



GEORGE H. W. BUSH FOUNDATION
FOR U.S.-CHINA RELATIONS
乔治布什美中关系基金会



China Data Analysis
& Research Hub



International Ecosystem Management Partnership
国际生态系统管理伙伴计划



Building the Green, Digital and Inclusive City of the 21st Century

Urbanisation and Agrifood System – Towards Coordinated Solutions to fight Climate Change, Biodiversity Loss and Ecosystem Degradation

Linxiu Zhang

Director, UNEP-IEMP

11 January 2024

Content

1

Urbanisation and agrifood system in the context of global environmental challenges

2

Empirical studies

- **Off-farm employment, food production and related carbon emissions**
- **Off-farm employment and dietary diversity**
- **Off-farm employment, diet structure and related carbon footprint**

3

Implications

Environmental challenges facing agrifood Systems

The three intertwined environmental (climate, biodiversity and pollution) emergencies that the earth is facing pose great challenges to the agri-food systems

Biodiversity & Ecosystems

Deforestation/vegetation loss
Land degradation/desertification
Freshwater/coastal/marine ecosystems



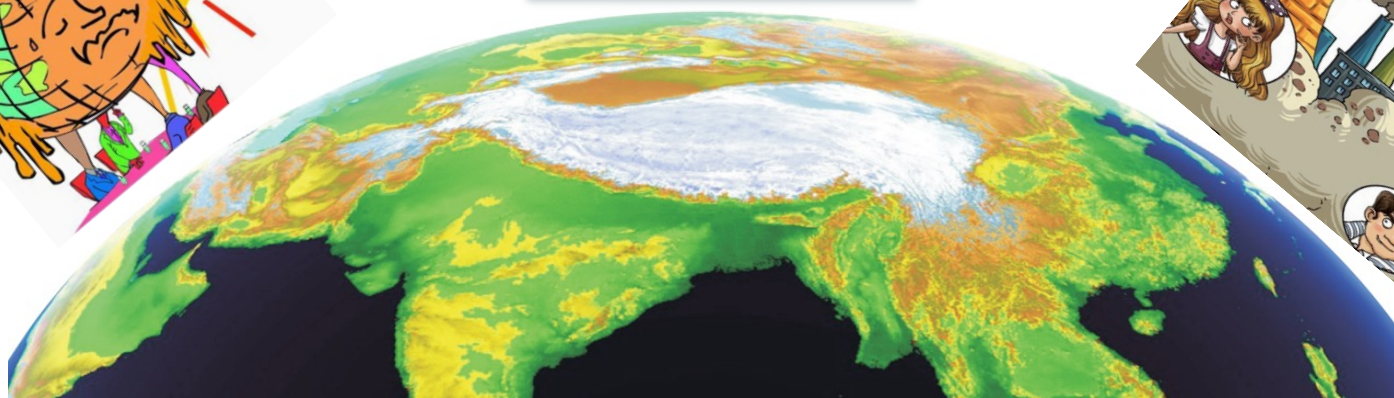
Climate Change

Increasing temperature
Increasing pest and disease
Natural disasters



Pollution

Industry/agriculture/urbanization
Chemicals/pesticide/waste
Water/soil/air pollution



Challenges to SDGs, and food systems... a closer look

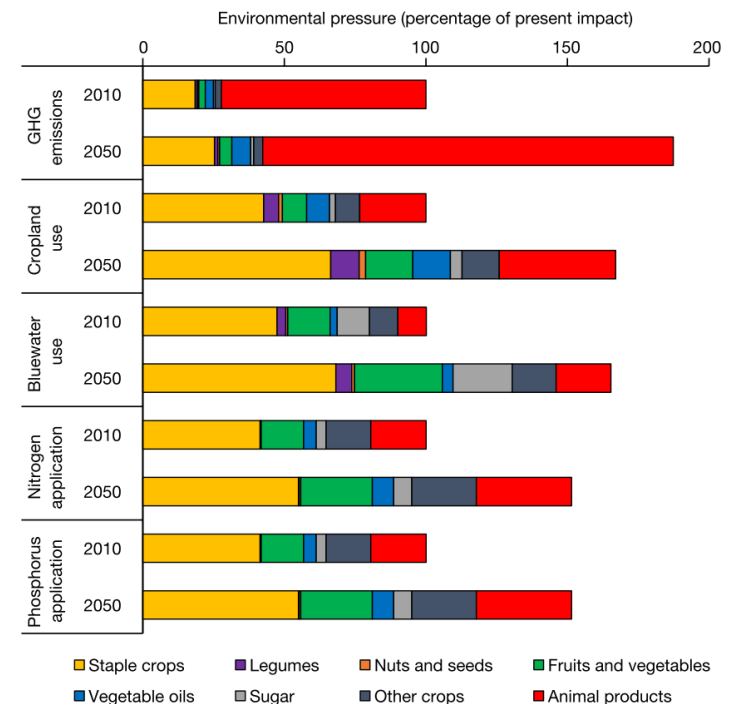


Today, many of the world's current food systems are failing – for people, for the environment, and for future generations. With only 10 years remaining, many of the 17 SDGs remain far out of reach. In many cases, unsafe or unsustainable food systems are part of the problem ([UN Food Systems Summit 2021](#)).

- Hundreds of millions of people are hungry with tens of millions more at risk due to the impact of COVID-19, even as **one-third of all food is either lost or wasted**
- Malnutrition in all its forms is now the **number one factor contributing to the global burden of disease** and reduced life expectancy. More than 2 billion people are overweight or obese
- Food systems contribute up to **29 per cent of all GHG emissions**, including 44 per cent of methane.
- Agriculture is also responsible for up to **80 per cent of biodiversity loss**; accounts for up to **70 per cent of all freshwater use** and **80 per cent of all deforestation**; and uses more than **one-quarter of energy** expended globally.

Need for food will continue to increase

Current trends are **unlikely to supply future demands for food, energy, timber and other ecosystem services** taking into consideration even moderate projections for land resources availability and the ongoing increase of population and nutrition improvement.

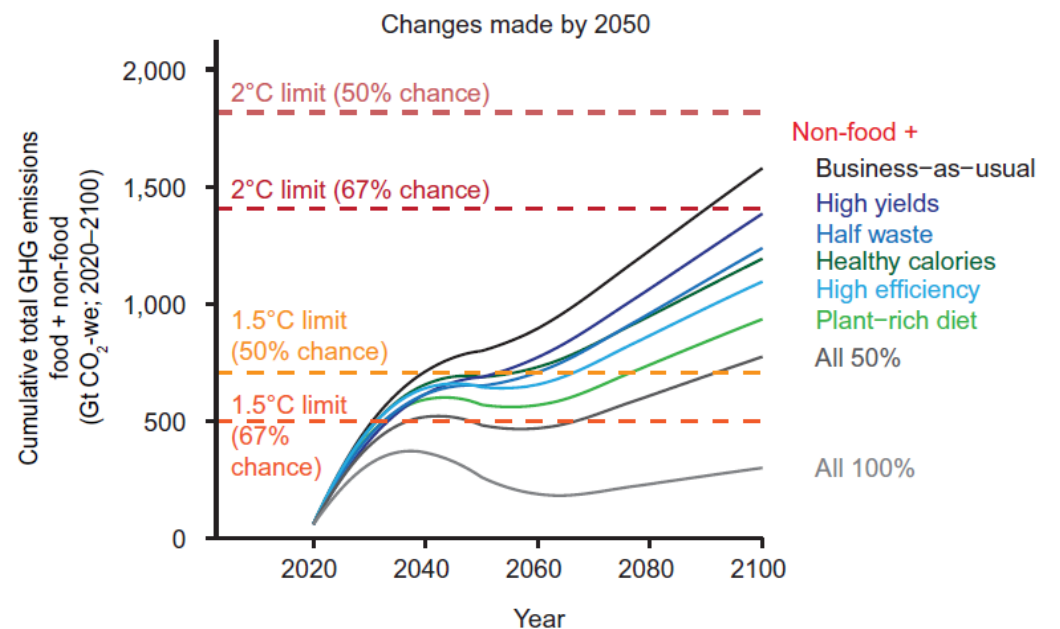
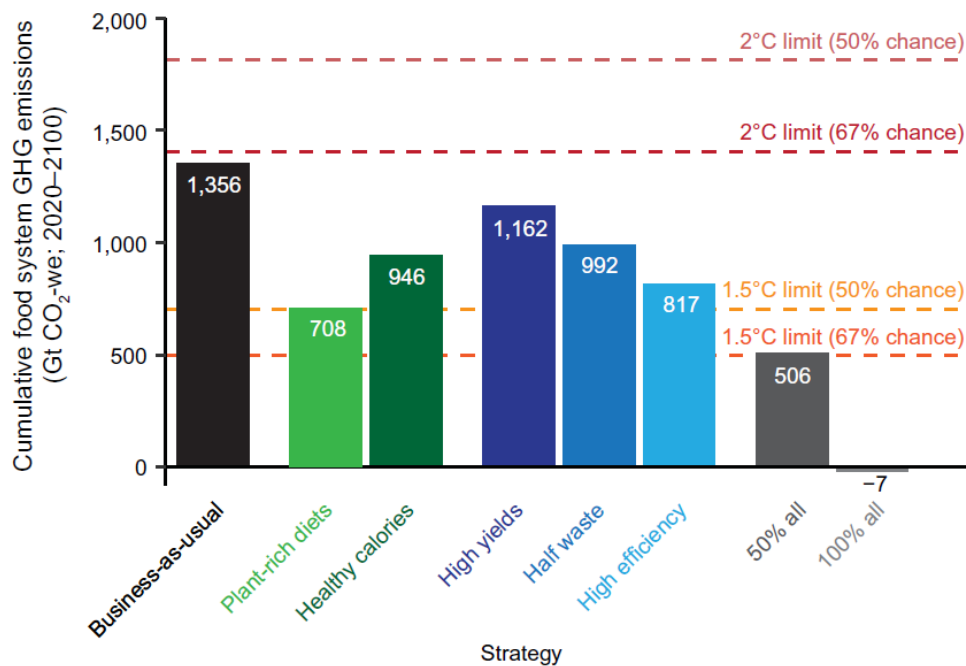


