Food, Agriculture, and Nutrition in South Asia

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BUILDING HEALTHY, SUSTAINABLE FOOD SYSTEMS

Tata-Cornell Institute for Agriculture and Nutrition
CORNELL UNIVERSITY | COLLEGE OF AGRICULTURE AND LIFE SCIENCES

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Food, Agriculture, and Nutrition in South Asia

FOREWORD

I am pleased to present this report—the third in the Tata–Cornell Institute's series on Food, Agriculture, and Nutrition. Although the initial report focused solely on India, and a follow-up report focused on the Indian state of Bihar, this latest publication takes a broader look at South Asia, examining trends in nutrition, agriculture, and food consumption across eight countries in the region, offering insights into the causes of widespread malnutrition and possible remedies.

The report, however comprehensive, does not aim to answer all questions related to South Asian food systems. There is no silver bullet for malnutrition, no set of policy prescriptions that, if implemented, will solve every problem in every country. Rather, the report is intended to spark debate among experts in academia and the policy world. I hope that it inspires research questions that enterprising young researchers will take on, contributing some progress in the fight against malnutrition in the region.

As we make clear in the report, food systems are immensely complex, and any policy interventions designed to improve nutrition outcomes cannot be made in isolation, but rather with consideration for the food system as a whole. Siloed decision-making leads to unintended consequences. This is true in government, in the development community, and in academia.

Because the issues afflicting food systems in South Asia are so complicated, they cannot be solved by individual entities alone. Malnutrition and the trends causing it do not often follow borders and administrative boundaries. Different countries, states, and localities may face common issues, and thus, can learn from one another. Effectively addressing malnutrition will require cooperation and alignment of activities on local, national, and international levels.

For both policymakers and researchers, timely and accurate data are crucial for understanding trends and charting the success or failure of a given policy. In South Asia, this report shows that such data are often unavailable for important nutrition-related indicators. This failing must be addressed in order to pave the way for effective policies.

Finally, as this report examines agricultural trends across South Asia, a significant amount of attention is given to the relationship between agriculture and the environment. In the medium- to long-term, the two can either strengthen or undermine each other. Farming is a significant contributor to greenhouse gas emissions causing climate change. At the same time, the impacts of climate change, such as increased extreme weather events like floods and droughts, pose threats to agricultural productivity. In any comprehensive effort to reform food systems so as to improve nutrition outcomes, the mitigating of emissions and increasing the resilience of the agricultural sector to a changing climate must be priorities.

I hope that you find this report useful and thought-provoking, and that it spurs productive conversations about the future of food systems in South Asia.

Prabhu Pingali
Director, Tata–Cornell Institute

EXECUTIVE SUMMARY

After 14 years of decline, hunger has been rising in South Asia (SA) since 2018.[1] The share of undernourished people increased from 12 percent in 2018 to 17 percent in 2021. In other words, the three-year increase in hunger wiped out 14 years of progress. The latest data has yet to be released, but there are no indications that the negative trend was reversed in 2022. Although the direct consequences of the COVID-19 pandemic were not as severe as in 2020 and 2021, in 2022, there were other crises—a war in Ukraine, floods in parts of SA, and policy failure in Sri Lanka. These acute events, coupled with continuous challenges caused by climate change, suggest that hunger data in 2022 will remain unchanged from the previous two years, at best. On the other hand, global efforts to curb hunger and other forms of malnutrition in SA and throughout the world have achieved unprecedented levels, with the UN Decade of Action on Nutrition only one part of these efforts. However, it is very likely that Sustainable Development Goal (SDG) 2—zero hunger—will not be met by 2030. Outside of the nutrition and development community, there is insufficient awareness that it takes years, if not decades, to reduce the prevalence of undernutrition, and it takes only two bad harvests, coupled with continuous climate extremes, and another large-scale, erratic challenge—such as a pandemic or conflict—to eliminate progress and cancel all efforts in reducing undernutrition.

At the same time, the prevalence of overweight and obesity is also on the rise in SA and throughout the world. In SA, overweight prevalence more than doubled between 1990 and 2016. Although the average prevalence of overweight among the adult population and among children under 5 is still half of the global value, it is notable that some countries in SA are outliers. Under 5 overweight prevalence in Bhutan has surpassed global levels, while the value in Maldives has approached the global average. As for overweight in adults, the prevalence in Maldives and Pakistan is accelerating at a high rate and may soon catch up with the global level.

In the past, SA mainly focused on hunger elimination, and great progress has been made. Yet, a proportion of the population has remained hungry despite various policy interventions and advances along the food chain. In the 21st century, in addition to undernourishment issues, SA needs to deal with obesity and micronutrient deficiency. Finally, global trends, such as urbanization, global trade, and climate change, with substantial impacts on nutritional outcomes, are part of the equation. Therefore, it has become clear that purely increasing food production is insufficient, and a new approach and policy instruments are needed. To create the new policy instruments, a deeper understanding of direct and underlying forces behind malnutrition is needed. Credible and timely data, which would enable deeper understanding of the incidence of malnutrition, is also missing; hence, additional resources are needed for data collection and analysis.

Although each country in SA is unique, there are numerous similarities with respect to agriculture, consumption patterns, and malnutrition outcomes. Some adjacent regions and districts in different countries have more in common than they have with regions within their respective countries. Best practices, effective policy instruments, successful stories, findings, knowledge, and even resources could be shared among countries in SA. Malnutrition, climate change, and pandemics know no administrative boundaries and should be addressed as such.

In this report, we examine why it is so difficult to end hunger and to halt obesity trends, what the appropriate lenses are to look at this problem, what the potential solutions are, and who should lead and who should support efforts to end malnutrition-related challenges. We analyze the food–agriculture–nutrition nexus by looking at the elements separately, and also, at their connections. Given that the region contains one-fourth of the world's population and that nutrition indicators, such as stunting, wasting, undernourishment, and micronutrient deficiency, are higher or nearly as high as in any other global region, its suggests that an appropriate approach to addressing malnutrition in SA could lead to substantial improvement on a global level.

The report is structured as follows:

The **first section** contains a snapshot of the current global malnutrition picture and SA's position within it. This section aims to facilitate easier navigation through the rest of the report, as it defines frequently used terms. Direct and underlying causes of malnutrition are also discussed. Finally, it sheds light on global food systems challenges and explores the interaction between food, agriculture, and nutrition.

The **second section** explores **nutritional outcomes** in SA and provides comparisons between South Asian countries. Causes, consequences, and policy interventions to address stunting, wasting, micronutrient deficiency, and obesity are discussed here.

[1] In this report, South Asia region refers to the area that includes Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

The **third section** analyzes **food consumption** in SA, examining the main challenges related to measurement techniques, data collection, and analysis. We present the main sources of calories in each country and explore the **nutrition transition (NT)** and its main drivers in the South Asian context. To that end, macro drivers such as urbanization, food distribution and sales, and the globalization of food trade are analyzed.

In the **fourth section,** we examine **agricultural trends** and their drivers in SA. Among other issues, we explore the role of agriculture in South Asian economies, measured by share in GDP and employment, land and labor productivity, and other indicators. Additionally, we present the main characteristics of agriculture, such as average farm size, irrigation intensity, and use of farm machinery, as well as the application of fertilizers and pesticides. We also look at cropping patterns and livestock production. A significant portion of this section is dedicated to the relationship between **agriculture and the environment.** We present findings on the effects of agriculture on land, water, and air, in addition to the relationship between those effects and nutrition and poverty. We also explore the main sources of greenhouse gas emissions from agriculture and potential mitigation measures.

In the **fifth section,** we propose **policy instruments** that could help, directly or indirectly, to address malnutrition challenges in SA. To enable easier navigation through the policy instruments, we group them by the phase of the food supply chain: production, processing, transport, retail, and consumption. We also provide the dimensions that policymakers should consider in deciding whether to implement an instrument.

Key messages of this report are:

1. **Policy interventions developed in isolation from other areas that they can affect directly or indirectly, often lead to trade-offs among those policies and unintended consequences.**

We present connections between food, agriculture, and nutrition, and we see that these three elements affect each other directly and indirectly. Most of the direct connections have already been widely studied, while the indirect connections are often insufficiently investigated and subject to disagreement. Therefore, policy instruments that rely on the existing studies often focus on the research within one of these three elements, or at best focus on the direct connections between them. The latter are typically narrow, in that they do not account for negative externalities. Addressing this issue must include analysis of unintended consequences.

2. **To create robust policy interventions, all necessary "ingredients" must be secured.**

Knowledge and deep understanding of a given area are necessary preconditions for any policy instrument, including knowledge of how the area is connected to others. To reach that ideal, researchers must be open to the idea that their findings are just a part of a larger picture.

To obtain the necessary knowledge, quantitative and qualitative research, backed with **credible and timely data**, must be in place. Currently, there is a significant lack of credible data in South Asia, and sometimes, data are nonexistent.

Finally, with knowledge, research, data, and respective results clearly communicated, it is necessary for **institutions** to be capable of implementing proposed interventions and to be able to work together with various stakeholders and interest groups, rather than working for them. Policy institutions on global, national, and local levels must be equipped with sufficient capacities.

3. **The current food–agriculture–nutrition challenges are too complex for any single entity (country, institution, research area, individual) to tackle alone.**

The food system, as a system of connections between all elements along and around the food chain, has been well defined. There is no single entity that has a monopoly over food systems and the issues facing them. Although it is argued that all participants in a food system must work together to change it and make it sustainable, the reality is often the opposite—each entity promotes only its own interests. Some conflicting interests can be resolved—interests of individuals, companies, and even research areas. National interests, on the other hand. have proven to be "untouchable;" it is unclear whether this situation can change. Without the alignment of the activities of entities on local, national, and international levels, it is not possible to reach food system sustainability.

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ABBREVIATIONS

AMR – Antimicrobial resistance
BMI – Body mass index
BPI – Biofortification Priority Index
CH_4 – Methane
CO2 eq – Carbon dioxide equivalent
COP – Conference of the Parties
CVD – Cardiovascular disease
DALY – Disability-adjusted life-years
DAP – Diammonium phosphate
DDS – Dietary Diversity Score
DHS – Demographic and Health Surveys
DQI – Diet Quality Index
DQI-I – Diet Quality Index – International
DQ-Q – Diet quality questionnaires
EED – Environmental enteric dysfunction
F&V – Fruits and vegetables
FAO – UN Food and Agriculture Organization
FBDG – Food-based dietary guidelines
FBS – FAO Food Balance Sheets
FPO – Farmer producer organization
FSA – Food Standards Agency (UK)
FSS – Food Systems Summit
GBD – Global Burden of Disease
GDD – Global Dietary Database
GDP – Gross domestic product
GDQS – Global Diet Quality Score
GHG – Greenhouse gas
GLEAM – Global Livestock Assessment Model (FAO)
HEI – Healthy Eating Index
HIC – High-income countries
HLPE – High Level Panel of Experts
HYV – High-yield varieties
IFPRI – International Food Policy Research Institute
IHME – Institute for Health Metrics and Evaluation
IPCC – Intergovernmental Panel on Climate Change
ITC – International Trade Centre
IYCF – Infant and Young Children Feeding
LDL – Low-density lipoprotein
LMIC – Low- and middle-income countries
LIC – Low-income countries
LSU – Livestock unit
MDD – Minimum Dietary Diversity Score
MDMS – Mid Day Meal Scheme, India
MIC – Middle-income countries
MINI – Multisectoral Indicators for Nutritional Improvement
MOP – Muriate of phosphate
N_2O – Nitrous oxide
N4G – Nutrition for Growth
NCD – Noncommunicable diseases
NT – Nutrition transition
OPHI – Oxford Poverty and Human Development Initiative
PDS – Public Distribution System, India
PoU – Prevalence of undernourishment
SA – South Asia
SDG – Sustainable Development Goal
SDIL – Soft drinks industry levy
SEEA – System of Environmental Economic Accounting
SNAP – Supplemental Nutrition Assistance Program, United States
SOFA – State of Food and Agriculture
SSB – Sugar-sweetened beverages
SUA – Supply and utilization accounts
TFP – Total factor productivity
UMIC – Upper middle-income countries
UNFCCC – United Nations Framework Convention on Climate Change
UNICEF – United Nations Children's Fund
UPF – Ultra-processed foods
USAID – United States Agency for International Development
USDA – United States Department of Agriculture
VAD – Vitamin A deficiency
WASH – Water, sanitation, and hygiene
WEAI – Women's Empowerment in Agriculture Index
WFP – World Food Programme
WHO – World Health Organization
WIC – Special Supplemental Nutrition Program for Women, Infants, and Children, United States
WTO – World Trade Organization

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1 Malnutrition in South Asia—A Global Perspective

While the prevalence of overweight and obesity in South Asia is getting more and more attention, we should not forget that South Asia hosts around 300 million undernourished people.

Mothers bring their children to be weighed at a clinic in Kolkata, India. *(Photo by Kakoli Dey/Shutterstock)*

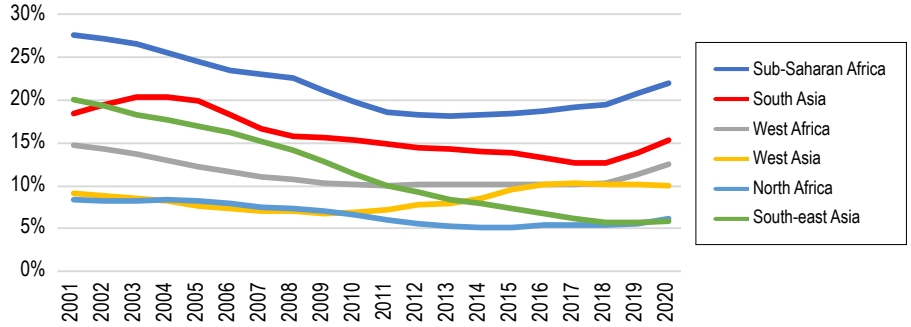
1.1 Malnutrition Trends and Level of Analysis

Compared to other global regions, undernourishment rates and micronutrient deficiency in South Asia (SA) are either the highest, or the second highest, while the prevalence of overweight and obesity is still lagging (Figures 1.1–1.3).

Malnutrition data suggest that the prevalence of undernourishment in global regions has a volatile trend, while overweight and anemia trends are relatively stable. Furthermore, the slope of overweight trends is very similar across the regions. While the regional average prevalence of overweight in SA is half the world average, which is almost 40 percent, the Maldives, Bhutan, and Pakistan have prevalence around or over 30 percent. Regional trends hide differences within SA. With respect to undernourishment and micronutrient deficiency indicators in SA, significant improvements have been made in the past several decades. However, in the last 10 years, these positive trends have either slowed down, plateaued, or even reversed in some cases. The trends are elaborated in Section 2: "Nutrition in South Asia." Various factors drive the trends, and the most recent events are described in Box 1. 1.

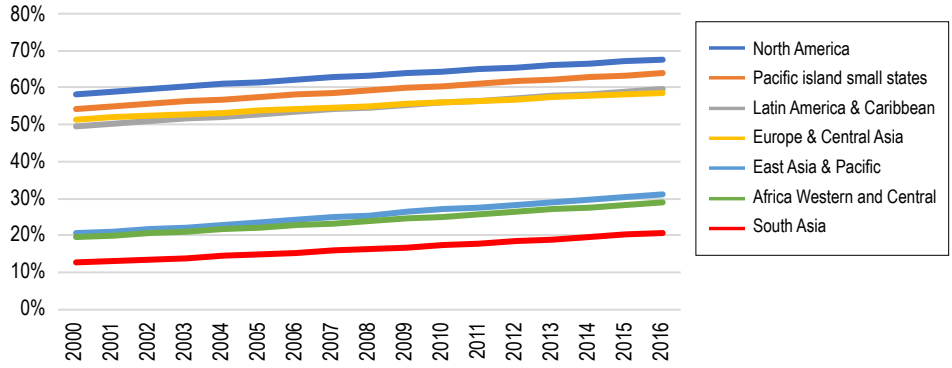
Global, regional, country, and local food consumption and associated nutrition trends can be used for approximation and illustrative purposes to reveal patterns. However, for detailed analysis, nationally representative nutrition surveys or census data should be used. Food consumption and the respective nutritional outcomes depend on many direct and indirect factors. However, consumption is ultimately an individual act; hence, the most appropriate way to look at and analyze outcomes is on an individual level. Even a household perspective on food consumption patterns may be misleading, due to intrahousehold food (mis)allocation.

Figure 1.1 | Regional prevalence of undernourishment, 2000–2019 (3-year average)



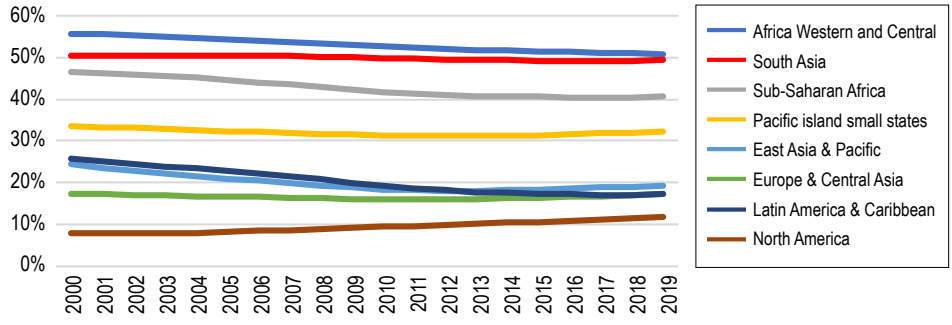
Data source: FAOstat

Figure 1.2 | Regional prevalence of overweight, 2000–2016



Data source: World Bank

Figure 1.3 | Regional prevalence of anemia among women, 2000–2019



Data source: World Bank

Box 1.1 | FOOD INSECURITY IN SOUTH ASIA

Food security in SA has not only been affected by recent developments in the region, but also by events in other countries, such as the war in Ukraine. This box presents major events in Afghanistan, Sri Lanka, and Pakistan that have affected and still affect food security; it also emphasizes the importance of resilient food systems.

A farmer tends his field in the Swat Valley, Pakistan. *(Photo by AMRUL AZUAR MOKHTAR/Shutterstock)*

Afghanistan is currently confronting instability and security issues that arose after the Taliban took control in August 2021, causing disruptions in food supply chains and an overall downturn of the economy. Sanctions imposed by the international community further pushed the country into isolation and caused international development projects to be halted overnight, in the midst of a global pandemic. Finally, adverse climate conditions culminated in a severe drought in 2021. Combined, all these factors exacerbated food shortages caused by lower wheat production and contributed to a rise in food prices, in general. Hence, the number of those experiencing acute hunger increased from 14 million in July 2021 to 23 million in March 2022 (60 percent of the total population), while 95 percent of the population is not eating an adequate amount of food.[a]

Sri Lanka has made substantial progress in the past two decades in economic development and food security. The prevalence of undernourishment has decreased from 16.5 percent in 2001 to 3.5 percent in 2020, while the gross domestic product (GDP) increased from US$15 billion to US$80 billion (current US$) in the same period. However, a combination of the COVID-19 pandemic, policy decisions, and political instability threatens to reverse this progress. According to the World Food Programme (WFP), nearly 30 percent of the population were food insecure in June 2022, while almost 90 percent of families eat less and buy cheaper less nutritious food.[b] One of the main reasons is consumer inflation, which was 70 percent in August 2022 (year-on-year), when food prices soared 85 percent. The rise in food prices was caused, to an extent, by the 2021 ban on imported chemical fertilizers. According to official sources, the ban was introduced to make farmers immediately switch to "organic production." Irrespective of whether the policy instrument was meant to increase organic production, or organic production was just an excuse to try to improve balance of payments, the ban led to a decrease of the 2021–22 maha rice crop yield by more than 30 percent, compared to the 10-year average, and of the 2022 yala crop by almost 30 percent.[c] Additionally, maize production is forecast to be 60 percent lower in 2022 than in 2021.[d]

[a] UN (2022), https://news.un.org/en/story/2022/03/1113982
[b] WFP (2023), https://www.wfp.org/countries/sri-lanka

Pakistan experienced heavy rains during the 2022 monsoon season, resulting in flooding in a third of the country. Some areas received five times more rainfall than the 30-year average. Two million acres under crops were affected, and 800,000 animals died. Furthermore, damaged roads and bridges are causing disruptions in supply chains. Sindh province, which was the worst affected, produces around a quarter of the country's agricultural produce. Together, these factors resulted in 30-percent food inflation (year-on-year); the price of onions, a major ingredient in meal preparation, increased 40 percent. Humanitarian aid has been implemented through the WFP, yet it is still unclear whether India will become directly involved in improving food supplies. From a practical and logistical perspective, India would be a natural partner, as it is a neighboring country with sufficient food supplies, particularly, perishable foods. From a political perspective, however, the situation is not as straightforward. Due to inflamed tensions around disputed areas, starting in August 2019, trade has been reduced significantly, and Pakistan is hesitant to ask India for help.

In addition to these three country-specific examples, armed conflict in Ukraine had a profound impact on global food availability, directly and indirectly. Cereal production in Ukraine, one of the largest global exporters, is estimated to decrease substantially—wheat by 40 percent, corn by 30 percent, and barley by 35 percent. Although some countries will increase and some decrease wheat production in 2022–23, the world will have 7.4 mt less wheat than in the previous year.[e] Fertilizer production has been negatively affected, too, leading to a sharp increase in prices. Diammonium phosphate (DAP), urea and muriate of potash (MOP) were between US$/mt 215 and mt 265 on January 1, 2020.[f] On April 1, 2022, MOP was US$/mt 562, urea was US$/mt 925, and DAO was US$/mt 954. While the price increases started before the conflict, they were certainly accelerated by it.

The sharp increases led to lower fertilizer usage and an increase in the price of cereals, as significant determinants of cost of production. More worrisome, some countries imposed cereal export bans, further limiting global availability of cereals, and consequently, pushing up prices even more. One of those countries was India, a major exporter of wheat in SA. Due to the complex international situation previously described, Afghanistan, Pakistan, and Sri Lanka will need to spend even more resources to improve food and nutrition security.

The examples show that food system resilience is a very important element, without which the number of food insecure people can soar within days. (The theoretical background behind resilience and some examples can be found in Box 2.2.) Long-term interventions to improve resilience are critical for achieving food and nutrition security. Some of the interventions are large irrigation or other infrastructure projects to prevent the flooding of houses and agricultural lands; positioning of sufficient grain stocks close to areas prone to natural disasters; educational programs to help farmers become less dependent on chemical inputs; and structural transformation of agriculture-driven economies. The changes should be synchronized with the change of cropping structure, so more nutritious crops could be grown in some areas now under staples. In addition, political stability and a suitable "business environment" for domestic and foreign direct investments is a very important determinant of resilience. To successfully implement these interventions, market integration, physical and institutional infrastructure, and human capacities must be improved. Although achievable, it would take years, if not decades, to reach goals. There are also short-term interventions, such as increased use of high-yield varieties (HYV); wider production of crops and breeds that are more resilient to climate extremes while having better nutritional characteristics; and better developed early warning systems to assist governmental preparation for natural disasters . In the three countries cited here, food availability appears to be the ultimate problem. To address this issue, the countries would either need to increase domestic production or work on comprehensive free trade agreements, particularly with neighboring countries. The agreements should favor nutrient-dense foods.

[c] Sri Lanka department of Census and Statistics, http://www.statistics.gov.lk/Agriculture/StaticalInformation/rubpaddy
[d] FAO, https://www.fao.org/giews/countrybrief/country.jsp?code=LKA&lang=AR)
[e] Colussi et al. (2022)
[f] Baffes and Koh (2022)

Intrahousehold food distribution shows whether all household members have equal access to food available to the household, or whether some household members have priority over others. In the State of Food Security and Nutrition in Bangladesh 2015 report, coping strategies of household members in food insecure households were analyzed. Coping strategies included: eating only rice, having smaller meals, skipping meals, or sleeping hungry. The report posits that female adults pay the highest price. On average, twice as many females had to resort to one of the strategies, compared to their male counterparts. Breakdown by number of household members who sacrificed in food insecure times reveals an even starker contrast—when only one household member sacrificed, regardless of the coping strategy, it was almost exclusively an adult woman in the household who suffered.[2] Therefore, household-level surveys, which might hide intrahousehold allocation, can be misleading.

While the individual-level approach is often the recommended level of analysis, reality dictates different tactics. For logistical and very often financial reasons, researchers rely on various methodologies that are much simpler and more affordable to implement, but still manage to capture most of the reality on the ground, with respect to food systems components. While certainly useful, it is critical for South Asian countries to perform nationally representative surveys, executed by properly trained and adequately compensated field agents.

1.2 The Malnutrition Puzzle

With hunger persisting and even increasing in some South Asian countries, SA also failed to address micronutrient deficiency. The prudent question to ask is why it is so difficult to eradicate hunger, given that available technology, advances in science, and increases in GDP would suggest otherwise? Are making larger investments all that stands between the current situation and tackling malnutrition? Is undernourishment caused by lack of food, or lack of access to food? Does hunger fall into the wicked problem category, implying that it is very difficult to be solved, as the problem is constantly evolving or it is too complex to be grasped?

One explanation why hunger and other forms of malnourishment present a persistent challenge is that they are often perceived in isolation from the underlying issues that drive them. Applying a more holistic approach might be useful. In the public health sphere, the One Health approach, based on systems thinking, looks at interconnections between people, animals, plants, and their shared environment from local, regional, national, and global perspectives. Food systems have already been recognized as a set of connections between and around food value chain stakeholders and their environment. Detailed conceptual framework of food systems has been analyzed by the High Level Panel of Experts (HLPE) on Food Security and Nutrition of the Committee on World Food Security (CFS).[3] The food system concept has been heavily promoted and widely discussed at all major global events, including at the 2022 United Nations Climate Change Conference, also known as the Conference of the Parties (COP27) in Egypt. Also, the UN Food Systems Summit was organized as a part of the UN General Assembly in 2021. Promotion of the "Food Systems" narrative in mainstream media, global events, and among a wide range of stakeholders is an impressive step forward for the food–agriculture–nutrition community. One might argue that there is no need to reinvent a "One Food System" approach. However, that position blurs the line between food and nutrition. The reality is that individuals who are food secure may still suffer from malnourishment, but those who are well nourished are food secure. To make sure that malnutrition is systematically addressed, the narrative should move from food

[2] James P Grant School of Public Health and National Nutrition Services (2016)

[3] High Level Panel of Experts (2017)

to nutrition, and from food security to nutrition security. To reach that goal, the "One Nutrition" approach should be gently introduced. There is an abundance of knowledge and understanding that could feed into "One Nutrition," and even if incomplete, should and could be translated into practice. As the "Food System" narrative has gained traction on a global scale, it could be confusing to abruptly introduce a new concept such as "One Nutrition." Instead, a gradual transition would be a preferred option.

As noted earlier, lack of a holistic approach could be one of the main reasons why malnourishment remains a persistent challenge. A siloed approach, the opposite of a holistic approach, is unfortunately dominating the current policy arena, and there are at least two main explanations for this emphasis.

The first reason is a lack of human capacities and insufficient understanding among the policymakers about the driving forces behind malnourishment trends. Continuous capacity building can address this shortcoming.

The second explanation is more challenging to resolve and is related to the operating mechanism of policymaking structure. Namely, each government, either at a central or a local level, aims to stay in power for as long as possible. To do so, they must serve different, very often conflicting interests. They should protect the well-being of their citizens, attract and keep private sector investors, and adhere to various international laws and conventions. Furthermore, in economies where agriculture plays a significant role, governments tend to appease groups of farmers who can otherwise mobilize masses to cause large-scale protests. Additionally, hunger in urban areas can also cause mass demonstrations and street riots, while micronutrient deficiency in urban areas has rarely caused anything more than a journal article. In other words, governments must carefully navigate between these groups and their interests. Additionally, some policy interventions are designed to address "burning issues," and those are also characterized as "bandage solutions."[4] Other interventions, which fundamentally cause structural changes, are meant to be of a mid- or long-term character. When the later are implemented properly, the results are visible in 2, 5, or 10 years, and results from any such intervention "risk" being claimed by the next administration. Balancing short-, medium-, and long-term interventions is as important as balancing the interests of different groups.

In addition to using the current knowledge found in academic research, as well as generating new knowledge, tackling food and nutrition systems challenges requires area experts to recognize, understand, and accept the importance of the expertise of other areas, and to understand that a solution in one area that creates a problem in another area is not a solution. Lack of a more integrated approach can and does lead to unintended consequences—trade-offs between different policy interventions. Area experts cannot be expected to excel in all food and nutrition systems elements; to understand the role of their research within the wider framework and the effects of their research on other parts of the system. Finally, experts should share their knowledge and jointly offer new solutions. If applied correctly, such an approach would facilitate synergies among different subject areas and policy instruments, minimizing the trade-offs among them.

In addition to how to look at undernourishment, it is important to know where to look at it. Hunger and undernutrition are traditionally perceived to be related to food shortage. Therefore, it has been agronomists and other agricultural specialists who have dealt with hunger, as the main assumption was that low crop yields and food production caused hunger. Sometimes, that is the case; yet, very often it is just one piece of a very complex puzzle. Additionally, some of the processes that lead to undernourishment also lead to obesity, which is becoming a leading cause of mortality and disability. Directing resources to tackle overnutrition-related conditions leaves fewer disposable resources for addressing undernourishment.

The inability to tackle malnutrition via higher crop yields facilitated the emergence of a slightly different approach. It has been argued that inequalities in nutrition outcomes are caused by basic determinants, such as the socioeconomic context

[4] Pinstrup-Andersen (2012)

Box 1.2 | MALNUTRITION-RELATED DEFINITIONS

Hunger — An uncomfortable or painful physical sensation caused by insufficient consumption of dietary energy.[a]

Prevalence of Undernourishment (PoU) — An estimate of the adequacy of a population's dietary energy, based on food availability, food consumption, and energy needs.[b] In other words, it measures the amount of calories consumed against minimum physiological needs. Historically, the Food and Agriculture Organization of the United Nations (FAO) has used PoU as a measure of hunger.

Food Security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[c] When food security does not exist, there can be moderate or severe food insecurity, which is based on the Food Insecurity Experience Scale. In addition to the traditional four elements of food security—food availability, access, utilization, and stability—recent efforts added two more components—agency and sustainability.[d]

Stunting — Impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is more than 2 standard deviations below the WHO Child Growth Standards median.[e] Stunting is often seen as an indicator of chronic hunger.

Wasting — Low weight-for-height. It often indicates recent and severe weight loss, although it can also persist for a long time. It usually occurs when a person has not had food of adequate quality and quantity and/or they have had frequent or prolonged illnesses.[f]

Underweight — Low weight-for-age. A child who is underweight may be stunted, wasted, or both.[g]

Micronutrient deficiency — Lack of vitamins and minerals that are vital to healthy development, disease prevention, and well-being. These nutrients are not produced in the body and must be derived from the diet.[h] Some of these are: iron, vitamin A, vitamin D, iodine, folate (vitamin B9), and zinc. Iron deficiency (anemia) is the most common form of micronutrient malnutrition globally.

Famine — Declared when certain levels of mortality, malnutrition, and hunger are reached. The conditions are that at least 20 percent of households in an area face extreme food shortages with a limited ability to cope; acute malnutrition rates exceed 30 percent; and the death rate exceeds 2 persons per day per 10,000 persons.[i]

Malnutrition — Refers to deficiencies or excesses in nutrient intake, imbalance of essential nutrients, or impaired nutrient utilization.[j] Coexistence of undernutrition and overweight is called a double burden of malnutrition, and when it also includes micronutrient deficiency, it is called a triple burden of malnutrition.

Overweight — Refers to an individual's body mass index (BMI) over 25.

Obesity — Refers to an individual's body mass index (BMI) over 30.

[a] FAO (2023b)
[b] FAO (2023c)
[c] FAO (2023c)
[d] HLPE (2020)
[e] WHO (2015)
[f] WHO (2023b)
[g] WHO (2023b)
[h] CDC (2022)
[i] UNHCR (2022)
[j] WHO (2023b)

and underlying social determinants, health care, and the living environment.[5] It has been argued that those determinants can be a source of unfairness, injustice, and social exclusion. Similarly, a study that examined food systems through the perspectives of history and political economy found that the changes within food systems will not be sufficient to address food systems issues, and higher level political and economic change will be necessary.[6] Arguably, the increase in funding should be disproportionally higher in addressing the underlying issues of malnutrition, as that would lead to much needed structural and long-term changes. All this implies that increased investments must be coupled with increased understanding of all the pathways and mechanisms that lead to malnutrition. Unfortunately, neither donors nor states have incentive for this approach, as the results are neither fast nor visible enough.

1.3 The Food–Agriculture–Nutrition Nexus

There is a direct link between agriculture, food consumption patterns, and nutritional outcomes. The strength of this link varies by how agriculture-dependent a population is. Where agriculture plays a substantial role in household activities, income, and food sources, and where producers are not well integrated into the markets, this link is very strong. Additionally, as countries move along the structural transformation pathway, the relationship between production and consumption becomes weaker.[7]

Agriculture is a very broad term. In context of this report, agriculture refers to the type of food produced, cropping patterns, and the breeds or varieties used. Modes of production are also important, including irrigation, input use, scale of operation, and degree of land fragmentation. Equally important is the use of inputs that can help farmers gain higher yields, yet can also negatively affect soil, water, air, and biodiversity, if applied inappropriately.

