China and changing food trends: A sustainability transition perspective

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Abstract

Introduction. Global population has witnessed significant changes in the way food is produced and consumed. Although this has benefitted population health, it has also contributed to climate change and unsustainable use of natural resources.

Materials and methods. Comprehensive literature review.

Results and discussion. The characteristics of four transition theories related to food are outlined to help explain population behaviour, namely demographic, nutrition/protein, food and sustainability transition. This is followed by a further desktop analysis of the changes occurring in China, the world's largest demography, and this country's contribution to a most-needed global sustainability transition.

The theoretical framework of transition theories used since the mid-20th century outlines changes in population behaviour impacting relationships between people and more recently with the natural environment. As a multidisciplinary field describing fundamental shifts in human societies, transition theories are very insightful in relation to food and nutrition. The demographic transition links industrialisation with fertility and mortality rates but also with food availability. During the nutrition transition, a change occurs in people's calorie intakes from different food groups. While the share of protein remains relatively stable, the initial transition from plant- to animal-based foods now changes in reverse with increasing ecological and health awareness. This nutrition/protein transition can result in a better dietary behaviour with reduction in over-consumption, losses and waste. The food transition explains the transformations on the supply side – how food is produced, processed and distributed, reflecting changes in agricultural methods, use of land, soil, water, fertilisers and chemicals, supply and distribution chains. More sustainable farming methods are currently being introduced in response to ecologically threatening trends as a result of land-use changes and use of chemicals. As distinct from the other concepts, sustainability transition does not describe an evolutionary pattern of changes but only the current most necessary transformation in development. It requires radical transformation and action towards reduced environmental footprints of all human activities, including food.

China's development has experienced similar transitions although with unique features. Its demographic transition has been influenced by the "one child policy" while the nutrition/protein transition has been fuelled by increasing income levels. Industrialisation of food production with application of chemicals is widespread but more recently, organic methods of farming are gaining momentum. Food security and production are recognised as a challenge and opportunity in China's sustainability transition with state-driven dietary efforts to contain domestic meat consumption.

Conclusion. China has the opportunity to play a prominent role in the global transition to improved food choices, as required by the current environment and climate emergency, by shifting its own eating habits and also contributing to the burgeoning field of new alternatives to livestock products.

Introduction

With a population nearing 1.5 billion (Worldometer, 2022), China is the world's largest demography. Its economic power has consistently risen since the opening up and reforming of the country's economy in 1978, which was followed by an extended period of Gross Domestic Product (GDP) annual growth of 10% and 800 million people lifted out of poverty (World Bank, 2022). China has also become a powerful player in manufacturing and technology development, resulting in being the world's top exporter of goods and services estimated at US$2.72 trillion in 2020 (World Population Review, 2022).

These pronounced changes over a relatively short period of time have significantly improved many aspects of the quality of life of Chinese citizens. One of them is availability and access to food. The Chinese staple diets where rice and other coarse crops occupied a prominent place have gradually been replaced with a variety of foods, including many that are processed and animal-based (Chang et al., 2018). This transition is one of several demographic and socio-economic changes experienced across the globe. The latest and most needed transition is that towards more sustainable ways of living, where environmental, social and economic priorities co-exist in an integrated way that looks after the well-being of people but also the planet.

There is ample evidence (Marinova et al., 2022, Tirado et al., 2018; Willett et al., 2019;) that changes in the way we produce food and in our eating preferences need to be part and a main driver in such a sustainability transition. What this paper explores is China's role in the global transition posing the question how this country can influence its own and planetary future. It uses the theoretical framework of transition theories to first outline the concepts. This is followed by evidence from China. The last section explores opportunities to impact the global sustainability transition through changing food preferences and novel alternative proteins which reduce the presence of livestock-sourced foodstuffs.

Materials and Methods

Material

Food is a basic necessity for human survival (Maslow, 1943). Throughout the centuries, the ways people have satisfied their demand for food has evolved. Globally, starvation and hunger have become less dominant while overweight and obesity have been radically on the increase, particularly among richer sections of society (FAO, 2019). While humanity has been successful in producing more food, this has largely come at the expense of the health of the natural environment and our production and consumption practices are threatening the well-being of all species on the planet (Marinova & Bogueva, 2022). How did we get to this situation? What changes have occurred in the process and most importantly, what transformations are needed to shift the downward spiral trends?

The paper explores the transitions in human behaviour as consumers and producers of food. It particularly analyses the changes in China, the world's largest demography, and links them to the global developments in search of sustainability transition.

Methods

This study is based on desktop analysis of existing literature and secondary data. It covers published and online sources related to major societal shifts in food consumption and production. This analysis allows to synthesise and describe historical trends in human

behaviour as well as outline the importance of future changes towards sustainable development in response to climate change, depletion in soil fertility, biodiversity loss, freshwater use and other major environmental challenges. By systematically integrating insights from a wide range of sources, the study provides a transdisciplinary overview of existing evidence and synthesis of areas in which research has been previously dispersed and disparate (Snyder, 2019).

Results and discussion

Theoretical framework and method

Transition theories are a multidisciplinary field that tries to explain human behaviour and following from that, fundamental shifts in human societies. The theoretical frameworks of transition studies vastly vary – from system thinking (Zolfagharian et al., 2019) to psychology and counselling (Bailey-Taylor, 2009), education (Jindal-Snape, 2021), economics (Topalli & Ivanaj, 2016), innovation (Twomey & Gaziulusoy, 2014), technology (Paredis, 2011), sustainable development (Geels, 2011) and politics (Avelino et al., 2016), offering different perspectives ranging from individual conducts of people and organisations to multi-level societal and governance developments to technological elements and new knowledge generation.