<https://blog.ucsusa.org/wp-content/uploads/Monsanto-web-page-feeding-the-world-in-2050.png>
 Springmann et al., Nature, 2018

Food production and consumption is in urgent need of significant reform

Greenhouse gas emissions from the agri-food system could push global warming above the 1.5°C target set by the Paris Agreement even if energy, transport and manufacturing were fully "green", or "carbon neutral".

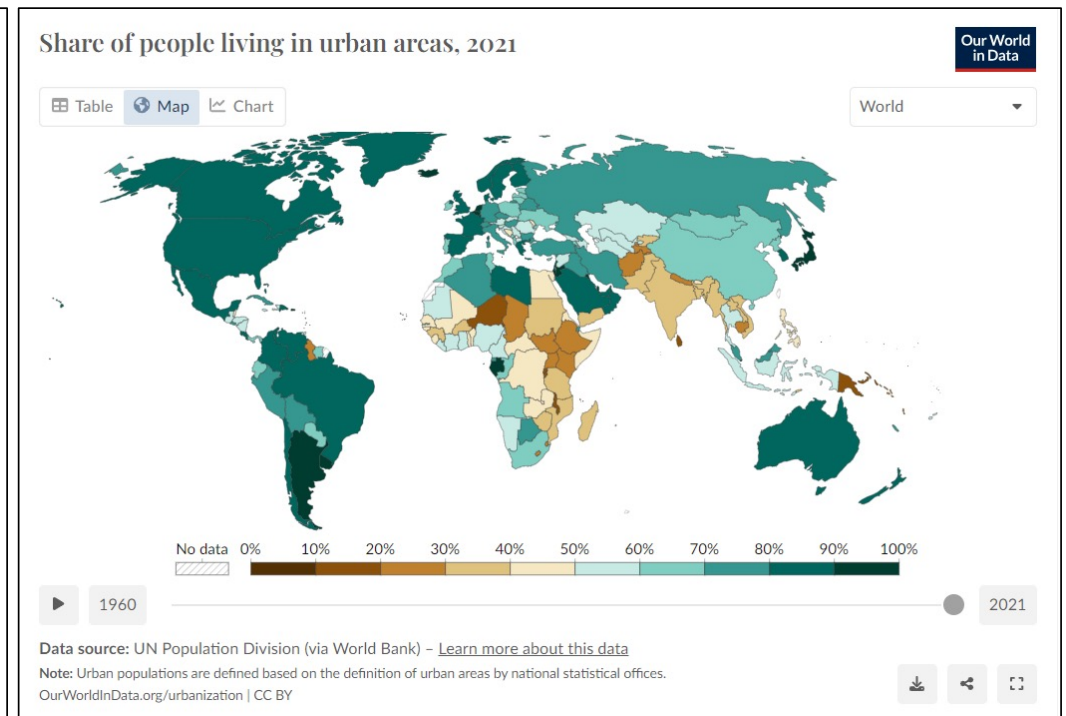
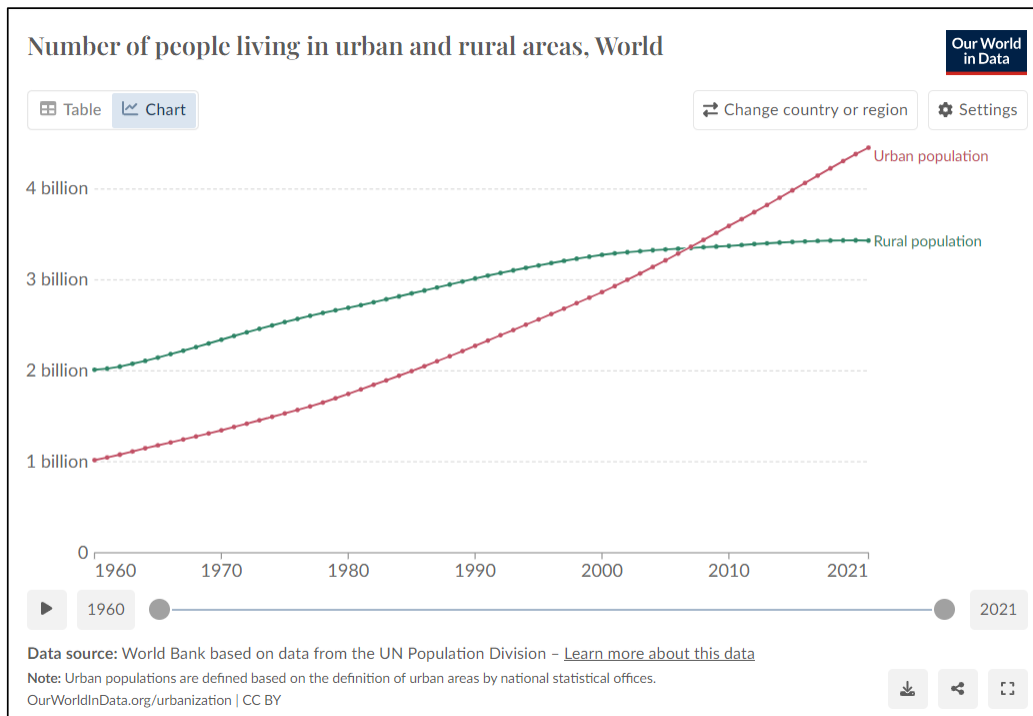
Meeting the 1.5°C target requires rapid and ambitious changes **both within and outside of the food system**.



(Michael A. Clark et al., Science, 2020)