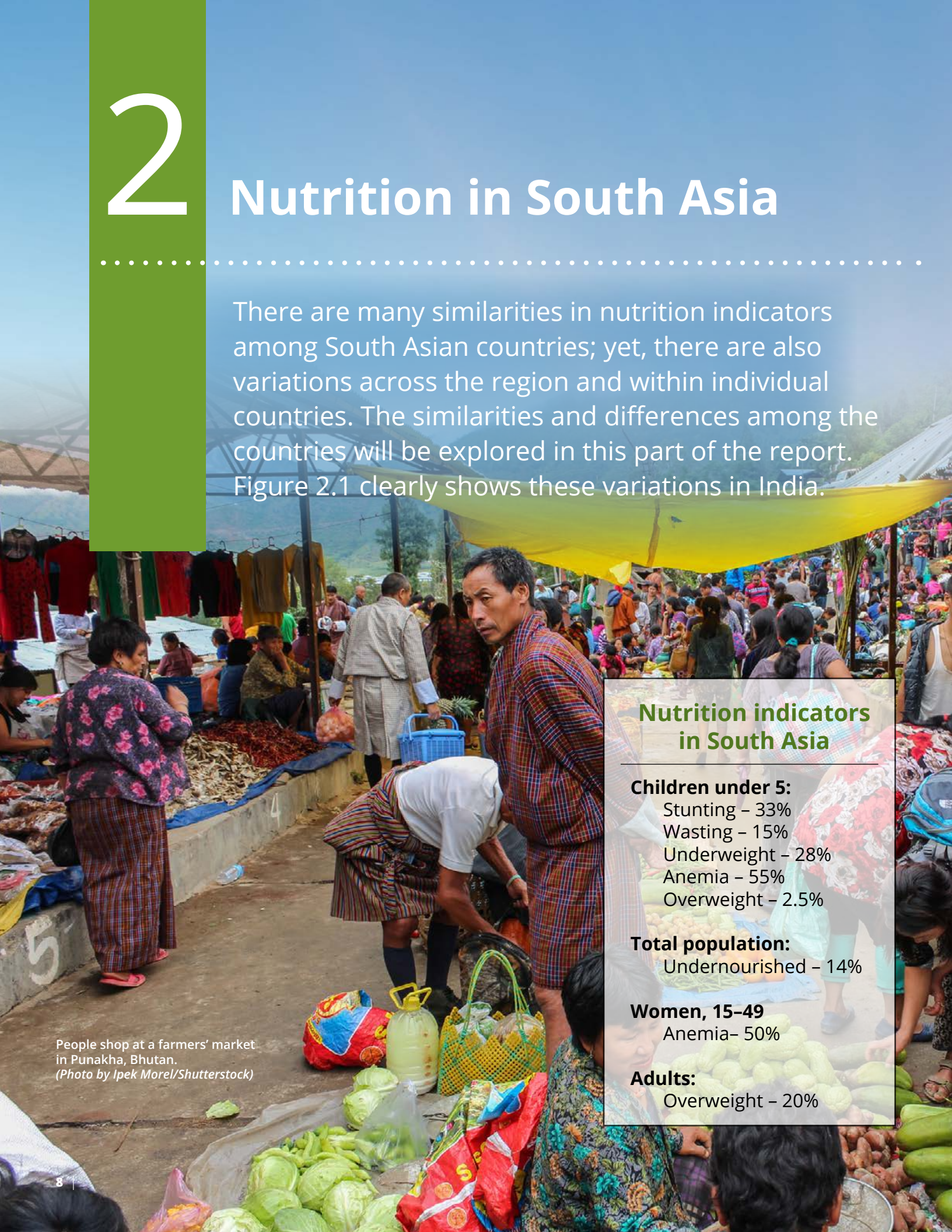
Consumption patterns describe what people eat. The consumption pattern of an individual is influenced by various factors, such as: food availability, accessibility, and affordability; personal preferences; social and cultural norms; intrahousehold dynamics; past experience; current health conditions of individuals or persons close to the individuals; and other factors. From a broader perspective, forces that influence food systems, and consequently, consumption patterns are human rights, international trade and aid policy, global governance, equity, ownership issues, public health, the environment, and others.[8] It can be measured by different metrics, including food records, food frequency questionnaires, and 24-hour recalls. Indicators, such as Minimum Dietary Diversity Score (MDD) and Minimum Meal Frequency, which are based on the three metrics, connect consumption to nutritional outcomes. They are often used to measure feeding practices among children 2–24 months old. The Global Diet Quality Score (GDQS) is a recently developed metric of diet quality, appropriate for use in low- and middle-income countries (LMIC). Although monitoring consumption patterns is important, it is also necessary to take a broader perspective by looking at other household indicators, such as those related to agriculture, which could provide inputs for better targeted priority interventions.[9]

Nutrition outcomes that are directly correlated with consumption patterns and food utilization, and which will be further analyzed in this report, fall under three broad categories: undernutrition, overnutrition, and micronutrient deficiency. Undernutrition can be measured in different ways, such as prevalence of hunger, undernourishment, food insecurity, stunting, wasting, famine, and underweight population. For overnutrition, the indicators include overweight and obesity. Finally, micronutrient deficiency is a separate category, as it can affect both undernourished and overnourished individuals. Some of the deficiencies include anemia, and vitamin A, zinc and iron deficiencies. Countries where all three forms of malnutrition are present, thus, suffer from the triple burden of malnutrition. The relevant definitions are presented in Box 1.2.

[5] Global Nutrition Report (2020)
[6] Giller et al. (2021)
[7] Pingali and Sunder (2017)
[8] Young (2016)
[9] Pingali and Ricketts (2014)

2 Nutrition in South Asia

There are many similarities in nutrition indicators among South Asian countries; yet, there are also variations across the region and within individual countries. The similarities and differences among the countries will be explored in this part of the report. Figure 2.1 clearly shows these variations in India.



People shop at a farmers' market in Punakha, Bhutan.
(Photo by Ipek Morel/Shutterstock)

Nutrition indicators in South Asia

Children under 5:
- Stunting – 33%
- Wasting – 15%
- Underweight – 28%
- Anemia – 55%
- Overweight – 2.5%

Total population:
- Undernourished – 14%

Women, 15–49
- Anemia– 50%

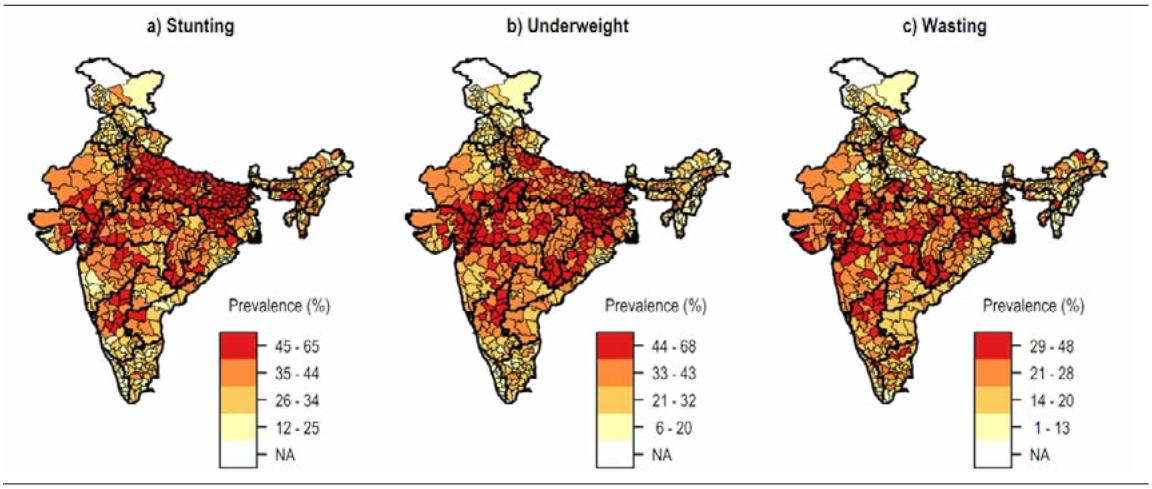
Adults:
- Overweight – 20%

2.1 The State of Nutrition in South Asia

Tackling nutrition issues in SA could significantly contribute to achieving Sustainable Development Goal 2 (SDG2)—zero hunger—on a global level because of the region's population size and scale of malnutrition. SA is currently home to a quarter of the global population. While population growth has slowed in most SA countries and the fertility rate is around 2,[10] in Pakistan and Afghanistan, it is 3.6 and 4.6, respectively. This indicates that further population growth can be expected in these two countries. With respect to nutritional outcomes, SA is the most affected world region in 4 out of 8 categories: "stunting < 5," "wasting < 5," "underweight < 5," and "anemia in women (15–49)."[11] SA is the second most affected region for "anemia < 5" and "undernourishment of total population," scoring slightly better than sub-Saharan Africa (Figure 2.2). More information about the global nutrition targets and national progress are provided in the Annex, Table A.1.

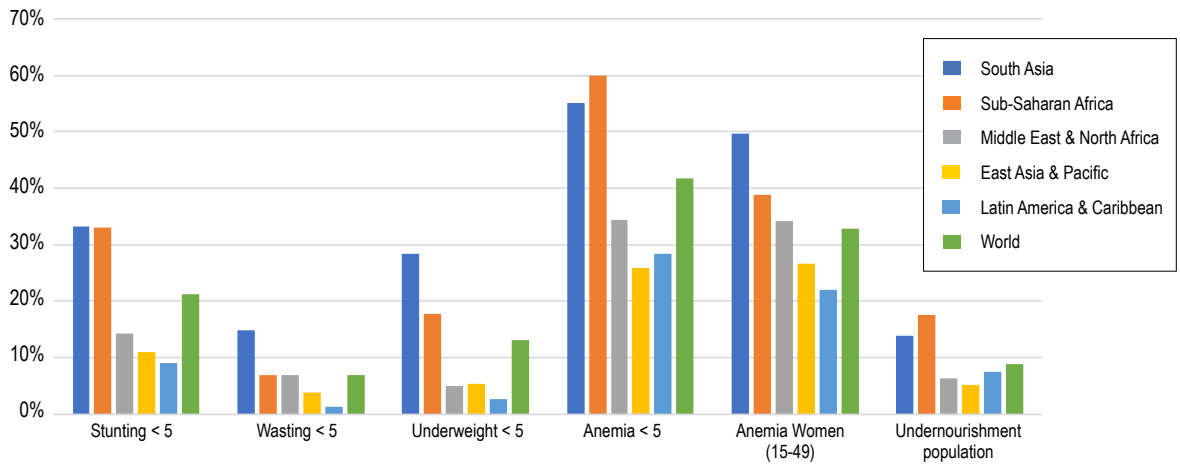
The nutritional outcomes for which SA, as a region, is performing better than the world average, are overweight prevalence in children and in adults. While world overweight prevalence of children < 5 is 5.6 percent, it is 2.5 percent in SA. For adult overweight, it is 39 percent on the world level but only 20 percent in SA. While regional-level data in this respect might appear encouraging, country-level data reveal that the situation is not so optimistic. Overweight prevalence among children < 5 in Bhutan (7.6 percent) is higher than the world average, while in the Maldives, it is very close to the world average. Thus, nutritional outcomes on the aggregate level can serve relatively well when looking at trends and broadly comparing countries and global or local regions. Individual-level data, however, provides the most accurate information for analysis, and therefore, is the most appropriate input for policy and intervention recommendations. The more one moves away from individual-level data toward the aggregate, the more misleading and confusing the results of data analysis can be. Hence, investing in high-resolution surveillance should be one of the top priorities in SA countries.

Figure 2.1 | Prevalence of stunting, underweight and wasting among rural children under 5 in India by district, 2015–16



Source: FAN India (TCI 2020)

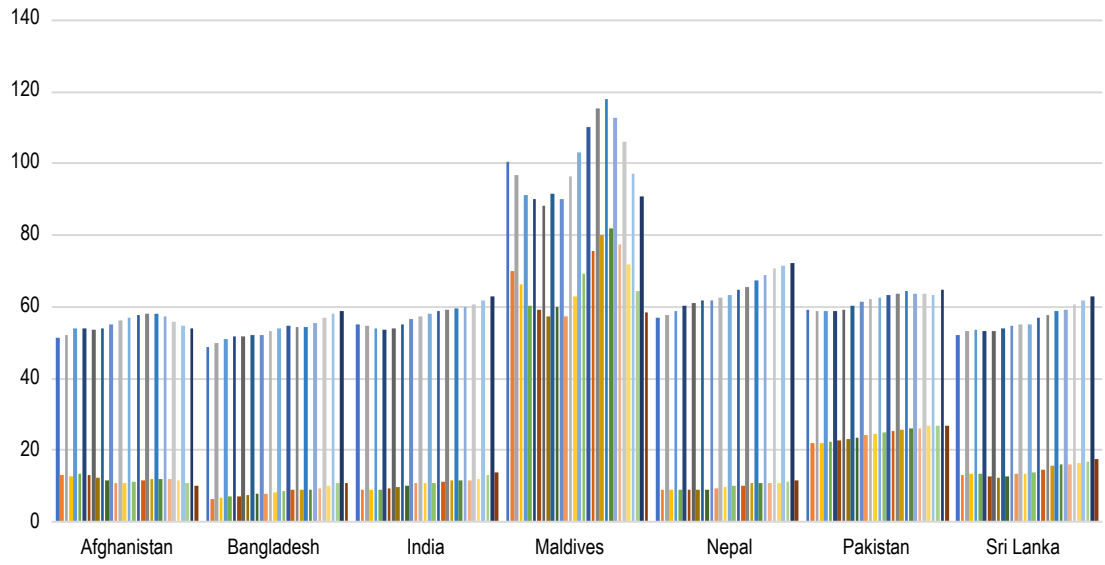
Figure 2.2 | Nutritional outcomes (stunting, wasting, underweight, anemia)—regional level



Data source: World Bank (2023b), World Development Indicators; stunting < 5, wasting < 5, underweight < 5 (2019); anemia < 5 and anemia, women 15–49 (2016); undernourishment population (2018).

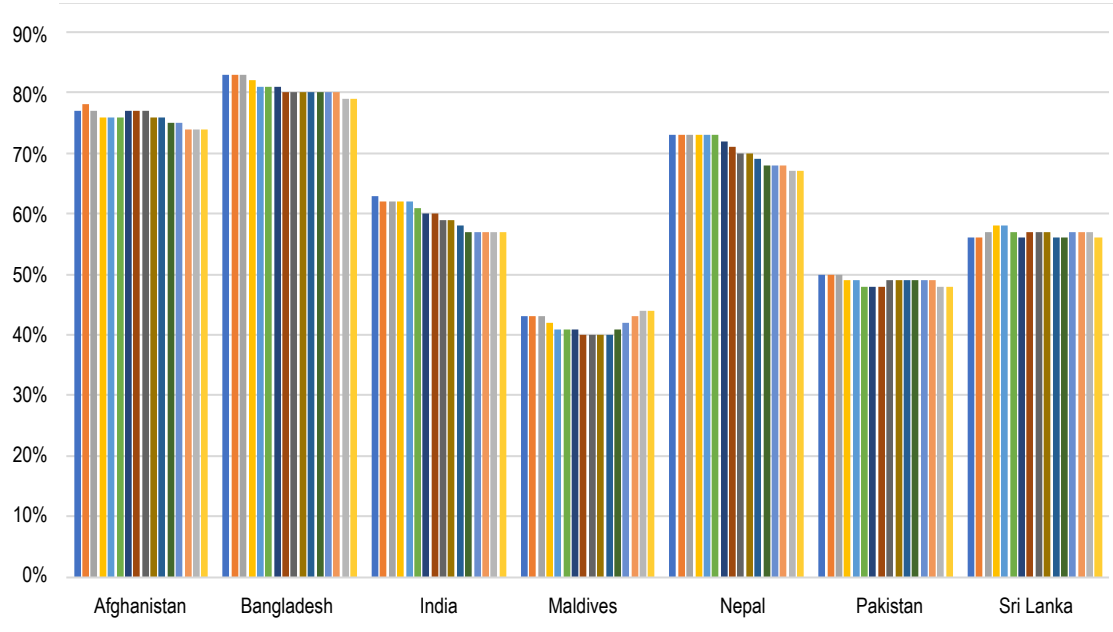
[10] A fertility rate of 2.1 represents a stable population level, where no growth or decline is expected.
[11] Development Initiatives (2023)

Figure 2.3 | Average total protein supply and proteins of animal origin in South Asia (g/cap/day), 2000–2017 (3-year average)



Data source: FAO Stat (2023)
Note: Each bar represents one year; the first bar in each country represents 2000 and the last bar 2017.

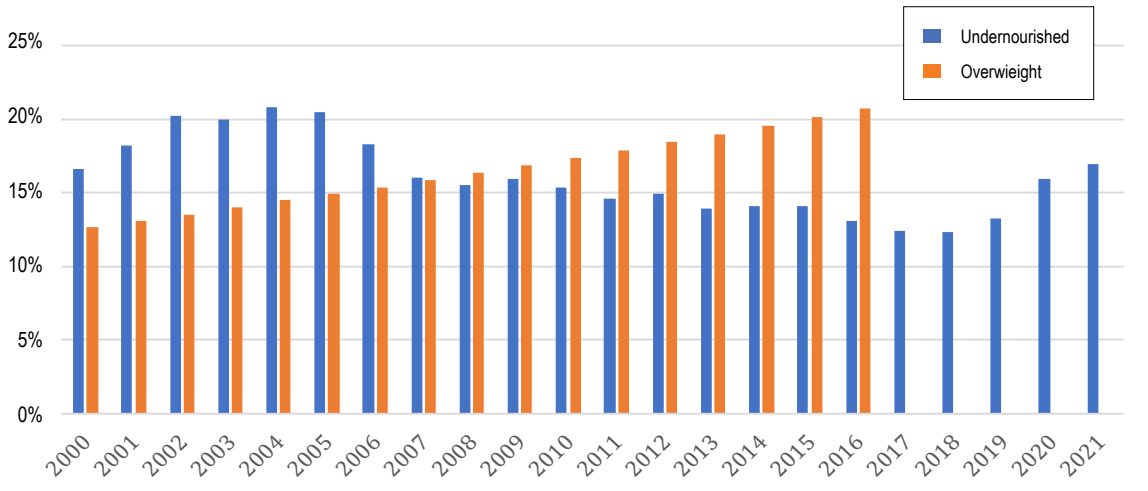
Figure 2.4 | Share of energy from cereals, roots, and tubers in South Asia (kcal/cap/day), 2000–2017 (3-year average)



Data source: FAO Stat (2023)
Note: Each bar represents one year; the first bar in each country represents 2000 and the last bar 2017.

Although food supply and consumption at the regional and national levels have shown a limited change in the past 20 years, changes in nutrition outcomes in SA were more noticeable (Figures 2.3–2.5). Overweight prevalence nearly doubled from 12 percent in 2000 to 20 percent in 2016, while undernourishment dropped by almost half, before bouncing back in 2018. This phenomenon, in which a relatively stable supply leads to differentiated nutrition outcomes, requires deeper analysis, to look at a potential degree of variability across and within countries, as well as different socioeconomic groups. Another pathway for the discrepancy is increased consumption of "new foods," which emerge as traditional ingredients are being deconstructed and reconstructed to form these new foods. Ultra-processed foods (UPF) are an example, which we analyze further in the "Nutrition Transition" (NT) section.

Figure 2.5 | Prevalence of overweight and undernourishment in South Asia, 2000–2021



Data source: FAOStat (2023) (undernourished); World Bank (2023b), World Development Indicators (overweight)

2.2 Nutrition Outcomes

Even though decreasing undernourishment is a positive trend reported in all South Asian countries, the region as a whole, and most of the countries in it, are still lagging behind the world average (Figure 2.6). Prevalence of stunting, wasting, and underweight in children under 5 is 33 percent, 15 percent, and 28 percent, respectively, compared to world averages of 21 percent, 7 percent, and 13 percent, respectively.

Stunting

The ***stunting rate*** in SA is higher than in any other region in the world. Except for the Maldives and Sri Lanka, all South Asian countries have prevalence of stunting much higher than the world average (Figure 2.6). World Bank and Demographic and Health Surveys (DHS) data (Figure 2.7) suggest that, in all South Asian countries, the stunting rate decreased over the past 30 years. However, there is great heterogeneity among countries. From 1991–2018, the rate in Pakistan declined 30 percent, while the rate declined almost 60 percent in Bangladesh.

Strikingly, data on stunting in Bangladesh was collected 22 times in the past 30 years, compared with just 3 and 4 times in Bhutan and Afghanistan, respectively. Data collection frequency is essential when it comes to policy design, monitoring, and evaluation. Without timely and credible data, it is very challenging to design an effective policy instrument, and even more difficult to measure its success.

According to WHO, childhood stunting is "one of the most significant impediments to human development. . . . It is a largely irreversible outcome of inadequate nutrition and repeated bouts of infection during the first 1,000 days of a child's life. Stunting has long-term effects on individuals and societies, including diminished cognitive and physical development, reduced productive capacity and poor health, and an increased risk of degenerative diseases such as diabetes."[12] These effects have long-term consequences on productivity, and eventually, on a country's economy. Action Against Stunting estimates that this form of malnutrition could cost South Asian countries up to 10 percent of their GDP per capita.[13] It is apparent why stunting eradication should be and is one of the top priorities in SA. An initiative, "Tackling Malnutrition Induced Stunting in Pakistan," sponsored by the Council of Common Interests in Pakistan, is planned to provide more than US$2 billion between 2020 and 2025 to tackle starvation and stunting.[14]

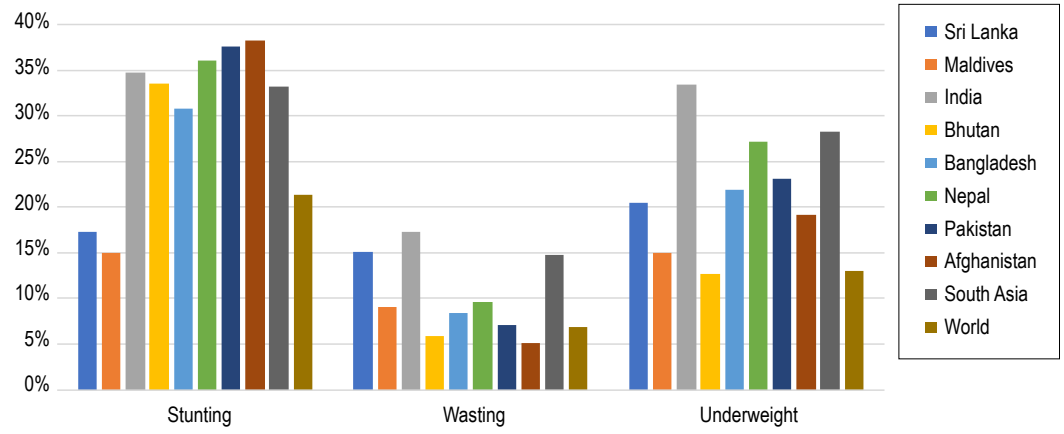
The causes of stunting are a combination of poor nutrition and recurrent infections or chronic diseases, which cause insufficient nutrient intake, absorption, or utilization.[15] Although poor nutrition is a direct result of food intake, infections and diseases can originate from various sources. One source is poor water, sanitation, and hygiene (WASH). The pathways between nutrition and WASH are explored in Box 2.1.

Food safety is another link that connects food, agriculture, and health. Compromised food safety contributes to inefficient uptake of nutrients and can lead to increased susceptibility to infections.[16] According to the World Bank, the level of economic development is correlated with food safety economic burden.[17] A country can be in one of four stages of economic development—traditional, transitioning, modernizing, or postmodern. The economic burden caused by inadequate food safety starts increasing during the traditional stage, through the transitioning stage, and peaks at the end of the transitioning stage and the beginning of the modernizing stage. It begins to decrease in the postmodern stage. More information on the major transmission routes of human foodborne diseases, as well as hazards that come from food, animal contact, human-to-human contact, and the environment, can be found in the Annex (Table A.2 and Figure A.1). Although food safety hazard transmission routes are well understood, research specific to SA is very scarce.

From a broader perspective, the occurrence of stunting depends on sociodemographic factors. Stunting rates are higher in poor households, where mothers are less educated, and in rural areas.[18] As Figure 2.8 depicts, stunting, wasting and underweight rates are not only higher among poorer people but are also higher in poorer states within India.

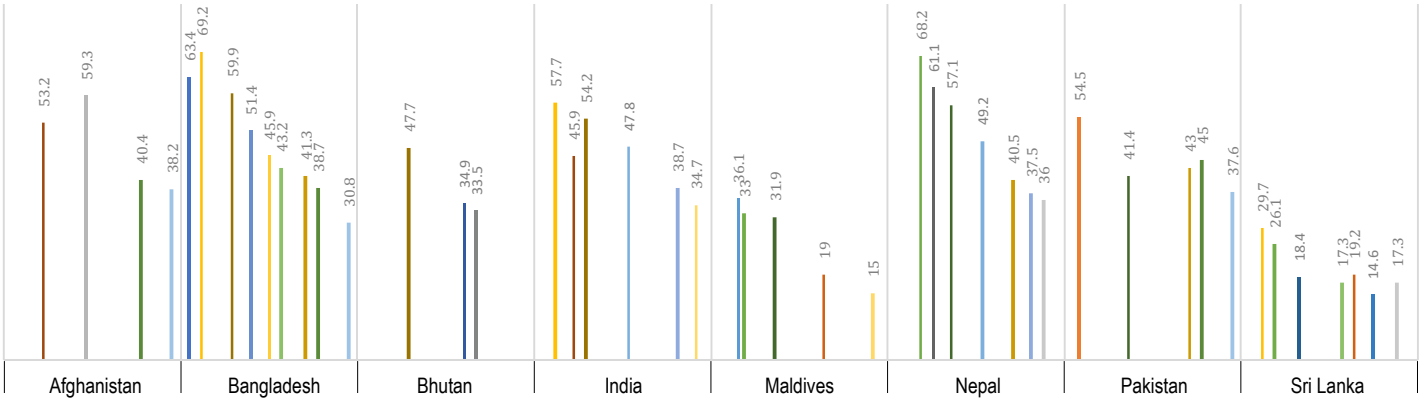
[12] WHO (2014b, 1)
[13] Action Against Stunting (2020)
[14] Shuja et al. (2020)
[15] WHO (2015)
[16] DeWaal and Haddad (2020)
[17] Jaffee et al. (2019)
[18] Manohar (2019) 7th annual Feed the Future Innovation Lab in Nepal.

Figure 2.6 | Prevalence of stunting, wasting, and underweight in South Asia



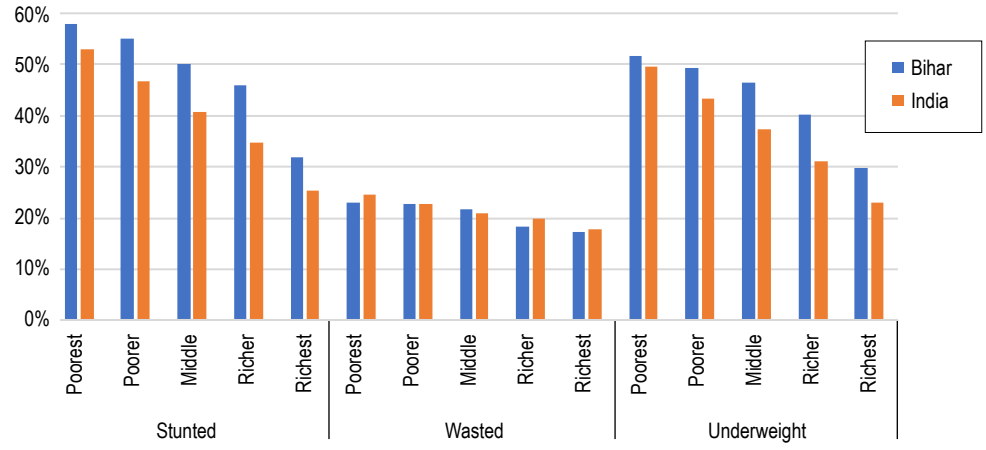
Data source: Data source: Stunting, wasting, and underweight of children < 5: World Bank (2023), World Development Indicators; Maldives DHS 2016–17 (DHS 2018)
Note: Most recent observation – Sri Lanka (2016), Maldives (2017), India (2017), Bhutan (2010), Bangladesh (2018), Nepal (2016), Pakistan (2018), Afghanistan (2018), South Asia (2019), World (2019).

Figure 2.7 | Prevalence of stunting in South Asia, 1990–2018



Data source: World Bank (2023b), World Development Indicators; DHS (2018), Maldives DHS, 2016–17
Note: For better visibility, one or more DHS rounds from Bangladesh, India, the Maldives, Nepal, and Pakistan have not been included, but that does not affect the general trends. X-axis denotes year, and Y axis denotes prevalence of stunting.

Figure 2.8 | Distribution of malnutrition per wealth quintiles in India and Bihar, 2016

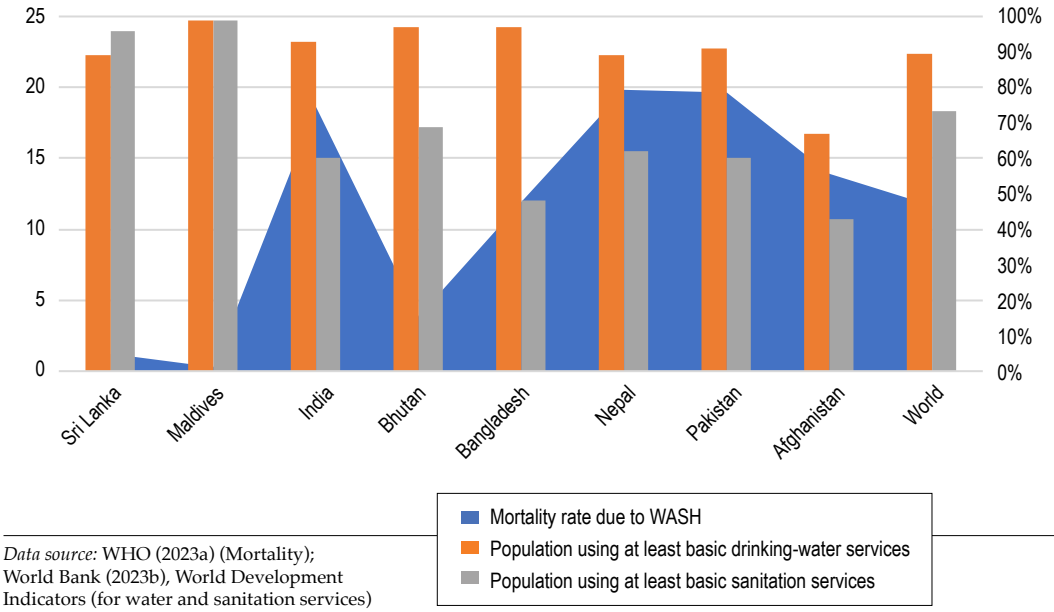


Data source: National Family Health Survey (NFHS)-4 (GoI 2016)

Box 2.1 | WATER, SANITATION, AND HYGIENE IN SOUTH ASIA

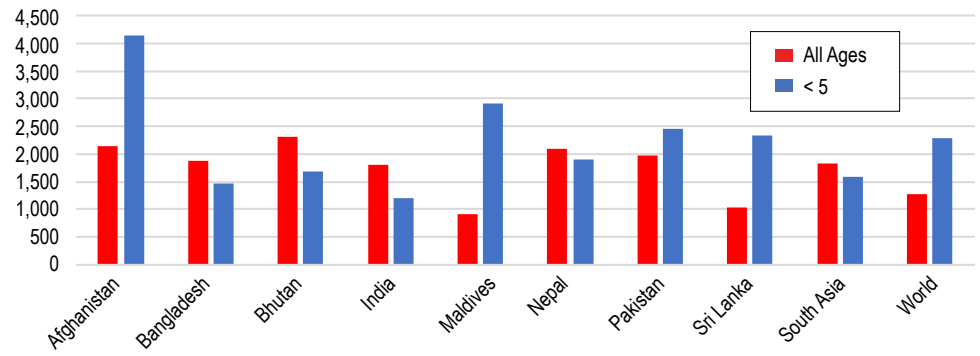
Poor water, sanitation, and hygiene (WASH) can be a determining factor in one's nutrition status. In theory, even if a person has an optimal diet, they could still suffer from malnourishment. However, the reality is that people who do not have access to proper WASH also rarely have optimal diets. Sivan Yosef argued that there are three direct pathways between WASH and nutrition outcomes.[a] The first is through diarrhea, which affects appetite, the absorption of nutrients, the immune system, and physical and cognitive development. The second is through parasitic infections, such as roundworm, whipworm, and hookworm, which also affect nutrient absorption and growth. Hookworm infections also cause anemia. The third pathway is through environmental enteropathy or environmental enteric dysfunction (EED), which leads to gut damage and poor nutrient absorption. Contrary to diarrhea, which occurs irregularly, EED can be a chronic condition.

Figure 2.9 | Mortality rate (per 100,000) due to water, sanitation, and hygiene in 2016 and proportion of population using water and sanitation services in 2017 in South Asia



Data source: WHO (2023a) (Mortality); World Bank (2023b), World Development Indicators (for water and sanitation services)

Figure 2.10 | Prevalence rate (per 100,000) of enteric infections in South Asia and globally, 2019



Source: Global Burden of Disease (IHME 2019)

[a] Yosef (2016)

Wasting

Like stunting, the ***wasting rate*** in SA is the highest of all global regions (Figure 2.6). Interestingly, national South Asian wasting rates are almost inverse, compared to stunting. Namely, the prevalence of wasted children < 5 in Afghanistan is the lowest among SA countries, while the stunting rate is the highest. Similarly, Sri Lanka has among the lowest stunting rate and almost the highest wasting rate of all SA countries. It is only India that has relatively high rates of both stunting and wasting. Another distinction between the two indicators is that in two countries, Bhutan and Nepal, wasting prevalence increased over time. In Bhutan, it increased from 2.5 percent in 1999, to almost 6 percent in 2010 (Figure 2.11). This change shold be viewed with caution, as the latest available data is from 2010, and the prevalence of wasting can change over the course of a year, even more over a decade.

Unlike stunting, which often reflects chronic hunger, wasting is perceived to result from an acute malnutrition episode, manifesting in children who are too thin for their height. According to a joint policy brief of WHO, the United Nations Children's Fund (UNICEF), and WFP, there are four main underlying causes of wasting: poor access to appropriate, timely, and affordable health care; inadequate caring and feeding practices; suboptimal food intake in terms of quantity and quality; and inadequate access to WASH.[19] Another very important factor that affects nutritional outcomes is resilience to food shocks, elaborated further in Box 2.2.

Furthermore, unlike in some other regions where wasting peaks around 12 months, in South Asian countries, the prevalence of wasting is highest at birth, which is related to maternal nutrition and breastfeeding.[20] A very critical finding for policymakers, it is important when promoting and implementing policy instruments.

Children affected by wasting "have weakened immunity, are susceptible to long term developmental delays, and face an increased risk of death, particularly when wasting is severe."[21] Cognitive deficit and increased risk of noncommunicable diseases are also associated with wasting.[22]

Although stunting and wasting are two distinct outcomes of undernourishment, they share numerous underlying causes and short- and long-term consequences. It is possible for the same child to suffer from both stunting and wasting. Surprisingly, these two nutritional outcomes are very often treated separately.

Box 2.2 | FOOD SYSTEM RESILIENCE

The United States Agency for International Development (USAID) defines resilience as "the ability of people, households, communities, countries, and systems to mitigate, adapt to, and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth."[a] From a food system perspective, resilience is defined as "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances."[b] The same authors argue that food system resilience has four elements: robustness—the capacity to absorb disturbance without losses; redundancy—the extent to which elements responsible for the shock absorption are replaceable; flexibility—the reactivity of a food system, which leads to recovery; and resourcefulness and adaptability, which determine how much of a loss can be recovered.

