

## 論文の内容の要旨

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論文題目 Food flow and agricultural landscape changes towards a sustainable city region  
in Tianjin, China

(中国天津市における持続的都市圏形成に向けた食料フローと農業ランドスケープの変化  
に関する研究)

Sustainable development of regional cities calls for viable regional-spatial strategies that strengthen the network of cities and their hinterlands. At present, the significance of urban-rural interactions has been well established for sustainable city development. Cities cannot be self-regulating without maintaining stable links with the surrounding areas from which they draw food and other bio-resource materials and into which they release their wastes. Recently, localized food production-consumption system strategies have received considerable attention in Europe, North America and Japan as a means of improving sustainability.

Agricultural activities play a vital role in maintaining the sustainability and conservation of urban and rural environments. In response to population growth, urban development, and climate change, Asian megacities and agricultural producers are facing complex challenges; bio-resources management has become a prominent area of research as well as an important policy issue in agricultural areas near large cities. The changing nature of the relationship between urban and rural land uses has deep consequences both for human quality of life and for the environment.

Most Asian megacities are located in rich alluvial deltas that have long served as the “rice-baskets” of their respective regions. The study was carried out in China’s national capital region, Tianjin, which is in the northeast part of the North China Plain and located on a low-lying alluvial plain along the mouth of the Hai River (38°34’N–40°15’N and 116°43’E–118°04’E). This

area has not only experienced rapid industrialization and urbanization (including the famous Jing-Jin-Tang Industrial Belt), but it also has played a pioneering role as an urban development model for other Chinese cities. Due to the rising demand for water caused by industrial and urban development and upstream irrigation construction, water has become a pronounced factor limiting development of the city.

This study attempts to identify and analyze the emerging form of the urban–rural relationship through examining the role of agriculture in the Asian megacity’s countryside. The main objectives of the study were (1) to identify the local and regional food flow and the extent to which the region’s food consumption depends on local production and to assess the relationships between urban, suburban, and rural areas in the region (*Chapter 2*); (2) to examine spatial-temporal and functional changes from 1993 to 2009 in terms of agricultural land use and food production in both suburban and rural areas of the city (*Chapter 3*); and (3) to explore whether the dependence of local consumption on local production could be improved based on the current trend of agricultural land use changes, in particular changes in paddy fields (*Chapter 4*). Furthermore, suggestions for how to promote a sustainable material cycle between urban and rural areas are discussed in *Chapter 5*. The main approaches were food flow analysis, landscape analysis by satellite image interpretation, and semi-structured and key informant interviews with local people.

A better understanding of food flows and the extent to which a region’s food consumption depends on its local production is important to understand future sustainable cities. *Chapter 2* examines food self-sufficiency and food flow in Tianjin, divided into three areas (urban, suburban, and rural), as a case study to gain a better understanding of local and regional food flow. The main objectives were to evaluate the city’s capacity for self-sufficiency within its administrative boundary by calculating a self-sufficiency ratio using statistical data at both the city and local scales, to estimate potential food flow at the city scale from data derived from field surveys of local markets and statistics provided by local government authorities, and to observe real flows of the two primary types of arable crops (cereal grains and vegetables) from semi-structured household interviews at the local scale. The results show that Tianjin has experienced a rapid increase in self-sufficiency capacity since the 1980s, and it appears to have the capacity to support the citizens within its borders. By 2007, the self-sufficiency ratio of major foods reached more than 140%, and in the case of milk, the ratio was 360%; the only category in which the agricultural sector did not meet demand was cereal crops. Even with these high ratios, wholesalers, retailers and consumers have chosen to use and exchange products from distant areas, utilizing regional food flow. In the urban area, local fresh vegetables (produced primarily in suburban areas) currently account for only 33% of the vegetable market, whereas the other 67% is supplied by other regions of China, and all cereal products consumed by the urban population are supplied by other regions. At the local scale, rural areas have had a surplus in all food categories studied since the 1980s, and suburban areas have a

history of high self-sufficiency for vegetables, poultry, and fish. However, a low degree of locally sourced product flow was observed. Most local cereal crops were consumed in agricultural production areas, but 70% of vegetables produced in rural areas flowed outside of the region and did not support local consumption in Tianjin.