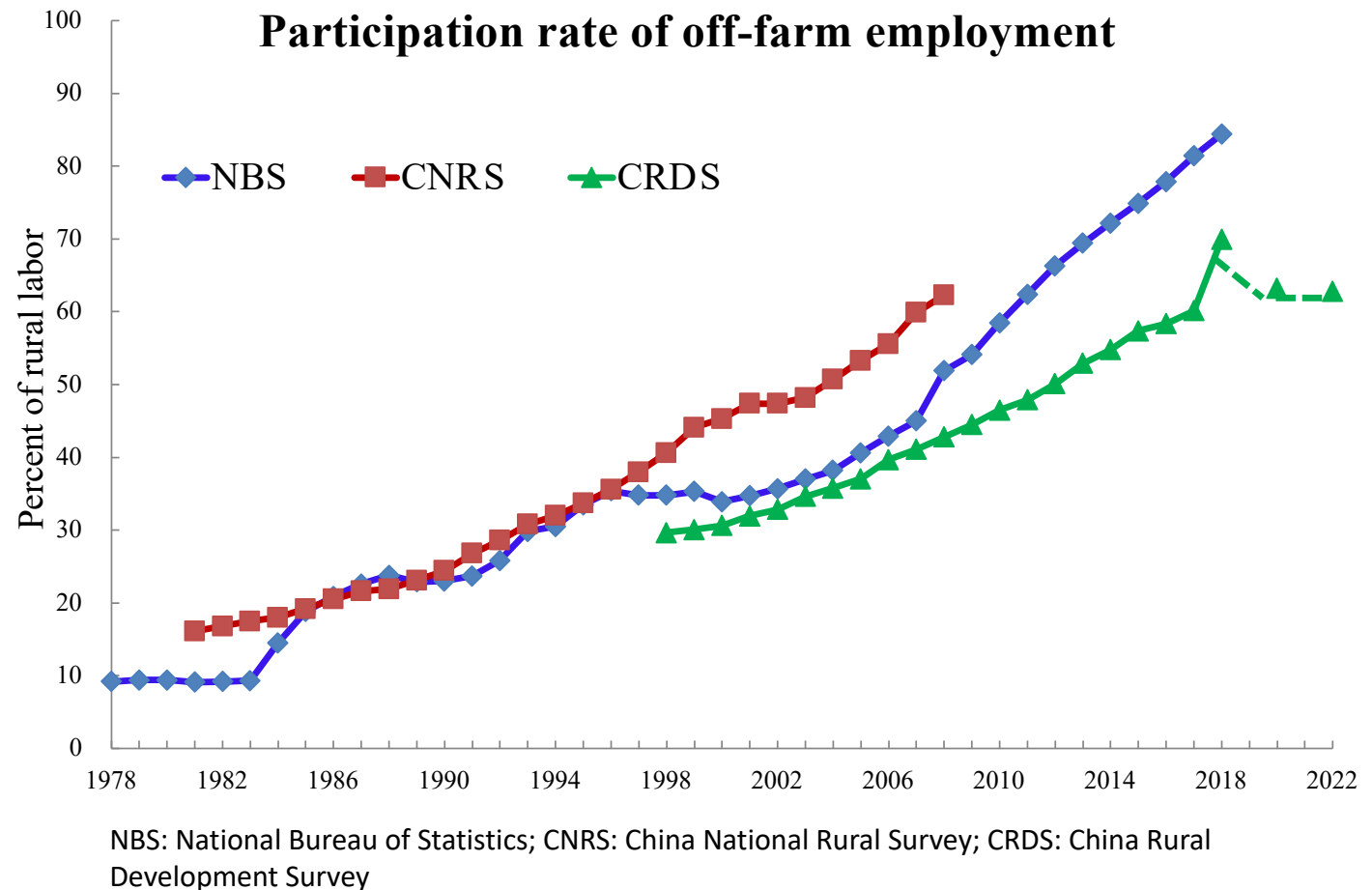
Rapid expansion of urbanisation

- Over **half of the world** (56.5% in 2021) live in urban settings, with the number of people in urban areas overtook the number in rural settings – **occurring in 2007**.
- In 2021, most countries more people live in urban settings, except those in **South Asia, Southeast Asia, and sub-Saharan Africa**.
- China has **62.5%** of people living in urban settings in 2021, compared to **17.9%** in 1978.



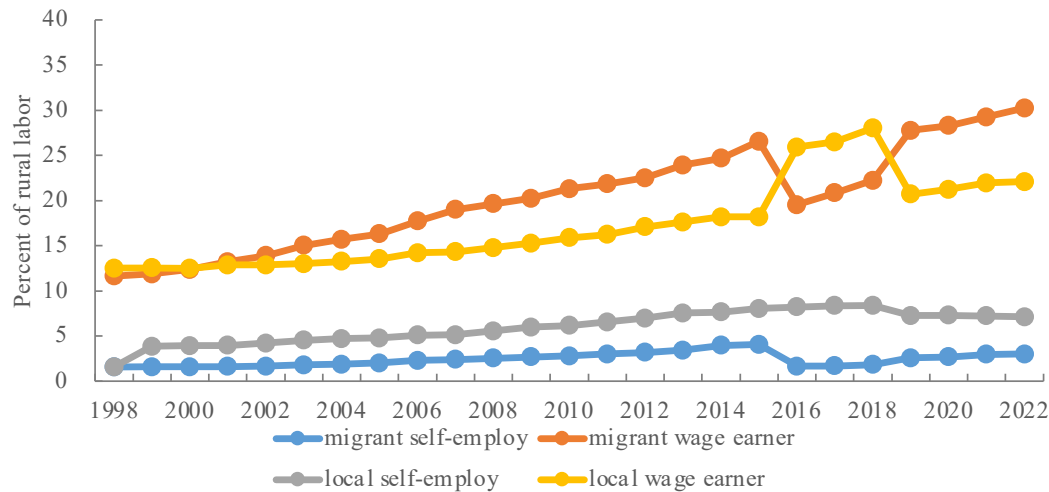
Evolution of rural off-farm employment along the urbanisation in China

- Urbanisation provides large **off-farm employment opportunities**, especially for rural residents.
- Off-farm employment among rural labor has been **increasing** during past four decades.
- From both macro and micro data, **over 60% (even 80%) of the rural labours** participate in off-farm employment.



Employment trend and destination of rural residents in China

- **Wage earners** in off-farm employment, mainly driven by urbanisation is increasing continuously.
- **Migrant wage earners** is leading the rural employment categories.
- An average of 6.8 months per year in 2022 is witnessed in migrant off-farm work.



Year	2007	2011	2015	2018	2022
Home town	42	41	37	39	40
Home county	15	18	20	24	23
Outside home county, but within province	18	19	21	18	19
Another province	26	20	20	20	17

On average, they left home town 6.8 months in 2022

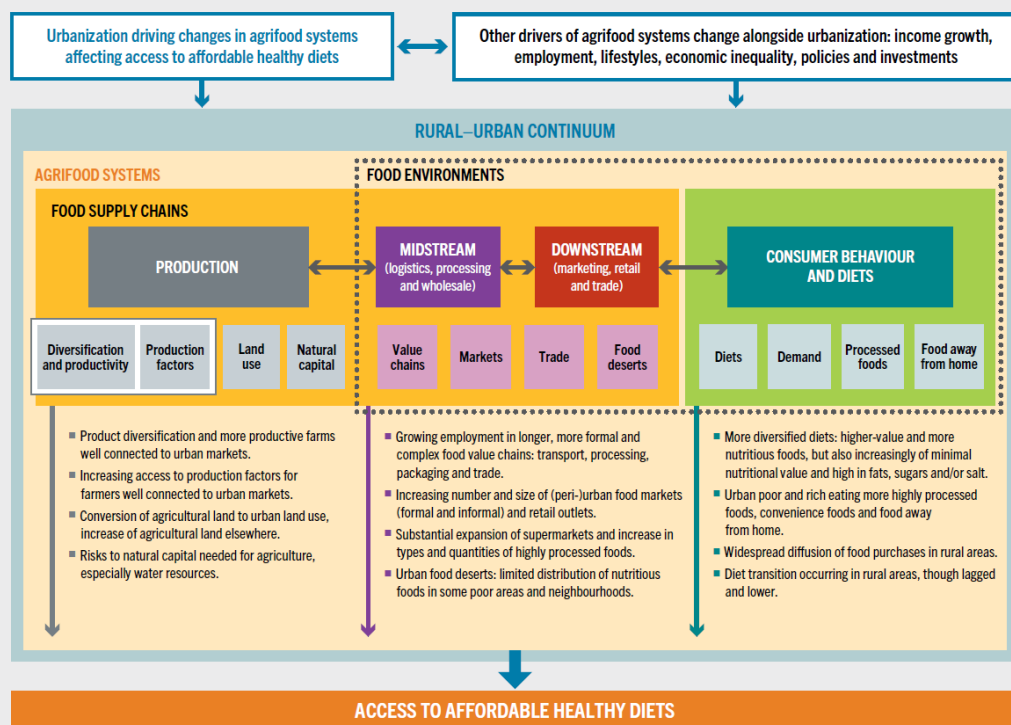
The comparison of migration and local work differentiated by employ types

The destinations of rural residents employment

Data source: China Rural Development Survey.