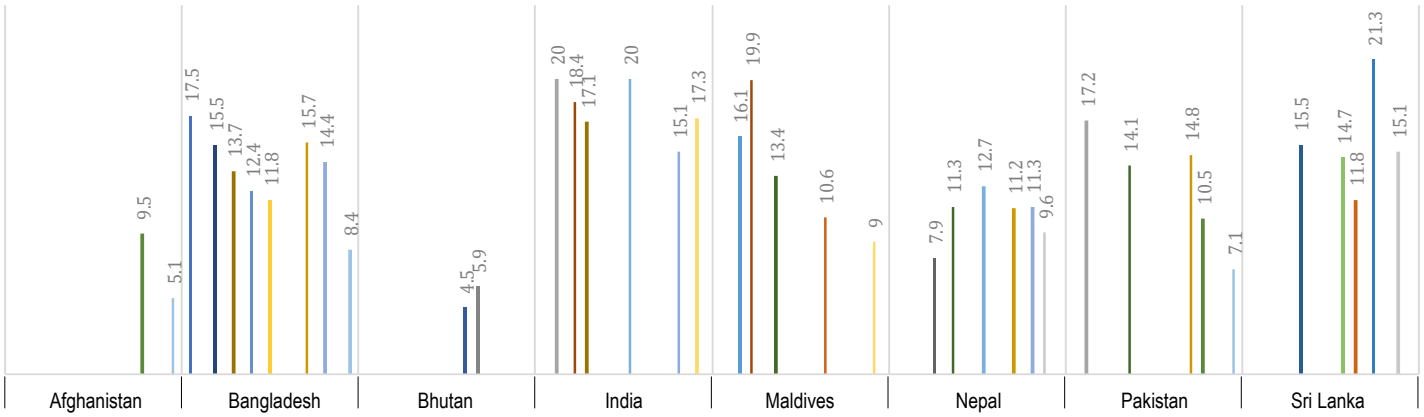
Although one of the SDG2 targets addresses the resilience of agricultural practices, it is also important to look at the broader picture for nutrition outcomes, namely, the resilience of food systems. During a scientific symposium, Agriculture to Nutrition: Pathways to Resilience, in Kathmandu in 2019, Dr. Srinath Reddy stressed the importance of food system resilience in addressing challenges posed by climate change, commerce, and conflict. At the same symposium, Dr. Gerald Shively presented the quantification of nutritional resilience, based on reversion to the mean following an adverse shock. He found that women and children from households that are market-oriented, those with more assets and better access to credit, and those from districts with more developed infrastructure experienced greater resilience.

FAO's flagship publication, *The State of Food and Agriculture (SOFA)*, centered agri-food systems resilience in its 2021 issue.[c] While the main reason for focusing on resilience was the COVID-19 pandemic and its impact on agri-food value chains, the authors also acknowledged the importance of resilience during droughts, floods, and armed conflicts.

[a] Shah (2012, 5)
[b] Tendall et al. (2015, 19)
[c] FAO (2021b)

[19] WHO (2014c)
[20] UNICEF. (2018)
[21] UNICEF et al. (2018, 2)
[22] Frison et al. (2020)

Figure 2.11 | Prevalence of wasting in South Asia, 1990–2018



Data source: World Bank (2023b), World Development Indicators
Note: For better visibility, one or more DHS rounds from Bangladesh, India, Maldives, Nepal, and Pakistan have not been included, but that does not affect the general trends. X-axis denotes year, and Y axis denotes prevalence of wasting.

Micronutrient deficiency

Micronutrient deficiency, also known as hidden hunger, is another nutritional outcome that affects a large share of the population in SA. It includes deficiencies in iron, zinc, iodine, and vitamin A. Fifty-five percent of children and 50 percent of women, 15–49, suffer from **anemia**, placing SA together with sub-Saharan Africa as the worst-performing global regions (Figure 2.2). Additionally, 50 percent of children in Asia suffer from **vitamin A deficiency**.

The prevalence of **anemia** in children under 5 and women of reproductive age has decreased over the period, 1990–2016 (Figures 2.12 and 2.13). While there is a positive trend in all SA countries, there is once again much heterogeneity in the success rate across the region. India managed to reduce child anemia from 76 percent to 57 percent in the period 1991–2016, while Nepal reduced its rate from 73 percent to 43 percent. Similarly, women's anemia barely decreased in Pakistan in 1990–2016, from 53 percent to 52 percent, while in Bangladesh it decreased from 55 percent to 40 percent.

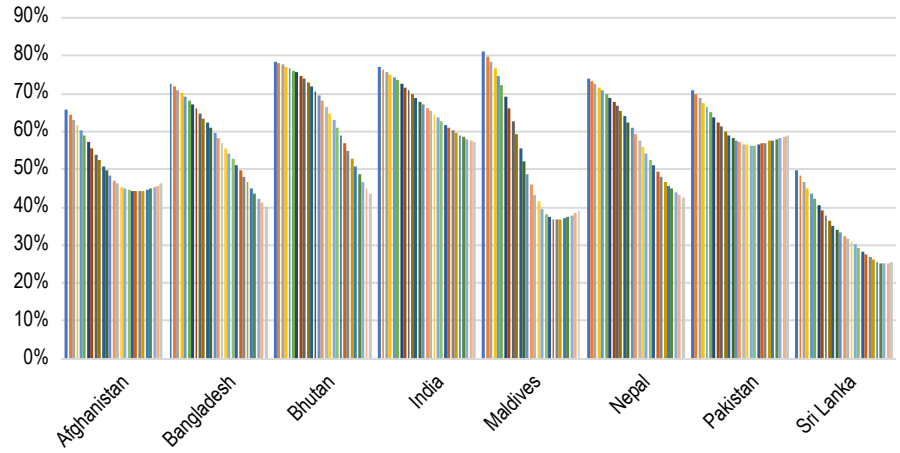
The causes of anemia are various, but inadequate intake of iron-rich foods and excessive loss of red blood cells are the most direct causes. Infectious diseases and genetic hemoglobin disorders also play a role.[23] Similar to other forms of malnutrition, the prevalence of anemia varies by socioeconomic factors.

Anemia impairs physical capacity and work performance, while maternal anemia is associated with mortality and morbidity among women and children, including risk of miscarriage, stillbirth, premature birth, and low birthweight.[24] Therefore, policy measures that target women's anemia simultaneously address children's malnutrition.

The State of Food and Agriculture 2013 reported that Middle Africa and SA were the two regions most affected by **vitamin A deficiency** in children under 5.[25] Within SA, the situation is not homogenous among the countries. This form of malnutrition affects more than 60 percent of children in India and Afghanistan, but only 10 percent in in the Maldives and Pakistan (Figure 2.14). Vitamin A supplementation is one of the measures commonly used to tackle vitamin A deficiency, and the coverage in South Asian countries varies from more than 90 percent in Sri Lanka, Bangladesh, Pakistan, and Afghanistan, to less than 50 percent in Bhutan. Another method for addressing vitamin A deficiency is food fortification, where cereal flours, vegetable oils, milk, infant formula, and spreads such as margarine could be supplemented.[26] Biofortification can also be employed, with the micronutrient content and bioavailability of a certain crop increased. For example, orange-fleshed sweet potatoes are biofortified for vitamin A. The Biofortification Priority Index (BPI) tool has identified 12 more crops and assessed the potential for investment in LMIC.[27] As vitamin A cannot be synthesized by the body, it must be obtained through diet or supplementation. Low intake of certain foods can lead to deficiency, including liver, milk, cheese, eggs, or green leafy vegetables, carrots, ripe mangoes, and other orange-yellow vegetables and fruits.[28] Vitamin A deficiency can occur early in life, as the transfer of vitamin A to a child through breast milk depends on maternal diet and health status.[29] Insufficient intake of vitamin A could lead to childhood mortality, night blindness, anemia, and susceptibility to infections. This is another example where policy measures targeting maternal health simultaneously address child malnutrition.

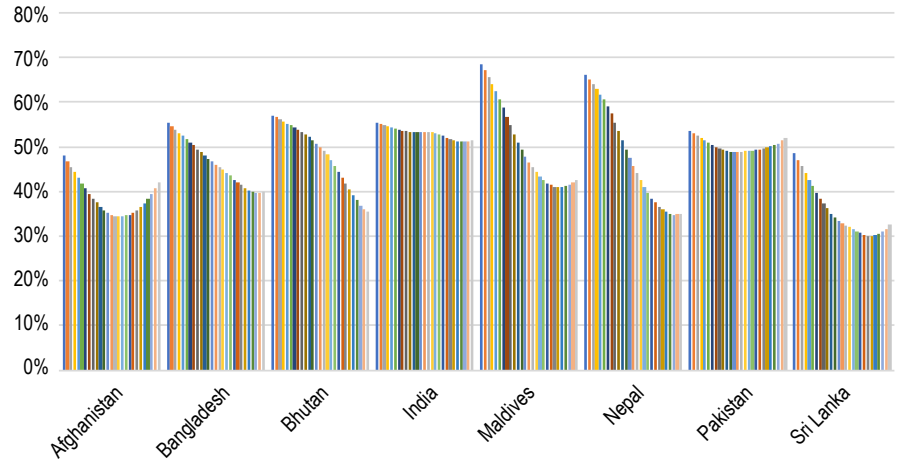
[23] Sunuwar et al. (2020)
[24] WHO (2014a)
[25] FAO (2013)
[26] Allen et al. (2006)
[27] Harvest Plus (2021)
[28] WHO (2009)
[29] Wirth et al. (2017)

Figure 2.12 | Prevalence of anemia in children < 5 in South Asia, 1990–2016



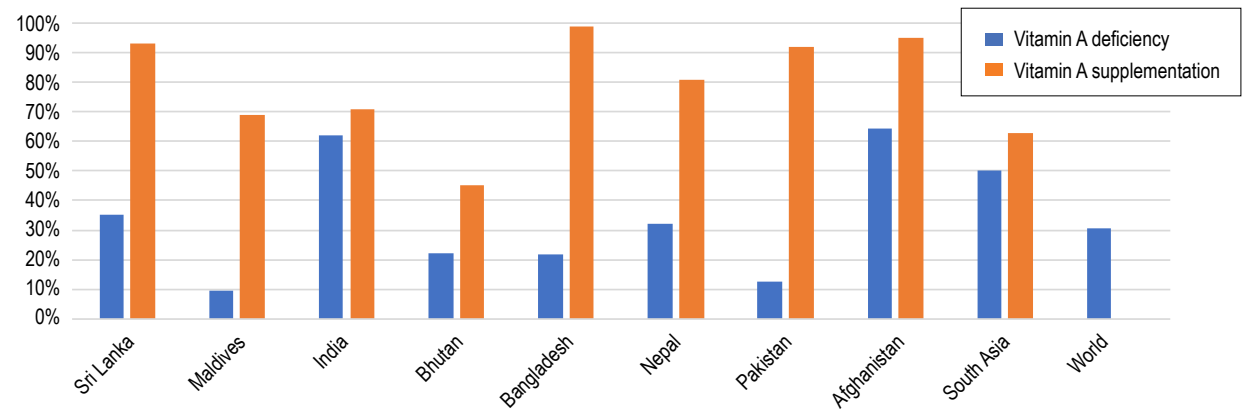
Source: World Bank (2023b), World Development Indicators
Note: Each bar represents one year—the first bar in each country represents 1990 and *the last bar 2016*

Figure 2.13 | Prevalence of anemia in women of reproductive age in South Asia, 1990–2016



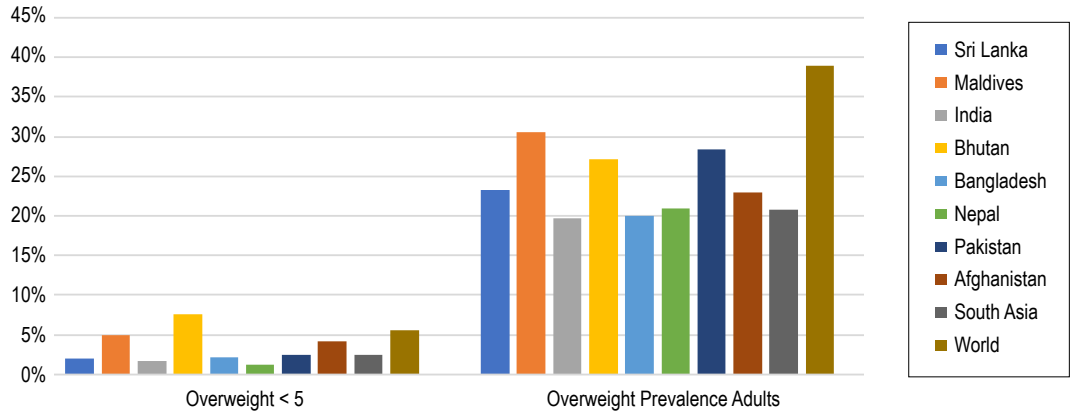
Source: World Bank (2023b), World Development Indicators
Note: Each bar represents one year—the first bar in each country represents 1990 and *the last bar 2016*

Figure 2.14 | Vitamin A deficiency and supplementation coverage in South Asia (% of children ages 6–59 months)



Source: Vitamin A supplementation coverage. World Bank (2023b), World Development Indicators. Most recent observations —Sri Lanka (2017), Maldives (2017), India (2016), Bhutan (2013), Bangladesh (2017), Nepal (2017), Pakistan (2017), Afghanistan (2017), South Asia (2016); Vitamin A deficiency—FAO SOFA (2013) (South Asia estimate includes Iran).

Figure 2.15 | Overweight prevalence in South Asia and the world



Source: World Bank (2023b), World Development Indicators
Most recent observation—Sri Lanka (2016), Maldives (2016), India (2016), Bhutan (2016), Bangladesh (2016), Nepal (2016), Pakistan (2016), Afghanistan (2016).

Overnutrition

While overnutrition in SA, generally, is below the world average, the prevalence of overweight children under 5 has already closed that gap, and in Bhutan, overnutrition is above the world average, while the Maldives and Afghanistan are very close to the average (Figure 2.15).

Before further exploring overweight trends in SA, it is useful to clarify what is meant by "overweight" and "obesity." These two terms are based on Body Mass Index (BMI) cutoff points: in adults, BMI > 25 represents overweight and BMI > 30 defines obesity. There is an ongoing debate over the suitability of BMI as an indicator for obesity; yet, for the purposes of this report, BMI is used. Also, it has been argued that the health risk associated with overweight and obesity manifest at a lower BMI in Asian populations than in Western populations, and thus in Asia, BMI > 23 should indicate overweight and BMI > 25 should indicate obesity. Due to a lack of consensus on this approach, we use the traditional cutoff points in this report.

As Figure 2.16 suggests, there has been a sharp increase in obesity rates in all South Asian countries since 1990, with the Maldives, Pakistan, and Bhutan leading the trend. Some argue that SA is witnessing an epidemic of obesity, overweight, and abdominal obesity, where the sharpest upward trend is in countries with the lowest initial prevalence.[30]

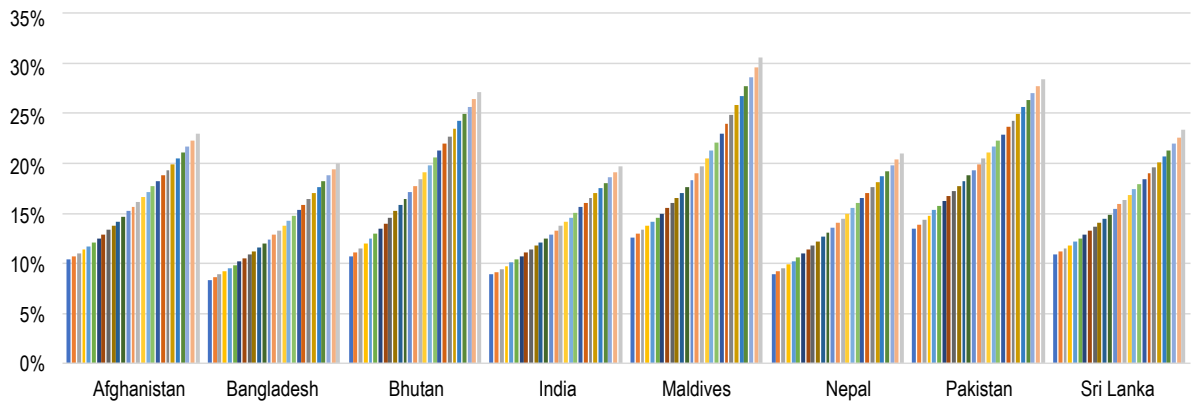
As with undernourishment, obesity is determined by various direct and indirect factors. Some of the indirect factors associated with obesogenic behavior in adolescent girls and women of reproductive age are presented in Figure 2.17. Access to obesogenic technologies, as well as obesogenic factors related to technology use and health behaviors are associated with a rise in overweight; yet, it has differentiated effects on men and women and populations in regions with different levels of economic development.[31] Structural transformation, which leads to a closer connection between urban and rural areas, leads not only to improved rural livelihoods but also to higher obesity rates in rural areas.[32]

As for the direct factors, food intake and energy expenditure influence obesity.

When analyzing food intake, one method is to look at actual food intake, as discussed in the next part of the report. Another option is to infer consumption patterns from health conditions that are often associated with food intake. To that end, looking at the Institute for Health Metrics and Evaluation (IHME 2018a) data can be useful. IHME estimates risk factors that contribute to total number of DALY (disability-adjusted life-years) on a national level. The main risk factors in South Asian countries are malnutrition,[33] air

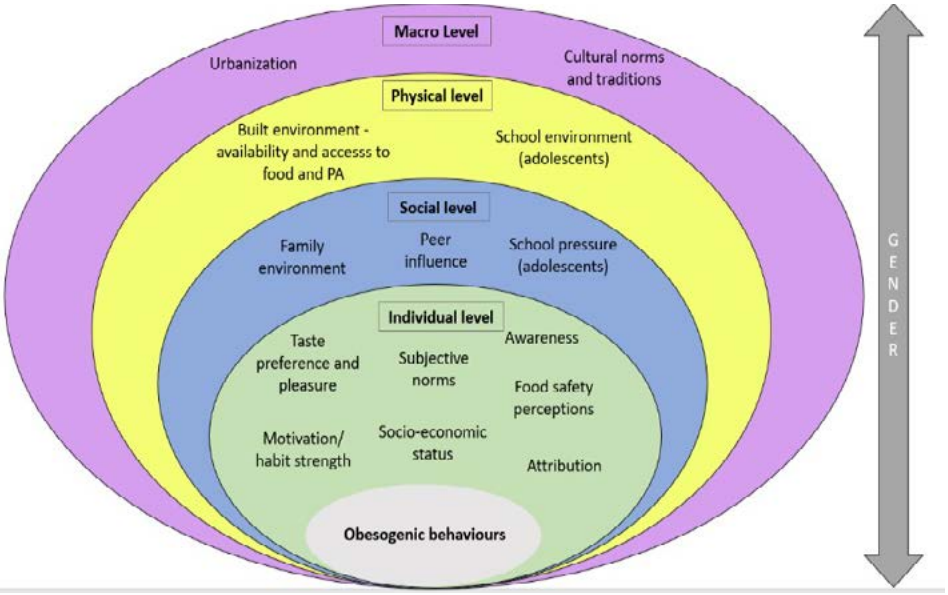
[30] Jayawardena et al. (2013)
[31] Aiyar, A., S. Dhingra, and P. Pingali. (2021)
[32] Aiyar, A., A. Rahman, and P. Pingali. (2021)
[33] By malnutrition, the authors mainly refer to child and maternal forms of malnutrition (including low birthweight, short gestation, child growth failure, non-optimal breastfeeding, and low intake of micronutrients).

Figure 2.16 | Overweight rates in South Asia, 1990–2016



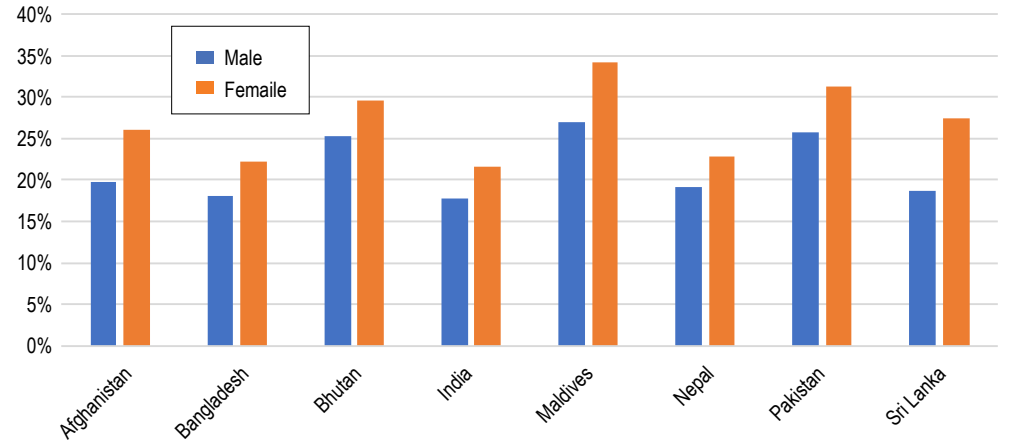
Source: Data source: World Bank (2023b), World Development Indicators
Note: Each bar represents one year—the first bar in each country represents 1990 and the last bar 2016

Figure 2.17 | Factors influencing obesogenic behaviors by adolescent girls and women of reproductive age



Source: Trübswasser et al. (2021)
Note: PA denotes physical activity

Figure 2.18 | Prevalence of overweight in men and women in South Asia, 2016



Source: World Bank (2023b), World Development Indicators

pollution, high blood pressure, dietary risks,[34] high BMI, high fasting plasma glucose, WASH, high low-density lipoprotein (LDL) cholesterol, tobacco, and kidney disfunction, among others. While those risk factors are not mutually exclusive, and some even affect others, IHME risk factors still provide some useful perspectives for the South Asian context. Throughout South Asian countries, 9 out of 10 top risk factors are the same, yet not necessarily in the same order. In all countries, except in Sri Lanka, while declining malnutrition is the most profound risk factor, the data show that, from 2009 to 2019, decline in risk exposure occurred in malnutrition, air pollution, and WASH. An increase in risk exposure was recorded for high blood pressure, dietary risk, high BMI, high fasting plasma glucose, high LDL, and tobacco and alcohol use. All risk factors that increased between 2009 and 2019 were associated with lifestyle and food consumption. These findings are entirely in line with the declining undernourishment and increasing obesity rates presented in Figure 2.5.

Energy expenditure through physical (in)activity is another important factor that contributes obesity. In SA, 33 percent are insufficiently engaged in physical activities. However, there is a large gender difference, with 23.5 percent of men and 43 percent of women registering insufficient physical activity.[35] Cultural and social norms related to women's outdoor physical activities may be one of the factors at play.[36] As per Figure 2.18, the prevalence of obesity in women is higher in all South Asian countries.

Regarding child overweight and obesity, it has been argued that dietary diversity, maternal BMI, and education, as well as household wealth status, are strong predictors.[37]

There are different types of malnutrition, and we briefly analyzed trends in stunting, wasting, anemia, vitamin A deficiency, overweight, and obesity. Food supplies and consumption on a national level have been relatively stable over time, while nutritional outcomes have changed. Overall, the prevalence of both undernutrition and overnutrition in South Asian countries are converging with global trends. Namely, average wasting and stunting among children under 5 are decreasing toward the world average, and overweight and obesity trends are accelerating, to catch up with global levels. This analysis suggests that South Asian countries follow the nutrition transition (NT) pathway, where growing economies and increasing income levels lead to less undernourishment and more overnutrition. More information about NT will be provided in the next section. To better understand these trends, it is necessary to look at regional differences within countries, but also differences among individuals with different education levels, wealth status, gender, and age.

Nutritional outcomes are driven by numerous factors, including household income, maternal education, access to health care, road infrastructure, proximity to markets, paternal and parental labor migration, maternal depression, agricultural production diversity, dietary diversity, and WASH. Some of these factors directly affect nutrition on an individual level, while others, such as trade, act on local, regional, country, or even global levels. Furthermore, it is important to note that different forms of malnutrition, such as stunting and wasting, can have common underlying causes, and as such, they can be addressed simultaneously.

National-level data can provide an indication of the overall trajectory of dietary patterns, yet such data can also be misleading. For example, while an increase in vegetable consumption is generally positive, its impact on nutritional outcomes depends on whether it is being consumed fresh or cooked, and if cooked, what cooking method is being used. Individual-level dietary surveys or other ways to collect food consumption data for individuals provide a much more comprehensive and accurate picture. For that reason, it is crucial that scientists and policymakers have access to such data.

[34] Dietary risks represent diets low in some food items (fruits, vegetables, legumes, whole grains, nuts and seeds, milk, fiber, calcium, seafood omega-3 fatty acids, polyunsaturated fatty acids) and high in others (red meat, processed meat, sugar-sweetened beverages, trans fatty acids, sodium).

[35] Guthold et al. (2018)

[36] Misra and Shrivastava (2013)

[37] Bishwajit and Yaya (2020)

2.3 Critical Challenges and Policies to Tackle Malnutrition

One of the main obstacles to effectively tackling malnutrition is a lack of understanding of the short-term (miscarriages, stillbirths) and long-term (cognitive, degenerative, lost productivity, etc.) costs of malnutrition. Since the financial consequences of different forms of malnutrition are well documented and quantified, it remains to be understood what it would take for governments to make larger and sustained efforts to address all forms of malnutrition. While local and international NGOs, international development, UN agencies, and the research community have a profound role in tackling malnutrition, the initial impetus must come from governments, as their financial power does not depend directly on donations and voluntary commitments, but it is secured by tax revenues. The role of each government should be to serve and take care of public health. After all, the healthier and the more productive the population, the more financially stable the country.

If a government decides to eradicate all forms of malnutrition, it must have sufficient institutional capacity to do so. While most high-income countries (HICs) are equipped to deal with malnutrition, that is not the case in low-income countries (LICs). Capacities must be sufficient on all levels—central, regional, and local. Additionally, the capacities include the ability to fully understand the complexity and power dynamics within food systems and to design win–win policy measures that avoid negative externalities. Administrations must rely on context-specific research, performed either solely by national research organizations, or in collaboration with international partners. Therefore, improving national research capacities is a precondition. Finally, to be able to provide accurate inputs for policy design, researchers need credible and timely data. The majority of LICs lack reliable data. While international organizations can be helpful in this respect, national governments must organize nationally representative surveys and censuses.

Policy instruments in this section mainly focus on eradicating undernourishment outcomes and micronutrient deficiency. The next section will discuss overnutrition-related policies. Policy instruments fall into two groups: those that directly address consumption and those that tackle underlying issues.

The first group of policies should make a sufficient amount of nutritious foods and nutritive supplements available, affordable, and attractive to those in need. These policies can target subjects directly or indirectly (for example, newborns through mothers). As we saw in the example of Afghanistan, where a vitamin A supplementation rate of almost 100 percent coexists with the highest vitamin A deficiency of all South Asian countries, there are rarely silver bullets when it comes to malnutrition, and several policies must be combined to address a single issue. Some examples are food fortification, biofortification, micronutrient supplementation, food coupons, cash transfers, and breastfeeding promotion. Compared to the second group, interventions from this group are relatively cheap and are easy to implement.

Interventions from the second group are more complex, as they target underlying drivers of malnutrition, such as poverty, injustice, power imbalance between different groups, social and cultural norms, food environment, and others. One of the primary ways to tackle poverty in agriculture-dominated countries is to increase the productivity of the most competitive farmers while creating off-farm opportunities for less competitive farmers. Governments must improve physical, institutional, and social infrastructure to better connect farmers to markets, in addition to providing reliable and high-quality extension support. Notably, improving productivity can lead to environmental degradation. This possibility is explored in Section 4: "State of Agriculture in Southeast Asia."

Creating an enabling environment for the expansion of financial services would help farmers to transition from producing staple crops to producing cash crops, or even move along the value chain to establish processing facilities. Governments could also assist by contributing to the collateral needed to secure a loan. Supporting the creation and introduction of professional management for farmer producer organizations (FPOs) is another way to integrate small- and large-scale farmers into the markets.

As much as the measures described here might seem complex and resource intensive, they are still relatively easier to implement than measures targeting injustice and power imbalance, which are often deeply rooted in societies and driven by social and cultural norms. Women's empowerment through education and the creation of self-help groups can be helpful. Yet, until men fully understand how important a woman's role is in the economic progress of a household, most gender-specific and gender-transformative policy measures will likely result in more responsibilities and work for women without commensurate gains in power and authority.

3 Food Consumption in South Asia

Food consumption patterns in SA, as in the rest of the world, have evolved over the past decades. This section examines two distinct aspects of food consumption—trends in consumption and the main factors and pathways that influence consumption. As with nutritional outcomes, there are certain food consumption characteristics that are common for the region; yet, cultural, ethnic, geographical, and other forms of heterogeneity in SA result in differences in eating patterns across and within countries.

Farmers share a meal in Dhaka, Bangladesh.
(Photo by Sk Hasan Ali/Shutterstock)

3.1 Food Consumption Measurement, Data Collection, and Analysis

There are several aspects of food consumption analysis that are critical to address before looking at eating patterns in SA. One aspect is how consumption is **measured**, whether by quantity, quality, or dietary diversity. A common approach is simply examining national-level data and analyzing the types of foods consumed. To this end, FAO Supply and Utilization Accounts (SUAs),[38] and one of its derivatives, Food Balance Sheets (FBS), are frequently used. FBS present consumption per capita of a given food by calculating the difference in supply and utilization, divided by population. On the supply side, there are domestic production, import stocks, and current stocks, while on the utilization side, there are exported quantities, livestock feed, seed, food used for manufacturing and nonfood uses, as well as losses during storage and transportation. While FBS are valuable sources of information, as they are the only source covering most of the countries and territories in the world, using a uniform methodology, there are also concerns around data accuracy. Furthermore, FBS provide information about foods available to the population but do not measure the amount of food that people actually consume, as food waste on a household level is difficult to capture. Additionally, FBS do not provide food consumption data of population subgroups, based on gender, age, and sociodemographic characteristics, nor regional differences within countries, and they certainly cannot capture intrahousehold food allocation.[39] Despite shortcomings, FBS are a foundational element for other global data sets and studies, such as the Global Dietary Database,[40] Global Nutrient Database,[41] and Global Burden of Disease,[42] which are presented in Box 3.1.

Another important aspect related to dietary data is data **collection methodology**. Diet is an individual-level characteristic, and the more one moves from individual- toward household-, regional- or country-level data, the less accurate the data, potentially resulting in misleading analysis and policy recommendations. Food frequency questionnaires, 24-hour dietary recalls, and household expenditure surveys are commonly self-reported tools used to record eating patterns. Some methodologies rely on individual food reporting, while others rely on food group reporting.[43] As there is no strictly prescribed set of rules on nutrition data collection, the data can be inconsistent and difficult to use for cross country or regional comparison. In addition to traditional

Box 3.1 | FOOD CONSUMPTION DATA SETS

Data sets, such as Global Dietary Database (GDD) and Global Burden of Disease (GBD) use FBS, among other data, in estimating food consumption.

GDD uses a range of sources that contain food consumption information, and by applying a prediction model, it estimates mean intake of dietary factors by country, year, age, sex, urbanicity, and education in 185 countries.[a] The dietary factors are clustered into four groups: foods (fruits, non-starchy vegetables, nuts and seeds, total processed meats); beverages (sugar-sweetened beverages [SSBs], tea, milk); macronutrients (protein, fat, fiber); and micronutrients (iron, zinc, various vitamins).

GBD uses a range of sources, such as studies providing nationally or subnationally representative estimates of food consumption—Euromonitor, FAO FBS, the United States Department of Agriculture (USDA) National Nutrition Database, nutrition surveys, and household budget surveys—and applies estimation techniques to produce age- and sex-specific data.[b]

A comparison of FAO FBS and GDD showed that there is a substantial difference in estimations.[c] Compared to GDD, FAO FBS overestimated individual vegetables and whole grain consumption and underestimated legumes, nuts, and seeds. Additionally, a comparison of the four food groups—fruits, nuts and seeds, unprocessed meat, and SSB—in GDD and GBD—showed that there are large differences in estimations for many countries.[d] The inconsistency in presenting consumption patterns can be counterproductive if policymakers rely on inaccurate data or estimations. Timely, credible, and nationally representative data sets would address this shortcoming.

[a] GDD (2019). Global Dietary Database
[b] Afshin et al. (2019)
[c] Del Gobbo et al. (2015)
[d] Beal et al. (2021)

[38] FAO (2023a)
[39] FAO (2001)
[40] GDD -Global Dietary Database (2019)
[41] IHME (2018b). Global Nutrient Database
[42] IHME (2019). Global Burden of Disease
[43] Herforth, Wiesmann et al. (2020)

Vendors sell bread in Kabul, Afghanistan.
(Photo by timsimages.uk/Shutterstock)

surveys, a relatively novel method of capturing dietary patterns relies on nutritional biomarkers. Since certain biomarkers derived from urine or plasma can indicate consumption of protein, red meat, fruit, vegetables, fish, or other foods, using biomarkers instead of self-reported consumption would overcome potential biases in self-reported data.[44] Additional information about data collection methodologies can be found in "Measuring Nutrition Transition" part of the Section 3.4.

Once food consumption data are collected, they are used to assess quantitative and qualitative characteristics of diets, since observing single foods and ingredients in isolation does not provide a comprehensive description of an individual's eating patterns. Looking at simple quantities and share in total diet of food and food groups consumed might help in identifying anthropometrically derived nutritional indicators, such as stunting, wasting, undernourishment, overweight, and obesity. Although the quantity of food consumed is an important parameter, it is also crucial to look at the qualitative composition of diets. To that end, different methodologies are used. Diet Quality Index – International (DQI-I) is used to assess individual diets in cross-cultural settings, which helps in cross-country comparison.[45] DQI-I contains two other indicators—Healthy Eating Index (HEI)[46] and the Diet Quality Index (DQI). Components of DQI-I are food variety, measured by the number of food groups and protein sources, adequacy of food generally recognized as being beneficial for health, moderation of food generally recognized as harmful for health, and food balance. Recently, 100 country-adapted diet quality questionnaires (DQ-Q) have been developed to further facilitate low-cost and context-sensitive data collection. HEI scores actual food quantities consumed against quantities recommended by nationally dietary guidelines (FBDG).[47] A very important feature of these indices is that they look at diets holistically. Alternatively, diets within a population can be identified by performing a cluster analysis, in which individuals who share similar dietary patterns are grouped in the same cluster; either individual-level or at least household-level data are needed for the analysis.[48] Finally, dietary assessment can be performed by using the dietary biomarkers methodology from blood/urine samples.[49]

Insights into reliable and timely dietary data can provide invaluable input for different purposes, such as the accurate examination of national food systems and the design of public health policies. In the case of wasting, often associated with an acute episode of hunger, it can be caused by an event, such as an earthquake. Dietary surveys performed several years before or after the event would not capture this nutritional outcome. Furthermore, diets can have regular variations across seasons, as the quantity and quality of foods depend on how soon after the harvest and/or selling of food products the consumption is taking place. There are also irregular consumption variations, influenced by particularly good or poor harvests, and often coinciding with extreme weather events. Thus, timely data is very important. According to the Global Burden of Disease, at least six risk factors in all South Asian countries are strongly and consistently associated with consumption patterns. It is thus critical to have credible data to address these risk factors.

