Science of the Total Environment 537 (2015) 343–351

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Multifunctionality assessment of urban agriculture in Beijing City, China

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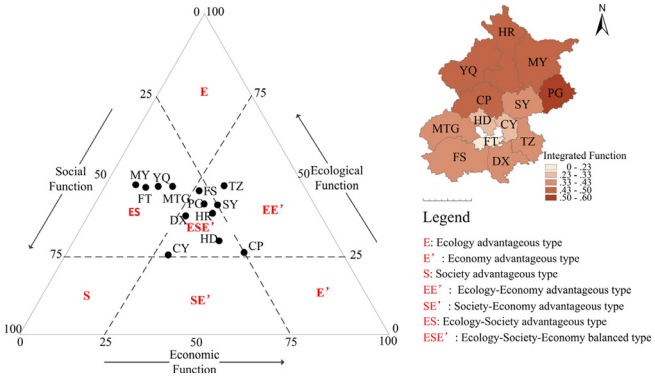
HIGHLIGHTS

- Urban agricultural function is divided into social, economic and ecological aspects.
- Integrated agricultural function is affected by topography and human disturbance.
- Triangle illustration method is used for urban agricultural functions zoning.
- 8 out of the 13 counties belong to ecology–society–economy balanced areas.
- Agricultural multifunctionality in Beijing City declines from north to south.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 5 May 2015
Received in revised form 27 July 2015
Accepted 27 July 2015
Available online xxxx

Editor: D. Barcelo

Keywords:
Multifunctionality assessment
Urban agriculture
Triangle illustration method
Beijing City

ABSTRACT

As an important approach to the realization of agricultural sustainable development, multifunctionality has become a hot spot in the field of urban agriculture. Taking 13 agricultural counties of Beijing City as the assessing units, this study selects 10 assessing index from ecological, economic and social aspects, determines the index weight using Analytic Hierarchy Process (AHP) method, and establishes an index system for the integrated agricultural function. Based on standardized data from agricultural census and remote sensing, the integrated function and multifunctionality of urban agriculture in Beijing City are assessed through the index grade mapping. The results show that agricultural counties with the highest score in ecological, economic, and social function are Yanqing, Changping, and Miyun, respectively; and the greatest disparity among those counties is economic function, followed by social and ecological function. Topography and human disturbance may be the factors that affect integrated agricultural function. The integrated agricultural function of Beijing rises at the beginning then drops later with the increase of mean slope, average altitude, and distance from the city. The whole city behaves balance among ecological, economic, and social functions at the macro level, with 8 out of the 13 counties belonging to ecology–society–economy balanced areas, while no county is dominant in only one of the three functions. On the micro scale, however, different counties have their own functional inclination: Miyun, Yanqing, Mentougou, and Fengtai are ecology–society dominant, and Tongzhou is ecology–economy dominant. The agricultural multifunctionality in Beijing City declines from the north to the south, with Pinggu having the most significant agricultural multifunctionality. The results match up well with the objective condition of Beijing's urban agriculture planning, which has proved the methodological rationality of the assessment to a certain extent.

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http://dx.doi.org/10.1016/j.scitotenv.2015.07.136
0048-9697/

1. Introduction

Agriculture is the foundation of human society's existence and development. With the improvement of science and technology alongside changing human needs, agriculture is not just limited to the traditional function of supplying agricultural products, but also carries many non-economic functions, such as ecological function, and social function (Peng et al., 2014, 2015). Dating back to ancient times, the function of agriculture was primarily to provide food (Li et al., 2015; Wu et al., 2014). Later at the dawn of economic development, agriculture became to additionally provide industrial raw materials and labor (Liu et al., 2014; Long et al., 2010). In today's world, the function of agriculture is enriched because human demands have turned from the basic material to the esthetic, including leisure, tourism, and other entertainment. Especially under such global threats to human development as environmental crises, energy crises, and food safety crises, people have begun to pay close attention to ecological protection of agriculture (Perring et al., 2012; Pywell et al., 2011). In recent years, due to the constraints of water and soil resources, labor costs, as well as the growing demand for other agricultural functions, developing agricultural multifunctionality has become an important goal and effective way to promote modern agriculture (Barral and Oscar, 2012; Liu et al., 2013; Smukler et al., 2010).