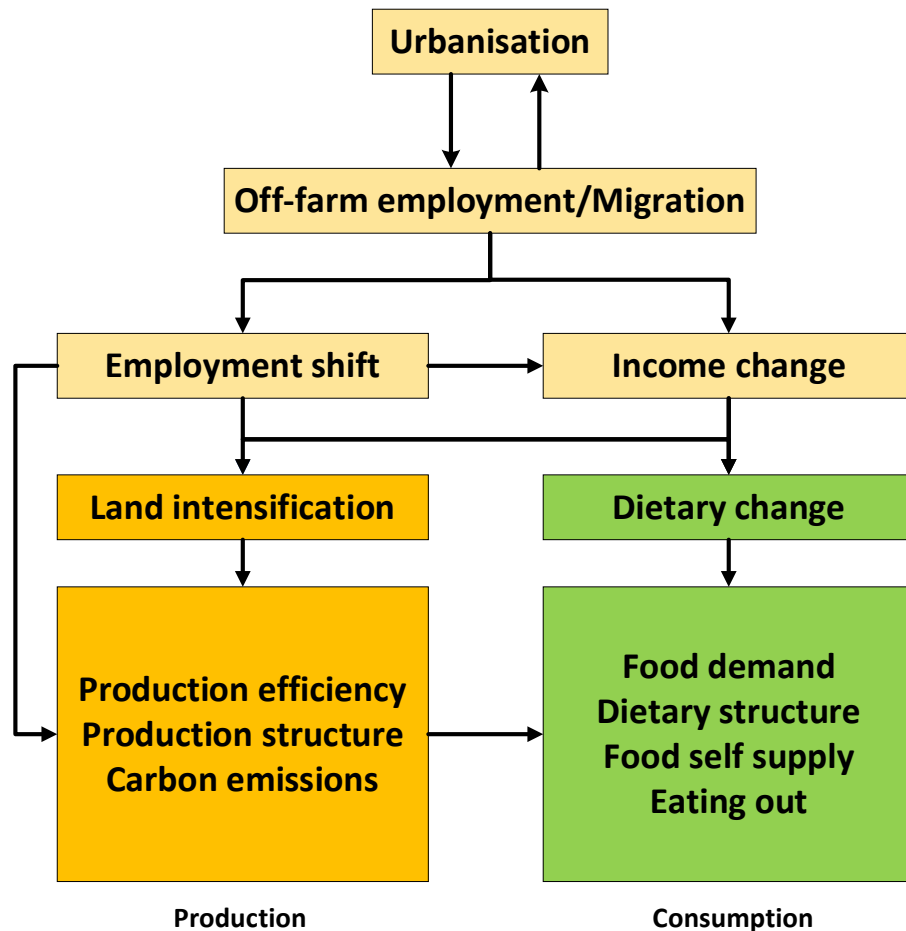
Urbanisation and agrifood system change

FIGURE 20 THE PATHWAYS THROUGH WHICH URBANIZATION AFFECTS AGRIFOOD SYSTEMS AND ACCESS TO AFFORDABLE HEALTHY DIETS



- Urbanisation has **multiple impacts** on agri-food systems along the **food value chain**, from food production to the final consumption.
- **Food Production:**
 - Land cover and land use change—reduction and fragmentation of farmland area—land productivity
 - Employment shift —off-farm employment—land intensification — production efficiency change/ planting structure change
- **Food consumption:**
 - Demand change
 - Diet structure change
 - More processed food and less self-supply food
 - Food away from home

Urbanization (off-farm employment) and agrifood system



Q1: How off-farm employment impact **land intensification**? What is its impact on land **productivity** and related **carbon emissions**?

Q2: What is the impact of off-farm employment on **food diversity**? What are the possible impact **mechanism**?

Q3: What is the **status of current diet**?

What is the impact off-farm employment on **dietary structure** and related **carbon footprint**?

Content

1

Urbanisation and agrifood system in the context of global environmental challenges

2

Empirical studies

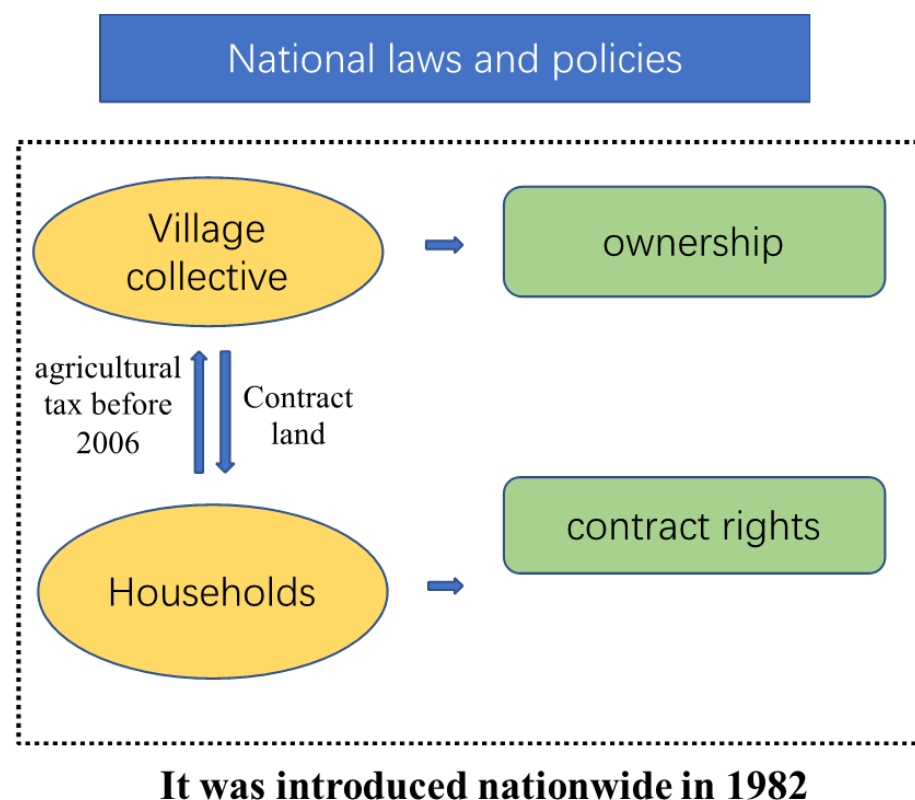
- **Off-farm employment, food production and related carbon emissions**
- **Off-farm employment and dietary diversity**
- **Off-farm employment, diet structure and related carbon footprint**

3

Implications

Off-farm employment, farmland size, carbon emissions

- **Farmland size** is considered as a critical element in improving agricultural productivity to achieve **food security**. However, farmland size was significantly **less than the modest scale** due to the farmland misallocation in developing countries.
- **Farmland rental market** is important to generate scale economics of agricultural production.
- Except for the reform of farmland ownership, **off-farm employment** shows significant effects on farmland rent in the context of urbanization.
- The environmental aspect (**carbon emissions**) of farmland rent is also unknown.



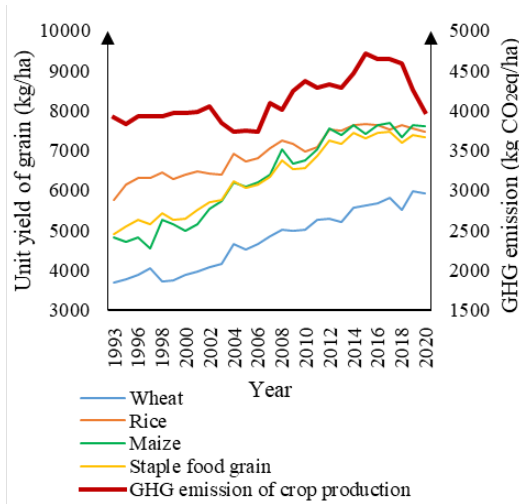
Stable off-farm employment has positive effects on the participation rate and area of farmland rent out

Variables	Participation rate of farmland rent-out (1=yes; 0=no)		Log (area of farmland rented out)	
	Probit	FE	OLS	FE
Off-farm employment (1=stable)	0.292*** (0.065)	0.051** (0.022)	0.331*** (0.078)	0.244* (0.126)
Control variables	YES	YES	YES	YES
Regional dummies	YES	-	YES	-
Year dummies	YES	YES	YES	YES

If at least 1 household member engage in off-farm employment in each of past four years, the probability of **farmland rented out** improves **by 5.1 percentage** (the average participation rate of renting out farmland was 24.44 percent in 2022) and the **area of farmland rented out** increases **by 0.244 percent**.

Data source: China Rural Development Survey

Land transfer scale, productivity, and carbon emissions



The trend of grain productivity and carbon emissions

The impact of land transfer and operation scale on carbon emission density

Variables	GHG emission intensity of crop planting	
Land transfer-in scale	2.202*** (0.860)	2.742** (0.959)
Land operation scale	-2.273*** (0.517)	-2.446*** (0.575)
Control variables	-	YES
Regional dummies	YES	YES

An **inverse relationship** between farm size and productivity has been highlighted as a recurrent phenomenon in developing economies. However, the **grain productivity** in China is still **increasing** with farmland scale up, not reaching the flipping point.