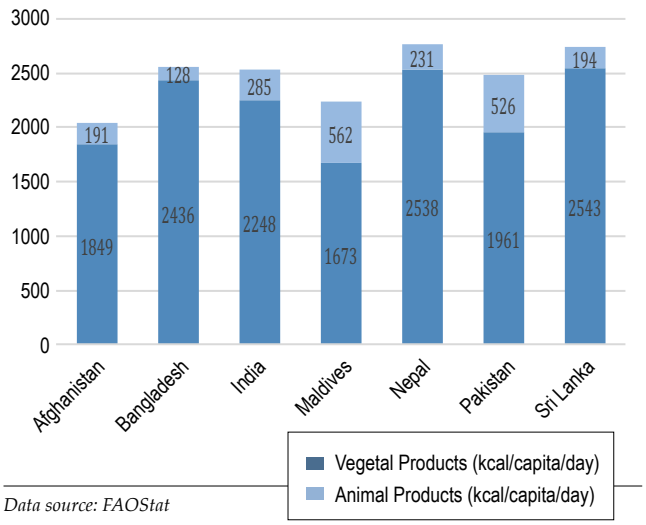
[44] Picó et al. (2019)
[45] INDDEX Project (2018). Diet Quality Index - International (DQI-I).
[46] USDA (2022). Healthy Eating Index (HEI).
[47] Food-based dietary guidance (FBDG) is being prepared on a national level to be used as a basis for optimal diet, and also to motivate food companies to align their food products with national recommendations. As new research and findings emerge, FBDGs are being revised by increasing/decreasing recommended quantities of certain foods for health or environmental impact purposes.
[48] Sauvageot et al. (2017)
[49] Landberg et al. (2019); Playdon et al. (2017)

3.2 Analysis of Food Consumption Trends in South Asia

Figure 3.1 shows calorie availability in South Asian countries and reveals whether the calories are of animal or plant origin. While both the amount and origin of calories vary across the region, all countries source most of their calories from plants, ranging from 95 percent in Bangladesh to 75 percent in the Maldives.

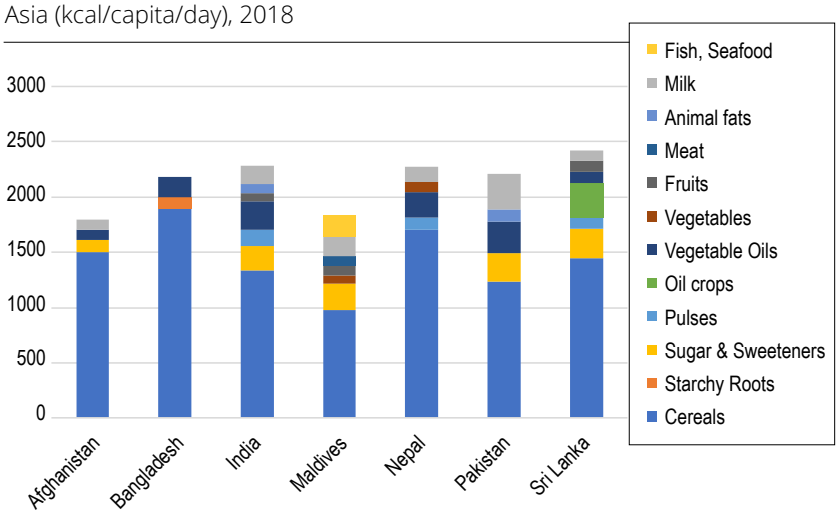
Figure 3.1 reveals the difference in total calorie intake, and Figure 3.2 provides a closer look at the major food groups consumed in South Asian countries in 2018. Two features stand out. The number of food groups contributing at least 3 percent of daily calories varies considerably—in Bangladesh and Afghanistan, it is 3 and 4 groups, respectively, whereas in India, the Maldives, and Sri Lanka, it is 7 groups. This indicator shows the degree to which diets are diverse or monotonous. Additionally, while the majority of calories in all countries comes from cereals, the share ranges from almost 90 percent in Bangladesh to slightly more than 50 percent in Maldives. Figure 4.12 in the "Crop Production in South Asia" section shows the dominant crops per area size in each country, reflecting an apparent correlation between agricultural production and food consumption.

Figure 3.1 | Total food supply in South Asia by calorie origin (kcal/capita/day), 2018



Data source: FAOStat

Figure 3.2 | Supply of major food groups in South Asia (kcal/capita/day), 2018



Data source: FAOStat
Note: Food groups are limited to those which contribute to more than 3 percent of daily calories

Millets are grown on a field in India.
(Photo by Leslie Verteramo Chiu/TCI)

We also explore the food groups that represent the core of diets in the region and more closely examine how food consumption trends have changed over time.

Figure 3.3 shows that in most of the countries in the region, cereals availability has been relatively stable over the past 20 years. In Sri Lanka, the availability of cereals steadily increased over the past 30 years. As for the composition of cereals, availability reflects domestic production (Table 3.1). Wheat is the dominant cereal in Afghanistan and Pakistan, while in Bangladesh, India, Nepal, and Sri Lanka, rice is the main grain. In the Maldives, where neither rice nor wheat is in the top five food products produced (Table 3.1), rice and wheat are equally available. Interestingly, the number of different cereal crops that constitute at least 3 percent of cereal calories also varies (Figure 3.4). In Afghanistan, Bangladesh, and the Maldives, wheat and rice are mostly consumed. In India, in addition to wheat and rice, sorghum, millet, and maize are part of the diet. Not only can cereal diversification affect nutritional outcomes, but it also contributes to the resilience of the food system.

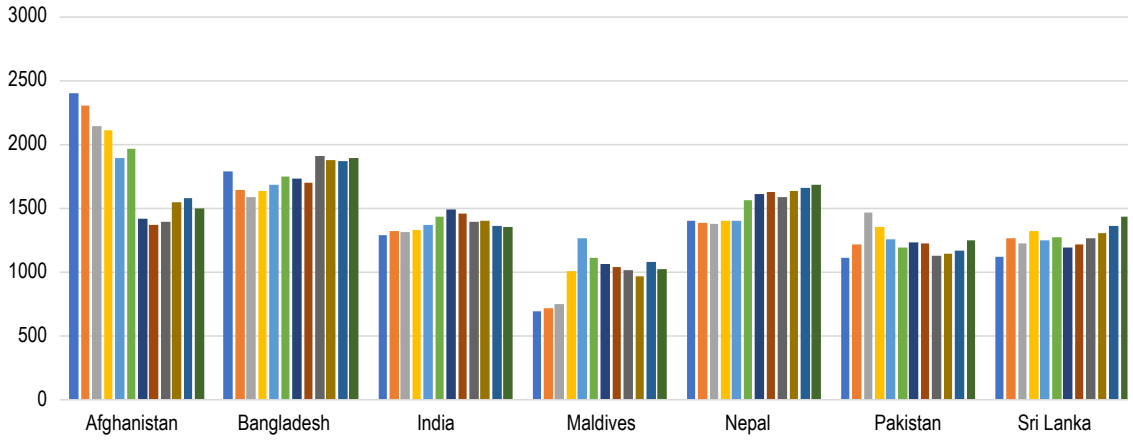
It is also important to note that some countries, such as India and Pakistan, are net exporters of cereals, while others are net importers (Figure 3.5). Maldives is an extreme example, as they are totally import dependent.

Table 3.1 | MAIN AGRICULTURAL PRODUCT BEING PRODUCED AND IMPORTED BY WEIGHT IN SOUTH ASIA, 2018

	Domestic production	Import
Afghanistan	Wheat, milk, grapes, potatoes, fresh vegetables	Wheat flour, wheat, sugar, potatoes, rice
Bangladesh	Rice, potatoes, sugar cane, maize	Wheat, sugar, palm oil, maize, soybean
Bhutan	Milk, maize, rice, potatoes	Rice, maize, sugar, soybean oil
India	Rice, sugar cane, wheat, milk	Palm oil, soybean oil, sunflower oil, sugar, cashew nuts
Maldives	Vegetables, nuts, roots and tubers, fruits, papayas	Rice, wheat flour, sugar confectionery, food prep,* non-alcoholic beverages
Nepal	Rice, vegetables, sugar cane, potatoes	Rice, maize, potatoes, soybean cake
Pakistan	Sugar cane, milk, wheat, rice	Palm oil, soybean, rapeseed, cotton lint, coffee
Sri Lanka	Rice, coconuts, plantains, sugar cane	Wheat, sugar, rice, dry onion, palm oil

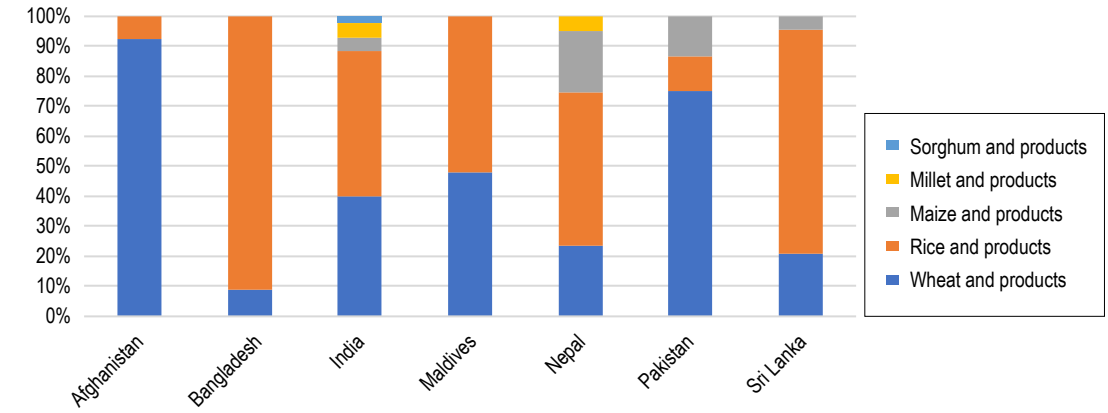
Data source: FaoStat
Note: Food prep—crop and livestock products, such as homogenized composite food preparations, soups and broths, ketchup, and other sauces, etc.

Figure 3.3 | Cereals availability in South Asia (kcal/capita/day), 1962–2017



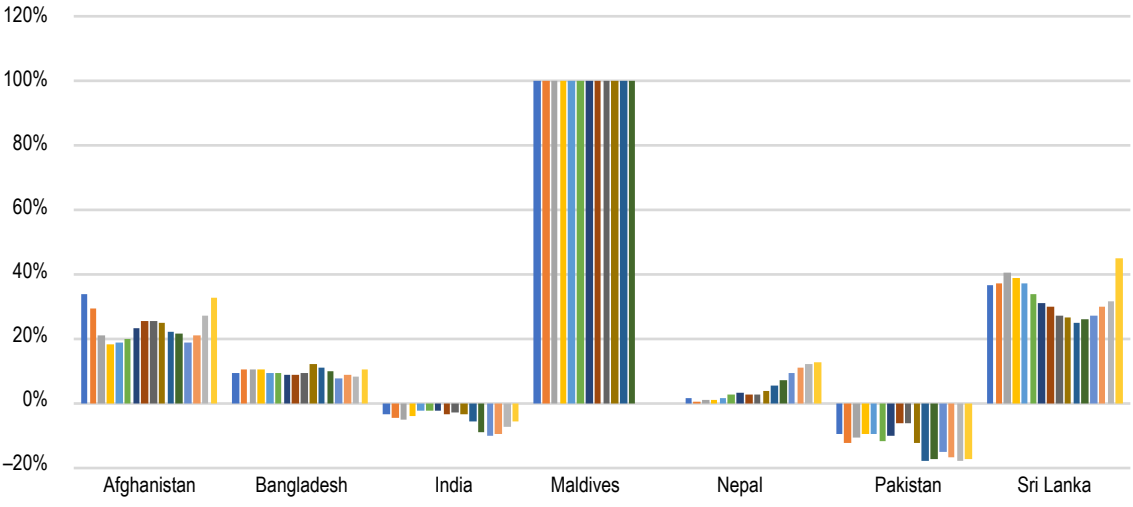
Data source: FAOStat
Note: Each bar represents 3-year average

Figure 3.4 | Cereals availability in South Asia (kg/capita/year), 2018



Data source: FAOStat
**Note: Cereals limited to those that contribute to more than 3 percent of daily calories*

Figure 3.5 | Cereal import dependency ratio in South Asia, 2001–2017



Data source: FAOStat

The "sugar and sweeteners" food group is notable because consumption of items from this group has been associated with a rise in obesity and type 2 diabetes. This group includes fructose, maltose, sugar cane, sugar beet, cane sugar, beet sugar, maple sugar and syrups, raw or refined sugar, molasses, sugar confectionery, glucose and dextrose, lactose, artificial sweeteners, glucose, and honey.

FAO statistics suggest that the main food supply indicators have not changed much in the past 20 years in SA (Figures 3.7 and 3.8). Except for Sri Lanka and the Maldives, where the share of dietary energy supply derived from cereals, roots, and tubers remained the same from 2000–2017, it has declined between 2 and 6 percentage points in other South Asian countries.

In the same period, average protein supply increased 5–26 percent, with the highest increase occurring in Nepal. Only in the Maldives was the actual protein supply relatively volatile, mainly driven by animal protein changes, and decreased in the period 2000–2017. As a small island state, Maldives's domestic food market largely depends on imports, international markets, prices, and foreign supply. The average supply of animal-sourced proteins has increased in all countries except Maldives and Afghanistan. Figure 3.8 clearly shows that while average protein supply is relatively similar in all countries, except Maldives, the composition of protein varies across the region. For example, while the share of animal protein in total protein in Bangladesh is around 20 percent, in Pakistan, it is slightly more than 40 percent. This is largely influenced by milk consumption in Pakistan, which is more than three times higher than in most South Asian countries (Figure 4.30).

As discussed previously, there is an issue with the accuracy of dietary data, and it is very important to be aware of what different population subgroups eat. Children have different diet-related health issues than adults, and men and women also differ in that respect. There is a difference in what the poorest and the wealthiest people eat, but also what urban and rural populations consume. Many factors influence food consumption and, hence, health outcomes, including level of education, type of job, household size, etc. Research that aims to capture the relationship between food consumption and health outcomes often uses incomplete or inaccurate data or relies on proxy information. To monitor food consumption trends, it is necessary to have dietary data over certain periods of time.

Dietary diversity score (DDS) is a commonly used indicator to assess nutrition adequacy and to monitor dietary patterns, by measuring the number of food groups consumed by an individual. There is no predefined number of food groups, and it varies between 5 and 24, depending on the level of food group aggregation. DDS is driven by different factors. One factor is production diversity, which points to the number of different crops grown or different livestock species raised at an agricultural household. As examples in Box 3.2 show, the relationship between production and dietary diversity is not linear. It also depends on market integration, location, harvest/yield, and other factors.

Box 3.2 | THE RELATIONSHIP BETWEEN PRODUCTION AND CONSUMPTION

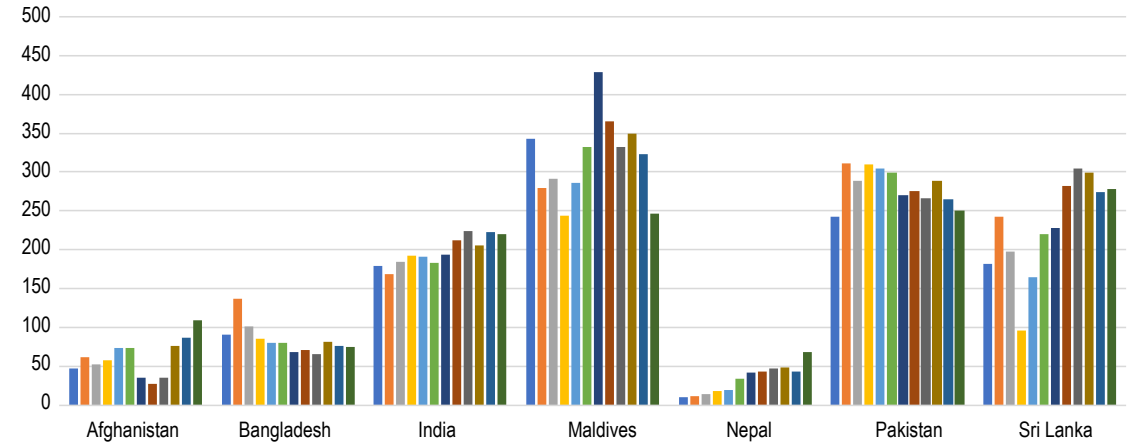
Agriculture is a unique sector, as sometimes producers sell all their products, while sometimes they also consume what they produce. For the latter, scholars and policymakers designed instruments promoting the production of nutritiously dense foods, assuming that producers would eat those products and improve their nutritional status. The idea is intuitive and simple, but its implementation and resulting nutritional outcomes are not as straightforward. One of the determinants of success for these interventions is market integration of production sites. Evidence suggests that production diversity tends to translate into diet diversity in regions where markets are not well developed.[a] Also, it has been argued that production diversification between farms, rather than diversification at the farm level, increases the supply of diverse foods.[b]

Research from Afghanistan reveals additional aspects of the interplay between diverse production and diverse diet. Crop diversity was found to be mostly important for dietary diversity in regular seasons, while in lean seasons, livestock production was found to play a stronger role.[c] Finally, research from Nepal, which examined the relationship between livestock ownership and animal product consumption in children, showed that small-scale animal production was positively correlated with egg and dairy consumption, while the same effect was not found for meat.[d]

Two of the concerns raised with respect to measures relying on agriculture–nutrition linkages is sustainability and scalability.[e] A study analyzing agricultural interventions for nutrition outcomes found that kitchen garden projects in South Asia were successful with respect to food production, diet diversity, and consumption.[f] However, it remains unclear whether those successful outcomes translated into improved health indicators, or whether the interventions are sustainable. Namely, the projects typically provide training in growing practices and the role of nutrition, as well as seeds and other inputs. Follow-up surveys 1, 5, and 10 years later are needed to determine whether the projects were sustainable.

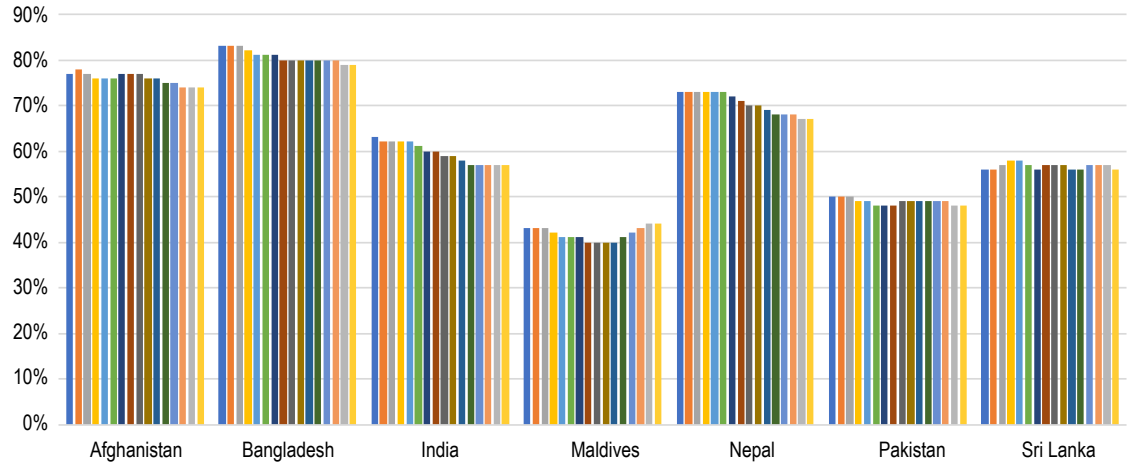
[a] Jones et al. (2014)
[b] TCI (2020)
[c] Zanello et al. (2019)
[d] Broaddus-Shea et al. (2020)
[e] Headey and Masters (2021)
[f] Bird et al. (2019)

Figure 3.6 | Sugar and sweeteners availability in South Asia (kcal/capita/day), 1962–2017



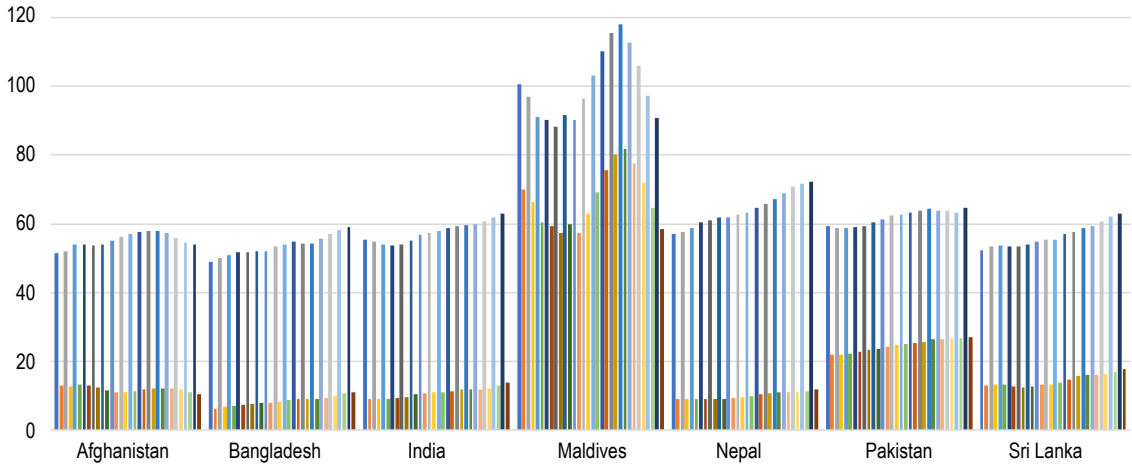
Data source: FAOStat

Figure 3.7 | Share of dietary energy supply derived from cereals, roots, and tubers in South Asia, 2000–2017 (3-year average)



Data source: FAOStat
Note: Each bar represents one year—the first bar in each country represents 2000 and the last bar, 2017.

Figure 3.8 | Average total protein supply and proteins of animal origin in South Asia (g/cap/day), 2000–2017 (3-year average)



Data source: FAOStat
Note: Each bar represents one year—the first bar in each country represents 2000 and the last bar, 2017

3.3 The Gender Dimension in Food Consumption

It has been argued that gender is one of the most prominent influences on nutritional outcomes. In this context, gender will refer to women's role in nutrition. Recent research findings suggest that women's dietary diversity, as well as diet quality, influence birth outcomes.[50] Women are directly linked to the nutrient intake of a child's first 1,000 days,[51] and they are very often in control of what is cooked in a household. Women's roles in agricultural production are equally important. On average, 40 percent of employed people in SA are defined as agricultural labor—56 percent of employed women and 37 percent of employed men (Figure 3.9). There is great variability among South Asian countries; in Nepal, almost 75 percent of women find employment in agriculture, but only 2 percent do so in Maldives. Women in SA are also involved in food purchasing decisions. Thus, women are believed to have a decisive role in determining the nutritional outcomes of their children, household, and wider communities.

The food- and nutrition-related responsibilities of women are substantial and well documented; the question is whether these responsibilities are coupled with women's power and authority. The Women's Empowerment in Agriculture Index (WEAI) measures women's empowerment and inclusion in the agricultural sector. It is a survey-based index composed of two sub-indices: one measures women's empowerment across five domains in agriculture, and another measures gender parity in empowerment within the household. The five domains are: agricultural production decisions; decision-making power related to productive resources; control of use of income; community leadership; and time allocation.[52] Each of these domains has a respective strand of literature. To address context-specific measurement errors of the WEAI, the Tata–Cornell Institute for Agriculture and Nutrition (TCI) modified the existing index for the Indian context.[53] Other South Asian countries would benefit from their own indices.

Nutritional outcomes, such as dietary diversity and iron status, are positively correlated with women's empowerment.[54] Gender dictates time-use as well. TCI alumna Dr. Vidya Vemireddy found that, in addition to the regular domestic work, women spend up to 5.5 hours per day in agriculture during the peak season. This is at the expense of some domestic work, personal care, and rest time, which in turn negatively affects their nutrient intake. Given the relationship between maternal and children's health previously discussed, it is clear that gender dynamics affect women and have long-term impacts on entire families. Similarly, men and women participate equally in productive work, yet women cover most of reproductive work, such as childcare, caring for other household members, caring for nonfamily members, and cooking, cleaning, and collecting water and fuel.[55] It should be noted that reproductive work, which is entirely unpaid labor, is performed at the expense of leisure time and that such time-use distribution between genders may influence nutritional and health outcomes. Between 1990 and 2013, labor force participation of women in South Asia declined from 35 percent to 30 percent.[56] The same report finds that the gender pay gap in urban areas in South Asia is 42 percent, while it is 28 percent in rural areas. Similar findings are presented in recently published in "The Status of Women in Agrifood Systems."[57] Some of the wider measures to address this injustice include investments in basic social services, as well as childcare services.[58]

In the first randomized controlled trial of its kind, women's empowerment was tested, as to whether it is a pathway by which a nutrition-sensitive program can reduce child wasting in Burkina Faso.[59] The authors referred to four domains of women's empowerment: purchasing decisions, health care decisions, family planning decisions, and spousal communication. They found that, mainly driven by spousal communication, women's empowerment contributed to the program's impact in reducing wasting, but there was no such evidence for anemia. As for family planning decisions, one study found that optimal spacing between births might help in reducing stunting in children.[60] Other evidence found that while women's empowerment is positively associated with adult men's, women's, and children's dietary diversity, nutrient intake benefits were restricted to adults only.[61] The authors also

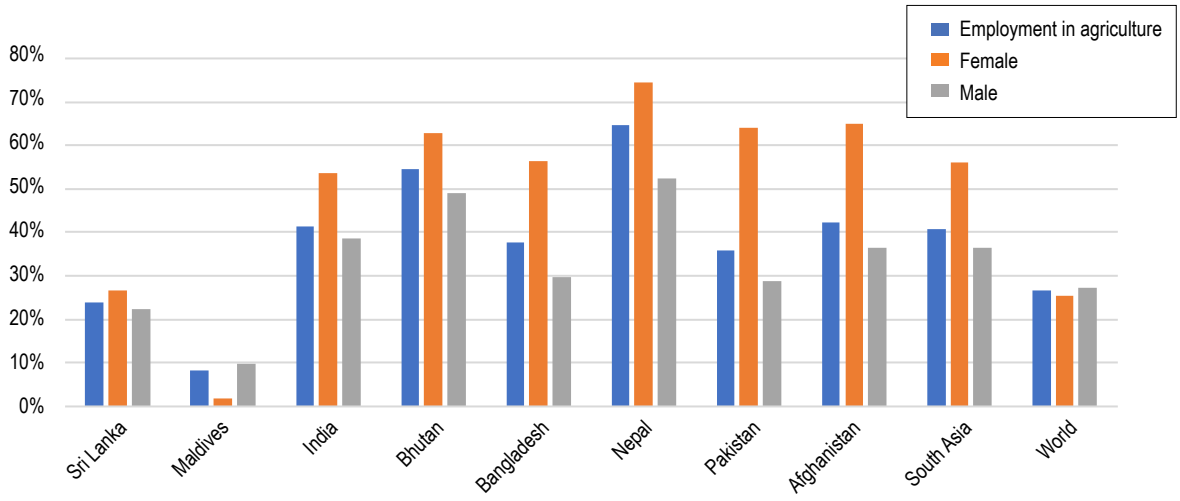
[50] Madzorera et al. (2020)
[51] This period refers to time between conception and age two and is crucial for a child's growth and physical and cognitive development.
[52] IFPRI (2012); WEAI was developed by International Food Policy Research Institute (IFPRI), Oxford Poverty and Human Development Initiative (OPHI), and Feed the Future (United States Agency for International Development [USAID]) in 2012.

found that, compared to empowerment, maternal schooling and socioeconomic status had greater impact on girls' protein, iron, and zinc intakes. These examples show that the relationship between women's empowerment and nutrition outcome is not linear and direct, and that there are other underlying factors which could enhance or undercut the relationship.

For reasons previously discussed here, the majority of nutrition-focused projects and research activities are focused on women. Very limited research has concentrated on men's role in nutrition outcomes. However, an example from Ethiopia shows that men's role is not negligible, and men's dietary knowledge had positive associations with both household and children's dietary diversity,[62] as well as women's dietary diversity. Including men in projects that are addressing gender power imbalances might help to achieve more effective and longer lasting results.

Afghan women carry washed dishes back to their village.
(Photo by solmaz daryani/Shutterstock)

Figure 3.9 | Employment in agriculture in South Asia by country and gender, 2018



Source: World Bank (2023b), World Development Indicators
Note: Employment is defined as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit

[53] TCI team members who worked on this project: research economist Soumya Gupta, alumna Vidya Vemireddy, researcher Dhiraj Singh, and TCI Director Prabhu Pingali.
[54] Gupta, Pingali, and Pinstrup-Andersen (2019); Gupta, Vemireddy, and Pingali (2019)
[55] Picchioni et al. (2020)
[56] UN Women (2016)
[57] FAO (2023f)
[58] UN Women (2016)
[59] Heckert et al. (2019)
[60] Dhingra and Pingali (2021)
[61] Sraboni and Quisumbing (2018)
[62] Ambikapathi et al. (2020)

3.4 Nutrition Transition

Next, we examine nutrition transition (NT) and explore further the relationship between food, agriculture, and nutrition. Additionally, we compare NT globally with NT in SA. We look at the main forces behind NTs and potential policy answers to the challenges created by NT.

The Nutrition Transition and its Characteristics

Nutrition transition is a global phenomenon, and no country is spared.

Nutrition transition typically leads to a rise in the overweight population and related noncommunicable disease, but undernutrition is still the major threat in SA.

Nutrition transition offers opportunities and presents threats to healthy eating patterns.

The goal of addressing the nutrition transition should be eradicating hunger in SA, without falling into the "overweight trap," and simultaneously addressing micronutrient deficiency.

NT, dietary changes, and global changes in dietary patterns are the terms frequently used in nutrition-related public health literature, often interchangeably. While dietary changes and global changes in dietary patterns explicitly refer to food consumption, nutrition transition involves changes in the level of physical activity too. Barry Popkin, who coined the term in 1993, argued that obesity ultimately reflects energy imbalance.[63] Popkin's work addresses both food intake, which can be seen as energy intake, and physical activity—a proxy for energy expenditure. He sees NT as a change in dietary patterns of societies over time. It starts with collecting food, often referred to as the paleolithic pattern (pattern 1), continues to famine (pattern 2), followed by receding famine (pattern 3), and degenerative disease (pattern 4), before ending with behavioral change (pattern 5).[64] Each of these patterns is characterized by dominant food patterns and associated health outcomes. Figure 3.10 depicts the last three patterns and their associated food and health outcomes.

As populations in SA are mainly transitioning from pattern 3 to 4 or are already in the midst of pattern 4, the key challenge is to minimize the time spent in pattern 4 or skip it altogether. That is, how do we eradicate undernutrition without "overshooting" into overnutrition?

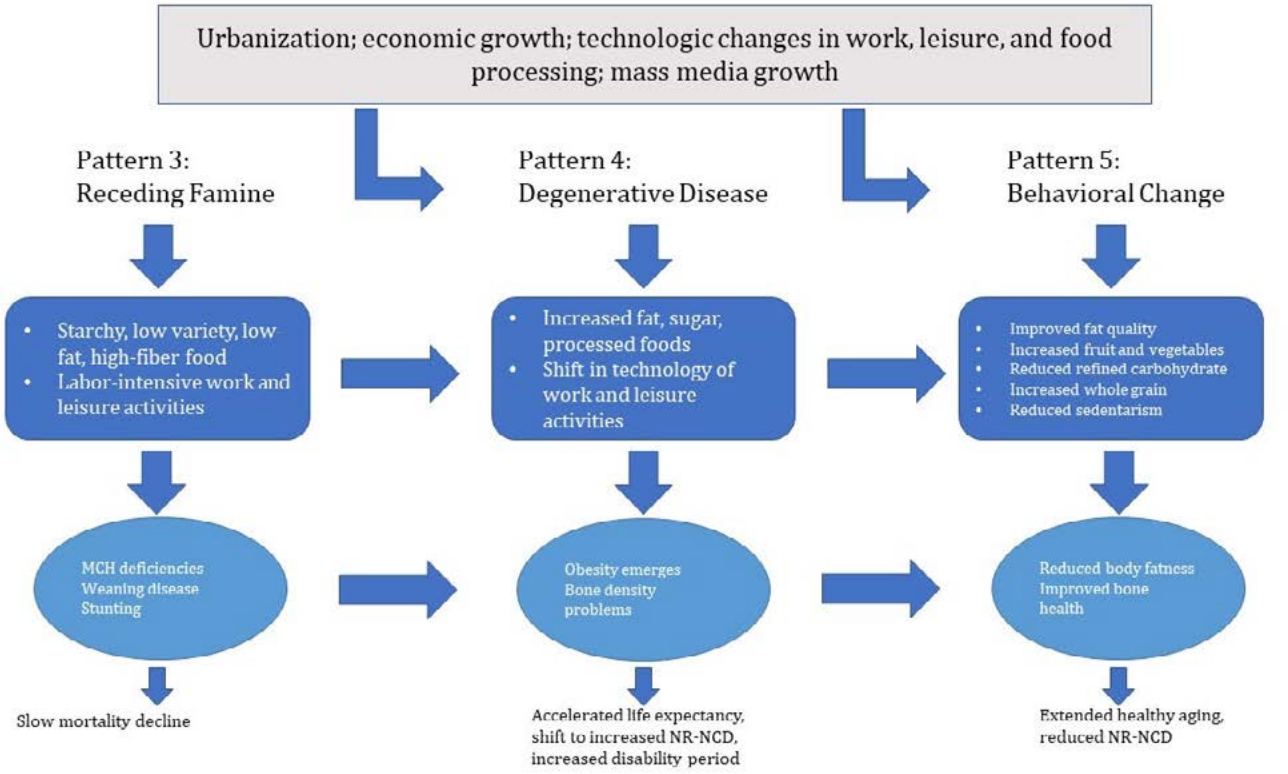
Not only are LMIC in SA and other parts of the world going through NT, but relative to HIC, the transition is happening at greater pace and at earlier stages of economic and social development.[65] Additionally, the decline in physical activity level is reflected in a shift from labor-intensive to capital-intensive occupations.[66]

NT-induced changes in dietary patterns involve a reduction in consumption of foods representing traditional diets and an increase in foods reflecting global and "Westernized" diets. This typically means reduced intake of pulses, coarse grains, staple cereals, and complex carbohydrates, in general, and increased intake of animal foods, refined grains, and foods that are high in fat, salt or sugar, energy-dense foods, and ultra-processed, packaged and convenience foods. Evidence for fruit and vegetable consumption is mixed.[67] In the Asian context, a convergence toward a Western diet led to increased intake of wheat, temperate fruit and vegetables, and high protein and energy dense foods.[68]

Comparing HIC, upper middle-income countries (UMIC), and LMIC, it was found that total sugar, fat, and salt consumption from processed foods and beverages plateaued in HIC, but increased rapidly in UMIC and LMIC. Carbonated soft drinks were the most significant sugar vector, in all country income brackets; oils and fats were the most significant fat vector for all country income brackets. Baked goods and biscuits were the most significant salt vectors in UMIC and LMIC; and chilled processed foods and baked goods were the most significant salt vectors in HIC. Processed food consumption increased rapidly in LMIC and most in UMIC, but slowed or declined in HIC. Beverage consumption increased most rapidly. There was regional-level convergence in processed food consumption, but with notable divergences at the country-level. Production to consumption pathways (foreign imports vs. domestic production) appears to be vector dependent.[69] Additionally, findings suggested that energy intake is driven more by eating frequency and less so by portion size.[70]

[63] Popkin et al. (2012)
[64] Popkin (1993)
[65] Popkin (2004); Hawkes et al. (2017)
[66] Popkin (2002)
[67] Hawkes et al. (2017); Kelly (2016); Popkin (2002)

Figure 3.10 | The last three patterns of nutrition transition



Source: Popkin (2006)
Notes: MCH – maternal and child health; NR-NCD – nutrition-related – noncommunicable diseases

NT, arguably, is characterized by both a convergence and divergence in diets.[71] The convergence of diets is reflected in the availability of the same products globally, in HIC and LIC, and in both urban and rural areas. However, market segmentation occurs with increasing incomes, as low-income parts of a society have limited access to some products.