Another distinctive area of interest in transition studies is population health and nutrition (Santosa et al., 2014). In fact, the oldest transition theory, namely the demographic transition (from high to low birth and death rates) developed in 1945 by Notestein (Diggs, 2020), originated in population studies. Furthermore, epidemiological transition analyses disease and mortality patterns across human populations (McKeown, 2009) while in the field of food, nutrition transition describes major dietary changes (Popkin, 2006), including the occurrence of obesity (Poulain, 2009).

Transition theory frameworks are also applied to area-based studies, such as related to Eastern Europe (Genov, 2021), China (Hong, 2016), Sub-Saharan Africa (Leshabari, 2021), Latin America (Juri et al., 2021), the European Union (European Environment Agency, 2017) or USA (Gersten, 2021). It is interesting to note the specific features of each transition as they relate to the geo-political, cultural and historical background of the place as well as access to technologies and knowledge.

A common feature of all transition theories' approaches is the difficulties to support the conceptual frameworks with reliable statistical data, quantitatively verifiable models and other hard evidence. There is also ambiguity in definitions, opacity of the way boundaries are established and how stability and change are conceptualised (Zolfagharian et al., 2019). Despite these challenges, transition theories continue to experience substantial interest from researchers and growth in conceptual, empirical and methodological insights. This contributes to building a broader and pluralistic body of knowledge that can guide and inform fundamental shifts in socio-technical systems (Zolfagharian et al., 2019) as well as the policy arena.

The work presented in this paper is based on literature review. We bring together four transition theories that are related to food production and consumer choices, covering in a historical order demographic transition, nutrition/protein transition, food transition and finishing with sustainability transition. Linking this analysis to the role of China in the last section is important on two levels: first, the size of the Chinese economy, and second, its access to traditional knowledge and production capacities.

Transition theories

Transition theories received a lot of attention since mid-20th century and are now increasingly becoming a burgeoning area of research. A Google Scholar search with the keyword "transition theory" produces 1.79 million hits between 1945 and 2009, and 2.26 million between 2010 and 2022. The focus here however is only on transition theories that are connected to development and food. These transitions are not happening separately or in a purely consecutive way. They are interlinked and, in many ways, synergistically reinforce each other. Another important conceptual observation is that whilst the demographic, nutrition/protein and food transitions have already occurred, transitioning to sustainability is currently emerging as a global priority, driven particularly by the nature of our food systems and dietary choices (Willett et al., 2019). Let's look at the explanatory patterns that these theories offer.

Demographic transition

Conceptualised in the 1940s by the demographer Notestein, this transition model describes stages in population growth based on fertility and mortality rates (see Figure 1) during which societies transition from a relatively stable low to relatively stable high population size.

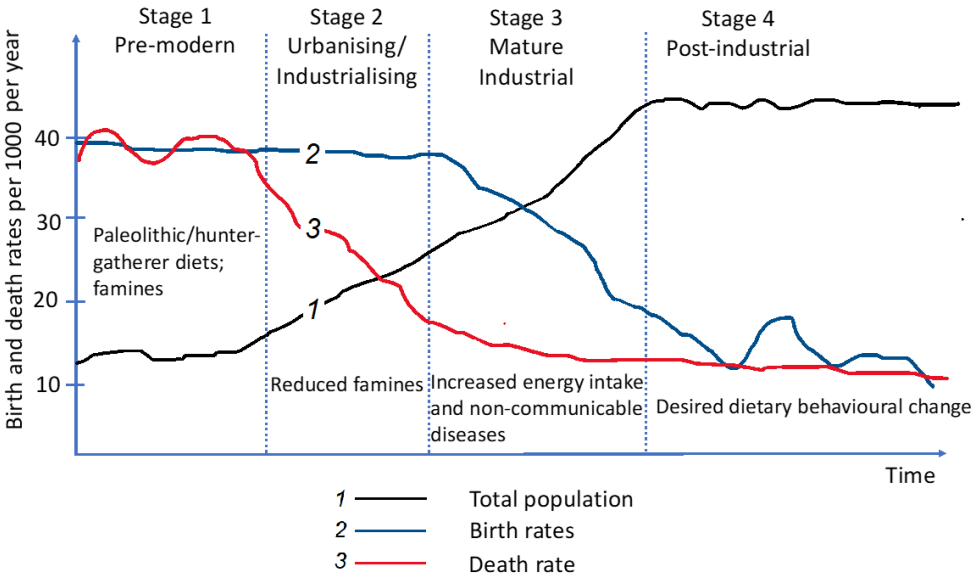

Figure 1. Demographic and nutritional transition model

These stages are also linked to urbanisation and industrialisation (GeogSpace, 2015). At Stage 1 or pre-transition, birth and death rates in so-called traditional societies are high but they cancel each other out, people's life expectancies are low and population numbers remain stable. This is followed by Stage 2 or the first phase of transition during which death rates significantly drop due to improvements in health care, medicine, hygiene, sanitation as

well as improved production, transportation and distribution of food. Societies also commence to modernise through industrialisation and become more urbanised. Birth rates however take longer to decrease as they are defined mainly by social factors, such as how society values children, their contribution to the household and old-age security of parents. As a result from the balance between birth and death rates, population numbers sharply increase. At Stage 3 or the second phase of transition, fertility rates also drop because of the changing social status of women, improved standards of living, increased mechanisation and less demand for workers as well as availability of family planning and contraceptives. Consequently, the combination between low death and birth rates results in steady populations at higher numbers than the original starting point. This leads to Stage 4 or post-transition, described also as post-industrial societies (GeogSpace, 2015).

