dams) building a privatized water supply network quickly and focusing first on roads. Here we question the capacity and the will of the Lao State to stand on a public policy bringing sanitary services to the whole country and population rather than bringing populations to public services by tending to concentrate populations around urban areas.

Accuracy and precision

Thanks to the fact we iterated these participatory maps until the usual saturation level (Guest *et al.* 2006; Bowen 2008), one may assume that the information we collected exists and has a value. To evaluate its quality (*i.e.*, the correctness of the figures we draw), several criteria should be considered:

1. Its exactitude: in a qualitative study, an issue first has to be defined depending on some parameters and variables. They circumscribe the issue. PBRM is the sole tool that may provide this exactitude regarding the spatial circumscription of the issue as it provides an exactitude regarding the topology of the issue (Saqalli *et al.* 2009). For instance, diseases in Laos are thematically and spatially circumscribed by both urban density and water;
2. Its precision: precision is the major flaw in the PBRM method. Interviewees position themselves on the map according to places they know (for instance, "between this village and this village"…) and according to mentally-constructed images of distance (for instance, "half the distance between these two points" or "at the entrance of the village"…). We consider, however, that this flaw is less important, especially in many southern countries where official statistics may provide data with several numbers after the comma without considering the fuzz reliability of both the source and the data;
3. Its completeness: PBRM allows the mapping of non-spatial phenomena (Table 5). To be precise, the investigation process allows the recording of causes and dynamics that have spatial impacts. Once we transfer PBRM results into spatially explicit models, it implies transferring spatial and non-spatial dynamics unlike land use and cover changes (LUCC) models (stochastic models, the artificial intelligence–based model, and the empirical-statistic model), which show spatial change processes or spatial consequences of non-spatial changes, regardless of their cause, meaning losing a large part of the complexity of the system studied (Maestripieri and Paegelow 2012). Thereby,

Table 5. Spatial accuracy versus precision.

	Spatially accurate	Spatially non accurate
Precise	God	LUCC, GIS, SMA
Not precise	PBRM	Art

combined with spatially explicit but not spatially driven models, such as object-based and agent-based models, PBRM is a primordial step (with the word "primordial" to be understood literally as a first and prior step) for a complete procedure that may be considered as having an advantage in terms of spatial modeling and forecasting.

Assessment tools versus accumulation of data

According to Ness *et al.* (2007) the purpose of sustainability assessment is to provide decision-makers with an evaluation of global to local integrated nature–society systems in short- and long-term perspectives in order to assist them to determine which actions should or should not be taken in an attempt to make society more sustainable. The main interest of the PBRM, used as an assessment tool, is eventually to support decision-makers. It has first another advantage: while scholars tend to focus on one discipline each, they also tend to solely consider the parameters of the related issue, and even the directly affecting one. For instance, a geochemist may tend to focus on physical factors affecting the spread of metal contaminants such as the wind direction and the frequency people have contacts with contaminant sources.

Is prevention better than cure? Outside of the European Union the precautionary principle is attacked and suspected of harboring trade protectionism or conveying a cautious attitude barring any technical innovation and the economic and social progress (Godard 2006). This concept highlights ethical choices between what is good and what is bad and might affect political decisions. If prevention has very few impacts on scientific decision/recommendation, assuming that a crisis or risk situation will have not serious consequence in the future is more difficult and puts the researcher in a delicate position. Crying wolf damages the credibility of the precautionary principle.

Methodological and educational aspects

The PBRM, when it is used on an open way:

- may provide indirect but major factors driving the level of contamination of the population. For instance, in Laos, the fact that a large part of the population did shift toward bottled water did reduce the level of contamination. Such an assumption should be of course checked and quantified but finding such a determining variable may not have been possible without investigating widely the issue;
- helps new scholars and students to quickly have an overall but locally characterized view of the investigated area. "Seeing the place like people see it" strongly supports the endowment of local perspectives and the understanding of people's behaviors.

But also to help local population to better understand risk (in a post-analytic step) in their extent and intensity. It represents a tool that improve their coping strategies related to a specific issue, without considering it as a form of empowerment for local inhabitants. Remoundou *et al.* (2015) argue that the need for further research into the relationship between risk perceptions and attitudes, and adoption of self-protective behaviors, is thus often stressed.

Extrinsic bias

Although we were able to bring a perfect and unquestionable methodology, we should face a wide range of unavoidable bias.

Spatial representation

An interesting and important point is related to the methodology and most specifically the spatial representation. Barnaud *et al.* (2013) even talk of the non-neutral role of spatial representations. They referred to the analysis of Roth (2007) by saying that "the use of two-dimensional spatial representations modify the way people perceive and manage space and resources. This author suggests that in the context of NRM in Northern Thailand, the use of maps and GIS led to a transition from a conception of space with overlapping and flexible boundaries (corresponding to the traditional communities' way of thinking about land use and natural resource management) to a conception of space with strict and fixed boundaries leading to think in terms of exclusion and inclusion (corresponding to the state top-down and centralized way to manage natural resources through the delineation of reserved and protected areas)" (Barnaud *et al.* 2013, p 157). PBRM requires and imposes a 2D map at regional scale without taking account of local (autochthonous) way of spatial representations. On the other hand, maps contain a lot of geographical information (rivers, roads, villages), perfectly known by the interviewees, which enhances the accuracy of the localization of information.

Social factors

Individual or collective perception are deeply affected by social factors (income and social status, physical environment, education, *etc.*). They can induce strong bias during sampling and mapping, which can reduce the representativeness of the interviewees (Saqalli *et al.* 2009). For instance, there is no extreme in Lao (persons, subjects), because interviewees were chosen by the DAFO officer. Interviews were mostly made with men in Tunisia and with institutional employees in Ecuador.

McShane *et al.* (2013) talk about cognitive biases and define it as the "result from the inadvertent misapplication of a necessary human ability: the ability to simplify complex problems, make decisions despite incomplete information, and generally function under the real-world constraints of limited time, information, and cognitive capacity" (McShane *et al.* 2013, p 39).

It relates in some way to the socially desirable responding (over-report favorable attitudes and under-report unfavorable attitudes) (Tellis and Chandrasekaran 2010), what Ecken *et al.* (2011) called desirable bias. In foresight studies this over-optimism can cause people to judge the extent to which an event is expected to occur as higher (lower) if this event is desirable (undesirable).

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