Although expanding **farmers' land operation scale** can significantly reduce the **carbon emission intensity**, the expansion of **land transfer-in scale** has the **opposite effect**, promoting the increase of carbon emission intensity, and **inhibiting the scale effect of land**.

Content

1

Urbanisation and agrifood system in the context of global environmental challenges

2

Empirical studies

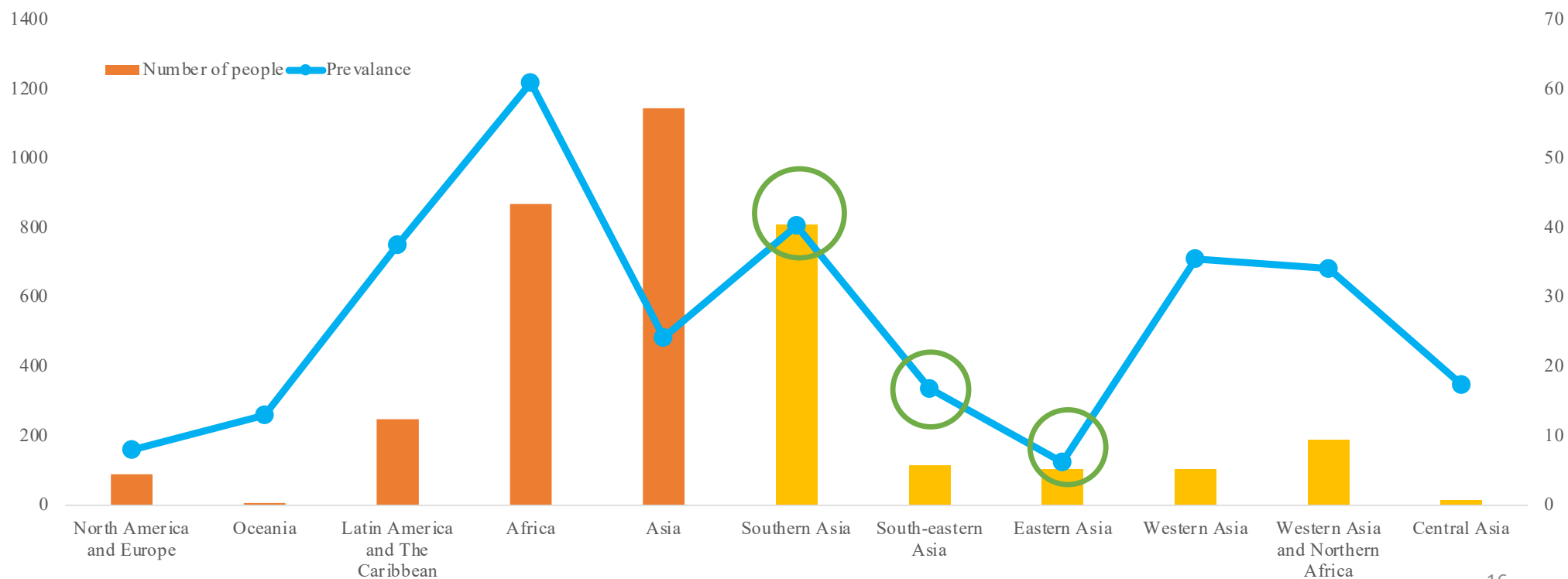
- **Off-farm employment, food production and related carbon emissions**
- **Off-farm employment and dietary diversity**
- **Off-farm employment, diet structure and related carbon footprint**

3

Implications

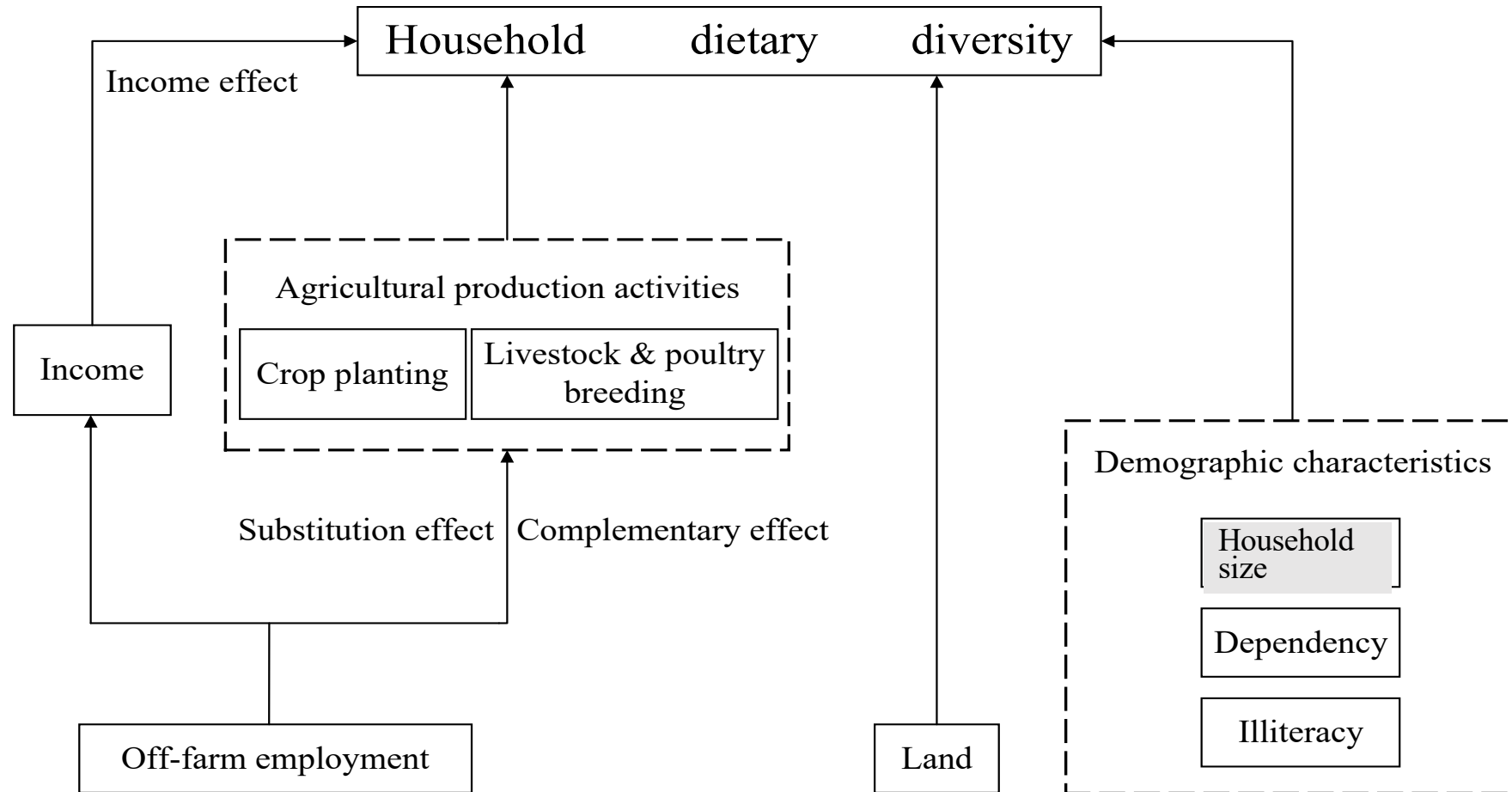
Challenges remain in achieving the SDG of “Zero Hunger” in Asia

- **2.4 billion** people face food insecurity in 2022 and nearly half of them living in Asia.
- **Southern, South-eastern, and Eastern Asia** are the mostly affected regions, with environmentally and economically vulnerable areas suffering more.
- **Off-farm employment** proves to be a good way to improve diet quality (**dietary diversity**).