Being a model, the demographic transition has its limitations in describing universal patterns in population changes. It has been a benchmark theoretical framework for western countries, particularly USA and Europe, while its applicability in other parts of the world, such as Africa and Asia, has remained unclear. The demographic transition concept is very much aligned with Adam Smith's "invisible hand" and liberal ideology which excludes the role of government in influencing demographic trends (Poulain, 2021). Different theories have been put forward, and in some cases statistically tested (Ranganathan et al., 2015), to explain the demographic transition, such as links between fertility, mortality and GDP or the role of education for women.

What happens at the post-transition stage is also unclear and subject to interpretation. Evidence from many European societies, such as Bulgaria, Germany, Italy or Sweden, as well as from highly industrialised countries, such as Japan or South Korea, shows birth rates falling behind death rates. Without migration, the populations of such countries would shrink. A shift in attitudes and norms within society from altruistic behaviour towards greater individual freedom and self-actualisation, manifested through delayed age of giving birth, the deinstitutionalising of the marriage and diversity in union types, results in decline in fertility rates below replacement levels described by some as the second demographic transition (Lesthaeghe, 2014; Zaidi & Morgan, 2017). Again, the role of government policies in influencing people's fertility behaviours is rarely discussed.

From the perspective of the demographic transition, China is very unique. Between 1980 and 2015, China had the "one-child policy" which restricted the number of children born in the majority of families to one. Access to adequate food and nutrition for China's large population was part of the state policy considerations. The "one-child policy" rapidly pushed the country into a post-transitional society where fast industrialisation was accompanied with increased life expectancies, improved living standards and government-encouraged below-replacement level of fertility (Feng & Mason, 2007). China is seen as an "overachiever" in its demographic transition which happened at an unparallel pace with the exceptional role of the state (Feng, 2011).

After the abolition of the "one-child policy", the post-transition demographic stage in China is yet to be fully understood, particularly with the impacts of the COVID-19 pandemic. What some describe as an "economic demographic transition" (Johnston, 2020) and "economic miracles" (Yuan & Gao, 2020) is now challenged by China's need to reduce its environmental impacts, including those related to food production and consumption.

Nutrition/protein transition

The term nutrition transition was used for the first time by Popkin in 1993 (Popkin, 1993). It describes a link between GDP per capita and structural changes in people's calorie intakes from different food groups with a shift from plant- to animal-based products. There is also wider availability of food. Increase in the overall calorie or energy intake is observed with the nutrition transition leading to obesity, including childhood obesity, and non-communicable diseases (Drewnowski & Popkin, 1997; Popkin, 2016). The evolution of diets loosely follows the demographic transition (see Figure 1). According to Popkin (2002, 2006) and Poulain (2021; Drenowski & Poulain, 2019), the following nutritional changes occur:

- Paleolithic and hunter-gatherer diets included a lot of fibre and carbohydrates from wild plants and low-in-fat meat from wild animals;
- Increased population numbers, establishment of settlements and the development of agricultural practices made cereals the main source of food but nutritional deficiencies and famines became a regular occurrence;
- The start of industrialisation and urbanisation reduced the exposure to famines and diets were based mainly on starchy foods, low in fat and with a lot of fibre; iron deficiencies were common;
- Technological progress, the use of fertilisers, mechanised equipment, irrigation and livestock husbandry, improved food security; this was accompanied with development of food processing, storage and distribution methods; overall the preferences for animal-based products, fats, sugar and processed foods increased contributing to larger energy intakes and leading to obesity and non-communicable diseases;
- Due to concerns related to health, climate change, safeguarding of the natural environment and animal welfare, people who live in societies with ample availability and choice of foods and who are sustainability aware, are making a conscientious decision to change their behavioural practices towards increased intake of vegetables, fruits, legumes, nuts and other plant-based options and reduced consumption of animal-sourced products.

A subset of the nutrition transition is the protein transition which highlights specifically the changes in relation to the sources of proteins. While the actual share of protein in the human diet remains relatively constant between 8% and 16% (Carpenter et al., 2021), the initial changes during the transition are from plant- to animal-based foods and more recently, in reverse – from animal- to plant-based foods, because of increased ecological and health awareness (Drewnowski & Poulain, 2019; Poulain, 2021; Tziva et al., 2020). Aiking and de Boer (2020) explain that the next protein transition is from primarily animal towards plant protein products, including analogues and whole foods such as beans and nuts, combined with reduction in over-consumption and of losses and waste during the supply chain and in the household. This will lead overall to better dietary behaviour.

Similar nutritional/protein transition has been observed in China. During the country's accelerated demographic transition, many measures were taken to reduce malnutrition and provide adequate access to food for all sections of society. This however happened with a shift towards increased animal-sourced foods as manifested through higher levels of consumption of meat, mainly pork (see Figure 2), and eggs (Popkin et al., 2012). With 90% of the Chinese population being lactose intolerant (Yang et al., 2013), dairy-based products have not experienced such a growth. However, the intake of processed foods increased while that of legumes, particularly soy, vegetables and fruits decreased. The prevalence of hypertension and diabetes in China has also been linked to increased energy intake combined with reduced physical activity and sedentary lifestyle (Popkin et al., 2012). China's "one-child policy" further contributed to overindulging children in energy-rich foods whose taste they like (Dearth-Wesley et al., 2011). Only disease outbreaks, such as the African swine fever in 2018–2019, have slowed down China's appetite for meat (see Figure 2).

