Crop diversity indicators: literature review and applications at farm level

Ghislain Geniaux, Stephane Bellon, J. Fleury, Guillaume Ollivier

Crop diversity indicators: literature review and applications at farm level

Geniaux G., Bellon S., Fleury J., Ollivier G.
INRA UR 767 Site Agroparc 84914 Avignon Cedex 9, France geniaux@avignon.inra.fr

INTRODUCTION

The effects of intensification and specialisation at farm and regional levels are often mentioned as leading to standardize both landscapes and agricultural practices, with subsequent losses in terms of biodiversity. Crop diversity is increasingly considered as a component of the sustainability of agroecosystems (Moonen and Barberi, 2008). Enhancing crop diversity would contribute to regulate pest populations, to reduce farmers' reliance on external chemical inputs, to foster risk aversion strategies, etc. Various methods appear in literature to assess crop diversity and its determinants. Indicators would provide an option to take into account the various dimensions included in biodiversity conservation. In this paper, we review selected references and test candidate indicators on a data set at farmland level for a whole region.

MATERIALS AND METHODS

First, a bibliometric approach (based on CAB and WOS database) was used to identify articles and reviews on crop diversity assessment, based on a set of queries[1]. 198 references were collated using citation manager tools (CiteSpace and EndNote). A short list comprising of 42 references was then selected through consensus building among the authors, representing various disciplines (agronomy, ecology and social sciences) as suggested by Jackson *et al*. (2007). Major research fields related to crop diversity were identified. A state of the art on crop diversity indicators was derived, according to these major research fields. The Shannon index (H') was elected, due to its multi-level coverage.
Second, using a unique GIS annual database on land use (25 to 50 cultural classes at plot level in 3 districts of Provence region –Nuts2- for 2000-2007), we estimated a set of crop diversity indices at various scales (farm, municipality, district). Our GIS also includes databases on farm characteristics (size, employment, and profit) and socio-economic data at communal level. Scale sensibility and agricultural and socio-economic determinants of crop diversity were studied for year 2007.

RESULTS AND DISCUSSION

Use of crop diversity indicators

Based on our bibliometric approach, crop diversity indicators fall into three main categories. First, they can be used as a component of broader agri-environmental assessments (Bockstaller, 1997), with a view to elaborate aggregated indicators usually represented as amoeba-type diagrams. They are mostly based on Shannon index or its adaptations, and can be tested on hypothetical agroecosystems (Gliessman, 2007). A second approach consists in using indicators as revealing different production patterns (e.g. organic versus conventional) or their relative intensity at various temporal and spatial scales. In this situation, indicators used include: biotic indicators (Buchs, 2003), adaptive capability of crops to inter-annual variations (Chloupek, 2004), intensity index (Herzog et al, 2006). In a third category of papers, indicators are intermediate variables which contribute to focus agri-environmental schemes toward specific areas or farm types (Piorr, 2003), based on the understanding of the determinants of farmers' behaviour (Cutforth, 2001). Indeed some authors cover a wide range of functions, whereas others give priority to the effect of crop diversity on specific environmental compartments. Most of the papers deal with the effects of agriculture on biodiversity, whereas studies of the effects of biodiversity on agriculture are scarce.

[1] For example, : TS=(agri* OR agro* OR "food product*" OR cultivated OR crop* OR intercrop* OR mono-culture OR tillage* OR plowing OR ploughing OR arable OR cultivation* OR tillage* OR farm* OR dairy OR grassland* OR rangeland* OR pasture* OR meadow* OR pastoral* OR grazing system* OR grazier* OR fodder* OR livestock* OR breed* OR herd* OR cattle* OR grower* OR gardening* OR grape* OR vine* OR "rural system*" OR agrar* OR horticult* OR arboricultur* OR "fruit product*" OR orchard* OR agrobiolog* OR fallow OR "field margin*" OR "field boundar*" OR pesticide* OR herbicide* OR insecticide* OR fertili*)
AND TS=("bio diversity" OR biodiversity OR "biological diversity" OR "plant diversity" OR "vegetation* diversity" OR "weed diversity" OR "animal diversity" OR "faunal diversity" OR "invertebrate diversity" OR "insect diversity" OR "microbial diversity" OR "bacterial diversity" OR "species diversity" OR "species richness")
ANDTI=(indicator* OR index* OR indice* OR indicateu* OR bioindic* OR bio-indic* OR "bio indic*") NOT TS=(fish* OR ocean* OR marine* OR sea$ OR genom* OR lake* OR coastline* OR fresh water*)

