Agriculture has been an important source of the human diet throughout human history; but its relationship with human societies has transformed over the long course of more than 10,000 y. Urbanization and agricultural commercialization are significant among such changes and wield considerable impact on human diets, nutrition, and health. This paper presents four studies examining the influence of agriculture on diet and general health: 1) the impact of urban allotment gardening on human health and wellbeing in Japan, 2) the preference of people in Japan for collaborations between citizens' farms and food-support organizations 3) the linkages between dietary diversity and agriculture in Indonesia, and 4) food sources and child nutrition in the deforested frontiers of Cambodia.

**Key Words** agriculture, allotment garden, forest, health promotion, nutrition

**Summary** Agriculture has been an important source of the human diet throughout human history, but its relationship with human societies has transformed over the long course of more than 10,000 y. Such shifts often signify risks and opportunities for human nutrition. This paper attends to two important agricultural changes for future human nutrition: urbanization and agricultural commercialization. The world's urban population is continuously increasing, and agricultural populations continue to decrease worldwide. The dominant type of agriculture has transfigured from subsistence to commercial in correspondence with these circumstances. These changes have also caused environmental problems including deforestation and loss of human-nature interactions. The following question may thus arise: What are the implications for health and the environment of a more globally distant or, conversely, more localized relationship between agriculture and human diet/nutrition? This paper presents four studies that have examined the influence of agriculture on the diets and general health of human beings. This mini-review will provide humanity the opportunity to reconsider the value of agriculture to health.

**Urban allotment gardening and its impact on human health and wellbeing**

Over three billion people currently live in cities and towns and this number is projected to soar to six billion (approximately 70% of the world’s population) by 2050. This increasing trend of urbanization will significantly influence human health and wellbeing; urban lifestyles are associated with a number of detrimental health outcomes, including decreased levels of physical activity, increased consumption of high-energy foods, and social and psychological stress. Indeed, chronic and non-communicable diseases such as depression, anxiety, high blood pressure, and diabetes are becoming increasingly common in urban areas. Consequently, the promotion of healthy lifestyles in towns and cities is now a major challenge for the domain of public health.

The urban cultivation of nature offers immense potential as an inexpensive intervention that can help address numerous health-related difficulties confronting metropolitan areas. It is increasingly evident that regular contact with nature such as visiting urban greenspaces proffers wide-ranging health and wellbeing benefits to city residents in the form of increased psychological wellbeing, general health, and social cohesion. Urban allotment gardens signify one such common space where urban residents can experience nature in daily life. The extant research has indicated the varied health benefits of allotment gardens. However, quantitative evidence remains scarce.

This paper will present the results of the two studies conducted recently by the author’s research group. The first study involved the administration of a questionnaire survey to 332 people in Tokyo to quantify the effects of participation in allotment gardening on their physical, psychological, and social health. The results of the questionnaire survey were utilized to compare five health outcomes self-reported by allotment gardeners (respondents who used allotments) and non-gardener controls (participants who did not use allotments). These five consequences were perceived general health, subjective health complaints, body mass index (BMI), mental health, and social cohesion. Accounting for socio-demographic and lifestyle variables, the regression models revealed that allotment gardeners reported significantly superior perceived general health, fewer subjective health complaints, better mental health, and more social cohesion than non-gardeners. No significant difference was found in the average BMI of garden-
ers and non-gardeners. These results suggest that regular gardening in urban allotment sites improves the physical, psychological, and social health of city residents.

The second study accomplished by the author’s group attempted to confirm the generality of the findings of the first study. To this end, it executed a systematic review and meta-analysis of research assessing the effects of gardening, including urban allotment cultivation, on human health and wellbeing. An extensive literature search was performed to accumulate empirical studies comparing health outcomes in a control cohort (non-gardeners or pre-gardening experience reporting) and a treatment group (gardeners or post-gardening experience reporting). The mean difference between the two groups vis-à-vis health outcomes was calculated for each study, and the weighted effect size was then determined for both investigations across samples and for the sets of subgroup studies. The systematic review identified 22 case studies (76 comparisons between the control and treatment groups) relevant for the meta-analysis. The case studies demonstrated a wide range of health outcomes including the alleviation of depression, reduction of BMI, and the enhancement of life satisfaction, quality of life, and social cohesion. Meta-analytic estimates demonstrated significant positive effects of gardening on the health outcomes for the full participant group as well as the sets of subgroup studies, but the effect sizes differed for eight subgroups. These results robustly evidence the beneficial effects of gardening on health and support the findings of the first study.

Chronic and non-communicable diseases are becoming more prevalent at an unprecedented pace worldwide, especially in developed societies. The results presented here are of great consequence for healthcare policy in such a context. They suggest that participation in allotment gardening in urban areas can potentially ensure improved and healthy lifestyles and can help prevent or alleviate health-related risk factors. It is thus recommended that policy-makers and health practitioners should recognize allotment gardening as an important health promotion tool and should encourage people to participate in it.

**The Japanese preference for collaborations between citizens’ farms and food-support organizations**

The proportion of low-income households has increased in recent years, in tandem with a rise in social disparities. The child poverty rate was 13.5% as of 2018, and was 48.1% for single-parent households. The relative poverty rate in Japan was worse than the OECD average. Food banks collecting items that are still edible and offering them to low-income households can help resolve the problems of both food-waste and poverty. However, it has been indicated that the supply of vegetables remains insufficient because dry foods are primarily offered to households. This study contemplated a future system of offering vegetables from citizens’ farms to low-income households through food-support organizations such as food banks and children’s cafeterias.