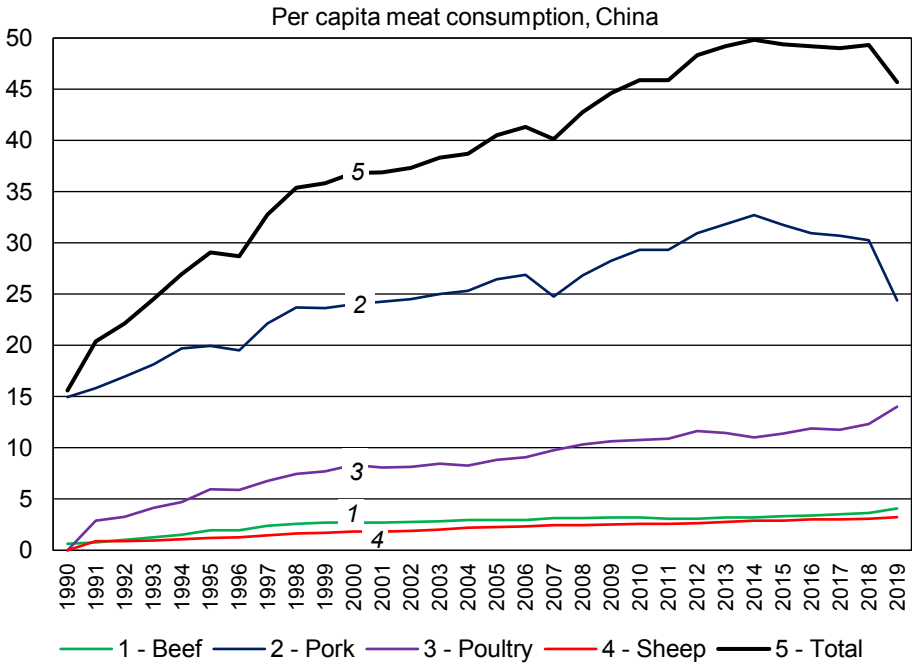

Figure 2. Annual per capita meat consumption, China, 1990–2019 (kg/person)

As in other parts of the world, the analysis of China's dietary patterns shows the significant benefits of whole-food, plant-based options and the surging interest in such choices (Campbell & Campbell, 2017). Educating Chinese citizens is revealed to be the most important factor in creating awareness about the benefits of a dietary balance and healthy staple diets (Chang et al., 2018) which is likely to result in desired behavioural changes.

Food transition

Food transition relates to transformations in the ways food is produced, processed and distributed. Although this area is more loosely defined compared to the other transitions, it reflects changes in agricultural methods – from subsistence to broad-acre farming, use of resources, such as land, soil, water, fertilisers and chemicals, supply and distribution chains and globalisation of food production. In economic terms, it describes the supply side of food, rather than demand represented through consumer needs and preferences as described in the nutrition/protein transition, although the two are interrelated.

Parallels can also be drawn with the other transitions as food production and supply were defining characteristics of historical periods in socio-economic development and the search for improved quality of life. The following four types of agricultural systems describe the food transition in modern times:

– Subsistence agriculture – localised on small plots of land surrounding the place of abode, small-scale to satisfy the needs of a family unit, diverse species of crops are

grown in season with primitive technology used, it is labour-intensive and with relatively small yields, livestock are raised but animal-based products are sparsely consumed; it is focussed on survival with little surplus for marketing or community sharing, crop failure or livestock dying expose the household at the risk of starvation; subsistence agriculture however is attuned to nature's cycles and less exploitative of natural resources, such as soil and water; it continues to be practised by rural communities in less industrialised parts of the world, such as in Africa (Mbatha et al., 2021) or Asia (Holmelin, 2021).

- Farming – this is mainly commercial food production on specially designated land cleared of native vegetation; in some cases, individual farms may be organised in village-level, community systems or farmers' cooperatives. It is estimated that 75% of the world's agricultural land is operated by family farms (Lowder et al., 2016). The types of crops produced or livestock raised vary. Farms have different levels of mechanisation and some may continue to provide only subsistence food for their families while others may be specialised and operate highly mechanised equipment.
- Industrialised agriculture – this represents intensification of agriculture to grow monocultures for commercial purposes on vast areas of land with the aim to achieve high productivity and crop yields through the application of fertilisers, insecticides, fungicides and herbicides as well as technology and irrigation equipment when needed. Industrialised agriculture (also referred as intensive agriculture) requires significant investment in machinery for planting, cultivation and harvesting followed by storage and transportation expenses (Britannica, 2017). The intensive cultivation of the land on an annual basis depletes the soil of its nutrients, particularly when crop rotation and fallow periods are not practised (Gupta, n.d.). In some cases, genetically modified organisms are used to increase yields and improve crop resistance to pests and climatic conditions. Livestock is also subject to industrial methods of intensification with the establishment of factory farming (Safran Foer, 2009) where animals are contained in small areas and exploited for their meat, milk or eggs. Antibiotics are given preventatively to animals in crowded conditions, particularly to chickens in broiler facilities and aquaculture fish, to avoid the spread of infections. These intensively produced agricultural commodities are traded on the global markets. The industrialised methods of food production cause significant environmental damage and contribute to deforestation, biodiversity loss, soil degradation, pollution and climate change as well as the exploitation of sentient animal beings. Nitrogen-induced soil acidification (Tian & Niu, 2015) and soil pollution with chemicals, plastics and other substances at higher-than-normal concentration (Rodríguez-Eugenio et al., 2018) have become a global problem threatening the health of this non-renewable resource essential for food production.
- More sustainable farming methods – in response to the threatening trends of transgressing the planetary boundaries because of land-use changes for food production (Steffen et al., 2015), there are many calls for transitioning to better farming methods and human diets (Willett et al., 2019). Examples include regenerative agriculture (Massy, 2018), agroforestry (Rosati et al., 2021), organic farming and seminatural habitat (Tscharntke et al., 2021), urban agriculture (Follmann et al., 2021; Puigdueta et al., 2021), circular agriculture (Marinova & Bogueva, 2022) as well as lab-grown meat (McClements, 2019). Application of artificial intelligence (AI), machine learning, drones and other smart technologies for precision farming are also helping reduce the environmental footprint of food while fresh and nutritious products are delivered to the consumers (Aggarwal & Singh, 2021; Choudhury et al., 2021; Jerhamre et al., 2022).