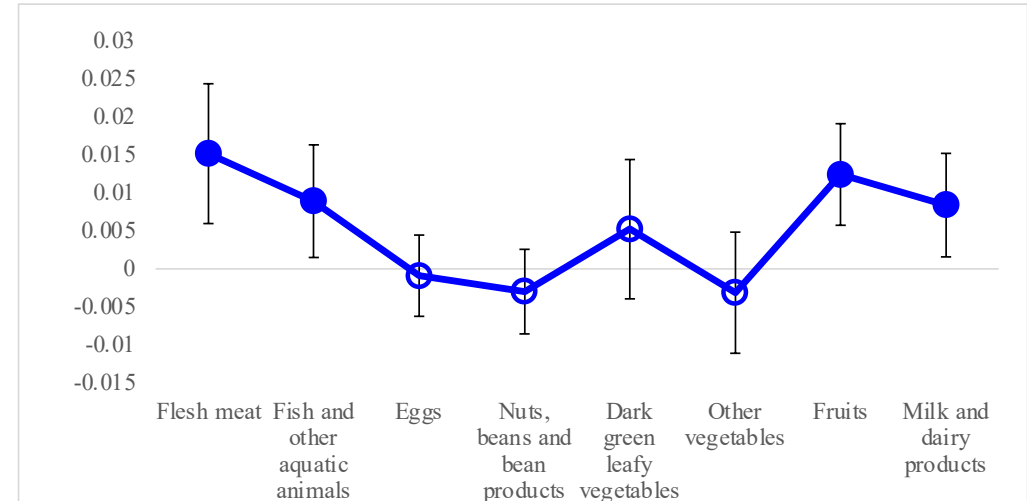
Source: FAO.

Conceptual framework



Off-farm employment and household dietary diversity

Variables	Household dietary diversity score			
	Poisson (1)	Poisson (2)	IVPoisson (3)	2SLS (4)
Off-farm employment	0.004*** (0.001)	0.003** (0.001)	0.032*** (0.007)	0.035*** (0.007)
Control variables	No	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Observations	1,166	1,166	1,166	1,166
Constant				5.002*** (0.233)



Note: The solid circle indicates the coefficient was significant and otherwise for the hollow circle.

- Off-farm employment has a significant and positive effect on **household dietary diversity** score in environmentally and economically vulnerable area of Asia.
- Off-farm employment has significant and positive effects on the consumption of the **food rich in protein and micronutrient**.

Data source: Sustainable Livelihoods Survey (UNEP-IEMP)

Mechanism of off-farm employment on dietary diversity

Variables	The number of crop species			
	All	Households with bottom 1/3 income	Households with middle 1/3 income	Households with top 1/3 income
	(1)	(2)	(3)	(4)
Off-farm employment	0.004** (0.002)	0.008** (0.004)	0.002 (0.003)	0.003 (0.003)
Season dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Observations	1,166	393	385	388

Variables	Raising livestock and poultry (1 = yes, 0 = no)			
	All	Households with bottom 1/3 income	Households with middle 1/3 income	Households with top 1/3 income
	(1)	(2)	(3)	(4)
Off-farm employment	0.000 (0.000)	-0.001* (0.001)	0.002*** (0.001)	0.000 (0.001)
Season dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Observations	1,166	393	385	388

- Off-farm employment is positively correlated with **crop diversity**, especially for the households with **bottom 1/3 income**.
- Off-farm employment has no effect on the probability of raising livestock and poultry on average, but it improved the **probability of raising livestock and poultry** in the household with **middle 1/3 income**.
- There is positive correlation between **off-farm employment** and **household income**, improving dietary diversity.

Data source: Sustainable Livelihoods Survey (UNEP-IEMP)

Content

1

Urbanisation and agrifood system in the context of global environmental challenges

2

Empirical studies

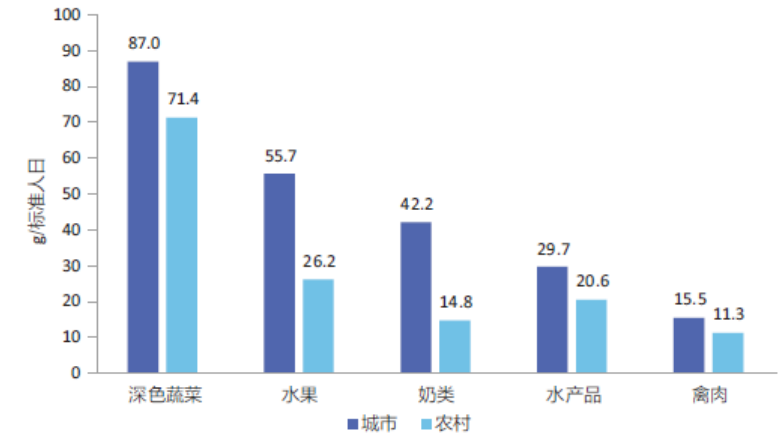
- **Off-farm employment, food production and related carbon emissions**
- **Off-farm employment and dietary diversity**
- **Off-farm employment, diet structure and related carbon footprint**

3

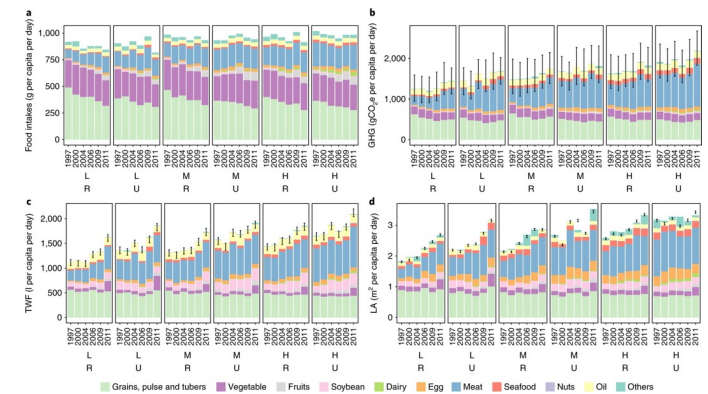
Implications

Imbalanced diet brings health and environmental threats

- The food consumption of rural residents in China is far away from dietary guidelines. The intake of **milk, fruit, aquatic products** and other foods in rural residents is still significantly lower than the national average.
- The problem of **dietary imbalance** is prominent and has become the main risk factor for chronic diseases, threatening public health.
- To feed 20% of the world's population with 7% of the world's farmland, China's excessive and inefficient use of fertilizers and pesticides has brought **a large amount of carbon emissions**.



Different food intake of urban and rural residents in China in 2015
(Chinese Population Nutrition and Health Status Study 2021)

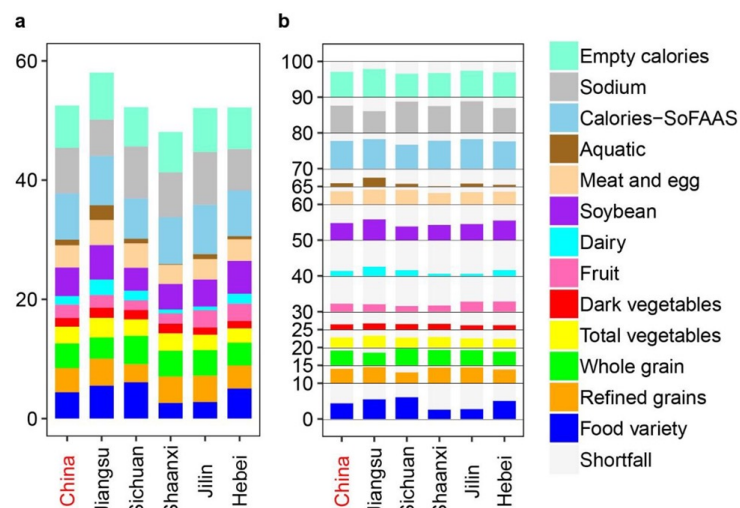


Individual daily food intake and its environmental footprints

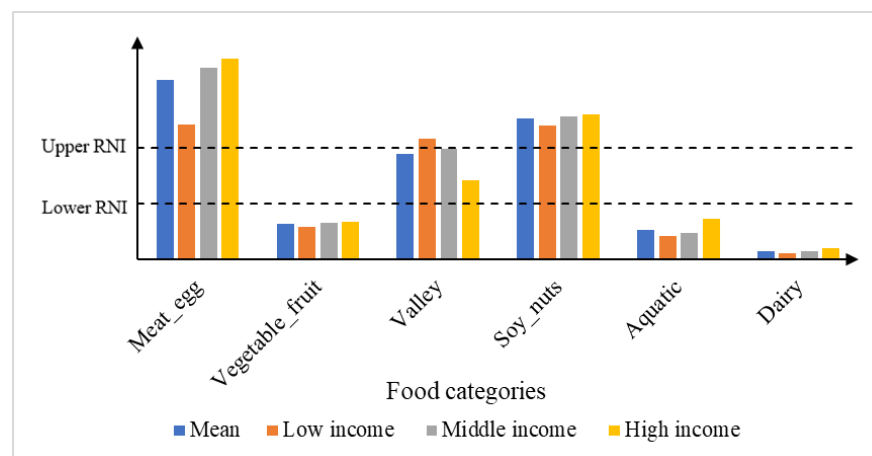
(He et al., 2018, Cui and Shoemaker, 2018)

Status of dietary pattern in rural China

- The diet in rural China **has improved significantly in the last decade**. The Chinese Healthy Diet Index (CHDI) has improved from 44.8 to 52.6.
- However the dietary structure is imbalanced. The rural residents over eat **meat and eggs, soy and nuts**, while their intake of **vegetables, fruits, aquatic products and dairy products** is far from enough.