Measuring nutrition transition

Although there is a consensus about what NT entails, it is less clear how to accurately measure it. Doing so requires accurately measuring what people eat over years and exploring the main drivers for certain types of diets.

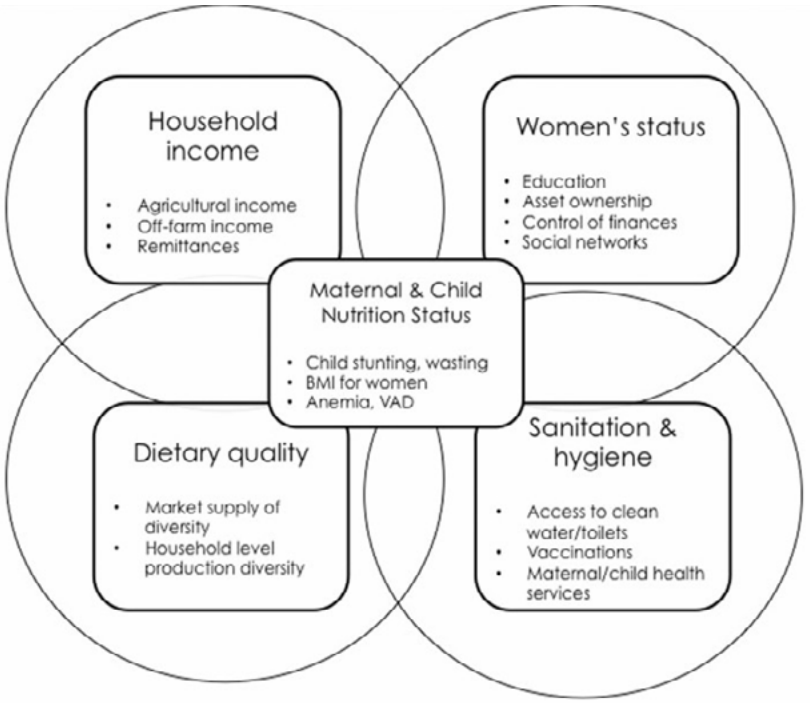
The methodology for measuring intake will depend on many factors, but one of the most determining is financial resources. The more granular the data, the more detailed and accurate the results.

Food consumption data are typically collected at individual or household levels, and technology can assist in data collection. Nielsen Homescan, which allows consumers/survey respondents to scan the barcodes of the products that they buy, has been used by researchers for more than 20 years. This enables researchers to look at the proportion of volume of household packaged foods purchases, to see to what extent different food groups contribute to calorie intake.[72] There are certain limitation to this approach. The higher proportion of products without barcodes being consumed—including products produced and consumed within the household as well as products purchased at food outlets —the higher probability of inaccurate data. There are other computer and web-based tools that use technology to facilitate 24-hour recall for food intake, such as ASA24 and Intake24.[73] These tools aim to significantly reduce data collection costs by providing computerized dietary recall systems, which aim to closely approximate live interviews. While some tools provide details on the quantity of foods consumed, other tools solely monitor food groups consumed.

Another method of data collection involves interviewing individuals about the food that they consumed in a past period, most commonly 24-hour, 3-day, or 7-day recalls. During the interview, the respondent should be able to provide detailed and accurate information on all foods consumed by household members during the recall period. The most common instruments for measuring dietary diversity and food security in LMIC are dietary diversity surveys, household expenditure surveys, and food security surveys.[74] Additional information about data collection can be found in Section 3.1.

[68] Pingali (2007)
[69] Baker and Friel (2014)
[70] Popkin and Kenan (2017)
[71] Hawkes (2006)
[72] Stern et al. (2016)
[73] ASA24(2022); Intake24 (2022)
[74] Walls et al. (2018)

Figure 3.11 | Multisectoral indicators for nutrition improvement (MINI)



Source: Pingali and Rickets (2014)
Note: VAD denotes Vitamin A deficiency

Commonly recognized limitations of data collection methodologies are lack of standardized surveys to appropriately capture ultra-processed foods (UPF),[75] superficial examination of dietary patterns, exclusion of certain demographic categories, insufficient attention given to the dynamics of change of dietary patterns,[76] and a lack of respondents' understanding of what should be included in their answers.[77] Some researchers involved in observational studies, for example, have noticed that certain snacks consumed were not reported by the respondents, thinking the snacks not noteworthy for reporting.[78] While this type of research is invaluable for a deeper understanding of food choices and the drivers behind them, it often prohibitively time-consuming and expensive. For timely policy measures, a very important precondition is to have timely data and to capture the region of interest—that is, for national policy instruments, it is necessary to have a nationally representative sample. Although surveillance of dietary trends entails frequent surveys, the reality is that countries in SA conduct surveys every 5–10 years, and some countries in SA do not have nationally representative surveys at all. Also, while consumption is ultimately an individual action, it depends not only on intra-household dynamics and allocation, but on many other factors previously described. For that reason, the design of an integrated set of interventions requires a set of multisectoral indicators and metrics.[79] Some of those metrics are presented in Figure 3.11.

Accurate estimation and a better understanding of the costs of malnutrition—through loss of productivity and health expenditures—might motivate governments to increase their capacities and investments in monitoring dietary trends.

Trends in food consumption can be analyzed from at least two angles. One is to look at separate food items, monitor changes over time, and examine whether a population increased or decreased their intake of certain food products or food groups during the study period.

Another angle is to use cluster analysis to group individuals by similarity of diets and to infer types of diets based on that information. The food consumption data can be collected by interviews, food frequency questionnaires, or share in expenditures. Applying this approach in the South Korean context resulted in findings that there are three main diets—the "Korean diet," dominated by rice, vegetables, and kimchi; the "Western diet," dominated by soda, eggs, and oil; and the "New diet," characterized by low sugar and high fruit and dairy product intakes.[80] In Bangladesh, this approach identified five diets: "least diverse," "traditional," "low vegetable/low fish," "moderately high meat," and "most diverse."[81] Applying this method to the Indian context, five diets were identified: "cereal-based," "processed food-heavy," "dairy," "balanced with dairy," and "balanced with meat" diets.[82]

Using cluster analysis, researchers determine the names and types of the most common diets, based on benchmarks imposed by the researchers themselves, which leads to arbitrary decisions. This method, however, provides a more comprehensive picture and is flexible enough to accommodate various regional settings and differences. To follow the existence of NT, or a lack of it, within a study population, one needs to compare the most common diets over time and to determine whether new diets emerge. The example from India found that the same five common diets were dominant between 1993–1994 and 2011–2012, suggesting habit persistence.[83] However, the proportion of respondents who were grouped into these five diets changed, signaling a redistribution within the same five diets.

The importance of nuance has been exposed in studies in which researchers conducted their work

[75] Walls et al. (2018)
[76] Popkin et al. (2012)
[77] Nichols (2017)
[78] Nichols (2017)
[79] Pingali and Ricketts (2014)
[80] Lim et al. (2014)
[81] Thorne-Lyman et al. (2020)
[82] Tak et al. (2019)

by combining interviews, focus group discussions, and analyses of government reports to explore changes in diets. While they found that the study population mainly retained their traditional diet, more sugar and vegetable oils were consumed and added to the traditional recipes.[84] Furthermore, applying an intergenerational social practice approach is very useful for understanding the less visible dynamics of food consumption.[85]

Drivers of nutrition transition

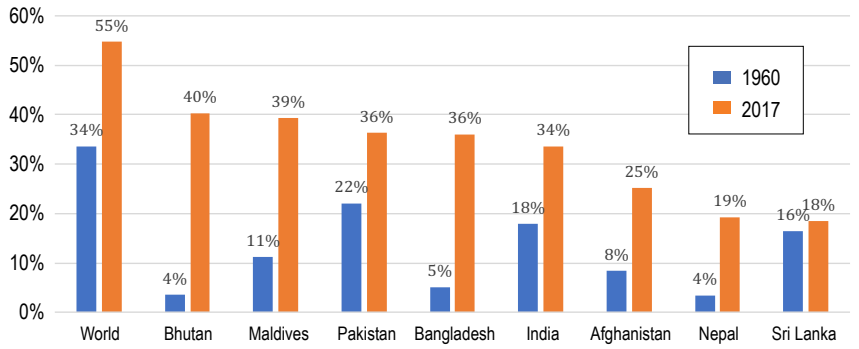
NT is not a negative phenomenon by default; it is a very complex set of interlinked mechanisms, and as we explore them, we should think about how to maximize the positive effects while eliminating or minimizing the negative effects. We can look at NT as a bundle of food choice changes and changes in energy expenditures. Thus, we need to understand what the individual food choice drivers are, how they interact with one another, and which of the drivers are more likely to lead to a decrease in undernourishment and which are more likely to increase prevalence of overweight and obesity.

When examining NT and food choice drivers, it is important to be aware that some drivers are relatively volatile, such as household income, food prices, and food availability. Other drivers are not as volatile, but evolve gradually, typically in one direction, such as the rate of urbanization and fertility rate. To investigate NT further, we use some less-volatile trends to examine how volatile drivers react to the slow changes and eventually how they are shaping diets. To that end, we will look at urbanization, food distribution and sales, and globalization of food trade. For each factor, we consider how it fits into energy intake and the energy expenditure narrative.

Urbanization

Increasing urbanization rates are a global phenomenon, and while the trend has remained unchanged for more than 60 years, the dynamics and rate of urbanization varies between countries. On a global level, the share of people living in urban areas was 34 percent in 1960, increasing to 55 percent in 2017.[86] The change in rate of urbanization in SA countries has been very variable (Figure 3.12). In Bhutan, the share of people living in urban areas increased more than 36 percentage points, while in Sri Lanka, the increase was only 2 percentage points.

Figure 3.12 | Urbanization rate in the world and in South Asia, 1960 and 2017



Data source: Our World in Data (2023)

Urbanization is important in the context of NT for several reasons. With respect to energy expenditure, life in urban areas is typically characterized by less labor-intensive occupations, changes in transportation, and decreased physical activity at home.[87] From the perspective of energy intake, food preparation time is limited in urban areas, which coupled with higher fixed costs of food preparation in smaller families, results in more food consumed or purchased away from home, even for poor households.[88] Time also is a factor in urban areas with higher earning potential incentivizing people to spend time on income-generating activities rather than on cooking.[89] Food consumed or purchased away from home is typically more energy dense than home-cooked meals. As for dietary patterns, compared to rural areas, urban dwellers consume more meat and other proteins, fruits and vegetables (F&V), processed foods, and non-basic foods like sugary snacks, but less dairy.[90] Recent research provides additional evidence that an increase in the proximity of rural areas to towns leads to an increase in access to processed foods and an increase in the risk of obesity for those living in the rural areas.[91] The urban–rural dichotomy comes with a caveat, as urban populations are very diverse in terms of socioeconomic status. Impoverished dwellers cannot afford many of the diverse food choices available. Moreover, research shows that poor people's preferences are skewed toward food items that provide high energy and have a long shelf life, which partly explains the low fruit and vegetable consumption.[92] In summary, urban areas provide very diverse and nutritious foods, as well as plenty of opportunities for physical exercise, yet only those who are not constrained by time and/or money can fully enjoy these "privileges."

[83] Tak et al. (2019)
[84] Lipoeto et al. (2013)
[85] Wertheim-Heck and Raneri (2020)
[86] Our World in Data (2023). https://ourworldindata.org/grapher/urban-and-rural-population
[87] Popkin et al. (2012)
[88] Haddad (2005)
[89] Pingali (2007)
[90] Hawkes et al. (2017)
[91] Aiyar, Rahman, and Pingali (2021)
[92] Cunningham et al. (2021)

Food distribution and sales

Food distribution and sales have substantially changed in LMIC, and this transition is closely connected to urbanization. The diffusion of modern retail outlets is going through different phases, starting with large cities and moving toward smaller ones, and starting with upper class households and moving toward the middle class, and finally, to lower classes. The supply is dominated by processed foods at the beginning of NT and gradually moves toward semi-processed foods and fresh produce.[93] The penetration of global supermarket chains induced several changes to local markets. The chains brought a certain set of standards for product quality and hygiene, and a range of new products, some of which are positively associated with improved health outcomes and some negatively. Furthermore, they induced the emergence of domestic chains that function like global chains, suppressing traditional wet markets.[94] As for fresh markets, there are mixed findings about their role in society and their contribution to NT. While supermarkets "occupied" a certain share of the market at the expense of wet markets, some consumers still have expressed preferences for wet markets for various reasons. Research showed that younger women find purchasing food at fresh markets more convenient, because their working hours are better suited to their needs, and shopping in supermarkets is more time-consuming than at traditional markets. Vendors at supermarkets do not provide all the services found in a traditional market, and finally, supermarkets are not fully trusted with regard to food safety.[95] Most of the reasons for the stronger preference for traditional markets are based on a personal relationship between customers and vendors, especially, in smaller towns where the relationships are more likely. Traditional wet markets are associated with increased vegetable consumption in Thailand and increased consumption of calories, carbohydrates, protein, and fat in China.[96] The two examples show us that divergent outcomes from the supermarkets/wet markets are location- and context-specific, just as are many other aspects of NT.

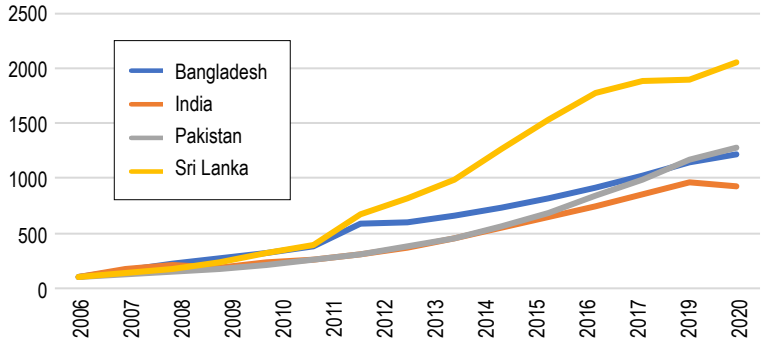
Another very important aspect of modern food sales and distribution is the marketing approach applied by supermarkets and chains. Expansion of mass marketing, coupled with increased income and changing employment patterns, arguably, contributes to changing dietary patterns.[97] As food marketing campaigns aim to maximize companies' profit, energy-dense foods or UPF are often heavily promoted, attracting many consumers, some of whom are unaware of the adverse health outcomes associated with their consumption. In other words, lack of knowledge is being abused. Even consumers who are informed about the health effects of these foods still consume them, as the immediate satisfaction that they derive from the consumption outweighs negative and often discounted long-term health consequences. In other words, there is a temporal disconnect between the cause and the outcome. Research has also discovered that youth in northeastern Thailand predominantly understand the link between fast food and obesity and heart disease, yet they continue the consumption of such foods, as social events combined with marketing campaigns contribute to the perception that the foods are modern and socially approved.[98] The perception that a product is or is not healthy, modern, and socially approved can play both ways. Some foods that were considered in some regions or time periods to be "a poor man's food" are quite the opposite in other areas and periods. Examples of those are bone broth, oxtail, lard, offal, and even millet. The perception of millet has varied from an inferior grain that people are embarrassed to eat to a very popular grain that is sold in health food stores.[99] Advertising power, in this case, has been instrumental.

As for food sales trends, Figure 3.13 suggests that there has been a significant increase in modern grocery retailers' retail value between 2006 and 2020. The increase ranges from almost tenfold in India to more than twenty times greater in Sri Lanka. Furthermore, market concentration in Bangladesh, India, Pakistan, and Sri Lanka is also prominent, with respect to modern grocery retailers. The top three companies in these four countries cover between 40 percent and 70 percent of the market share, and they show an upward trend.[100] These two occurrences suggest that modern grocery retailers will probably have even more influence on consumers' food habits.

Whereas in Bangladesh, India, and Pakistan, packaged cooking ingredients and meals show the greatest increase, in Sri Lanka, it is dairy products and alternatives. These trends have and will continue to have significant impacts on agriculture. It can boost agriculture and the food industry where market demand is met by national producers and the food industry. For this to occur in SA, where the dominant form of agriculture is small-scale farms, significant efforts must be made to integrate producers into food value chains. We examine these efforts further in the "State of Agriculture" section. If domestic demand is met by imports from other countries, agriculture and farm income could be negatively affected, and farmers will be forced to diversify production or to increase their reliance on off-farm income.

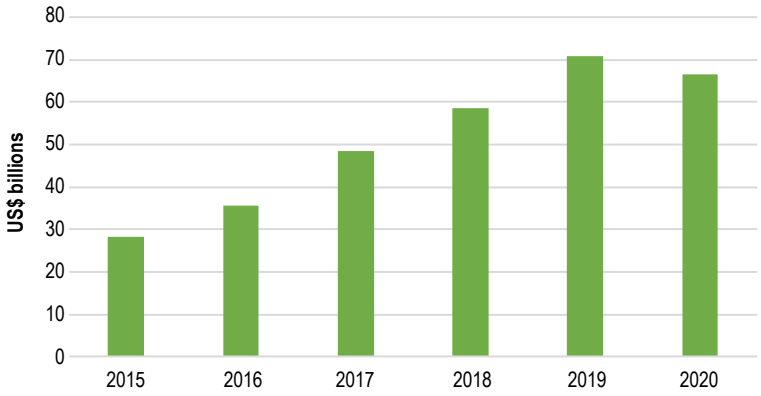
[93] Reardon et al. (2012)
[94] Popkin et al. (2012)
[95] Wertheim-Heck and Raneri (2020)
[96] Hawkes et al. (2017)
[97] Hawkes et al. (2017)
[98] Seubsman et al. (2009)
[98] Nichols (2017)
[100] Euromonitor International. (2023). Passport data.

Figure 3.13 | Change in retail value from modern grocery retailers in current local prices in South Asia, 2006–2020 (2006 = 100)



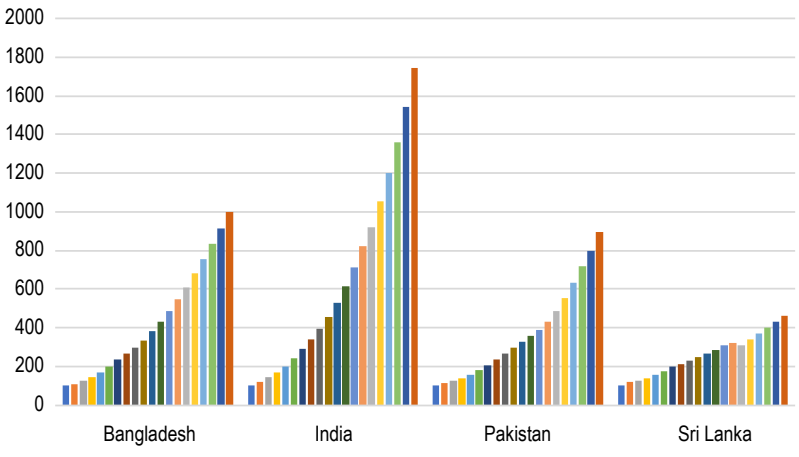
Data source: Euromonitor Passport

Figure 3.14 | India revenue from e-commerce (goods and services), 2015–2020



Data source: Euromonitor Passport

Figure 3.15 | Packaged food retail value trend in local currency in South Asia, 2006–2025 (2006=100)



Data source: Euromonitor Passport
Note: 2021–2025 predicted values; Packaged food: Cooking Ingredients and Meals, Dairy Products and Alternatives, Snacks, Staple Foods

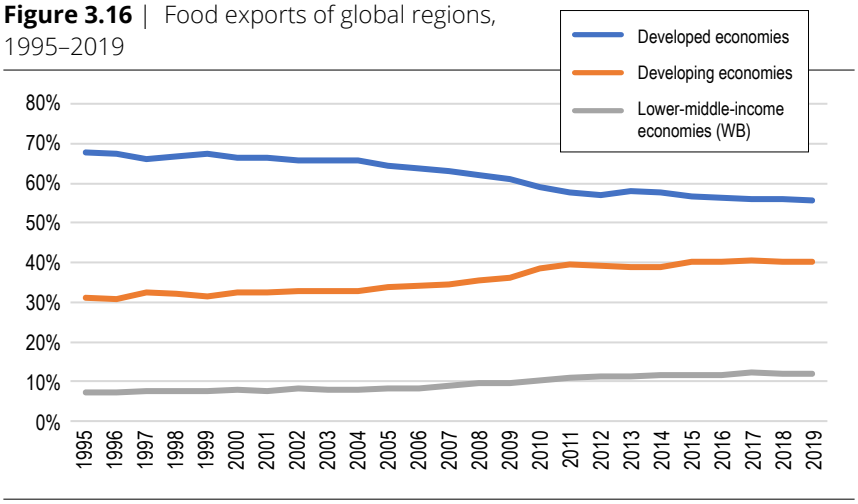
Globalization of the food trade

Globalization of the food trade led to greater diversification of the food supply worldwide. The economics behind liberalization suggested that more liberalized markets would reward efficient food producers and would lead to a broader range of food products for consumers, who would then maximize their own utility using disposable resources. It is important to be aware that trade liberalization is part of wider context of economic, political, and social globalization.[101]

A positive example of the globalization of the food trade is the availability of fresh F&V throughout the year, irrespective of geographic location, but predominantly in HIC. However, there have been concurrent trends that are less favorable with respect to health outcomes. It has been argued that high-value, non-bulk packaged goods, such as pastries, prepared foods, and chocolate, are actually the most dynamic component of global trade.[102] Additionally, processed foods high in sugar, salt, and oil have the largest competitive advantage in global markets, as they are cheaper to produce, transport, and store, compared to their unprocessed counterparts.[103] Furthermore, global agriculture, coupled with trade policies, led to a sharp increase in the availability of cheap vegetable oils and fats, resulting in higher availability and consumption of highly processed foods.[104]

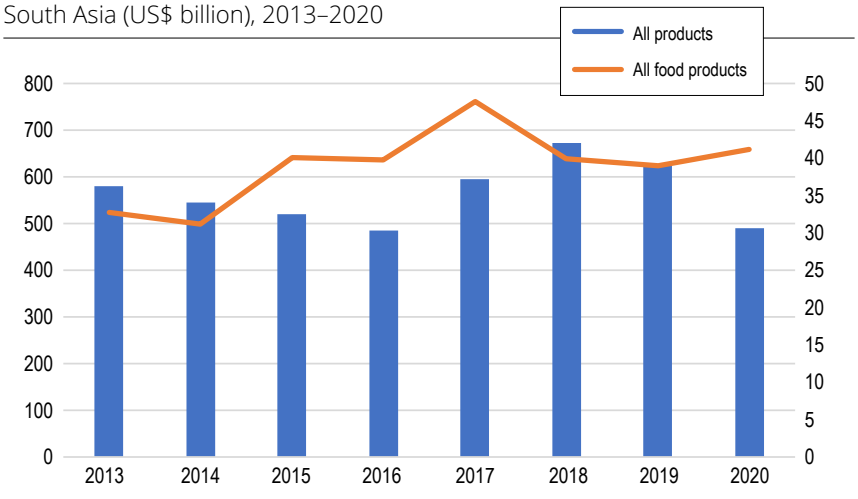
Interestingly, the share of different regions in food exports has changed in the past 25 years. While developed economies significantly dominated food

Figure 3.16 | Food exports of global regions, 1995–2019



Data source: UNCTADStat (2021)

Figure 3.17 | Total imports and food imports in South Asia (US$ billion), 2013–2020



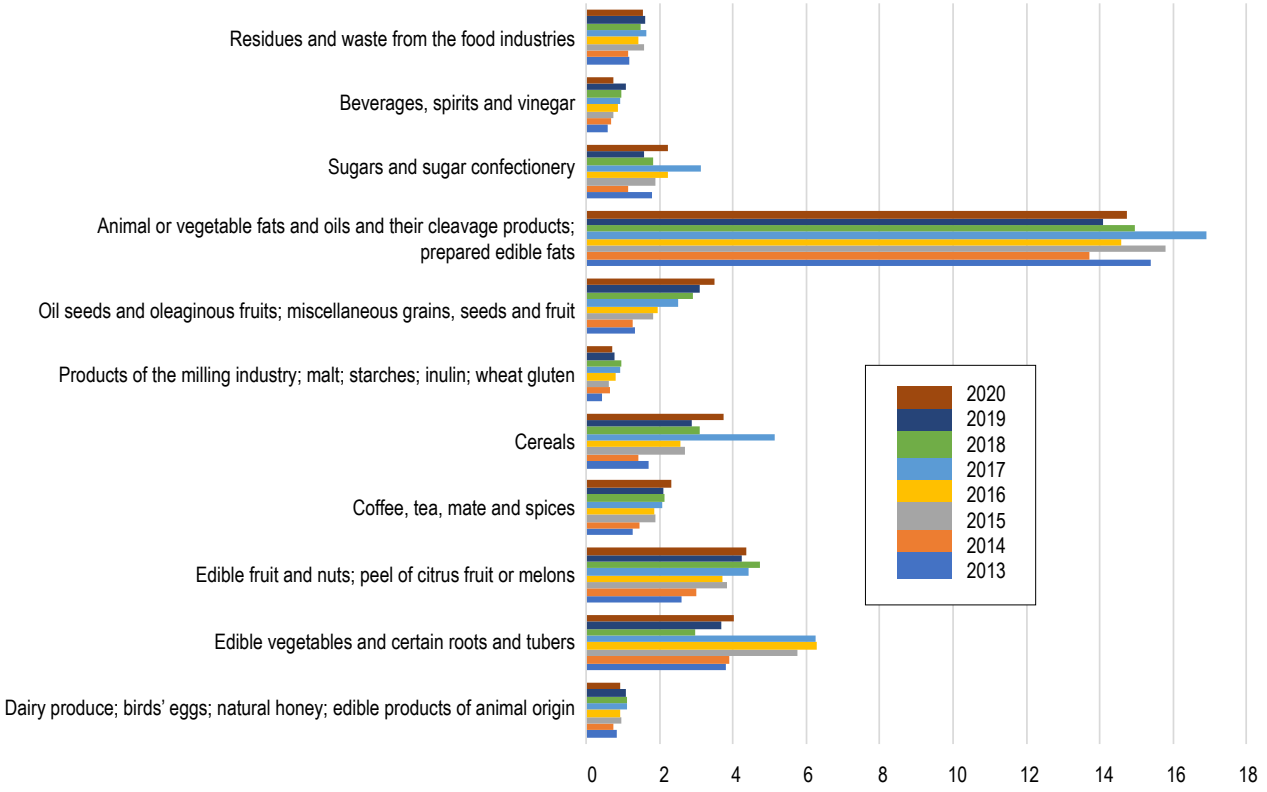
Data source: International Trade Centre (ITC). 2003. Trade Map

[101] Lin et al. (2018)
[102] Pingali (2007)
[103] Kelly (2016)
[104] Hawkes (2006); Drewnowski and Popkin (1997)

exports in 1995, with nearly 70 percent of global exports, this share declined to 55 percent by 2019. Developing economies increased their share in global food exports from 30 percent to 40 percent in the same period (Figure 3.16).

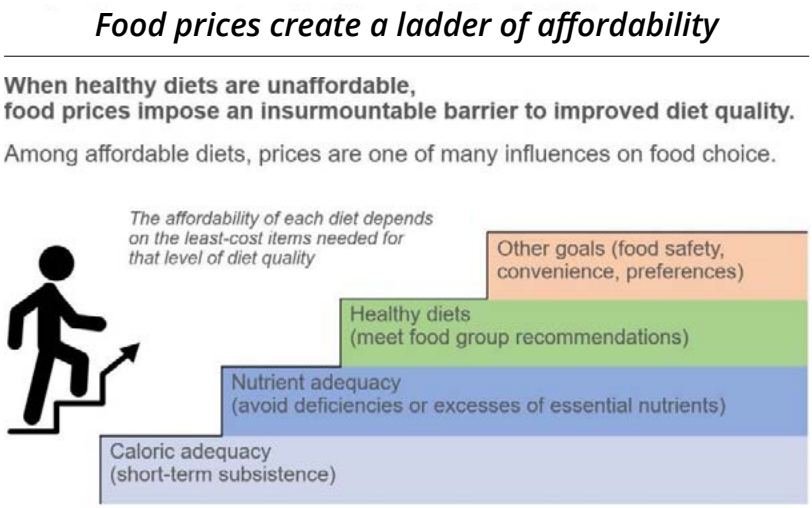
In SA, food imports have shown a volatile trend over the past seven years (Figure 3.17). However, imports of animal or plant fats and oils mostly dominate import value in the region (Figure 3.18). In addition to fats and oils, the following items make up a significant share of imports: edible vegetables and certain roots and tubers; edible fruits and nuts, coffee and tea; cereals, and sugar and sugar confectionery.

Figure 3.18 | Import of all food products, South Asia in US$ billions, 2013–2020



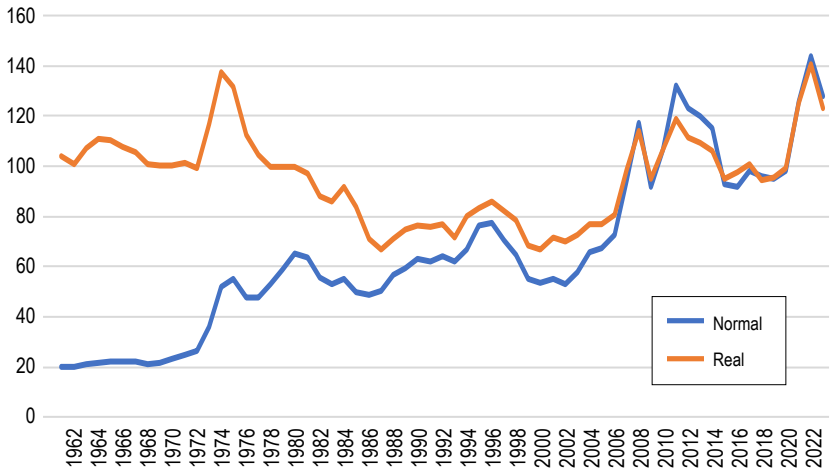
Data Source: ITC (2023). Trade Map
Note: Only those food products with import values of more than US$1 billion in any of the years are included. Excluded categories are live animals; meat and edible meat offal; fish and crustaceans, mollusks and other aquatic invertebrates; lac; gums, resins, and other vegetable saps and extracts; preparations of meat, of fish or of crustaceans, mollusks or other aquatic invertebrates; cocoa and cocoa preparations; preparations of cereals, flour, starch or milk; pastry' cooks' products; preparations of vegetables, fruit, nuts or other parts of plants; tobacco and manufactured tobacco substitutes. Two other categories were not included due to their role in food import: live trees and other plants, bulbs, roots, etc., cut flowers and ornamental foliage; vegetable planting materials, vegetable products not elsewhere specified.

Figure 3.19 | Ladder of food affordability



Source: Food Prices for Nutrition Project (2020)

Figure 3.20 | Food Price Index in nominal and real terms, 1961–2023 (2014–2016) (2016=100)



Source: FAO (2023d)
**Note: The real price index is the nominal price index deflated by the World Bank Manufactures Unit Value Index*

Other food choice drivers

In addition to the three global trends influencing NT, there are several very important factors that directly affect food choice and NT in the long run. **Price** is one of the most important determinants of food choice. Scholars have argued that there are three groups of food items: the first group, which is also the cheapest, includes foods that provide only caloric adequacy; the second group provides adequate nutrients; and the third, and most expensive group, secures a healthy diet.[105] The same study found that almost all populations in South Asian countries can afford an energy-sufficient diet, the majority can even afford a nutrient-adequate diet, but only a minority can afford a healthy diet. Additionally, on a global level, it is estimated that almost 3.1 billion people could not afford a healthy diet in 2020.[106] Additionally, Food Prices for Nutrition Project added a fourth group of target goals beyond healthy diets (Figure 3.19).

Based on the annual values of FAO's Food Price Index (Figure 3.20), it could be assumed that the *State of Food Security and Nutrition* publication in 2023 will report an even higher number of people who cannot afford a healthy diet. However, it is encouraging that the Food Price Index has declined from 140 in 2022 to 123 in 2023.[107]

The EAT–Lancet Commission on Food, Planet, Health attempted to investigate whether it is possible to feed 10 billion people around the world with healthy and environmentally sustainable diets.[108] The report concluded that it is possible by changing eating patterns and production systems and by reducing food waste. The Commission also proposed a diet that would contribute to this goal. However, research analyzed the cost of the proposed EAT–Lancet diet using real life data from three states in India, concluding that it would cost 3–5 times more money than what the population currently spends on food.[109] For future policy instruments, it is very important to take affordability into consideration, and should there be an asymmetry between what people are advised to eat and what they can afford, to invest efforts into leveling the two. Similarly, it is important to assess the impact of current policy instruments on prices, and consequently, on food consumption. Some authors argue that it is possible that by subsidizing and reducing the price of staples like rice, the relative price of other local staples such as millets increases, lowering the consumption of latter.[110] The effects of subsidies on nutrition are examined further in the next section.