The first point was addressed via a questionnaire survey conducted in December 2019 for food banks and children’s cafeterias throughout Japan. Responses were received from 38 food-bank groups and 94 children’s cafeterias. Nearly 90% of children’s cafeterias responded positively to collaborations with citizens’ farms; however, food banks without any experience in handling vegetables were reluctant to cooperate. The issue of past experience exerted a significant effect on the intention and possibility of food banks receiving vegetables from citizens’ farms. Concerns about when the vegetables would be served and the quality and types of vegetables exercised a significant adverse influence on the ability of food banks to receive vegetables from citizens and the food banks shared this reservation.

Conjoint analysis was performed using four types of land use to investigate preferences apropos different land-use patterns: a) citizens’ farms without collaborations with food-support organizations, b) citizens’ farms with such collaborations, c) parks, and d) open spaces for disaster prevention. An online survey was conducted throughout Japan in August 2021 with 11,520 respondents. The results revealed the highest preference for open spaces for disaster prevention. People who knew about citizens’ farms, who had experienced vegetable gardening, and who had a higher emotional affinity toward nature evinced a stronger preference for citizens’ farms with collaborations with food-support organizations.

The third facet of evaluating the actual intention of using the farms was probed through an online questionnaire survey with respondents who had registered a preference for citizens’ farms with or without collaborations with food-support organizations in the previous survey. Respondents living in four prefectures (Tokyo, Saitama, Kanagawa, and Chiba) in the Kanto area were targeted (n=4,720) and the survey was conducted in December 2021. The results elucidated that around 30% of the respondents would like to use citizens’ farms with or without collaborations with food-support organizations. However, only one-third of this 30% were willing to pay a usage fee. The fee of 2,510 JPY/mo (21.8 US$/mo) was asserted as acceptable and this value remained the same for citizens’ farms with or without collaborations with food-support organizations.

**The linkages between dietary diversity and agriculture in West Java, Indonesia**

Dietary diversity is a key concept for balanced nutritional intake and this theory has attracted attention as a complementary indicator vis-à-vis individual energy and nutrient (protein, vitamin, etc.) intake. Dietary
Nutrient deficiency in children in the deforested front of Cambodia in relation to different food sources

Deforestation is a driver of biodiversity loss and climate change. Macroscopic analyses have suggested that it could also cause vital consequences for human nutrition, including the nourishment of children. A study was initiated in Cambodia by the author’s group. The forests in this region are disappearing at the fastest rate in Southeast Asia. The study examined the nutritional status of the children living in forested areas and probed the roles discharged by discrete food sources: edible items that were purchased, self-produced, wild, and shared by neighbors.

The weights and heights of 161 children aged 5–10 y and residing within and around the Prey Lang Wildlife Sanctuary in Stung Treng Province of Cambodia were measured in February 2020. Their food intake (24-h recall) and the source of each food item were also surveyed.

Stunting (HAZ ≤ −2), underweight (WAZ ≤ −2), and acute malnutrition (BMI-Z ≤ −2) were observed in one-fourth, one-fourth, and one-tenth of the children, respectively. Intake was insufficient for many nutrients, except for sodium and vitamin C. Serious deficiencies were observed for zinc, copper, potassium, calcium, vitamin A, and vitamin B1 (thiamin). More than half of the children did not even reach 50% of the Recommended Dietary Allowance for these nutrients (RDA).

The sufficiency of nutrients ingested by each child (NT) was also assessed by counting the number of nutrients (maximum 14) for which the RDA of the corresponding age and sex was satisfied. The observed minimum, maximum, and mean NT of the children were 0, 13, and 3.66, respectively. When the purchased food was removed from the calculation, the mean NT dropped to 0.56, and most children could not meet the RDA for any nutrients, except for vitamin C, which could be acquired from locally grown fruits. The impact of removing self-produced food was not as substantial as the elimination of purchased food, but there was also a moderate drop in mean NT = 2.62 and RDA sufficiency in energy, protein, dietary fiber, phosphorus, iron, and vitamin C. There was little change in mean NT and the overall pattern of nutrient sufficiency (3.53 and 3.43, respectively) when wild food (that from forest, fallow, stream, etc.) and shared provisions were eliminated.

The preliminary results evinced that purchased food was the most important food source and that it supplied numerous nutrients to the children, followed by self-produced food. The contribution of wild and shared food items was very small in terms of satisfying RDA levels. However, the study results also implied that food supplied from these sources was insufficient to meet the nutrient requirements of many children for most nutrients, except for sodium and vitamin C. Better access to food markets and enhanced provision of nutritious and diverse foods from the local agricultural system would be crucial aspects of consideration in planning livelihood support programs in the region. Attention must also be paid to the potential structural shortcomings of the local food system in which some vitamins and minerals (especially zinc, copper, and potassium) and vitamins appear difficult to access.

Disclosure of state of COI

No conflicts of interest to be declared.

Acknowledgments

These studies were supported by JSPS KAKENHI (16K00631, 17KT0073, 19H04343) and the Mitsui & Co. Environment Fund (R18-0044).