China's food transition mirrors the global trends but displays its own characteristics. In pre-modern times up to 8th century, China had equal-field distribution of agricultural land to peasants which allowed for self-sustenance and slowed down accumulation of wealth but gradually declined with population growth (Britannica, 2016). Soring population numbers resulted in severe food shortages and inefficient distribution caused famines. Chinese farmers developed many classical farming practices to maintain and manage the productivity of the land, including application of organic manure, crop rotations, intercropping and multiple cropping combined with engineering solutions through reservoirs, levelling the ground and building terraces (Gong et al., 2001). These techniques are now considered pre-cursors of sustainable farming methods.

Although subsistence agriculture is still practised in villages and some rural parts of the country, since the 1980s agricultural mechanisation is widely used making farming very productive (Xinhua, 2019). Industrialised agriculture is now vastly spread in China and increased productivity is achieved through the application of pesticides and synthetic fertilisers (Scott & Si, 2020). As in other parts of the world, the run-off from the applied synthetic nitrogen fertilisers causes the formation of nitrous oxide, a greenhouse gas 260 times more powerful than carbon dioxide (IPCC, 2014). Research evidence from China shows that these types of fertilisers reduce the microbiological diversity in the soil making it more susceptible to pathological strains (Zhou et al., 2017). The nutritional shift to more meat-based proteins is reinforced through fast-food chains contributing to the westernisation of the Chinese diets (Wang Y. et al., 2016). Furthermore, China's changing dietary preferences and demand for meat are triggering massive land-use changes around the world for the expansion of livestock grazing and intensive feed production at the expense of native vegetation (Stoll-Kleemann & Schmidt, 2017).

More recently, there has been a major swing towards organic food production and sustainable agricultural practices (Scott & Si, 2020). Such changes are encouraged and supported by the Chinese state through national sustainable agriculture policies and plan with the view to support population health, achieve ecological protection and economic benefits. The food challenge for China is complex (GAP Report, 2018) but positive changes are emerging as a top-down approach by the state but also with the bottom-up efforts of individual producers and community groups (Scott & Si, 2020). There is also most rapid development and investment in AI to support more sustainable farming methods (Galaz et al., 2021).

According to Warnaar and Methorst (2017), the stage we are in the food transition means that the human population needs to start producing and consuming food in a completely different way. Reduction of food loss and waste is one such aspect, with industrialised Asia losing 28% of food in the supply chain from (and inclusive of) on-farm harvesting through to the final consumer waste (Our World in Data, n.d.). Online shopping and home delivery with environmentally friendlier packaging are also becoming increasingly common in China and all over the world in the search for healthier and better food practices.

Sustainability transition

Compared to the other transition frameworks, the sustainability transition does not describe an evolutionary pattern of changes but only the current and most necessary transformation we need to see within the concept of development. In other words, sustainability transition indicates the latest stage of development with the fundamental changes occurring in human history driven by social and environmental imperatives, including climate change, environmental deterioration, biodiversity loss and soil depletion. From a demographic transition perspective, the sustainability transition can be aligned with the latest phase of mature industrial society and progress to post-industrial ways of

development when the size of human population stabilises. Sustainability transition, however, is not so much about the demographic dimensions of human population but about the way people live on Earth (Dovers & Butler, 2015). Its main focus is not on how many people are there, but on their consumption patterns, technological choices, the pollution they generate in the air, waters, soil and land, the governance models which define socio-political and economic pathways, and what is fair and just for current and future generations as well as for other species with whom we inhabit the same planet. Technological advancements are likely to shape the sustainability transition overall and in specific areas, such as energy, transport, buildings, industry as well as agriculture, sometimes referred to as separate sustainability transitions (e.g. by the European Commission, 2020). According to the EAT-Lancet Commission (Willett et al., 2019), food will define the 21st century.

A sustainability transition is defined as a "radical transformation towards a sustainable society, as a response to a number of persistent problems confronting contemporary modern societies" (Grin et al., 2010, p. 1). Ultimately a sustainability transition delivers sustainable development which can be described as a process of navigating between two sets of boundaries – those of the planet and the social foundation of basic needs (EEA & Eionet, 2016). Food is an essential part of basic needs but food systems have encroached and transgressed planetary boundaries. An extension of sustainability is regeneration as the harm caused to the planet's ecosystems needs to be reversed. This includes the damage caused by food production which has been the single largest driver of environmental degradation (Willett et al., 2019). Regeneration requires bringing science and practice together integrated with spirituality in a holistic way that reflects fundamental shifts in people's behaviour based on increased awareness, education, leadership and empowerment (Gibbons, 2020).

Most of the literature about sustainability transition takes a multi-level perspective, where:

- The landscape (macro level) is defined by external structures;
- The regimes (meso level) are relatively stable configurations which determine what is normal; and
- Niches (micro level) are protected spaces where innovations can develop without the pressures from the regimes within the existing landscape (European Commission, 2020).