Local agricultural production is the main driver of self-sufficiency and food flow. Agricultural processes are connected with the increased urbanization that has accompanied the urban regional development in Tianjin. An accurate understanding of changes in agricultural land use and their driving factors has important implications for assessing food security and policy making. In *Chapter 3*, Landsat images are used to evaluate agricultural land use changes at the landscape scale in suburban and rural areas in Tianjin from 1993 to 2009, based on two case studies. The main driving factors of the changes were investigated at the farm scale through a survey of local farmers. The image classification results showed an obvious loss of agricultural land since the early 1990s in suburban areas, similar to what has occurred in other peri-urban areas in developing countries. Two other notable trends in land use, which differ from those of other peri-urban areas, were observed: (1) land was converted from the production of traditional perishable food to the production of staple foods, in this case, from vegetables and fruits to maize; and (2) there was a shift from staple production to fiber production, in this case, from paddy rice and maize to cotton. In rural areas, a similar shift from staple food to fiber production was noted during the study period, in this case, from rice and maize to cotton. Two other results, which differ from those of suburban areas, were found: (1) a relatively small amount of land had been converted from the production of staple foods to fresh food, in this case, from maize to vegetables; and (2) recently, some land has shifted back from fiber production to the production of staple foods, in this case, from cotton to rice. Through semi-structured household interviews, a scarcity of water was noted as an important problem for agriculture in Tianjin—this was found to be a primary factor for agricultural land use change both in suburban and rural areas. Beyond the limitation of clean water, suburban farmers had to adjust their agricultural activities by adapting to an insufficient amount of labor and the use of treated wastewater from urban areas for irrigation. Rural farmers' activities, however, were still driven by market mechanisms and government policies.

Changes in local production have accounted for the trend of food self-sufficiency levels and contributed to the current regional and local pattern of food flow. Specialized vegetable production in rural areas generated an active flow from the rural areas of Tianjin to other Chinese regions, whereas the decreased production of paddy rice was only able to support consumption in the production areas themselves, so there was no local surplus to flow locally. *Chapter 4* explores whether it would be possible to enlarge the production area for local consumption, in this case of paddy rice, to enhance food security and develop a more sustainable urban–rural system. Further understanding of the dynamics of the traditional rice-dominated agriculture area was undertaken

both at the county and village level in rural areas through a comparative study of the planting area of recent annual crops, precipitation variability, and water flow. The manner in which the involved stakeholders attempt to cope with and adapt to a constantly changing environment was also determined through semi-structured and key informant interviews. With limited water flow from the outside and in response to recent historic precipitation variability, local people adjusted to both year-to-year variability and extreme events through collective and individual actions in the short term by changing planting areas and switching crops. Annual rainfall and water flow records show that a serious and continuous drought occurred during 1999–2003. The drought compelled farmers to shift paddy fields to field crops, and some irrigation and drainage systems were also destroyed. As they switched to less water-intensive crops (e.g. cotton), the farmers appeared to be making a relatively permanent adaptation to water stress, but in so doing, many have become more vulnerable through worsening pest and disease management and a low level of self-sufficiency. Although most villagers were willing to replant paddy rice, shifting land use back to paddy cropping to adapt to the more recent increased precipitation has not been common because of damaged irrigation and drainage systems and a lack of willingness of community leaders to maintain the systems as they previously did. Only farmers in a few villages, which maintained their properties well and had leaders who seemed aware of the importance of traditional crops, succeeded in switching back to paddy cropping again. The possibility of enlarging the paddy rice production area will most likely be highly dependent on local institutions in initiating and supporting adaptations and participating in collective irrigation regimes.

In conclusion, the food flow and self-sufficiency analysis indicated that Tianjin needs to recognize the high level of productivity of its local area and reduce its dependence on the capacity of other regions to supply its food needs. A better relationship between urban and rural areas through local food production and consumption needs to be re-established. Water is currently the largest barrier to increasing food production in the city. In order to improve self-sufficiency and establish a localized food flow, it is necessary to enhance the resilience and adaptive capacity of local agricultural communities and associated stakeholders to cope better with not only the constraints but also the opportunities of climate variability and urbanization. It is also important to give policy support to localized food production and consumption as well as addressing people's interest in local products for the future sustainability of the urban–rural system in Tianjin.