Measurements and scaling issues

Most of empirical works are data driven: crop diversity indexes often use national or county data on crops (Harish 1998), sometimes coupled with socio-economic Census data (Jaskulki 2007), a scale at which a simple richness index may be sufficient. However, spatial distribution of crop diversity can lead to different results between local crop diversity and global measure of crop diversity; the use of more complex composition index like Shannon or Simpson indexes does not solve this issue. Sensibility to scale of diversity index based on land cover is a well documented field in ecology, but needs to be adapted to farm crop data. Dinh Van (2003) proposed an analysis of crop diversity measurement and its socio-economic determinants at farm level. We did not identify studies focussing on the evolution of crop diversity at farm level for a region.

Contribution of case studies

Case studies have been engaged for a district where vector map of land registry is integrally available (Vaucluse). A comparison between farm, municipality or district level has been implemented for year 2007. Results are largely divergent between theses 3 scales. Shannon diversity index at municipality (or district) level is unable to take into account the high number of farms with only one crop. Crop diversity at municipality or district level depends on the spatial distribution of farms with one or two crops, i.e. those having low crop diversity at farm scale. Hence, a stratification based on farm size is necessary to have consistent results at both levels. An index of dominance may be a useful complementary index. Spatial autocorrelation of these small farms with only one crop could also help to assess potential differences between diversity index at farm and at communal or regional level. Structural determinants (farm structure, type of main crop, distance to Central Business District…) and spatial distribution of this diversity are introduced.

In a dynamic perspective, preliminary results for 2000-2007 period clearly show that cessation of farming (and to a smaller extent, entry to farming) plays a major role on crop diversity, whereas crop diversification at farm level has a minor effect, at least in our study area.

REFERENCES

Bockstaller C., 1997. Use of agro-ecological indicators for the evaluation of farming systems, *European Journal of Agronomy*.

Buchs W., 2003. Biotic indicators for biodiversity and sustainable agriculture - introduction and background, *Agriculture Ecosystems & Environment*.

Chloupek, O. 2004. Yield and its stability, crop diversity, adaptability and response to climate change, weather and fertilisation over 75 years in the Czech Republic in comparison to some European countries. *Field Crops Research*.

Cutforth, L. B. 2001. Factors affecting farmers' crop diversity decisions: an integrated approach, *American Journal of Alternative Agriculture*.

Dinh Van D., 2003. Study of the effect of socioeconomic factors on crop diversity in some studied ecosites. On-farm management of agricultural biodiversity in Vietnam. *Proc. Symp*., Hanoi, Vietnam, 6-12 December, 2001.

Gliessman S.R., 2007. Agroecology. The Ecology of Sustainable Food Systems. 2nd Ed. *CRC Press*.

Jackson L.E., Pascual U., Hodgkin T., 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agric. Ecosyst. Env*.

Jaskulski D. 2007. Diversity of field crops in the Kujawy and Pomorze Province.*Fragmenta Agronomica*

Herzog F., 2006. Assessing the intensity of temperate European agriculture at the landscape scale, *European Journal of Agronomy*.

Moonen A. C., Barberi P., 2008. Functional biodiversity: An agroecosystem approach, *Agriculture Ecosystems & Environment*.

Piorr, H. P. 2003. Environmental policy, agri-environmental indicators and landscape indicators, Agriculture Ecosystems & Environment.

ACKNOWLEDGEMENTS: this work was supported by SEAMLESS EU project.