This perspective is justifiable for many sectors in the economy but in the case of food, people's values and behaviour are manifested with each meal they take and each person is potentially a "niche" for innovation and behaviour change. Such a way of conceptualising food's place in a sustainability transition is empowering allowing for leadership to be demonstrated until what are considered "niche" behaviours become the new norm. New production and consumption practices need to be mainstreamed and old preferences which exploit nature's biophysical systems and farm animals need to be phased out (see Figure 3). In the theory of societal transitions, this is described as the X-curve framework (Loorbach, 2014; Hebinck et al., 2022).

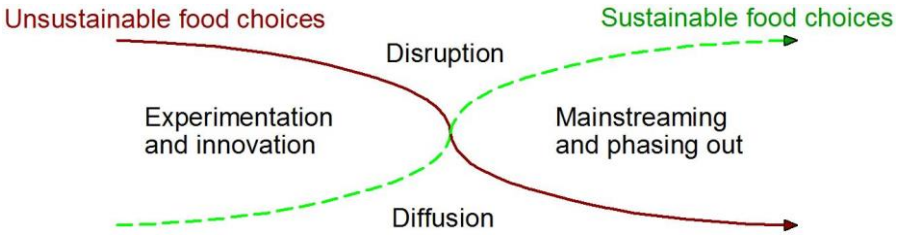

Figure 3. Sustainability transition in food
Source: Based on European Commission (2020)

Flexitarianism or voluntary reduction in the consumption of animal-based proteins (Raphaely & Marinova, 2014) is an example of a niche behaviour in a country like Australia which has one of the world's highest levels of meat supply on a per capita basis. There is mounting evidence that meat, and particularly red meat, is detrimental to the natural environment (Poore & Nemecek, 2018), has much higher greenhouse gas emissions compared to plant-based options (Clark & Tilman, 2017), takes up disproportionately more land (Ritchie & Roser, 2019a), represents an inefficient energy and protein conversion in the supply of food (Eshel et al., 2014; Ritchie & Roser, 2019b) and is potentially carcinogenic (WHO, 2015). Flexitarianism acts as a disruptor to the current unsustainable food preferences and the innovations in the alternative proteins market aim to ease its diffusion, that is broader adoption. Despite representing the best nutritional choice, the appeal of traditional legumes, nuts, vegetables, grains, fruits and other plant-based foods has gradually declined. The development, experimentation and innovation in novel plant-based analogues of familiar animal-sourced foods, such as sausages, mince, nuggets, mayonnaise, cheese and cultured meat, aspire to attract consumers. Such products are seen as a way to progressively shift food preferences by imitating the taste and look of familiar animal-sourced products. When decreased consumption of animal-based foodstuffs is achieved, and in the case of Australia this reduction should be by 80-90%, sustainable food choices will be mainstreamed with old addiction to livestock-based products significantly reduced or phased out. The interest in plant-based milks is particularly strong in western societies because of their better environmental performance (Marinova & Bogueva, 2020) and cow's milk is gradually being displaced.

Food's contribution to the sustainability transition is not only through the types of products consumed. The status quo can be disrupted with new production ways, including for the humble fruits, vegetables, nuts, grains, legumes and tubers. There are numerous new technologies that are gaining momentum (McClements, 2019) and we are witnessing rapid advancements in areas, such as vertical farming, hydro-, aero- and aquaponics (Marinova & Bogueva, 2022). Agroecology (FAO, 2018) is another field that links food production with the ecology to help transition to sustainable food and agricultural systems and in response to the global 2030 Sustainable Development Goals (SDGs). It covers principles and approaches for human society to live in harmony with nature (Franzluebbers et al., 2020), allow it to regenerate and heal.

Sustainable food choices are essential for a sustainability transition and any progress made in other areas, such as electricity, transport or buildings, will be defeated by the burden human diets pose on planetary health. Conservatively estimated, food systems are responsible for 34% of the global greenhouse emissions (Crippa et al., 2021). It is only academic whether we describe the shift to sustainable development as one or many sustainability transitions and lament the methodological complexities and challenges in studying these transformations (Geels, 2011; Zolfagharian et al., 2019). Embracing this latest transition framework is much more about practice than theory.

The economic development transition that China has undergone since 1978 has been characterised as a "socialist market economy" in which the state is coordinating the building of a harmonious society based on prosperity (Hong, 2016). Four decades of exceptional economic growth have accelerated urbanisation and taken hundreds of millions of people out of poverty. However, this has come at a high environmental cost with substantial levels of pollution and greenhouse gas emissions. China's economy is now "in a transition period from rapid development to high-quality development" (Cheshmehzangi & Chen, 2021, p. 56) with targets to reach a carbon peak before 2030 and decarbonise by 2060 through top-down socio-

economic development plans and bottom-up economic incentives and technology development (Liu et al., 2022).

Food security and production are recognised as a challenge in China's sustainability transition and the country has a National Plan for Sustainable Agricultural Development 2015–2030 (Cheshmehzangi & Chen, 2021). Its focus is on improving people's livelihoods and building resilience to disasters while safeguarding the natural environment. Furthermore, there is convincing evidence that it is more energy-efficient and financially beneficial to focus on the production of vegetables and legumes, such as soy, than to produce or import meat given China's farmland, water and other resource restrictions (Cheshmehzangi & Dawodu, 2019). This is supported by government policies but some argue that dietary changes for reducing meat intake have to be a gradual and slow process (Cheshmehzangi & Chen, 2021). In the next section, we look at how China can specifically contribute to a global sustainability transition.