[105] Herforth, Bai et al. (2020)
[106] FAO, IFAD, UNICEF, WFP, and WHO (2022)
[107] FAO (2023d). World Food Situation.
[108] Willett et al. (2019)
[109] Gupta et al. (2021)
[110] Cunningham et al. (2021)

In addition to price, **food availability** can also influence dietary patterns. It has been argued that universal human traits favor palatable diets that might involve some less healthy options, and that it is rather mere availability than the physiological mechanisms which drive dietary patterns.[111] This would imply that measures that reduce the availability of less healthy foods would lead to their reduced consumption. Also, because household dynamics very often has a strong impact on dietary patterns, we should distinguish gender dynamics from parents–children dynamics. Very often children have a strong influence on what will be consumed in households. Belief that giving children food they prefer to eat can prevent undernourishment, parents and grandparents sometimes provide suboptimal diets to their children, even when aware that these are not the healthiest options.[112] In those cases, it is very important to understand the channels through which children get the inspiration of what they want or do not want to eat. Additionally, parents' education is associated with dietary patterns of a household.[113]

Most of the numerous factors which can influence dietary habits fall under the class of food environments. Broadly, "Food environments are created by the human-built and social environments. They are the physical, social, economic, cultural, and political factors that impact the accessibility, availability, and adequacy of food within a community or region."[114] Additionally, food environments have been characterized as a combination of external and personal domains, where external domains are availability, price, vendor and product properties, as well as marketing and regulations, while personal domains are accessibility, affordability, convenience, and desirability.[115] It is important to note that food environments are particularly context- and location-specific. A recent attempt to bring the food environment concept closer to policymakers but also to a broader audience involved Australia's Food Environment Dashboard, where the authors assessed a set of food environment indicators and proposed potential actions to address traps of the current food environment in Australia.[116]

Price and availability, as well as food environment in a broader sense, favor energy dense, cheap foods with longer shelf life and ease of preparation. All combined, this leads to negative effects of NT for a big share of SA as well as the global population.

The role of ultra-processed foods in nutrition transition

UPF are very often part of the NT debate. They are also associated with transnational corporations, trade liberalization, industrialization of food systems, technological change, and globalization,[117] and other trends already analyzed in the previous sections of the NT chapter. However, it is not always clear what UPF are, and what the difference between UPF and processed food is. Processed foods are sometimes positioned in contrast to whole foods, and hence, they can easily be labeled "unhealthy food." Is that always the case, however? To address this question and to contribute to clarification of the role of food processing in NT, we start with relevant definitions. Processed food is any food that is altered in any way.[118] Alteration can be as simple as freezing, drying, or crushing. Some foods and ingredients, such as sunflower oil, would not exist without processing. Others, such as potato would not be edible without processing.

When it comes to vitamin content, researchers show that there is no significant difference between refrigerated and frozen broccoli, cauliflower, corn, green beans, green peas, spinach, blueberries, and strawberries, and they do not find evidence which suggests that those fresh products outperform the frozen ones in terms of nutritional value.[119] Yet, freezing food extends the shelf life and contributes to food waste reduction. It has been argued also that food processing is used to convert raw agricultural produce into edible and safe products, but it also contributes to improved nutrition.[120] One of the ways to improve nutrient value is through food fortification, which we discussed in the "Micro-nutrient deficiency" section.

On the other hand, there is a recognized association between increasing amounts of consumed processed products and obesity levels. To make the distinction and establish a relationship between different levels of processing on one hand, and diet quality and health outcomes on the other, the NOVA classification was developed. There are four groups of food products in the NOVA classification: unprocessed or minimally processed foods; processed culinary ingredients; processed foods; ultra-processed food and drink products.[121] One of the aims of NOVA classification was to help consumers make informed food choice, by advising them to base their diet on the first three groups of products and to avoid or substantially limit the intake of the fourth group—ultra-processed food and drink products. The rationale for this recommendation is supported by the argument that the NT is being driven by shifts in diets toward UPF, rich in sugar, fat, and salt, while at the same time being deprived of fiber and nutrients.[122] It has also been argued that the more food product is processed, the higher the glycemic response is and the lower the satiety potential.[123] Consequently, it has been argued that UPF-dominated diets lead to obesity and noncommunicable disease (NCD).[124] Highly

[111] Drewnowski and Popkin (1997)
[112] Wertheim-Heck and Raneri (2020)
[113] Hawkes (2006); Thorne-Lyman et al. (2020)
[114] Rideout et al. (2015, 1)
[115] Turner et al. (2018)
[116] Australia's Food Environment Dashboard (n.d.)
[117] Monteiro et al. (2018); Baker et al. (2020); Baker and Friel (2016)
[118] NHS (2021)
[119] Li et al. (2017)
[120] Knorr and Augustin (2020)
[121] Monteiro et al. (2016)
[122] Walls et al. (2018)
[123] Fardet (2016)
[124] Ares et al. (2016); Baker et al. (2014); Juul et al. (2021); Rico-Campà et al. (2019)

processed food, defined as the foods made by combining refined carbohydrates and fat and accompanied by sodium and food additives are more effective in activating reward-related neural systems than minimally processed foods, hence, acting as addictive substances leading some individuals to consume these foods compulsively.[125] To explain what ultra-processing means, NOVA authors argued that it includes "fractioning of whole foods into substances, chemical modifications of these substances, assembly of unmodified and modified food substances, frequent use of cosmetic additives and sophisticated packaging" and to identify UPF, one should look at the ingredients list and check whether it contains substances never or rarely used in the kitchen.[126] The explanation of how UPFs are being generated might be one of the answers to the question: how does the same food availability in SA lead to different nutrition outcomes over time?

By using the aforementioned definition and coupled with examples of foods that belong to one of the four distinct categories, the NOVA approach is a very appealing tool to help consumers make healthy choices. Also, compared to traditional methods of grouping foods, NOVA made a step forward in making distinction between grilled chicken and chicken nuggets, for example.

Even NOVA authors acknowledge, however, that it is sometimes not very simple for consumers to understand that a simple staple such as bread can be in either the third or fourth group, depending on the production method. Other authors have concerns about using a blanket rule on food classification based solely on processing stage and ignoring nutritional values of the foods.[127] They argue that there are food processing techniques which improve nutrition characteristics of foods, and which would be classified as ultra-processed foods according to NOVA, and hence, the food which should be avoided. They argue that NOVA method is simply wrong. Another group of authors also acknowledges imperfections of the NOVA approach by exposing classification criteria as ambiguous and inconsistent and identifying potential underlying themes of processed food classification: extent of change; nature of change; place and purpose of processing.[128]

Thus, classifying foods as healthy/unhealthy, based solely on processing stage and procedure, could place some nutritious foods in the "wrong" category. Making the same distinction, based solely on nutrients, might place some ultra-processed and potentially addictive foods in the "healthy food" category, just because a few micronutrients have been added to energy-dense foods. Combining the two approaches with additional dimensions (one or two) might be an optimal approach, yet the question is whether researchers with opposite arguments could agree on a single methodology? The current status suggests that they cannot. As with other areas of food debate, it is consumers who suffer from these methodological "conflicts," when they receive mixed messages from different sides. As a consequence, consumers make food choices based on their own knowledge, experience, and information to which they are exposed, even when some of the information, which derives from social media, can be quite questionable.

Irrespective of the methodological approach to defining processed foods and their health impact, it has been shown that between 1998 and 2012, relative annual growth in sales of frozen products, snacks, and soft drinks was much higher in LMIC, and more of SA countries are in this group, than in HIC.[129] The growth in HIC, UMIC and LMIC, respectively, was 1.2 percent, 6 percent, and 7.7 percent for frozen food; 0.1 percent, 2.8 percent, and 5.4 percent for snacks; and 0.4 percent, 2.8 percent, and 9.9 percent for soft drinks. This trend, coupled with the influence that transnational food and beverage corporations have on food consumption by controlling availability, price, and nutritional quality, suggests that future policy measures could potentially make the biggest impact by adjusting food environment.[130] Some of the more concrete policy measures that have proven to be effective in the context of unhealthy food or in controlling tobacco and alcohol are also proposed in context of the broader category of UPF. These are fiscal policies, which involves taxation, front-of-package warning labels, marketing bans of UPF, school food policies, media campaigns, as well as neutralizing and minimizing industry interference in health policymaking.[131]

The World Cancer Research Fund collated policy instruments, which were implemented by governments around the world, grouping them into two categories—policy measures which promote healthy diets, and those which promote physical activity and active lives.[132]

[125] Gearhardt and Hebebrand (2021)
[126] Monteiro et al. (2019, 936)
[127] Knorr and Augustin (2020)
[128] Sadler at al. (2021)
[129] Monteiro et al. (2013); Moodie et al. (2021)
[130] Baker and Friel (2016)
[131] Popkin et al. (2021)
[132] World Cancer Research Fund (n.d.) Nourishing and Moving Policy Databases.

Trends which involve nutrition transition and proposed policy instruments

As we discussed in previous sections, there are a few trends that coincided in SA. The urbanization rate significantly increased in most of the countries; retail value from modern grocery retailers, as well as packaged food retail value, increased between 10 and 20 times over the past 20 years; and the value of animal and vegetable fats and oils is now a dominant category in imports of SA as a region. At the same time, prevalence of overweight has doubled in the region between 1990 and 2016, while undernourishment rates have decreased 40 percent between 2001 and 2018. A common theme for all these trends is that they are associated with NT. Furthermore, research shows that type 2 diabetes has affected the South Asian population a decade earlier than other groups in the transition.[133]

Current models estimate that by 2050, 45 percent of the population globally will be overweight, while the rate of underweight population will halve, with the absolute number stagnating between 0.4 and 0.7 billion.[134] In other words, both overweight and underweight trends will continue. Therefore, what are the preconditions for the overweight trend to cease, or even reverse, and at the same time, the underweight downward trend continue? Or to put it into policy perspective, what policy instruments should be implemented to reach this dual goal? Moreover, given the available data sets, existing research findings, and awareness concerning NT in the past 30 years, why it has been so difficult to stop the increase of overweight rates and to eradicate hunger, and why have the existing policies failed? Is there a lack of knowledge and human capacities, or is it too expensive to implement appropriate policy measures? Is the long-term nature of food consumption-related policy instruments in direct conflict with the short-term nature of governments' terms, which are typically four years long? Are there food systems players that are (un) intentionally undermining policy efforts to address overweight and undernourishment trends? Are there some other global underlying trends, such as unequal access to schooling, health care provision, and better paying jobs? Is it a combination of all these factors, or are there other relevant factors? It has been argued that developing countries' capacities to deal with NCD are much lower than the capacities of developed countries when in the same phase of NT.[135] Yet, it seems that most developed countries have also had only very modest results in dealing with obesity rates. Recent research found that 14 obesity strategies with 689 wide-ranging policies were published in England in the period 1990–2020, but without success in obesity reduction.[136] The researchers argued that the main reasons for this failure are the lack of implementation potential of the proposed policies and insufficient evaluation of the results, which has led to repeated mistakes, larger focus on consumers, and smaller focus on the food environment within which the consumers make food choice. It is only recently that the United Kingdom decided to impose nationwide policy instruments to reduce children's exposure to products high in fat, salt, and sugar advertising on TV and online, hence, modestly targeting the food environment.[137] Having said that, it has been reported that the government postponed the implementation several times, with the last decision to postpone it to 2025.[138]

Broadly, identifying and quantifying drivers of changes in food consumption can help in designing effective policy instruments. Some of the generally recognized drivers are changes in behavior, food environments, and food systems.[139] There is also a need for simultaneous targeting of multiple components of food systems,[140] involving interventions aimed at both the supply and demand side and along the whole value chain from agricultural inputs to food consumption at home and away from home. Finally, policy must be very context-specific; otherwise, it may not work, or even worse, it may create counter effects.

Some of the commonly existing policies include import taxes or domestic taxes for certain products; front-of-the-package labeling with mandatory ingredients lists on the packaging; strong negative "warning" logos; strict regulations on ingredients that cannot be used in food production; regulations on types of foods allowed to be sold in schools; support of production of certain foods and crops; safety net measures that might include food distribution, vouchers for food distribution or cash transfers; and raising awareness about healthy eating habits.

Taxes

Trade liberalization could be a factor in facilitating NT and the rising rates of obesity and cardiovascular diseases (CVDs).[141] Therefore, it has been proposed that lowering tariffs on healthier foods and increasing tariffs on unhealthy foods should be introduced.[142] To implement this policy on a global scale, and to be in

[133] Misra et al. (2014)
[134] Bodirsky et al. (2020)
[135] Popkin (2002)
[136] Theis and White (2021)
[137] Government of the United Kingdom (2021)
[138] Broadbent (2022)
[139] Hawkes et al. (2017)
[140] Baker et al. (2020)
[141] Thow and Hawkes (2009)
[142] Thow et al. (2011)

compliance with the World Trade Organization (WTO) rules, it would be necessary to agree on which foods are healthy and which are unhealthy. As discussed in the previous section, that decision can be challenging. For some foods, the classification would be relatively simple, for others it is more complicated, such as with foods that are healthy when consumed in moderation, yet unhealthy if consumed in excess. Additionally, another challenge related to import tariff would be to not to tackle local supply of the same products, where a consumption tax rather that import tax would be preferred.[143] One of the most common consumption taxes is a tax on SSB. Multiple cities, regions, and countries introduced this tax. In 2018, the United Kingdom introduced the soft drinks industry levy (SDIL), with the levy rate based on sugar content. As a result, producers reformulated drinks, leading to an average household consuming the same quantities of drinks, yet with a sugar consumption of 10 percent less.[144] While the policy instrument seems to have achieved its desired outcome, in that sugar consumption decreased and SSB producers did not suffer financially, the overall effect on health, which was the ultimate goal, is yet to be determined. It will mainly depend on what the reformulation entailed, and whether the producers replaced sugar with something that has negative, neutral, or positive health effects. Similarly, in 2014, Mexico introduced tax on all non-alcoholic drinks with added sugar, irrespective of sugar content. Research from 2020 found that compared to the pre-tax period, fewer respondents declared that they belonged to medium- and high-sugar soft drink consumer categories, and more respondents claimed to be consumers of zero or low-sugar soft drinks.[145] According to the World Bank Global SSB Tax Database, Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka also introduced different instruments in their SSB tax design.[146]

Food labeling

In addition to sugar tax, food labeling is one of the most commonly analyzed policy instruments. The labeling includes only the ingredients list in some cases, or additional information in other cases. In the United Kingdom, the Food Standards Agency (FSA) introduced nutritional labels on prepackaged foods.[147] The label reveals calorie, fat, saturates, sugars, and salt content information. To make it more visible, intuitive, and simple to understand, the FSA introduced a traffic light labeling system for fat, saturated fats, sugar, and salt content, where green denotes a healthier food choice and red denotes foods which should be eaten less often and in smaller amounts. Additionally, a pilot scheme called "eco-score" has been introduced recently in the United Kingdom.[148] The scheme, supported by the government, Nestlé, Marks & Spencer, Sainsbury's, the Co-op and Costa Coffee, will provide information, which will be also presented through the traffic light system, to reveal the environmental impact of a product. Also, in 2016, Chile introduced a warning label, with a black stop sign, for food and drink products that contain added sugars, sodium, or saturated fats in amounts that exceed nutrient and calorie thresholds.[149] Products with the black label are restricted from child-directed marketing, and their sale is banned in schools. This is an example of well-integrated policy instruments. While food labeling can and should be beneficial to the consumers, it is also very important to analyze who created a label and for what purpose, as the labels sometimes can be misleading and confusing, especially for less literate populations. Also, it is important that methodologies used to create thresholds and labels are being scrutinized and reviewed by relevant public health authorities, particularly, if those methodologies were developed and backed by the private sector, and especially, by multinational companies in the food chain.

School meals and other food transfer programs

School programs have a very high potential in tackling not only threats coming from NT and malnutrition, but also in shaping healthy life habits by promoting healthy eating behavior and physical activity.

Evidence from Ghana suggested that school feeding intervention by introducing one hot meal daily had a positive effect on height-for-age in children, 5–8 years, and particularly in girls, but no effect was seen in children, 9–15 years.[150] A case study from Amsterdam showed that a twin approach, which targets both direct consumption (by educating children on healthy eating and physical activity) and food environment (by involving parents and food shop employees), produced very positive and tangible results—added sugar and processed snack food intake has decreased, as has waist circumference and blood pressure.[151] The two case studies from Ghana and Amsterdam presented different strategies to tackle undernutrition and overnutrition. The Mid Day Meal Scheme (MDMS) that provides cooked meals for children enrolled in grades 1–8 in India was designed not only to improve nutrition of the students, but also to increase school enrollment,

[143] Martin (2018)
[144] Pell et al. (2021)
[145] Sánchez-Romero (2020)
[146] World Bank (2023a)
[147] FSA (2020)
[148] Foundation Earth (n.d.)
[149] Taillie et al. (2020)
[150] Gelli et al. (2019)
[151] Hawkes et al. (2017)

retention, and attendance.[152] The scheme has been evolving over time. Whereas the original program focused on energy intake, later changes introduced nutritional components. MDMS has had positive impact on school enrollment and attendance, but the nutritional outcomes are still unclear.[153] For the duration of the school programs, it has been argued that interventions should last for at least eight months, or one academic year.[154]

In addition to school meals, there are programs that involve either direct food transfers through food banks in many countries or subsidized foods, such as the Public Distribution System (PDS) in India, Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in the United States, and many other schemes, which governments and NGOs can use to improve food and nutrition security of wider populations. As central or local governments shape most of the food transfer programs, it is an obvious policy instrument to steer the population toward more nutritious and diverse foods, and away from less healthy options.

Supporting production of nutritious foods

Another approach to improve a population's diet would be to use policy instruments to lower the price of those foods which have relatively high nutritive values. This could be done either through targeted agricultural subsidies of primary production, particularly for products such as fruits, vegetables, and pulses, or through lowering sales tax for those products. An alternative would be removing or lowering subsidies for competing crops, such as rice, wheat, and maize. However, there must be sufficient capacities to produce and market highly nutritive foods, and often, perishable foods. While large-scale farmers would very likely be able to switch to the production of those foods, small-scale farmers could face challenges. To facilitate their transition, it is necessary to create an enabling environment for smallholder transformation and to reorient agriculture research and development priorities, so that the enabling environment includes infrastructure investments, efficient land markets, and secure property rights while research reorientation targets diversification out of the primary staples.[155]

While several studies have assessed the relationship between food price policies and nutrition outcome, there is insufficient robust evidence that such a relationship exists.[156] One of the potential reasons is that lowering fruit and vegetable prices, through production subsidies, might not necessarily lead to an increase in fresh fruit and vegetable consumption. On the contrary, it could lead to the consumption of highly processed, energy dense, and nutritionally poor products, if F&V are being used in the processing industry. Therefore, assessment of such a policy instrument would need to take into consideration the form in which the subsidized products are being consumed. One such study assessed the impact of subsidized weekly boxes of F&V on the short-term health of disadvantaged Aboriginal children.[157] The research showed that, after participating in the program for 12 months, there was a decrease in oral antibiotics prescribed and there was an increase in levels of hemoglobin. Other indicators, such as the proportion of children classified as overweight or obese, have remained unchanged. Much more research is needed to support these results in the South Asian context.

Other policy interventions

Health ministers of five Latin American countries—Argentina, Brazil, Paraguay, Uruguay, and Bolivia—designed policy recommendations for the protection of traditional diets in June 2021.[158] They argued that priority should be given to the production of food commonly used in traditional diets, and which is also healthy, diverse, and culturally appropriate. While it is not yet known how this initiative will be practically implemented, it came in response to the recognized threat from the high prevalence of NCD. The example from South Korea suggests that this approach could be a promising one. In South Korea, its rapid and strong economic growth occurred without a typical NT path. It has been argued that the promotion of traditional diets, where kimchi has an important role, along with rising awareness of how activities largely contributed, led to relatively slow, NT-related health outcomes.[159]

Based on the evidence provided in this document, it appears that policy instruments should support healthier food consumption, and the resulting health outcomes should target the environment in which consumers operate. To that end, it is necessary to understand pathways that lead to the existing food environment in each South Asian country and even in subnational regions, as they are very context-specific. While some measures could work in many world regions, some might not yet, and without appropriate research, it is hard to predict outcomes.

[152] MDMS (n.d.) Mid Day Meal Scheme, https://www.akshayapatra.org/indias-mid-day-meal-scheme
[153] Pingali et al. (2017)
[154] Singhal et al. (2021)
[155] Pingali (2007)
[156] Dangour et al. (2013)
[157] Black et al. (2013)
[158] MERCOSUR/RMS/AGREEMENT No. 02/21
[159] Kim et al. (2000)

4 State of Agriculture in South Asia

Agriculture in South Asia not only plays an important role in livelihoods and food security, but it also affects overall economy, population health, and the environment. The following section will provide a snapshot of certain agricultural dimensions in SA, such as the role in the national economy and employment, input use, farm size, cropping patterns and yield gap, and the relationship between agricultural production and the environment.

A Sri Lankan farmer leads his cattle.
(Photo by Prasad Tharanga/Shutterstock)

Major Characteristics of Agriculture in South Asia

Small and fragmented parcels of land

Low added value per worker

16% share of agriculture in GDP

60% of women's employment in agriculture

Input use greatly varies across SA

Crop yield greatly varies across SA

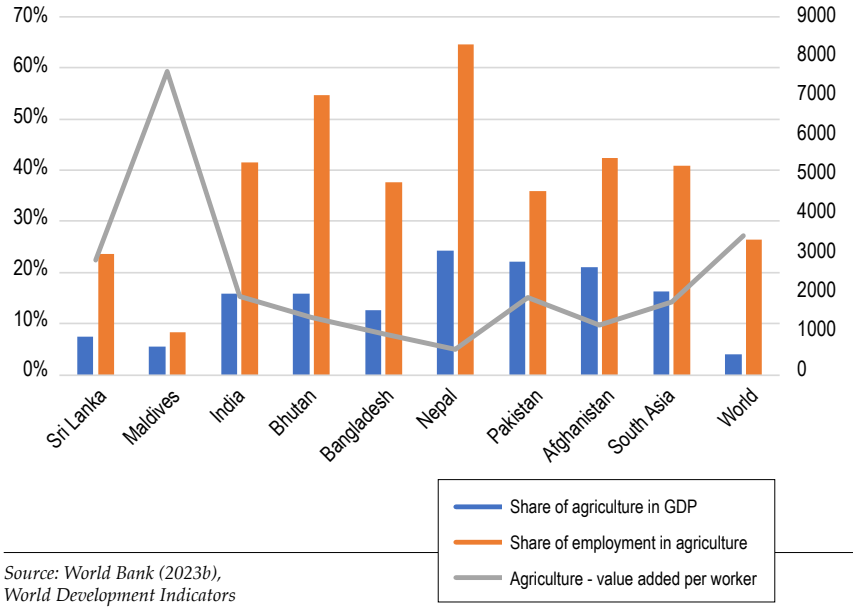
Greenhouse gas emissions on the rise

4.1 Role of Agriculture in South Asia

The share of agriculture in total GDP in SA is higher than the global average—16 percent in SA, compared to 4 percent globally. Furthermore, it appears that value added from agriculture is negatively correlated with share of employment in agriculture (Figure 4.1). In 2021, value added from agriculture, as a share of GDP was 1.3 percent in high-income countries, 9 percent in middle-income countries and 25.6 percent in low-income countries.[160] Therefore, it is important to understand how a LIC can develop agriculture and increase value added from agriculture in absolute terms, while reducing the share of value added from agriculture in total value added. It would entail an increase in agricultural productivity, coupled with structural transformation of the economy. It is a strategic decision whether to concentrate efforts and resources into developing agriculture first, and then to follow with other services and industries, or to try to develop all at the same time? Answers to those questions are very country- and context-specific, and some of the context attributes are presented in the figures in this section.

Share of agriculture in GDP in all SA countries is higher than the world average. Additionally, within SA, it varies from 5 percent in the Maldives to almost 25 percent in Nepal (Figure 4.1).

Figure 4.1 | Productivity in agriculture (constant 2010 US$), and share of agriculture in GDP and employment in the world and in South Asia, 2018



Source: World Bank (2023b), World Development Indicators

[160] World Bank (2023b), World Development Indicators (data for LIC are from 2018)

Table 4.1 | LAND AND LABOR PRODUCTIVITY IN ASIA AND OTHER GLOBAL REGIONS, 1990, 2000, 2010, 2014

Country/Region	Land productivity (in constant 2004–2006 US$)				Labor productivity (in constant 2004–2006 US$)			
	1990	**2000**	**2010**	**2014**	**1990**	**2000**	**2010**	**2014**
Sub-Saharan Africa	198	255	321	332	1,326	1,597	1,885	2,105
Latin America and the Caribbean	268	340	467	509	5,833	7,955	12346	14,235
Middle East and North Africa	1,232	1,724	1,940	2,149	2,908	3,765	4,468	4,765
Asia and the Pacific	611	847	1,156	1,278	984	1,150	1,749	2,183
Afghanistan	54	67	92	99	823	628	640	630
Bangladesh	1,073	1,633	2,396	2,648	355	473	679	753
Bhutan	229	200	273	279	650	626	460	427
India	719	930	1,292	1,488	624	710	873	968
Nepal	704	910	1,238	1,514	463	469	473	530
Pakistan	595	807	1,057	1,145	1,398	1,584	1,517	1,580
Sri Lanka	900	996	1,154	1,072	589	644	756	733

Source: IFPRI (2018)

Farmers tend to freshly planted rice on terraces in Nepal. *(Photo by anandoart/Shutterstock)*

Table 4.2 | OUTPUT AND TOTAL FACTOR PRODUCTIVITY GROWTH IN ASIA AND OTHER GLOBAL REGIONS, 1990, 2000, 2010, 2014

Country/Region	Output growth (%)			Total factor productivity growth (%)		
	1991–2000	2001–2010	2010–2014	1991–2000	2001–2010	2010–2014
Sub-Saharan Africa	3.3	3.8	2.9	2.1	0.8	0.2
Latin America and the Caribbean	3.1	3.5	2.4	1.3	2.2	1.1
Middle East and North Africa	3.5	3.2	1.2	1.7	1.2	1.6
Asia and the Pacific	3.7	3.5	2.7	1.5	1.3	1.5
Afghanistan	2.0	3.2	1.8	2.8	–1.4	0.5
Bangladesh	3.2	3.7	2.1	–0.3	0.9	0.7
Bhutan	0.2	2.9	0.8	0.2	1.7	–0.9
India	2.6	3.2	3.5	0.5	1.2	2.7
Nepal	2.8	2.8	5.0	0.4	1.6	–1.1
Pakistan	3.5	2.3	2.7	1.1	0.5	0.7
Sri Lanka	1.1	2.6	–0.7	–1.1	1.3	–2.8

Source: IFPRI (2018)

Also, value added per worker in agriculture is highest in the Maldives (US$7,500), and lowest in Nepal (US$650). More details on land and labor productivity in agriculture, as well as growth in agriculture between 1990 and 2014, are presented in Table 4.1.

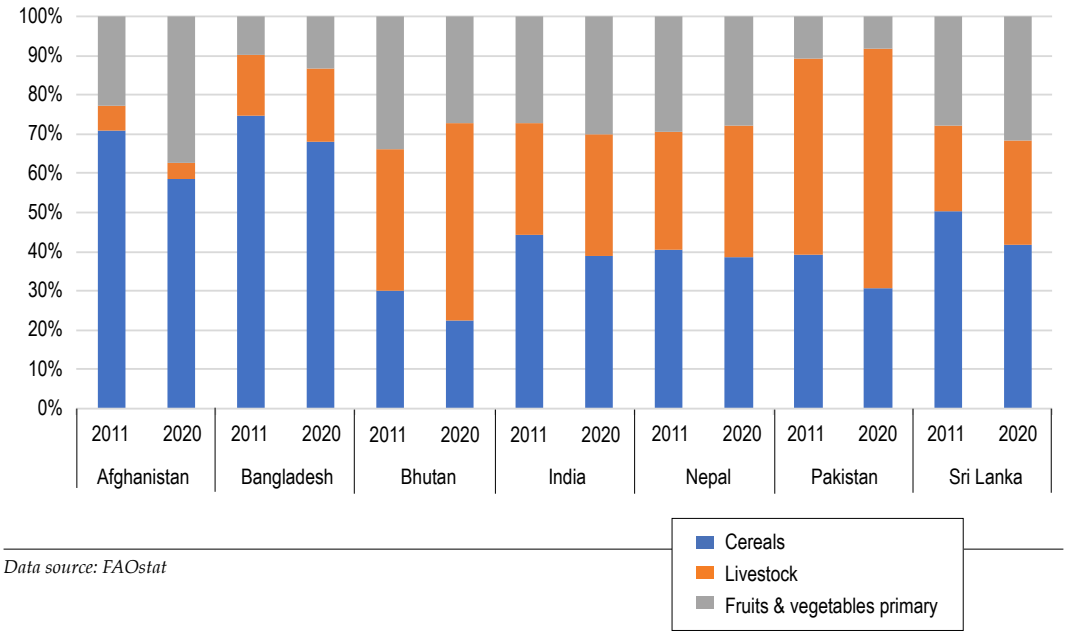
Table 4.1 presents the ratio of total output to agricultural area (land productivity) and to the number of economically active persons in agriculture (labor productivity) between 1990 and 2014. Compared to other regions, Asia and the Pacific region, which includes SA and other countries, performs better than Latin America and countries of sub-Saharan Africa (SSA), with respect to land productivity, and it lags on labor productivity. Within SA, land productivity in Bangladesh is 26 times higher than in Afghanistan. Breakdown of the share of agricultural land use in the following section will partially explain such a stark difference. As for labor productivity, SA countries do not differ as with land productivity; the best performing (Pakistan) has 4 times higher labor productivity than the worst performing (Bhutan).

Total factor productivity (TFP) reflects the efficiency of use of land, labor, capital, and inputs. Only in India was TFP growth consistent in the period 1990–2014. In other countries, it was either very low, or even negative (Table 4.2).

Figure 4.2 depicts the share of agricultural production practices in total value. While the majority of Bangladesh value comes from cereals, in the case of Pakistan, it is livestock production—and milk production value is more than half. While there are various factors which influence labor productivity, the type of production is one, and it is therefore not surprising that labor productivity in Pakistan is twice as high as in Bangladesh. The figure also shows that, in all SA countries, the share of value derived from cereals is decreasing, while the share from F&V and/or livestock is increasing.

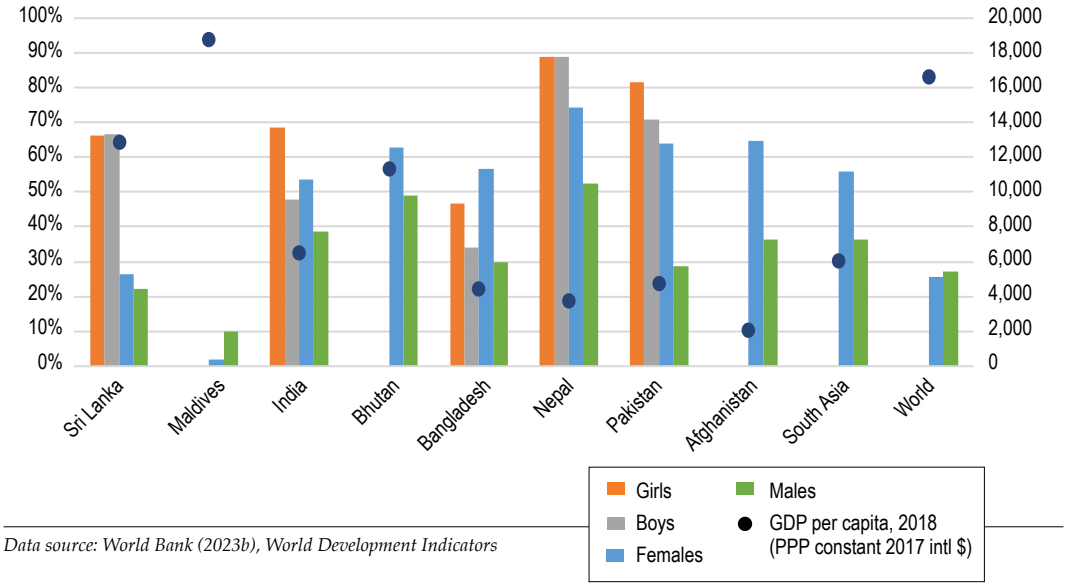
In addition, labor productivity depends on the share of population involved in agricultural production. As Figure 4.1 shows, participation in agriculture is inversely correlated with value added from agriculture. Furthermore, the role of females in agricultural production is very significant in all South Asian countries. Of all women employed in Nepal, 75 percent works in agriculture, compared to Bhutan, Afghanistan and Pakistan, where women's employment in agriculture is 65 percent (Figure 4.3). Additionally, there are "traditionally female" and "traditionally male" activities in agriculture, which

Figure 4.2 | Share of cereals, livestock products, and fruits and vegetables in agricultural value, in South Asia 2011, 2020 (Constant 2014–16 US$)



Data source: FAOstat

Figure 4.3 | Male and female employment in agriculture and national GDP per capita in the world and in South Asia, 2018



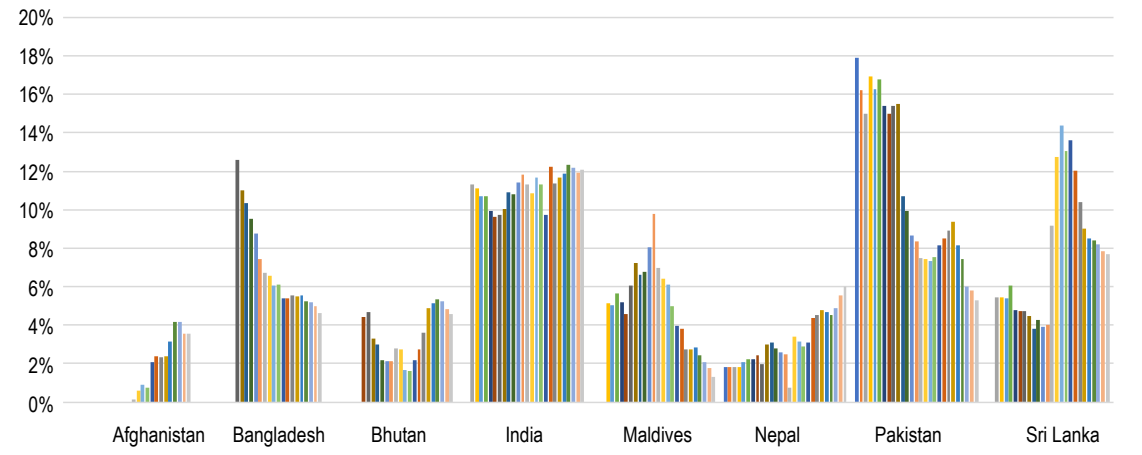
Data source: World Bank (2023b), World Development Indicators

current and future policy instruments should take into consideration.

Advancements in agriculture can rarely occur without investments, either from the state or the private sector. Ideally, in a free market economy, the private sector would lead the development, while the government would provide an enabling environment and invest where no private sector player can afford to invest, such as in large infrastructure projects. Figure 4.4 shows the share of credits provided by the private sector to producers in agriculture, forestry, and fisheries.