CHDI for rural residents in China and in five provinces: (a) the average CHDI scores for rural residents; (b) the value and shortfall for each indicator.



Per capita food consumption and recommended nutrient intake in rural China in 2019. (Upper RNI: Maximum recommended nutrient intake; Lower RNI: Minimum recommended nutrient intake)

The economic and environmental co-benefits of dietary improvement in rural China

- A **synergy of environmental impact reduction and food expenditure reduction** could be achieved with a more balanced diet (CHDI improved to 70 with meat reduction and vegetables increase), though **regional heterogeneity** exists.

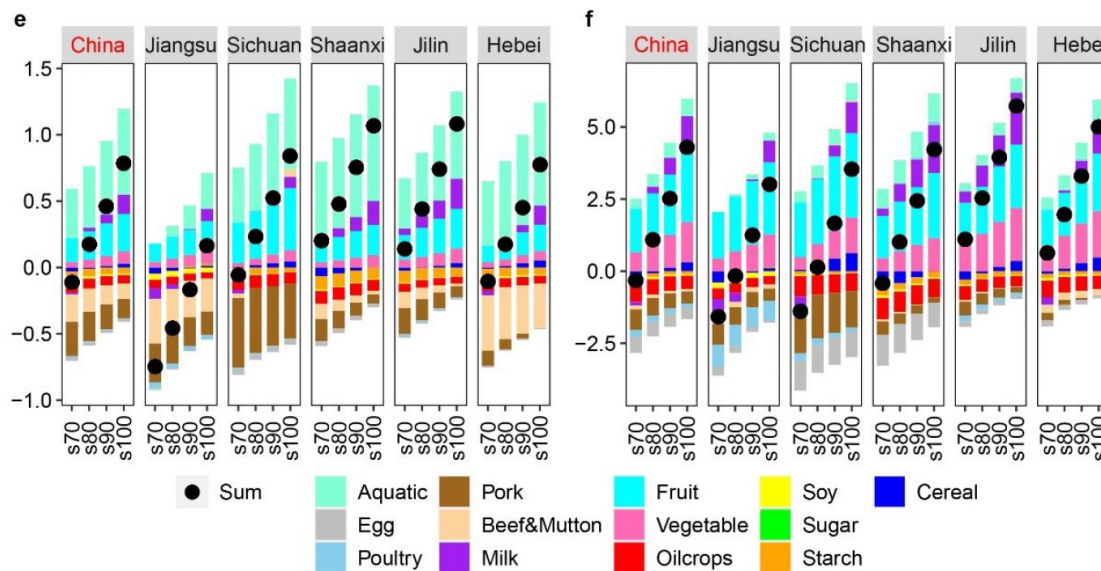


Table S6. Changes of daily expenditure (Yuan/capita) on food when CHDI score achieves 80. Note that the expenditure and price are in current value of 2019.

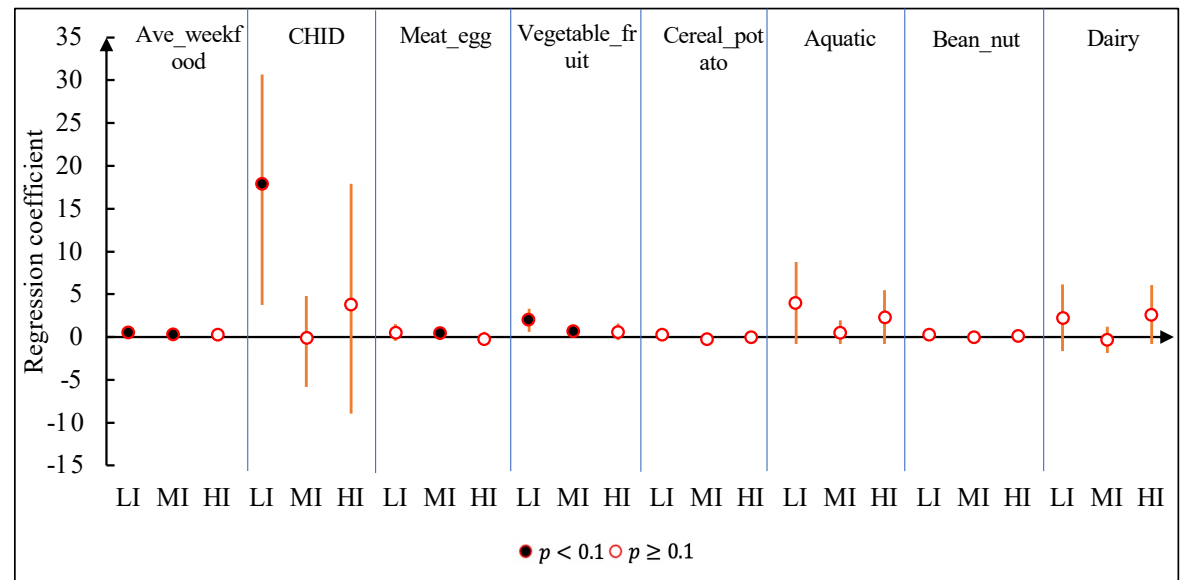
Scenarios	China	Jiangsu	Sichuan	Shaanxi	Jilin	Hebei
Current diet						
Per capita income, 1000 Yuan	24.4	41.8	27.9	15.9	19.1	16.5
Share of food expenditure in income	8.7%	5.8%	9.2%	13.0%	10.2%	9.8%
s80						
Cereal	-0.08	-0.26	0.24	-0.40	-0.06	0.10
Starch	-0.12	0.01	-0.08	-0.23	-0.19	-0.12
Sugar	0.00	0.00	0.00	0.00	0.00	0.00
Soy	-0.09	-0.21	-0.04	-0.08	-0.04	-0.07
Oilcrops	-0.53	-0.36	-0.67	-0.66	-0.43	-0.54
Vegetable	0.91	0.73	0.67	0.74	1.22	1.21
Fruit	1.80	1.85	1.91	1.88	1.67	1.66
Milk	0.23	-0.30	0.02	0.60	0.74	0.08
Beef&Mutton	-0.11	-0.19	0.00	-0.06	-0.05	-0.26
Pork	-0.59	-0.66	-1.29	-0.40	-0.42	-0.20
Poultry	-0.20	-0.67	-0.19	0.05	-0.19	0.05
Egg	-0.49	-0.18	-1.02	-0.74	-0.28	-0.26
Aquatic	0.43	0.08	0.49	0.63	0.44	0.53
Total change	1.15	-0.16	0.03	1.35	2.42	2.17
Share of food expenditure in income	10.4%	5.6%	9.2%	16.1%	14.9%	14.2%

Changes in environmental footprints and expenditure on food when the CHDI scores improved to 70 (s70), 80 (s80), 90 (s90), and 100 (s100): (e) phosphorus footprint (gP/capita/day); (f) expenditure on food (yuan/capita/day).

Off-farm employment improves diet quality while limiting carbon footprint

- **Off-farm employment** has significantly increased household food consumption in rural China, and the increase in food consumption is **not achieved at the expense of the environment, but dietary structure adjustment**, especially for **low-income families**.