China's contribution to a global sustainability transition

Because of the size of its population and economy, China can influence all aspects of the global sustainability transition – from energy to industrial production, buildings and technology. With the focus of this article specifically on food, we discuss two particular aspects, namely the state-driven dietary changes to contain domestic meat consumption and China's knowledge and expertise in alternative proteins.

Domestic transition

China's latest 2016 dietary guidelines, namely the Balanced Diet Pagoda, limit the intake of meat and poultry to 40–70 g per day to "help promote healthy lifestyles and physical strength" aimed at reducing risk for many chronic diseases and mortality (Wang, S.-S. et al., 2016, p. 649). The message to the consumer also is that meat, poultry, fish and eggs should be eaten in moderation which is in contrast to the encouragement to eat plenty of vegetables, fruits, tubers and bean products, including soybeans. An analysis by the Global Panel on Agriculture and Food Systems for Nutrition (2016) shows that 880 projected deaths per million in 2050 can be avoided in China by reducing red meat consumption.

The Chinese state is responding proactively to the scientific evidence not only by adjusting its dietary guidelines towards less red meat consumption compared to the 2007 Food Pagoda (Wang, S.-S., 2016), but also through social marketing campaigns. What is particularly interesting is that the social marketing campaigns, such as Less Meat Less Heat More Life (2016) by the Chinese Nutrition Society in collaboration with WildAid China, explicitly link meat consumption with climate change, habitat loss and other environmental deterioration (Table Debates, n.d.). The promotion advertisements and video used in the campaign that reached millions of Chinese citizens included China's most famous actress Li Bingbing, the very popular Hollywood actor Arnold Schwarzenegger and was directed by James Cameron. It endorses the efforts of the Chinese Government to decrease the actual consumption in China by 50%. In reality, this reduction is more than the one included in the Diet Pagoda, and represents the combined effort to restore the public good of health and environmental well-being. James Cameron explicitly draws attention to hypocrisy in the global environmental movement saying: "How can I call myself an environmentalist when I'm contributing to environmental degradation by what I eat?" (Shoard, 2016, para. 4).

Although on a per capita basis, Chinese eat around half of the daily meat consumed by Australians or Americans, there is still a well-defined trend to increase the intake of animal

proteins as population wealth improves (Whitton et al., 2021). Given the size of China's population, this consumption results in more than twice the amount consumed in USA and requires substantial imports of feed and meat products. The efforts by the state aim at reversing the trend of increasing meat consumption and also promote preservation of healthier traditional diets. Compared to other government positions, the Chinese state is showing strong leadership in an area that is considered complex and difficult to navigate.

The empirical evidence confirms the complexity of the efforts to speed up the nutrition/protein and food transition in China. In recent years, the cultivation of staple crops, such as sorghum, millet and rye, has decreased to give space to high-yield and economically more profitable potato and rice (Chang et al., 2018). Overall, Chinese diets have moved away from the traditional healthy balanced and nutritious composition towards foods that are high in fat, nutritionally poor and energy dense as exemplified by choices of animal-sourced products (Chang et al., 2018).

Added to this is food waste, with Chinese households wasting 64 kg per person per year (UNEP, 2021). Although this is not at the extreme end of the spectrum on a per capita basis – Australians waste 102 kg per person per year, it amounts to a staggering 91 million kg per year. The state again is using social marketing to promote a 40% reduction through the "clean plate" (*Guang Pan*) campaign launched by the president Xi Jinping (Sheldon, 2020). The higher the animal-based content, the higher the environmental footprint of food waste.

The current trends in increased meat consumption (see Figure 2) need to be seen also within the context of China's history in producing nutritious food. Relatively recently, a negative (from a sustainability point of view) X-curve transition has occurred to introduce meat and western types of diets disrupting traditional food practices. Soybean, considered the "miracle crop" (Guo et al., 2021), was domesticated thousands of years ago. Different methods of processing soybeans into tofu, yuba (dried tofu skin) and soymilk were developed first in China and then spread all over the world (Marinova & Bogueva, 2022). Soy-based products contain all nine essential amino acids for humans and are also a good source of vitamin B1 and important micronutrients, such as iron, calcium, manganese, phosphorus, magnesium, copper and zinc. From a food production point, soybeans are a legume and help maintain soil fertility through nitrogen fixation, making them suitable for crop rotation.

With the nutrition/protein transition, soybeans however have become a popular crop for making animal feed. It is estimated that 85% of the soybeans consumed in China are eaten by livestock (Nepstad, 2021). China's raising consumption of meat, and pork in particular, has fuelled the global demand for and imports of soybeans, including from Brazil, USA and Argentina, where this has led to deforestation, loss of biodiversity and the use of genetically-modified varieties to increase yields. Similar to beef, the protein conversion of pork is extremely inefficient – 91.5% of the proteins fed to the animal are lost in the process of producing meat for human consumption (Alexander et al., 2016). Soybeans can easily provide these proteins directly to create a diet nutritious and healthy for the planet.

China's 14th Five-Year Plan focussed on high-quality and sustainable development provides a roadmap for a sustainability transition. It also emphasises the "greening" of food production through the use of organic methods. At the moment, China is the 4th largest provider in the world of organic soybeans (Nepstad, 2021) for direct human consumption with farmers given incentives to switch to this crop. If meat demand is curbed, this would have immediate and long-term benefits for people's well-being and ecological health. In 2014, the state-owned enterprise Sinograin became the first to implement an international standard for responsibly produced soybeans, which includes zero deforestation and no land conversion for agricultural purposes as well as no application of synthetic fertilisers. This is driven by a top-down approach and bottom-up demand.