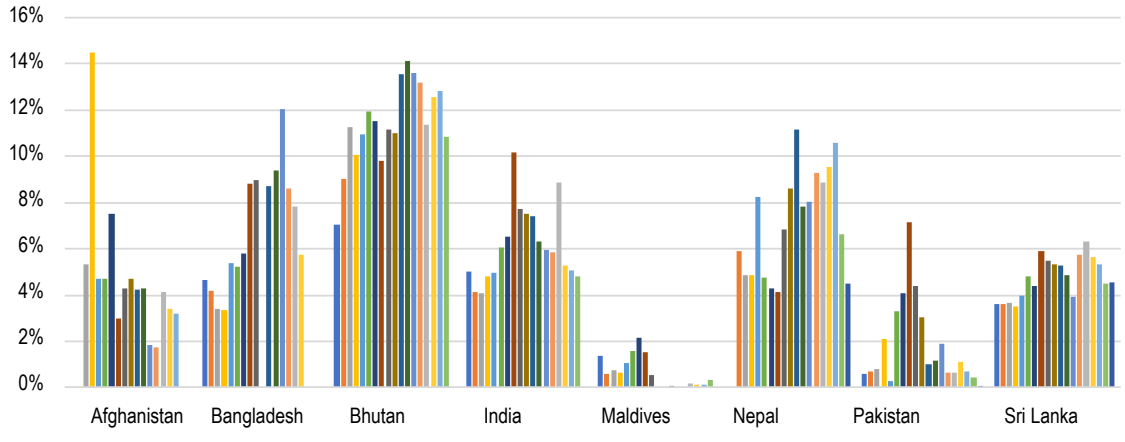
Countries, where employment and GDP from agriculture is very high, would strongly benefit from private and state investments, as a large part of the population is already involved in agricultural production. While data suggest that India has a stable inflow from private sector, and this number is increasing for Bhutan and Nepal, in other South Asian countries, there is a downward trend. One of the main preconditions for increased credit activity is market stability and predictability. Another precondition that attracts private investors is skilled labor. All South Asian countries need to make significant efforts in both market stability and skilled labor to receive attention from the private sector. Additionally, the government must provide an environment that enables the financial industry to thrive.

Figure 4.4 | Share of credit for agriculture in South Asia, 1994–2020



Data source: FAOstat

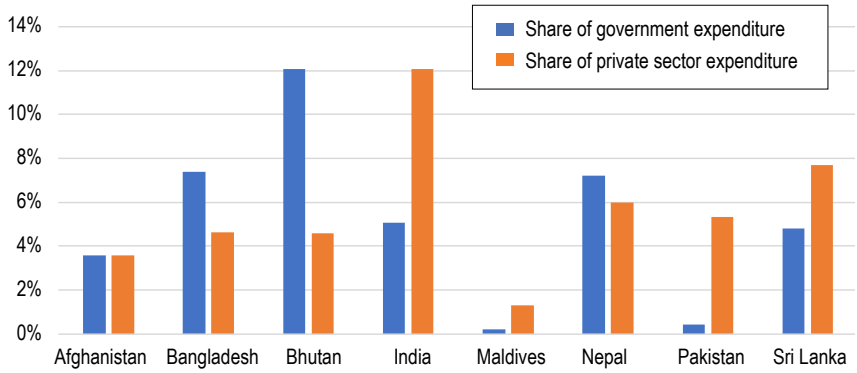
Figure 4.5 | Share of central government expenditures on agriculture in South Asia, 2003–2017



Data source: FAOstat

A quick glance at Figure 4.6 suggests that, in some South Asian countries, share of credits to agriculture is much higher than share of government expenditures. This is the case in India, the Maldives, Pakistan, and Sri Lanka. While the governments of Bhutan, Bangladesh, and Nepal are allocating more than 7 percent of their budget to agriculture, those efforts must be complemented by creation of an enabling environment, which incentivizes the private sector to invest along the food value chain. Deeper analysis of the breakdown of credit recipients would provide us with more targeted policy recommendations.

Figure 4.6 | Government expenditure (2016–2019) and private sector expenditure (2020) on agriculture in South Asia



Data source: FAOstat

Food products play a significant role in global and regional trade. Still, most South Asian countries are net importers when it comes to food products traded within or outside of SA. India is the only exception as it produces a surplus both in regional and global markets. While Pakistan has a positive trade balance in the regional market, it is worth noting that only 3% of food products are imported from the regional market and 97% come from countries outside of SA. The connection between trade and nutrition outcomes has already been covered to some extent in the NT section, and it has been associated with the rise in NCD. In this section, more attention is paid to undernourishment. To that end, there are several questions which we try to address: Should food and nutrition security be addressed by domestic production or import? If there is a scope for domestic production, what are the necessary preconditions so that farmers start producing those goods? How does a state choose what food products to import and what to produce? Should countries choose the products to import based solely on nutritive values, price, or on whether the import goods have been produced in a sustainable manner (and who can verify if the production was a sustainable practice)? Are global markets developed enough to provide food products that satisfy all three conditions?

To answer these questions, one needs to look at the foods that are in deficit in a population's diet. Referring to Figure A.2 (Annex), an average diet in South Asian countries, if an "average" can be defined, lacks fruit and vegetables, poultry, fish, eggs, and red meat. The common features of the lacking foods are that they are costly, have high nutritive value, are perishable, and their production is potentially a significant source of greenhouse gas (GHG) emissions. To increase supply of the foods in national production, some needs must be met for: high quality seeds and seedlings; highly productive animal breeds; sufficient cold storage capacities; continuous and resilient feed source; and high food safety standards coupled with well-trained producers. In addition to those conditions, insurance and credit markets must be developed. Until these minimum standards are met, it is unrealistic to develop the high-level investment industries; the government role is invaluable in meeting these needs.

As for imports, the government typically lets importers decide where the food will come from, and importers are profit-driven. Hence, the nutritional value of the food and environmental footprint of the production site is not the importer's main priority. This shortcoming can be addressed only on a global level, and WTO should take the leading role.

Policy interventions for "better" agriculture

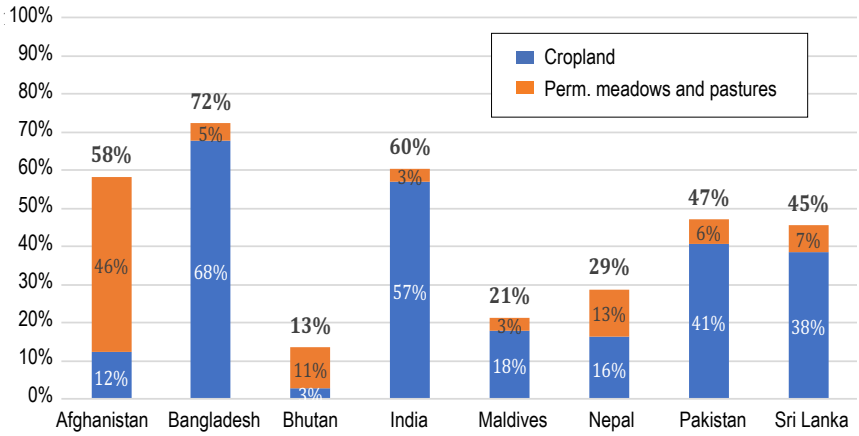
Agriculture in SA plays very important roles: employing a large proportion of the population, generating a substantial part of national GDP, and to a large extent, dictating national eating patterns. Therefore, it is a government's role to support farmers be more productive, and also, to create an enabling environment for the emergence of off-farm job opportunities, in or outside of food value chains. In that sense, smallholder farmers have a choice of either continuing with mainly subsistence agriculture, which leads to poverty traps and malnutrition, or alternatively leads to increased productivity, and eventually to market integration, either through FPOs or some other form of cooperatives. As for primary production, measures targeting land, labor, and capital productivity are essential. Also, given that the majority of women in employment are engaged in agriculture, every opportunity must be used to tailor policy to women's needs and abilities. Skilled labor is one of the necessary preconditions for increasing productivity, where both the state and the private sector have roles to play—either

through reliable extension service or other channels. Introduction and promotion of HYV and breeds heavily involves the private sector, or cooperation between state-sponsored research organizations and the private sector. F&V and animal production provide needed nutrients; yet, they are typically capital intensive. To increase productivity in these sectors, the state must invest in infrastructural projects that enable quick transportation of perishable products. In addition, the presence of a financial industry is necessary to provide credits for buying machinery, establishing cold storage facilities, and introducing high food safety standards. Efforts to improve agricultural productivity must be coupled with high environmental standards, where, in addition to regulations, consumer awareness and premium price exist for the products that fulfill more than prescribed minimum standards. Import regime is another sphere in which the state has a role, for example, in lowering tariffs for products with higher nutritional content. In a global market, states can lobby for a universal approach to incorporating environmental damage into the price of food products. Finally, the state can support agricultural producers by providing market stability and predictability, and interventions ranging from land tenure to secured import of feed in the case of local shortage. All of the measures combined would facilitate structural transformation, which results in increased absolute output from agriculture and decreased share of agriculture to national GDP.

4.2 Main Characteristics of Agriculture in South Asia

To better understand agricultural practices in South Asia, as well as average farm size and use of inputs and the effect on the environment, it is important to be aware of land use. As Figure 4.7 depicts, share of land used for crops and animal husbandry in total land area varies from 13.5 percent in Bhutan to 72.2 percent in Bangladesh. Agricultural land is not used in the same way throughout SA. In Afghanistan and Bhutan, the majority of agricultural land is used as permanent meadows and pastures; in other countries in SA, the situation is the opposite—a substantial majority of agricultural land is used as a cropland, for arable land and permanent crops. Table 4.3 provides more details on agricultural land classification.

Figure 4.7 | Share of agricultural land and land use in South Asia, 2019



Data source: FAOstat

Table 4.3 | LAND CLASSIFICATION

Agricultural land Land used for cultivation of crops and animal husbandry	**Cropland** Land used for cultivation of crops	**Arable Land** Arable land does not include land that is potentially cultivable but is not normally cultivated	**Temporary crops** **Temporary meadows and pasture** **Temporary fallow**
		Permanent crops Land cultivated with long-term crops that do not have to be replanted for several years (such as cocoa and coffee)	
	Permanent Meadows Land used permanently (five years or more) to grow herbaceous forage crops through cultivation or naturally (wild prairie or grazing land).		

Source: FAOstat

Irrigation is one of the main crop yield determinants in SA. In 2019, rice was harvested from more than 60 million ha in SA, where some form of irrigation is used in most of the production sites. In Table 4.5, the yield of irrigated crops is between 1.6 and 2.5 higher than of rainfed crops. From a caloric perspective, it is hard to imagine food security without irrigation. In times when resilience to climate and political shocks is invaluable, more crops under irrigation could save millions from hunger.

As much as irrigation is essential for production and food security, there are some negative consequences associated with current practices. Excessive irrigation can lead to groundwater depletion, so that water cannot replenish fast enough, potentially causing long-term, underground water availability issues. A study that analyzed main irrigation types in India (dug wells, tube wells, and canals) and winter crops found that, due to water depletion trends, cropping intensity is expected to decrease 20–68 percent.[162] The researchers also found that canal irrigation could be used as a substitute for ground irrigation in some regions, while other regions will need to apply a different adaptation approach. There are ways to prevent excessive irrigation, but there may also be some negative externalities associated with the prevention. Recent research analyzed the effects of a policy instrument that mandated farmers in Punjab to postpone rice sowing closer to monsoon season, to prevent groundwater depletion. Evidence suggests that postponed sowing caused delays in post monsoon burning season and increase in air pollution.[163] Another irrigation-associated issue is soil salinization, as irrigation contributes to salt deposition, which can cause damage to crops. Finally, rice grown under flooded conditions can lead to GHG emissions, as elaborated in the "Agricultural Production and Environment" section.

Figures 4.8 and 4.9 show source and irrigation patterns in SA. Regions where groundwater irrigation is present will more likely suffer from water depletion, salinization, and reduced crop intensity. Countries which predominantly depend on surface water irrigation, however, are less resilient to dry periods.

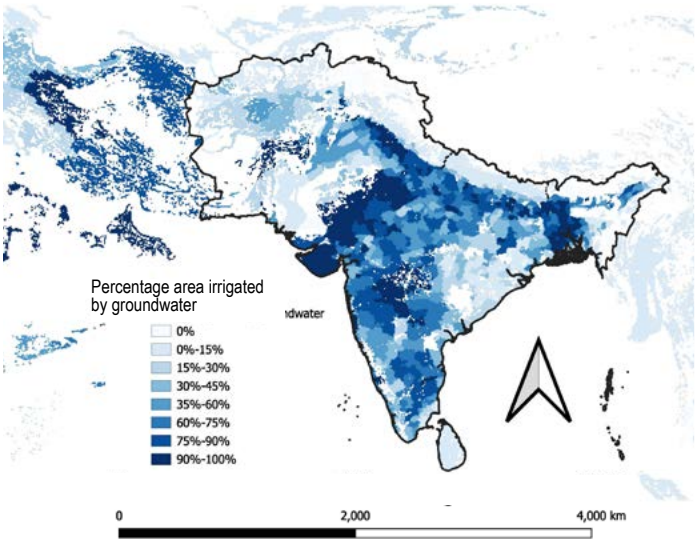
Table 4.4 | AVERAGE FARM SIZE IN SOUTH ASIA

Country	Dominant farm size and their share*
Afghanistan	1–5 ha (44%)
Bangladesh	<1 ha (84%)
Bhutan	<1.2 ha (56%)
India	<1 ha (68%)
Nepal	<1 ha (80%)
Pakistan	<1 ha (43%)
Sri Lanka	0.1–8 ha (54%)

Source: Various publications
** Dominant farm size—the value denotes the most common farm size; it should be noted that, in Sri Lanka, the second most common farm size is <0.1 ha, with 45 percent of farms belonging to this category. Detailed breakdown of farm groups is in Annex, Table A.5.*

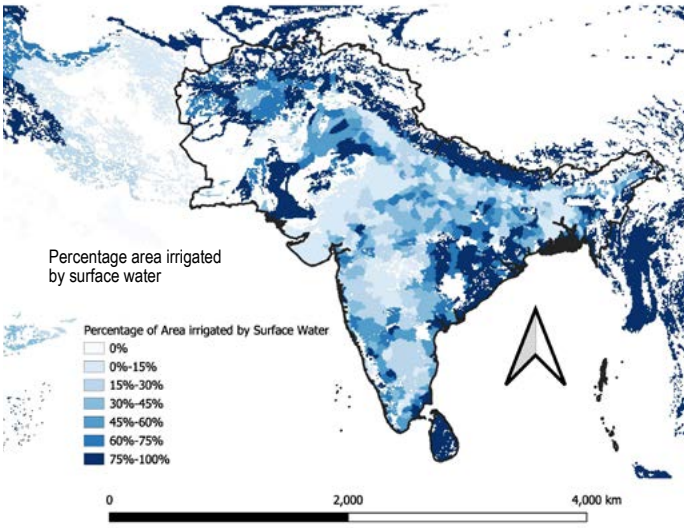
[161] FAO (2021a)
[162] Jain et al. (2021)
[163] Liu et al. (2022)

Figure 4.8 | Groundwater irrigation in South Asia, 2013



Data source: FAO–Aquastat

Figure 4.9 | Surface water irrigation in South Asia, 2013



Data source: FAO–Aquastat

Table 4.5 | IRRIGATION IN SOUTH ASIA, 2017-2019

Country	Irrigated cropping intensity* (%)	Share of arable land equipped for irrigation** (2017–2019) (%)	Ratio between rainfed and irrigated yields***
Afghanistan	115 (2011)	41	2.1
Bangladesh	118 (2008)	71	1.6
Bhutan	112 (2007)	35	1.8
India	139 (2006)	45	2.2
Nepal	163 (2006)	65	2.5
Pakistan	111 (2008)	65	2.4
Sri Lanka	156 (2006)	47	1.7

Source: Irrigated cropping intensity (FAO); Share of irrigated agricultural land (FAOstat); Ratio between rainfed and irrigated yields (AQUAstat)[161]
** Irrigated cropping intensity—the ratio of the harvested irrigated crop areas over the area equipped for full control irrigation actually irrigated. (Source: FAO AQUAstat)*
*** Share of arable land equipped for irrigation—Share of arable land area equipped with irrigation infrastructure and equipment to provide water to crops, which are in working order. The equipment does not have to be used during the reference year. It includes areas equipped for fully controlled irrigation by any of the methods of surface, sprinkler, or localized irrigation, and it also includes areas under partially controlled irrigation methods. (Source: FAOstat)*
**** Ratio between rainfed and irrigated yields—Average ratio between irrigated and rainfed irrigated based on yield estimations from* Agriculture Toward 2080 *(FAO unpublished) (Source: AQUAstat)*

The use of fertilizer is another factor that has led to substantial increase in crop yield and is important for achieving food security. Coupled with irrigation, HYV, and investments in agricultural research and infrastructure, fertilizer use contributed to lifting millions of people from hunger and poverty during the Green Revolution.[164] However, as in the case of irrigation, overfertilization can negatively affect the environment and health. Therefore, two fertilizer-related challenges have been at the forefront of research. One is the optimum fertilization rate, and the other is affordability and use of fertilizer in agricultural production. When it comes to the optimum fertilization rate, which should lead to increased production and maximized fertilizer-use efficiency, data suggest that Afghanistan achieved the highest efficiency (59%) in 2014, while most countries in SA achieved not more than 35%.[165] The traditional approach to assess the optimum amount of fertilizer needed should be based on the soil nutrient content and crop-specific nutrient needs. However, practice has shown that there are certain shortcomings to this approach. Namely, errors due to soil sampling and analysis methods result in inaccurate soil nutrient needs estimates, which are basis for the fertilization rate.[166] The same study argued that information about past management practices and yields are more informative than soil analysis. A more holistic approach to fertilization involves not only soil nutrient content, but other soil characteristics as well. The TCI Soil Health Project aims to improve soil health, to increase agricultural productivity, reduce malnutrition, and improve the environment in rural India. In addition to physical markers of soil health, the project also relies on biological and chemical soil markers to achieve its goals.

As for the affordability and use of fertilizers, recent research analyzed fertilizer policies in Bangladesh, India, Nepal, and Sri Lanka, finding that the major constraint to restructuring fertilizer subsidies has been insufficient understanding of farmers' decision-making on the type and quantity of fertilizer to be used, and their response to price and non-price signals.[167] In the study, the authors also referred to several attempts to abolish fertilizer subsidies, and eventually, their reinstatement, due to economic or political considerations. For those reasons, fertilizer use in most South Asian countries has been on the rise for the past 60 years. Table A.6 in Annex provides more information about the use of fertilizers in SA.

Use of machinery can lead to improved agricultural productivity. As Figure 4.10 suggests, there is a high variation in the rate of use of machinery for land preparation. While Nepal and Bhutan appear to lag behind other South Asian countries, it should be noted that topography and farm size play a major role in this usage. Average farm size is presented in Table 4.4.

Table 4.6 | TRACTORS PER 1000 HA OF ARABLE LAND IN SOUTH ASIA

	Last year available	Tractors per 1,000 ha of arable land
Afghanistan	2009	0.0
Bangladesh	2006	0.4
Bhutan	2008	1.4
India*	2003	17.6
Nepal*	2008	17.1
Pakistan	2006	14.5
Sri Lanka	1982	16.3

Source: FAO (2022b)
Note: The data collected refer to three types of tractors (wheel, crawler, and track-laying); for countries marked with an asterisk (*), a fourth type of tractor (pedestrian tractor) was included, as of 2000.

[164] Pingali (2012)
[165] Our World in Data – Nitrogen use efficiency (2023)
[166] Schut and Giller (2020)
[167] Kishore et al. (2021)

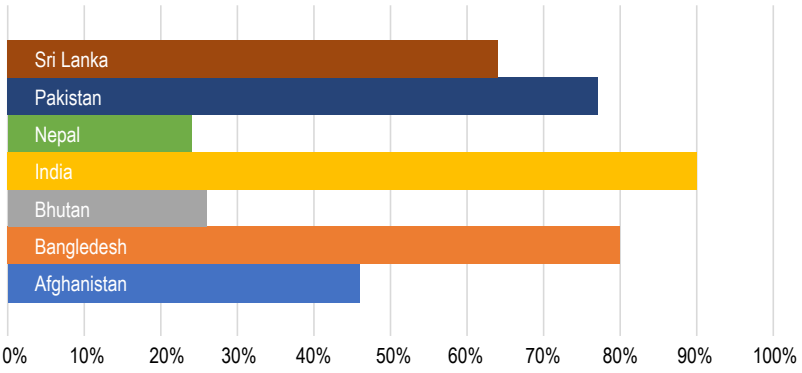
Another potentially limiting factor for higher adoption rates in some countries is lack of infrastructure and service. To overcome an affordability issue, renting machinery has been a dominant activity in some South Asian countries. In Pakistan, the rental market for tractors and harvesters has 90 percent of the market share. In this respect, FPOs can also be very useful.

The State of Food and Agriculture 2022, however, describes a different picture. Table 4.6 shows "Tractors per 1,000 ha of arable land" presented in *SOFA* 2022.[169]

There are several explanations for the discrepancy between Figure 4.10 and Table 4.6. A closer look at the table reveals that some data are as old as 40 years, and most of the data are from the period 2003–2009. The oldest data in the graph are from 2003, while the rest are between 2010 and 2019. In addition, it is important to note that different types of machinery have been included in the report, and *SOFA 2022* gives a clear explanation for this difference. Sometimes a discrepancy between different sources of data can be minor, but in this case, they are substantial. Therefore, it would be useful to have a uniform methodology of reporting of machinery in agriculture. Until then, data users must be very cautious about accuracy and credibility of data, as it can have significant consequences for the policy instruments dependent on the data.

Finally, pesticide use is on the rise in some countries of SA. In Figure 4.11, the rate of pesticide use in Bangladesh is shown to be almost as high as in North America. Appropriate use of pesticides might be crucial for achieving food and nutrition security, but overuse can be detrimental to human and animal health, as well as the environment. Therefore, increased use of pesticides must be coupled with very strict regulations, which need to be enforced on the ground.

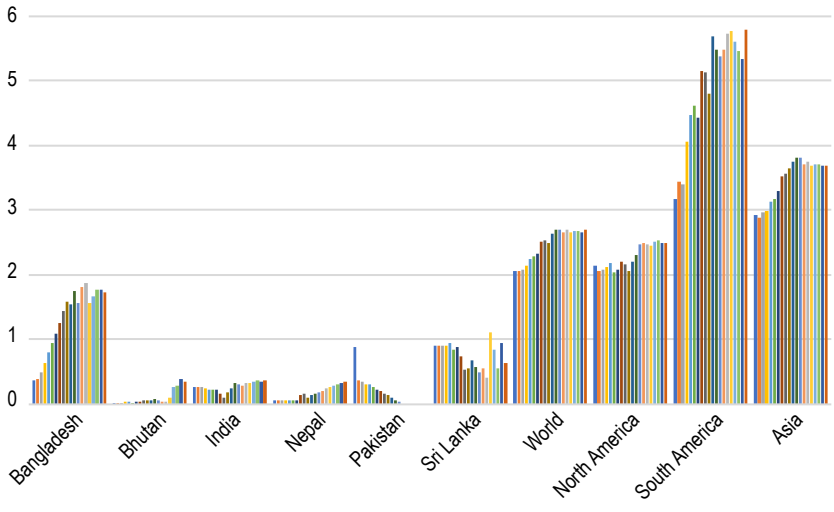
Figure 4.10 | Use of farm machinery in South Asia



Data source: Afghanistan – Maletta and Favre (2003); Bangladesh – Aryal et al. (2019); Bhutan – Royal Government of Bhutan (2019); India – Bhattarai et al. (2018); –Nepal - Government of Nepal (2013); Pakistan – Government of Pakistan (2010); Sri Lanka – Government of Sri Lanka (2017)

Note: Some authors argue that rice area plowed by tractors in Sri Lanka in 2010s is 98%.[168]

Figure 4.11 | Pesticide use in South Asia and global regions (kg/ha), 2000–2019



Data source: FAOStat

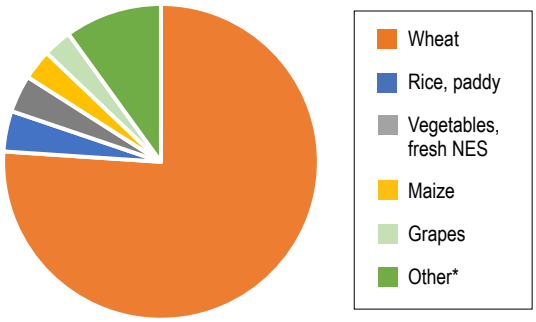
[168] Abeyratne and Takeshima (2020)
[169] FAO (2022b)

4.3 Crop Production in South Asia

Field crop production in SA is dominated by rice and wheat. However, in some countries, the most dominant crop occupies almost 80 percent of the harvested area, while in others, it is less than 30 percent. Figure 4.12 shows the top 5 crops by harvested area, while "other" category includes top 6-10 crops by harvested area.

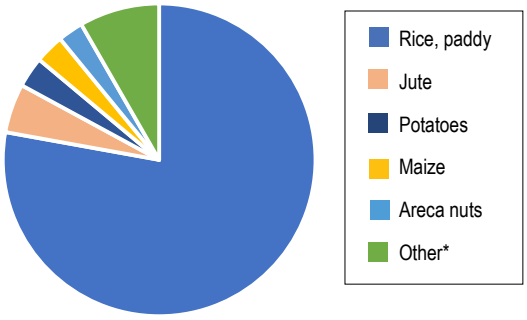
Figure 4.12 | Share of top 10 crops in South Asia, by gross area, 2019

AFGHANISTAN



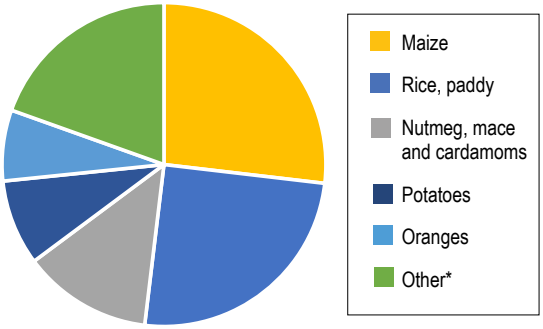
*Note: Other includes barley, pulses NES, potatoes, seed cotton, and watermelons.

BANGLADESH



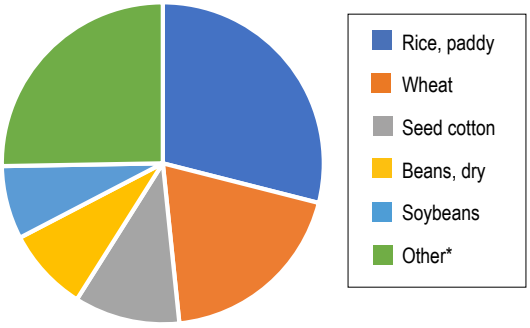
*Note: Other includes wheat, rapeseed, fresh vegetables NES, rubber, and dry onions.

BHUTAN



*Note: Other includes dry chilies and peppers, buckwheat, roots and tubers NES, areca nuts, and pulses NES.

INDIA

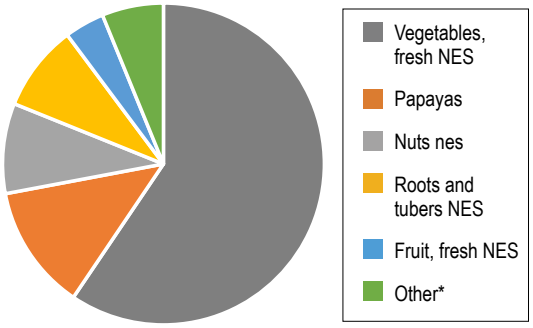


*Note: Other includes chickpeas, maize, millet, rapeseed, and sugar cane.

Data source: FAOstat
Note: NES denotes "not elsewhere stated"

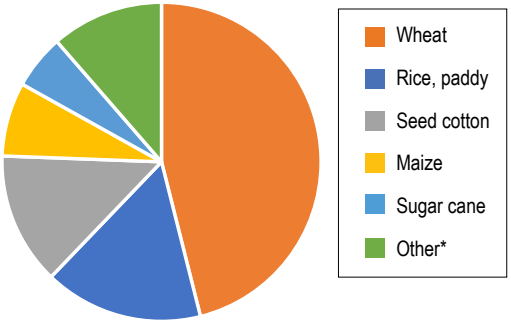
Farmers harvest paddy in Kathmandu, Nepal.
(Photo by gorkhe1980/Shutterstock)

MALDIVES



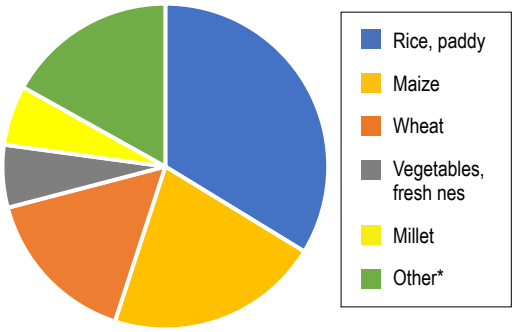
*Note: Other includes pulses NES, coconuts, sorghum, areca nuts, and maize.

PAKISTAN



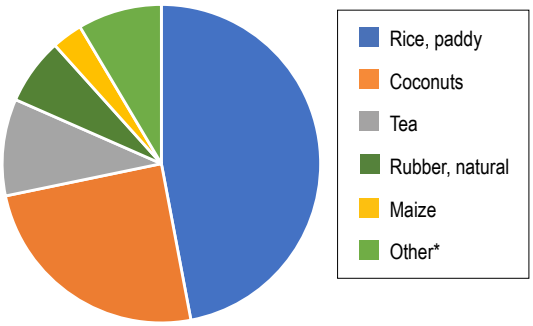
*Note: Other includes chickpeas, millet, rapeseed, mangoes, mangosteens, guavas, and dry beans.

NEPAL



*Note: Other includes lentils, mustard seed, potatoes, sugar cane, and pulses NES.

SRI LANKA



*Note: Other includes wheat, rapeseed, fresh vegetables NES, rubber, and dry onions.

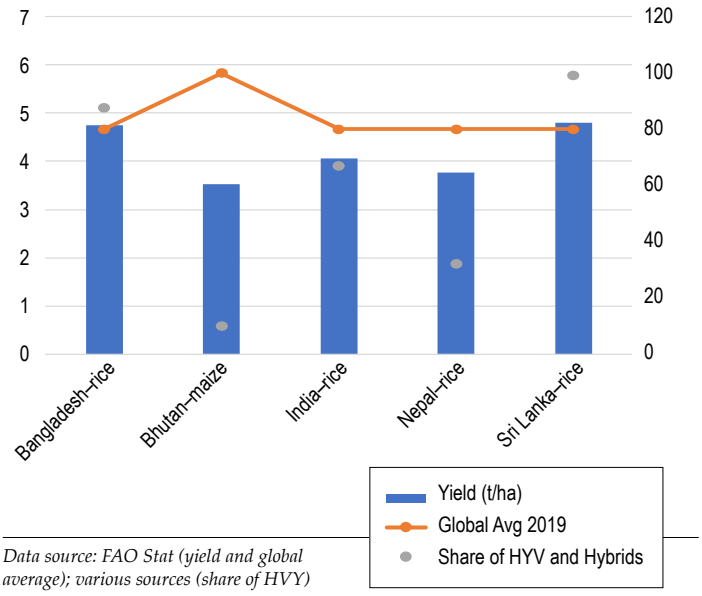
In predominantly agricultural economies, especially those with inadequate food market infrastructure, production largely dictates consumption patterns and associated nutritional outcomes. Diversification of production contributes to resilience and risk management, in general. Relying on one crop may pose a risk when there is a large-scale pest infestation. Attempts to diversify crops through the crop diversification program in India did not achieve expected results, due to strong disincentive to diversify.[170] Policy instruments to diversify crop production might be very challenging, yet not impossible to implement. They could target supply side (farmers), or demand side (consumers), as increased demand for certain crops, such as millet, vegetables, or animal products, might motivate producers integrated in the markets to reorient their production practices.

Table 4.7 | AVERAGE YIELD OF DOMINANT CROPS IN SOUTH ASIA AND IN THE WORLD, 2019

Country–main crop	Yield (t/ha) (t/ha)	Global avg. 2019	Yield gap 2018
Afghanistan–wheat	2.10	3.55	1.8
Bangladesh–rice	4.74	4.66	0.2
Bhutan–maize	3.52	5.82	5.9
India–rice	4.06	4.66	0.8
Nepal–rice	3.76	4.66	2.4
Pakistan–wheat	2.81	3.55	1.9
Sri Lanka–rice	4.80	4.66	1.2

Data source: FAOstat (yield, global average), Our world in Data (yield gap)

Figure 4.13 | Gap between average yield of dominant crop and global average yield in South Asia, 2019



Data source: FAO Stat (yield and global average); various sources (share of HVY)

As for the yield of the dominant crops, some countries are close to or even exceed the world average, while others are still lagging (Table 4.7). The table also captures the difference between actual and attainable yields at respective locations—the yield gap. Although the former group of countries must put an emphasis on the environmental footprint of the production and introduce relatively high standards, coupled with implementable policy instruments, the latter must do the same, in addition to increasing productivity.

Ways to increase agricultural productivity were discussed in the previous section, and one way is a higher share of HYV in agricultural production. As Figure 4.13 shows, there is a correlation between HYV and yield.

Figure 4.14 presents the map of cropping patterns in South Asia.