The concept of agricultural multifunctionality can be traced back to the "rice culture" of Japan in the late 1980s, yet it was not until 1992 that it officially appeared in the United Nations Conference on Environment and Development in Rio de Janeiro. Since the heated debates in the 30th session of the FAO conference and the 8th meeting of UNCSD, multifunctionality has become a hot spot of academic research on agricultural landscapes. Zhen et al. (2014) points out that future land-use decisions should carefully consider the balance between land resource conservation, agricultural production, and urban expansion. Meanwhile, she highlights that the research can contribute to local policy making with the aim of meeting the objectives of a required multifunctional land use concept (König et al., 2014). Studying agricultural multifunctionality can not only provide theoretical support for construction of an agricultural system, but also offer a new way in practice to solve the problem of a weak and inefficient agricultural industry. Current study on agricultural multifunctionality mainly includes both qualitative research and quantitative research (Ewert et al., 2011). The former is mainly about relevant policy debate. For example, Brunstad et al. (2005) argued that Norway's support for agriculture was not appropriate from the perspective of the public good; according to the OECD report on agricultural policy research in China, the Chinese government had excessively intervened in agriculture, which is against the development of agricultural multifunctionality. The latter is mainly about the assessment of various agriculture functions and consumers' willingness to pay for them. For example, Lankoski and Ollikainen (2003) analyzed the optimal externality supply of the agricultural environment with an investment and land configuration model.

Agricultural function assessment is one of the key topics in quantitative multifunctionality research. It can be roughly divided into two categories: one focuses on some certain agricultural functions, such as ecological services (Gavier-Pizarro et al., 2012; Palm et al., 2014), agricultural externality (Swift et al., 2004), biological diversity (Roth et al., 2008; Zechmeister et al., 2003), and agricultural landscape (Flick et al., 2012); and the other is agricultural integrated function assessment. For theoretical innovations, Madureira et al. (2007) put forward the comprehensive assessment framework for non-commercial output of an agricultural landscape; and Randall (2007) proposed the assessment process for agricultural non-commercial output. For regional case studies, Li et al. (2005) assessed the function of an agricultural ecosystem in Hubei Province using the Analytic Hierarchy Process (AHP) method; Tipraqsa et al. (2007) adopted multivariate regression to estimate the agricultural productivity which integrated four functions. However, far more studies are conducted with a special focus on the quantification of agricultural functions, without fully excavating the connotation of multifunctionality or identifying the characteristics of multifunctional region. In addition, research on the interrelation among different agricultural functions is still inadequate.

The development of urban agriculture in general and urban horticulture in particular is one of the major strategies spontaneously adopted in developing countries to benefit urban dwellers (Orsini et al., 2013). Urban agriculture, which is located in urban and its extension area, is a kind of modern agriculture closely relies on and services to urban area, usually metropolitan area. Multi-method approaches have provided valuable information on the character of urban agriculture, especially cultivation in urban and peri-urban area (Lynch et al., 2013). Both the diversity representation of urban agriculture and the quantification of urban agricultural functions are important in determine the roles of agriculture in sustainable urban development and conducting urban planning accordingly (Aubry et al., 2012). However, the benefits of urban agriculture for livelihood support, food security and environmental protection are more recognized on the international than the local level (Drechsel and Dongus, 2010). More case studies are still needed to quantify the relationships among the different benefits of urban agriculture.

As one of the cities which practiced urban agriculture early in China, Beijing's agricultural functions have shifted from only producing agricultural and sideline products to a combination of employment security, ecological conservation, sightseeing and leisure, and rural cultural heritage. Therefore, taking Beijing City as the case study area, in order to realize sustainable development of urban agriculture, this research is aimed to quantify the integrated agricultural function according to such three aspects as ecological, economic and social functions, to analyze the combination of agricultural functions using triangle illustration method, and to assess the agricultural multifunctionality through spatial overlaying of advantage areas for each kind of agricultural functions.

2. Methodology

2.1. Study area

Beijing City is located in the northwest part of the North China Plain (39°28′–41°05′N, 115°25′–117°30′E), with a total area of 16,400 km^2. It is higher in the northwest, with the highest elevation of 2294 m, and lower in the southeast, with the lowest point at 6 m. Mountains and hills above 100 m account for 62% of the whole city, and plains below 100 m account for 38%. Beijing's agricultural landscape is diverse as a result of the rich landform types, and complex natural conditions. The vertical differentiation of climate, vegetation, and soil, also provides a suitable environment for a variety of agricultural crops.

Generally speaking, Beijing's agriculture has developed in four stages. Firstly, it was the traditional agriculture stage before 1978. The agricultural output of crops was the dominant developing target, far exceeding forests, livestock, and fishing. With the core target of increasing grain yield, a large number of high quality farmland was built and managed by the municipal government. Secondly, it was the integration stage between grain crops and economic crops during 1979–1991. China's reform and opening-up policy promoted the birth and development of peri-urban agriculture. Compared with the previous phase, both the values of rural social output and agricultural output increased significantly. The gap between the proportions of food and vegetable planting was narrowed, and farmers' income was increased distinctly. Thirdly, it was the transforming stage from peri-urban agriculture to urban agriculture during 1992–2002. During this period, six kinds of agriculture were focused, i.e. facility agriculture, breeding agriculture, food industry agriculture, export-profit-gaining agriculture, exquisite agriculture, and sightseeing agriculture, which highlighted the importance of agriculture for urban development and urban dwellers' demand. Furthermore, according to the sustainable concept of ecological city construction, the value of ecosystem services provided by urban agriculture has attracted more and more attentions.