Consumers' preferences in China are also changing, particularly among young people and those who are more environmentally oriented. A 2019 survey conducted by the Swiss Federal Institute of Technology found that 55% of Chinese citizens supported reduction in meat consumption and a range of policy initiatives that could facilitate such a change (Meat Atlas, 2021). They include higher taxes on meat products (30% higher), 75% vegetarian options in public cafeterias, elimination of subsidies for meat producers, reducing the prices of plant-based alternatives (by 30%) as well as frequent information campaigns and supporting low-income households. Another 2019 study by the European Investment Bank shows that 78% of the Chinese respondents have already reduced the size of their red meat portions and another 14% are intending to do this to fight climate change (Meat Atlas, 2021). This was also the highest population share from all 30 surveyed countries.

Although less than 5% of the Chinese population identify as vegetarian or vegan, 87% have tried plant-based meat alternatives (Global Food Institute, 2018). In fact, China is one of the fastest-growing markets for plant-based alternatives with demand predicted to increase by 200% within five years driven by consumer interest in health and sustainability but also in taste (DuPont Nutrition & Biosciences, 2020). Variety and novelty of food products are particularly important for young consumers but taste and texture are critical for the success of these new and more sustainable protein options. According to market research (DuPont Nutrition & Biosciences, 2020), the vast majority of consumers, namely 78%, believe that plant-based alternatives are going to become a mainstream option. What is of particular interest is that in China people with higher attachment to meat are more likely to buy the plant-based alternatives (compared to vegan and vegetarians) while the opposite is the case in USA (Bryant et al., 2019). China can build on its millennia-old traditions in consuming and processing soy and other plants to create novel foods that satisfy consumer expectations and disrupt the current meat tends facilitating a sustainability transition encouraged and supported by the Chinese government.

Global opportunities

According to Alexander et al. (2016), if the average Indian diet (which contains around 5 kg of meat per person per year) is adopted globally, only half of the current arable land would be needed to feed the world. They also stress that the types of food commodities are more important than the quantities because of the large land and environmental footprint of meat and other animal-based foods. China can play an important part in a global transition to more sustainable food choices.

The plant-based alternatives have had a long history as an industry supplying Buddhist temples and prestigious restaurants to showcase culinary skills (Global Food Institute, 2018). Many of the companies are small-scale but they have already ventured on a global scale providing vegetarian duck, chicken, beef, seafood and sausages to countries, such as Australia, Canada, New Zealand, USA and the rest of Asia, including large supermarket chains, fast-food and specialised restaurants (Global Food Institute, 2018). China is a dominant supplier of soy and pea protein to the world processing 79% of the global soy protein isolate, 50% of the global textured soy protein and 23% of the global soy protein concentrate (Siu, 2019). Technology advancements in extruders, 3D printing and locally grown quality whole foods, including soybeans, will further strengthen China's position in the global opportunities in the sustainability transition.

Conclusions

The first three transition frameworks related to development and food, namely demographic, nutrition/protein and food transitions, describe major shifts in population behaviour. They are associated with improved standards of living and food security. However, the current food systems are not delivering the best outcomes for humanity. Malnutrition – from undernourishment to obesity and associated non-communicable diseases – is contributing to shorter life spans while food production is one of the major causes for the deterioration of the natural environment (Lindgren et al., 2018). The fourth transition, namely a sustainability transition, is required to respond to the major challenges and persistent problems triggered by human activities on the planet. Food is a defining aspect of the sustainability transition and the current moment in history.

As countries go through different phases of development towards a stage when population numbers are expected to stabilise, we also see dietary changes with reduced famines and increased energy intake, driven among others by animal-based foods, and meat in particular. The current stage of this protein transition represents not only an inefficient use of resources but also threatens human well-being and the health of the biophysical systems on the planet, including contributing to climate change, destruction of natural habitats through land-use conversion, biodiversity loss and soil degradation. To counteract this destruction, a conscientious desired transition towards predominantly plant-based foods is at the core of the sustainability transition which will trigger innovation, diffusion and mainstreaming of new dietary products known as alternative proteins together with resurrection of the importance of the humble vegetables, fruits, legumes, whole grains and nuts.

There is already evidence, particularly from China, that people are embracing reduced consumption of animal-sourced products with 92% of the country's citizens willing to do this to fight climate change (Meat Atlas, 2021). Supported by social marketing and endorsed by government initiatives, China can become a significant contributor towards the changing food trends domestically and globally. It can facilitate a faster sustainability transition by shifting its own eating habits and also contributing globally to the burgeoning field of new alternatives to livestock products. From a defining characteristic of the 21st century (EAT-Lancet Commission, 2019), food can become a message of hope and regeneration empowered by a new holistic awareness and spirituality (Gibbons, 2020) redefining the meaning of being human.

Following in the vein of previous research on food transition and sustainability transition, this study is the first to conceptually link the two. It also positions food, and plant-rich choices in particular, as a defining characteristic of the urgently required sustainability transition making it a priority global agenda. The potential of China to be part and positively influence such changes has not been previously explored and the insights provided here bring hope and optimism.

This qualitative conceptual analysis can be expanded in the future with quantitative evidence about the adoption of plant-rich diets, including plant-based analogues, across the world and specifically in China. Another interesting direction of future research is to understand the driving motivations behind any responses by consumers and producers to these new opportunities. Young people in particular have been very active in the area of climate change and it will be worthy to investigate how they react to imbedding food choices in the regeneration agenda for the planet. New research will also need to bridge our understanding of the place of food choices in exacerbating global inequalities.

From a transition, sustainability will have to become the normal way of human existence. With this, food will no longer defy life on Earth but instead will provide support and future answers.

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