Variables	(1)	(2)	(3)
	lnave_weekfood	lnave_weekfood	lncarbon emission
	Robust OLS	2SLS	2SLS
off_farm	0.021 (0.020)	0.262*** (0.086)	0.076 (0.087)
gender	-0.028 (0.081)	-0.035 (0.080)	-0.031 (0.081)
marriage	-0.067 (0.077)	-0.120 (0.086)	-0.158* (0.087)
age	-0.004 (0.002)	-0.005** (0.003)	-0.001 (0.003)
proportion_men	0.157 (0.106)	0.204* (0.107)	0.095 (0.109)
edumean	0.017** (0.008)	-0.004 (0.011)	0.009 (0.011)
ratio_16	-0.981*** (0.147)	-1.252*** (0.178)	-1.095*** (0.182)
ratio_65	0.017 (0.082)	0.282** (0.129)	0.045 (0.132)
land	0.010 (0.010)	0.002 (0.014)	0.005 (0.014)
poultry	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
distance	-0.004 (0.004)	-0.004 (0.004)	-0.007* (0.004)
market	0.002*** (0.001)	0.001 (0.001)	0.001 (0.001)
lnincome_vid	-0.027 (0.030)	-0.019 (0.034)	-0.001 (0.035)



Effects of non-farm employment on household per capita food consumption and related carbon footprint

The impact of non-farm employment on household food consumption of different income groups

Content

1

Urbanisation and agrifood system in the context of global environmental challenges

2

Empirical studies

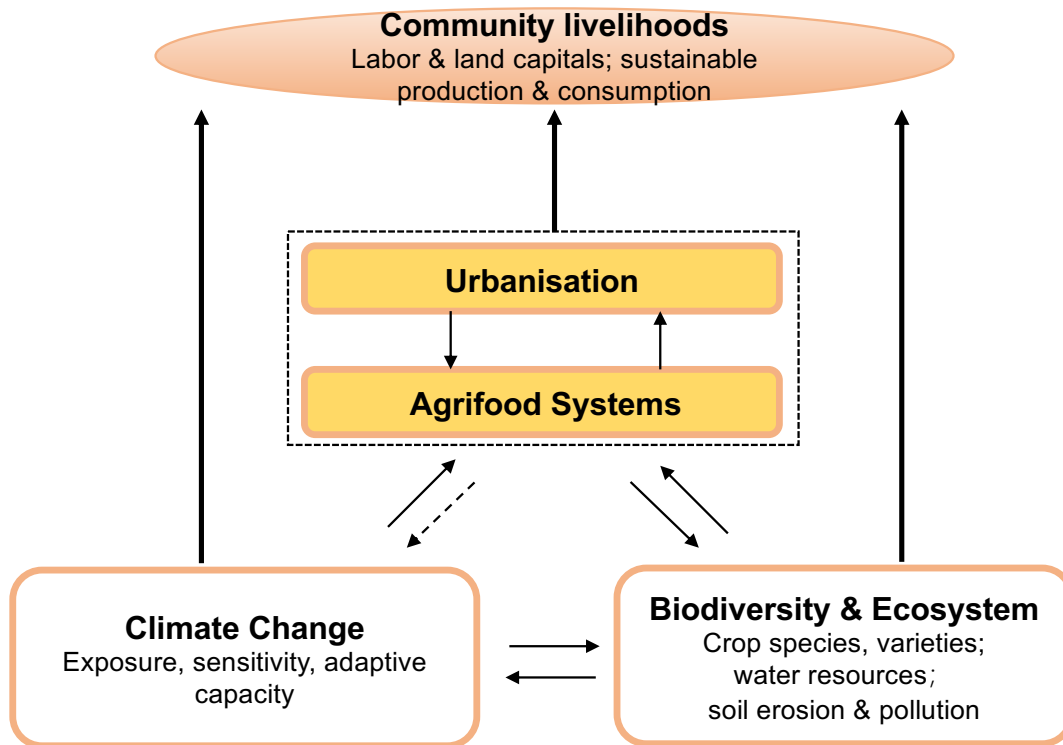
- **Off-farm employment, food production and related carbon emissions**
- **Off-farm employment and dietary diversity**
- **Off-farm employment, diet structure and related carbon footprint**

3

Implications

Nexus approaches to enhancing agri-food systems resilience in urbanisation

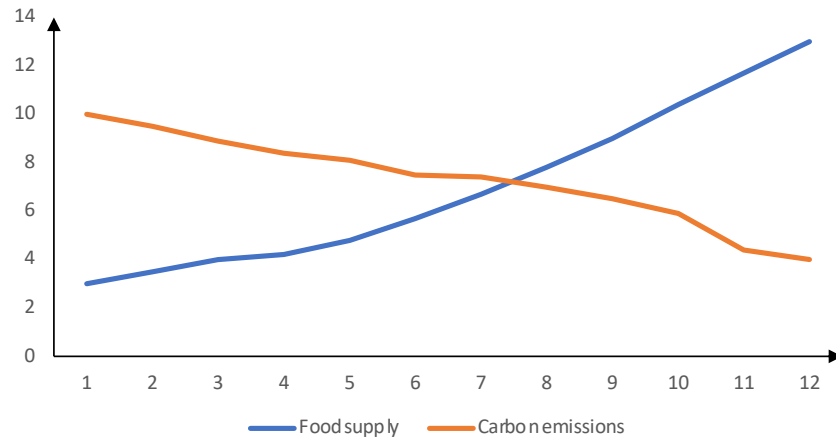
How to do it?



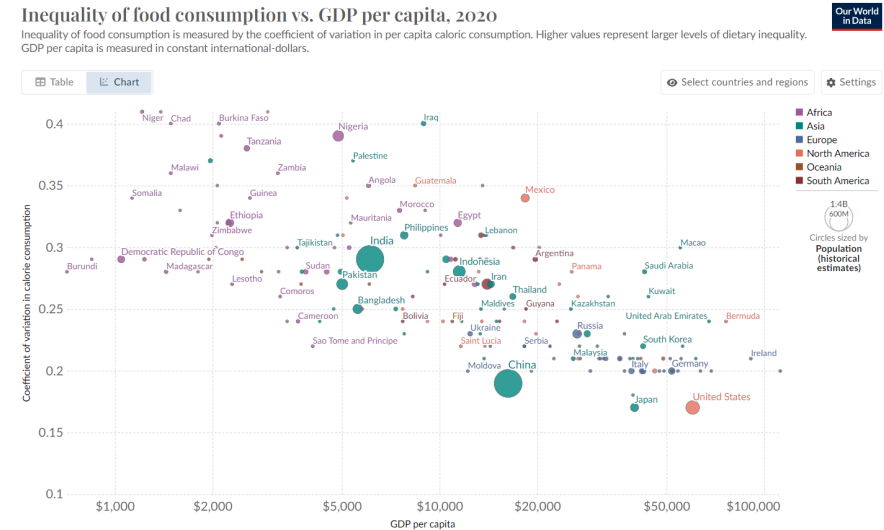
- **System thinking and nexus approach for multi-benefits**
- Enhance the **interactions and interlinks** between urban and rural areas, agricultural and non-agricultural sectors
- Consider **economic, environmental and nutritional** aspects in agrifood system transition
- Sustainable and environmentally friendly **food supply chain**
- Improve the **inclusiveness** in the urbanisation considering diet inequalities

Decouple of food supply and environmental impact and reducing inequalities

Diagram of food supply and carbon footprint change



- Urbanisation trigger more food demand due to **more population** and **nutrition improvement**;
- **Land productivity improvement** is greatly needed to meet the needs of citizens;
- **Decoupling** of **food supply** and **carbon emissions** is essential;
- More **environmental perspectives** are needed, including **pollutions** and **biodiversity loss**.



- More people rely on food on **market** in urbanized society;
- The poor spent **more of their income** on food and the possibility of **imbalanced diet** is higher for them;
- The inequality issue in **developing countries** is even worse than developed economies;
- Pay more attention to and **addressing sustainable food supply** for the poor.

Emerging forms of agricultural practices in urban areas



Urban agriculture is a local food system of growing plants and raising livestock in and around cities, as opposed to traditional rural areas.

Benefits

- Increases **Food Security**
- Creates a Sense of **Belonging**
- Produces **Healthy Food** You Can Respect
- Provides a **Learning Opportunity**
- Makes **Efficient Use of Land**
- **Entertainment** functions
-

Challenges

- **Law and institutional** regulations
- Unsuitable **conditions** (sunlight, soil, humidity, pests, wildlife)
- Food **processing difficulties** including storing
- **Health risks** (polluted water, use of agrochemicals)
- **Compete for land** with other purposes (PV panels)
-

<https://borgenproject.org/tag/urban-farming/>

<https://www.powerhousehydroponics.com/5-benefits-of-urban-farming/>

Thank you!

<http://www.unep-iemp.org>

Linxiu Zhang
Director of UNEP-IEMP
linxiu.zhang@un.org

UN Environment Programme-International Ecosystem Management Partnership (UNEP-IEMP)
c/o: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A
Datun Road, Chaoyang District, Beijing 100101, china