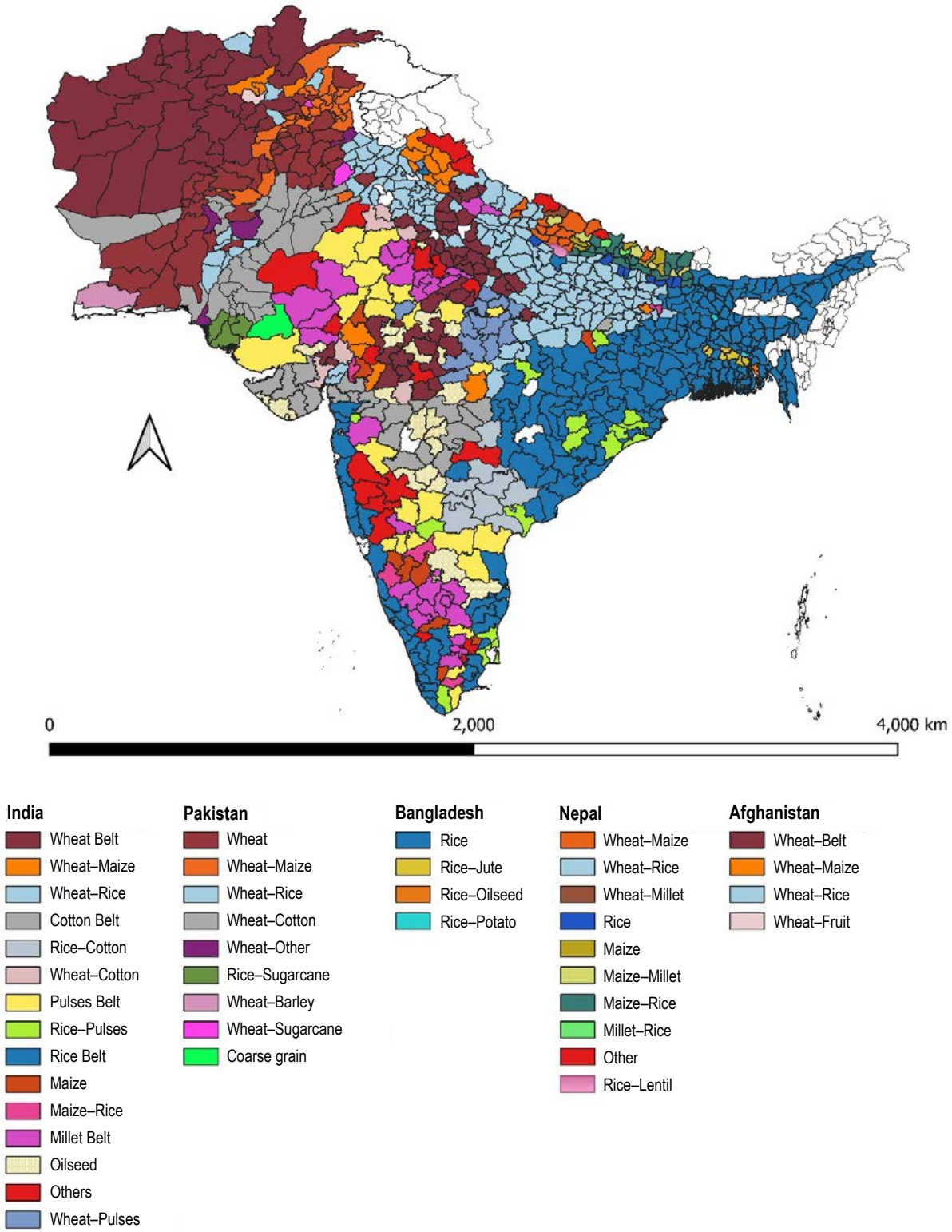
As climate conditions change from arid in the west (Afghanistan) to humid in the east (Bangladesh and eastern parts of India), the cropping patterns change from wheat-dominated areas to rice-dominated ones (Figure 4.14). Between these two areas, there is a large belt of rice–wheat cropping pattern that extends throughout the Indo-Gangetic plain. The western shore of India has been dominated by rice production. The central area of Pakistan and India is under cotton, pulses, and maize.

Figures on distribution of animals in South Asia (Figures 4.15–4.19) show that concentration of all animals in Afghanistan is very low, while in Bangladesh, it is very high. In Pakistan, most buffaloes, cattle, goats, and chickens are concentrated in the same area—in the fertile parts of Punjab, Sindh, and Khyber Pakhtunkhwa (KPK). Concentration of buffaloes and cattle in India complement each other, while chicken production is concentrated in the central and southern parts of the country.

Interestingly, major maize production areas do not overlap with the highest concentration of cattle (Figures 4.14 and 4.16). Although there are crops other than maize that can make high quality fodder, such as sorghum, those crops are not widely produced. Instead, as the cropping patterns and distribution of cattle maps indicate, the highest concentration of cattle is in rice or wheat–rice areas. This suggests that most smallholder livestock producers rely on rice and wheat residues as fodder, which could explain the relatively low milk productivity per animal (Table 4.8). Low milk and meat productivity per animal have direct and indirect negative effects on human nutrition, as well as on GHG emissions from agriculture. Milk and meat are very important sources of protein and micronutrients. As for GHG emissions, in addition to rice production, cattle are the main source of GHG from agriculture in South Asia. More details about GHG emissions is provided in the section "Emissions from Agriculture."

[170] TCI (2020)

Figure 4.14 | Cropping patterns in South Asia

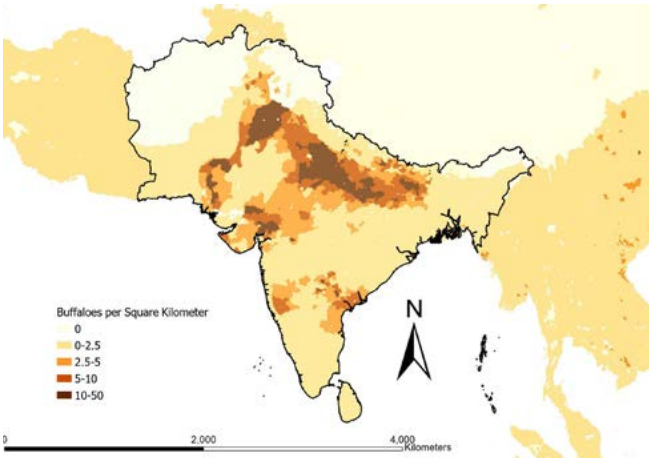


Source: Various sources

4.4 Animal Production in South Asia

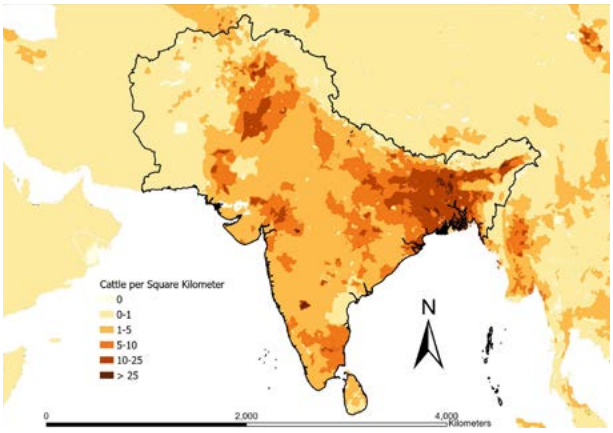
Figures 4.20 and 4.21 show the number of livestock units per hectare and share of certain animals in total number of animals.[171] As we can see, Bangladesh has the highest and Afghanistan, the lowest concentration of animals in SA, measured by livestock unit. These data are consistent with Figures 4.15–19.

Figure 4.15 | Distribution of buffaloes across South Asia, 2015



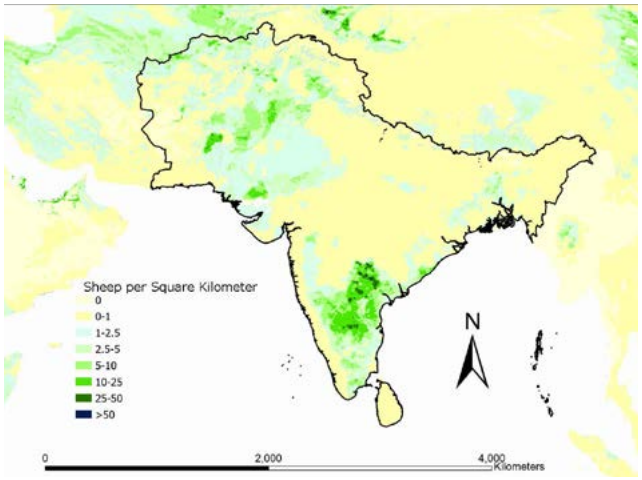
Source: FAO (2023e). Gridded Livestock of the World.

Figure 4.16 | Distribution of cattle across South Asia, 2015



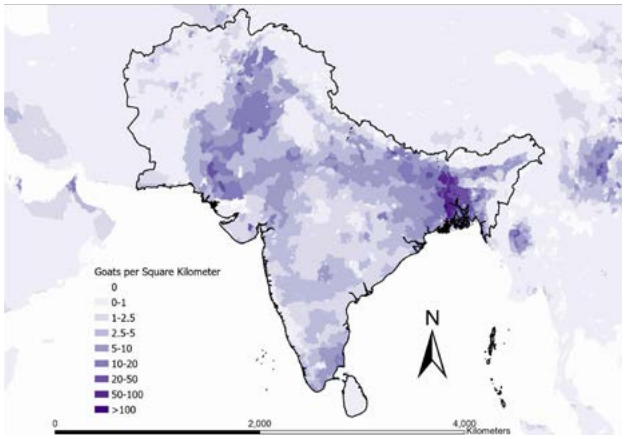
Source: FAO (2023e). Gridded Livestock of the World.

Figure 4.17 | Distribution of sheep in South Asia, 2015



Source: FAO (2023e). Gridded Livestock of the World.

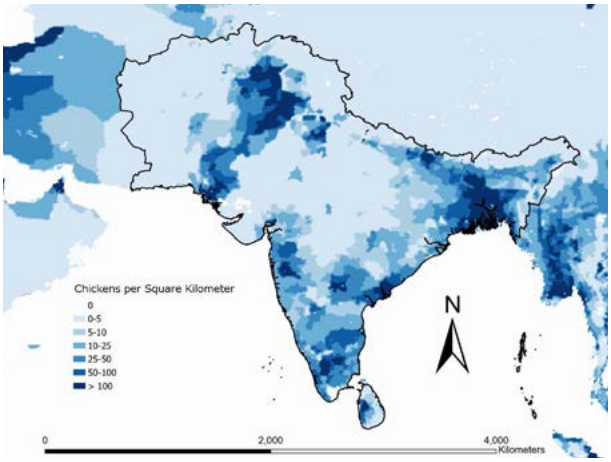
Figure 4.18 | Distribution of goats in South Asia, 2015



Source: FAO (2023e). Gridded Livestock of the World.

[171] A livestock unit (LSU) is a reference unit which facilitates aggregation and comparison of different animal species. One LSU refer to 1 dairy cow. As a comparison, 1 sheep or goat is 0.1 LSU, which means that one dairy cow equals 10 goats. One pig is 0.3 LSU, and 1 broiler chicken is 0.007 LSU. More information can be found at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)

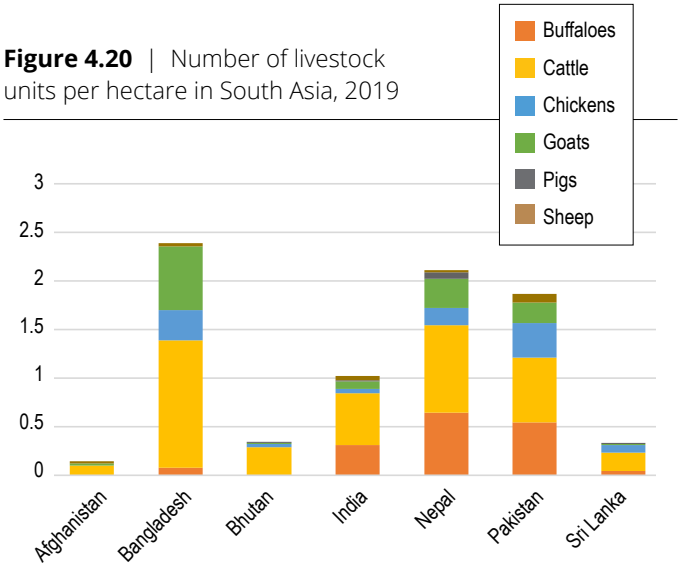
Figure 4.19 | Distribution of chickens in South Asia, 2015



Source: FAO (2023e). Gridded Livestock of the World.

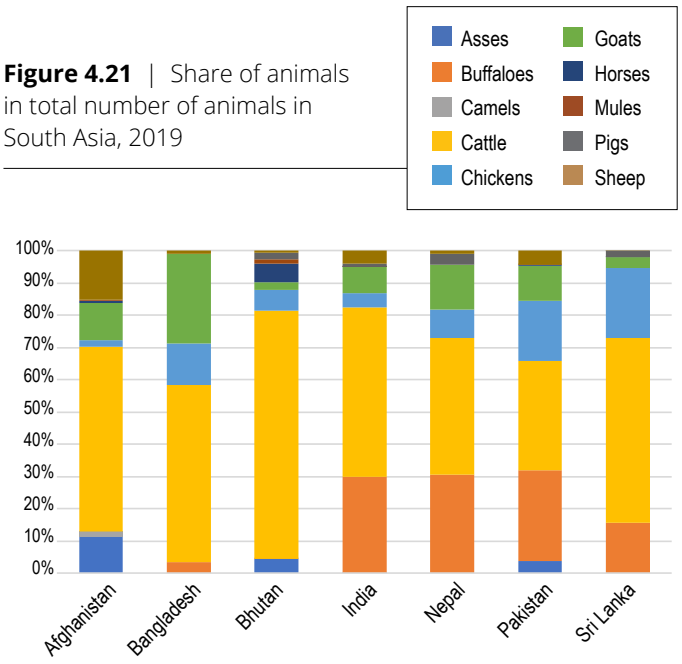
From Figure 4.21, we see that cattle, buffaloes, chicken, and goats are the dominant animals in SA. Production and the main challenges related to keeping those animals will be presented next.

Figure 4.20 | Number of livestock units per hectare in South Asia, 2019



Data source: FAOstat

Figure 4.21 | Share of animals in total number of animals in South Asia, 2019



Data source: FAOstat

Table 4.8 | 3-YEAR AVERAGE ANIMAL-SOURCED FOOD PRODUCTION AND SELECTED COUNTRIES, 1961, 2019

	Buffalo milk (kg/animal/year)			Cow milk (kg/animal/year)		
Country	**1961**	**2019**	**change (%)**	**1961**	**2019**	**change (%)**
Afghanistan				504.3	524.0	3.9
Bangladesh	400.0	393.7	–1.6	250.0	205.2	–17.9
Bhutan	400.0	996.5	149.1	257.0	1,387.3	439.8
India	901.3	2,030.9	125.3	441.2	1,680.4	280.8
Nepal	1,656.2	858.8	–48.1	325.4	703.0	116.0
Pakistan	1,637.7	2,297.7	40.3	887.2	1,460.6	64.6
Sri Lanka	326.0	835.5	156.3	292.9	1,144.3	290.6
China*	350.0	503.6	43.9	1,203.2	2,571.1	113.7
New Zealand				2,678.8	4,330.8	61.7
World	934.3	1,901.5	103.5	1,774.9	2,654.1	49.5

	Egg production (kg/animal/year)			Chicken meat production (g/animal		
Country	**1961**	**2019**	**change (%)**	**1961**	**2019**	**change (%)**
Afghanistan	2.50	2.03	–18.92	800.00	800.00	0.00
Bangladesh	1.65	2.59	56.84	727.67	699.64	–3.85
Bhutan*	2.00	4.87	143.75	703.05	1,273.31	81.11
India	4.90	14.04	186.31	900.01	1,528.86	69.87
Nepal	3.95	5.84	47.69	799.93	758.97	–5.12
Pakistan	2.73	8.96	227.90	787.33	1,192.25	51.43
Sri Lanka	7.63	13.13	72.12	1,000.00	1,312.81	31.28
World	7.61	10.81	41.97	1,152.94	1,629.69	41.35

	Goat milk production (kg/animal/year)			Goat meat production (kg/animal)		
Country	**1961**	**2019**	**change (%)**	**1961**	**2019**	**change (%)**
Afghanistan	41.98	43.36	3.27	13.00	13.01	0.06
Bangladesh	80.00	90.39	12.99	7.00	7.00	0.04
Bhutan			8.94	8.99	0.48	
India	99.94	167.34	67.44	10.00	10.01	0.07
Nepal	50.00	65.87	31.74	9.00	11.86	31.73
Pakistan	90.71	142.01	56.55	10.90	11.71	7.41
Sri Lanka	30.00	115.81	286.02	19.92	20.01	0.48
World	93.69	94.21	0.55	10.72	12.52	16.71

Data source: FAOstat
*Note: 3-year average for all countries is based on 1961–1963 and 2017–2019 periods. When there were rapid changes in year-on-year data, official data or the last consistent years were used.

Table 4.9 | FISH FARM PRODUCTION IN SOUTH ASIA (T)

	2010	2011	2012	2013	2014	2015	change (%) 2010–2015
Afghanistan	2,250	2,850	3,480	4,110	4,760	5,450	142.2
Bangladesh	1,310,000	1,520,000	1,730,000	1,860,000	1,960,000	2,060,000	57.3
Bhutan	46	75	78	70	139	149	223.9
India	3,790,000	3,680,000	4,210,000	4,560,000	4,890,000	5,260,000	38.8
Nepal	28,230	30,950	34,500	36,020	43,400	48,000	70.0
Pakistan	140,101	141,935	142,832	148,120	148,381	151,174	7.9
Sri Lanka	8,058	11,912	8,840	30,881	34,220	36,038	347.2

Source: Our World in Data (FAO Fishstat)

As we discussed in the "State of Food Consumption" section, the only animal-sourced food group in South Asian diets is milk,[172] with the Maldives being the exception. Bangladesh has very high cattle density, yet milk productivity is very low, relative to other South Asian countries. This has negative effects on nutrition, and also on the environment, where cattle holding is one of the major sources of GHGs. Therefore, it is very important to work on increasing productivity in animal keeping. While aquaculture is on the rise in all South Asian countries, this increase has not significantly translated into better nutritional outcomes, as the consumption of aquatic products is still very low.

Increasing milk productivity

Shifting from subsistence to market-oriented production is a necessary precondition for increasing productivity in dairy farming in Asia. To achieve that, farmers need to improve productivity of local breeds, as well as access to new breeds and technologies, veterinary services, undisrupted feed supply, markets, and credits, as milk production is a capital-intensive industry. Research analyzing milk production trends in Bangladesh and the region found that smallholder dairy producers sell their milk either through traditional markets or through cooperatives.[173] The share of traditional markets is 76 percent in India, 40 percent in Sri Lanka, 98 percent in Pakistan, and 90 percent in Bangladesh. Additionally, the researchers argued that compared to traditional markets, selling milk through cooperatives involves a small price gap through the country, provides better milk quality, and market assurance.

Increasing chicken meat and eggs productivity

Intensification of eggs and chicken meat production is not as capital-intensive as milk production. In the case of small-scale production, it is very good source of animal protein, and as mainly women are involved with chicken rearing, it is an important factor in women's empowerment.[174] Production consolidation occurs at different rates. Although, in Bangladesh, 65–70 percent of poultry is kept in "backyard" systems, this share in India is 20 percent.[175] Increasing demand for animal-sourced food in South Asian countries will incentivize further growth of the poultry sector. The main challenges to sustained sector growth will be health-related issues, such as: antimicrobial resistance (AMR), zoonoses such as avian influenza, and bacterial food poisoning. Outbreak of the latter two could significantly shift consumers' interest away from chicken meat and eggs.

Agricultural production policy instruments

F&V, poultry, fish, eggs, and red meat are not consumed enough in SA (Annex, Figure A.2). Therefore, it is important to make those foods more available and affordable to the consumers. While social and religious norms might prevent increase of red meat consumption in some countries and regions, increased production of other needed foods could have a significant positive impact to the nutritional status of South Asian populations, if appropriately complemented by other policy instruments discussed in the "Nutrition Transition" section. A common feature of those products is that they are perishable and require either very short supply chains or an efficient cold chain. Additionally, these are capital-intensive productions, and as elaborated in the previous policy section, require policy instruments to promote such practices.

[172] *Note: Only food groups which constitute more than 3 percent of daily calories were included.
[173] Uddin et al. (2011)
[174] Wong et al (2017)
[175] One Health Poultry Hub (n.d.)

As for F&V, it is essential to provide efficient and continued irrigation. The example of rice irrigation showed us that inappropriate policy instruments, and too low price of water can lead to environmental challenges. Therefore, policy instruments should target only environmentally friendly irrigation technologies. As for the other field crops, it is important to continue working on high salt-tolerant crops. Unless it is organic production, increased investments in the F&V industry would involve increased use of pesticides. While appropriate use of pesticides could be invaluable in saving crops and farmers' livelihoods, governments would need to impose and enforce very strict regulations. Finally, adverse weather conditions might have a significant negative impact on F&V yields, and policy instruments would need to support expansion and promotion of technologies that mitigate those effects.

Animal-sourced foods are also a very good source of nutrients. Increasing urban population and rising incomes will increase demand for these foods. States, which have physical conditions to produce poultry, fish, and eggs, should ensure that the "increased demand signal" reaches farmers and help farmers increase production to meet increased demand. Support to farmers involves enabling access to new breeds and technologies, veterinary services, and undisrupted feed supply and markets. Risk to human health is higher from animal production than from F&V cultivation. AMR, which results from excessive use of antibiotics in animal production, must be prevented through continuous training and strict regulations. On the other hand, zoonoses such as avian influenza are out of the control of farmers, and states must invest in efficient surveillance systems, coupled with farmers' training. Animal-sourced foods are very sensitive to high price fluctuations. Although the cycles are widely studied, states must find a way to absorb part of the price shock, as that is one of the most important production determinants. Compared to some other countries, or field crops in SA, research in the field of poultry, fish, and egg production in SA is very scarce, and this situation must change to enable policymakers to design appropriate measures.

4.5 Agricultural Production and Environment [176]

Agriculture largely depends on natural capital, but it also affects it. It is in humanity's best interest to preserve it and enhance it. Intensive agriculture, and in particular, monoculture can negatively affect soil, air, water, and biodiversity. In addition, it has been estimated that emissions from agriculture contribute to 10–14 percent of total global emissions in the period 2007–2016, and that excludes emissions from land use change.[177] These factors combine to negatively influence agricultural productivity, which in agriculture-dominated countries will have a significant negative ripple effect on livelihoods, farm income, food consumption, and nutritional outcomes.

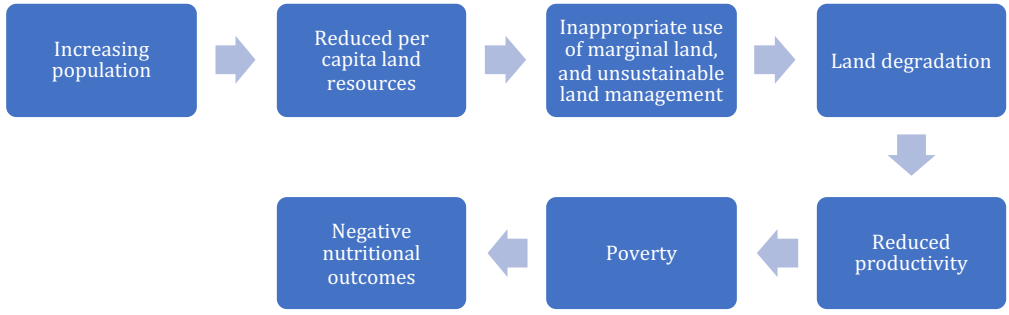
Land degradation can be induced by human activities or natural processes. Some natural processes like erosion, though, can also be caused or intensified by human activities.[178] Productive capacity of soil is crucial for production of sufficient quantities of nutritious foods for growing population, but also for the livelihoods of those who depend on agriculture. Hence, it is of utmost importance to increase the productive capacity. Agriculture can affect productive capacity in different ways. Excessive use of fertilizers can cause soil acidification, heavy metals pollution, and changes in the soil microbiome.[179] Inappropriate agricultural techniques in slope areas, as well as inadequate change of land use and overgrazing might trigger erosion, removing the most productive layer of soil.[180] Use of heavy machinery might cause soil compaction, which decreases land's filtration capacity and increases the risks of waterlogging. Irrigation, which uses water rich in minerals, might lead to soil salinization.[181] Although these are examples of some factors which can degrade soil health and productivity, it is important to note that there are agricultural techniques which prevent acidification, erosion, compaction, salinization, and which lead to healthy and productive soils. As Figure 4.22 shows, land degradation may be a part of global trends, such as growing population, which can lead to poverty, and in turn negatively affect nutrition and health, as previously discussed in this report.

Figure 4.23 shows how land degradation might lead to poverty. It assumes that the rural poor tend to remain in an area, rather than moving to urban areas and other rural areas, where the same scenario can occur. Furthermore, it shows that when land productivity declines, the rural poor, to compensate for the loss of land, seek an income in off-farm employment or in local resources exploitation, such as fuelwood, wild foods, and fodder. There are also conditioning factors (in boxes), which influence whether a household would descend into a spiral of land degradation and poverty.

[176] Part of the "Agricultural Production and Environment" section has been published in Pingali and Plavšić. (2022).

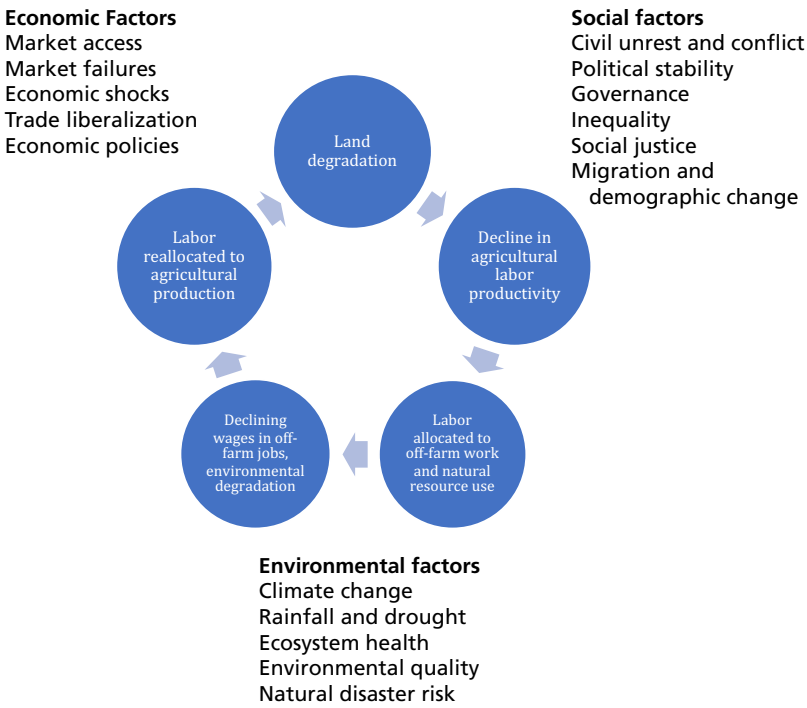
[177] Mbow et al. (2019)
[178] Flanagan (2020)
[179] Lin et al. (2019)
[180] Kairis et al. (2015)
[181] Smedema (1990)

Figure 4.22 | Relationship between increasing population, land degradation, and poverty



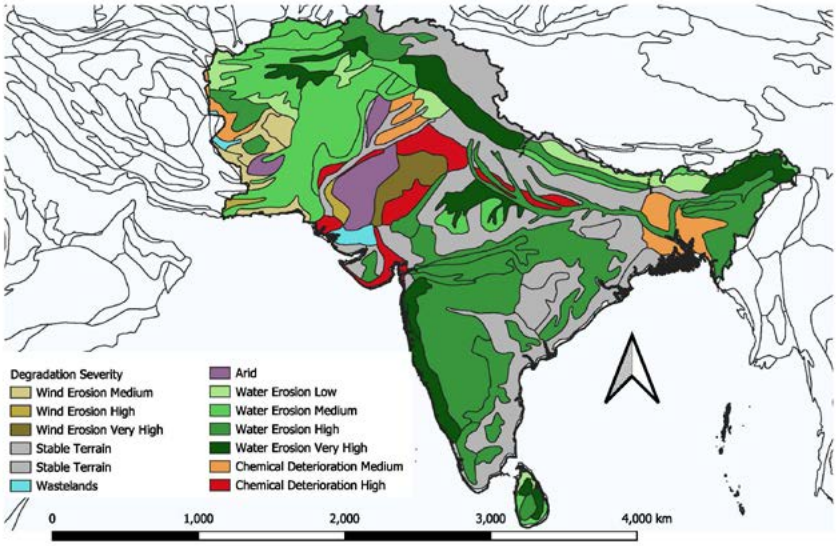
Source: Alexander, Priyankari (2016). "Land degradation in South Asia." FAO, www.sacep.org/pdf/News-Letter/Top-Stories/2016/March/2016-03-30/Land-Degradation-in-South-Asia.pdf

Figure 4.23 | Factors which influence the relationship between land degradation and poverty



Source: Barbier and Hochard (2018)

Figure 4.24 | Soil degradation patterns in South Asia, 1990



Source: International Soil Reference and Information Centre, https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/9e84c15e-cb46-45e2-9126-1ca38bd5cd22

Agriculture is the second largest anthropogenic source of **air pollution**.[182] The main sources are ammonia releases from fertilizer use and domestic animals. Additionally, some areas in SA are affected by crop residue burning. Although the burning practice helps farmers quickly prepare soil for the following crop, it also has a substantial negative impact on air pollution, and also, on topsoil quality and microorganisms.[183] Finally, emissions from agricultural machinery and diesel pumps used for irrigation also contribute to air pollution.

Water pollution is another "by-product" of agricultural practices. Nutrient runoff occurs when chemical or organic fertilizers are not entirely being "absorbed" by the crops, but are instead drained first into deeper soil levels, and eventually, into lakes, rivers, and oceans. This process, also known as leaching, can result in overgrowth of algae, leading to additional disruptions in marine ecosystems.[184] Intensive aquaculture is another source of water pollution, and it can negatively affect water quality, imbalance of biodiversity, and the ecosystem.

It has been argued that there are five direct causes of **biodiversity** loss: (1) changing use of sea and land, either to grow food or to build towns and cities (the biggest driver of biodiversity loss); (2) direct exploitation of organisms, such as overfishing; (3) climate change; (4) pollution; and (5) invasive non-native species.[185] Similarly, another report cites the global food system as the primary driver for biodiversity loss.[186] When discussing the relationship between agriculture and biodiversity, it is important to make a distinction between loss of biodiversity caused by expansion of agricultural areas at the expense of nonagricultural areas and loss of biodiversity within agriculture. Specifically, modern agriculture often involves a high degree of specialization, which has impacts on the biological diversity of grown crops and breeds, but also on the biodiversity of the environment that surrounds agricultural production.[187] Some indigenous varieties and breeds are being replaced by imported, high-yielding hybrids and breeds. Also, some crops, which were traditionally part of local diets, have been replaced by cash crops or mainstream crops—for example, millet has been replaced by rice. Finally, modern agricultural practices, characterized by high levels of inputs, may have negative effects on pollinators and the surrounding ecosystem.

To accurately monitor and quantify both positive and negative effects of agriculture on the environment, it would be necessary to monetize the value of natural capital—land, air, water, biodiversity, minerals, forests, etc. Many countries have already started this process, but there is a lack of globally adopted methodology. So far, there has been an increased uptake of Systems of Environmental Economic Accounting (SEEA) globally, from 49 countries implementing SEEA in 2006 to 89 countries in 2020. In SA, Bhutan, India, Nepal, and Pakistan implemented SEEA, while Bangladesh and Sri Lanka plan to implement SEEA. The United Nations Statistical Commission adopted the SEEA Ecosystem Accounting in March 2021.[188] Still, integrating natural capital into national accounts has many challenges, including ecosystem complexity, lack of data and data sharing, methodological challenges, limited government capacity, lack of institutional coordination, and lack of political will.[189]

Estimation of costs of land degradation might involve defensive expenditures (costs associated with preventing land degradation), lost production, replacement cost, user cost and restoration or reclamation costs.[190] Applying this approach, it has been estimated that provisional yearly cost of land degradation in SA was around US$10 billion[191] in 1989. This amount was 2 percent of the regional GDP or 7 percent of agricultural GDP. Of all sources of land

[182] Lelieveld et al. (2015)
[183] Chen et al. (2019); Jain et al. (2014); Sukul and Kumar (2020)
[184] Wurtsbaugh et al. (2019)
[185] IPBES (2019)
[186] Benton et al (2021)
[187] Pingali (2019)
[188] SEEA (n.d.)
[189] Brandon et al. (2021)
[190] FAO (1994)
[191] FAO (1994)

degradation, water erosion had the most significant effect—US$5.4 billion, followed by wind erosion, salinization, fertility decline, and waterlogging. Lowering of the water table was not included in the estimation. Figure 4.24 shows the land degradation map in SA.

Previously, we discussed how agriculture can negatively influence the environment, but it does not mean that every agricultural practice harms the environment. However, in order to protect the environment, while not compromising economic viability or production, agricultural producers must be aware of and trained to apply techniques, which are location- and crop/breed-specific, and which can be learned through the combination of traditional knowledge, modern science, and formal training. Learning methods are also context- and location-specific.

Mitigating negative impacts from agriculture

There are many agricultural practices being promoted to mitigate the negative environmental impact of agriculture. The term "sustainable agriculture" has been circulating for years, and recent attempts have aimed to quantify the relationships within sustainable agriculture.[192] A special Intergovernmental Panel on Climate Change (IPCC) report, which deals with food security, uses the term sustainable integrated agricultural systems to encompass several agricultural practices.[193] It is called integrated, as the practices combine an agroecosystem's mitigation, resilience, and sustainability functions. The four practices described in the IPCC report are agroecology, climate-smart agriculture, conservation agriculture, and sustainable intensification. Although this report will not explore each of those practices in detail, it will present some of the measures included in each of the practices included in the IPCC report.

Agroecology: efficient microclimate management; soil cover; appropriate planting time; and genetic diversity.

Climate-smart agriculture: enhancing soil organic matter; conversion from conventional tillage to minimum tillage; improved fertilizer management practices; mixed farming systems integrating crops, livestock, fisheries, and agroforestry.

Conservation agriculture: permanent soil cover; appropriate crop rotation.

Sustainable intensification: improvement of efficiency (precision agriculture, genetic improvements, irrigation technology, organizational scale-up); substitution (green fertilizer, biological control, alternative crops, premium products); system redesign (system diversification, pest management, nutrient management, knowledge transfer).

The IPCC report covers not only positive sides of the integrated agricultural systems, but also points to potential shortcomings. What is common for all the practices is that they are location- and context-specific, and it is essential to understand the necessary preconditions for each of the systems to achieve the desired outcomes. Zero budget natural farming is one of the directions in agriculture promoted by the Indian government, but it is yet to be determined if it can deliver sufficient quantities of products in the long run, or whether it is an economically sustainable practice. Another recent example from the region, where environmentally friendly practice has been promoted, is organic agriculture in Sri Lanka. The sudden shift from conventional to organic practice caused a significant reduction in food output. More details about what happened in Sri Lanka is provided in Box 1.1. Therefore, it is very important to be aware not only of the agro-climatic context but also of sociocultural–economic context where a measure would be implemented.

Another agricultural practice that is referred to more and more in literature is regenerative agriculture. From a purely agronomic perspective, this practice is linked to two main goals—restoration of soil health and reversal of biodiversity loss.[194] Since regenerative agriculture, among other techniques, involves reduced tillage, agroforestry, crop rotations, green manures, etc., it is clear that there are many similarities between this agricultural practice and the other four covered in the IPCC report.

Current evidence suggests that there is a positive relationship between applying agroecological practice and improving diets. A study from Ecuador found that those who applied principles of agroecology in their operations outperformed those who did

[192] Zhang et al. (2021)
[193] Mbow et al. (2019)
[194] Giller et al (2021)

not, in both nutrient adequacy and dietary moderation.[195] Additionally, synthesis review, which looked at studies that explored the relationship between agroecology, on one hand, and food security and nutrition, on the other, came to a similar conclusion that most of the analyzed studies found positive outcomes of agroecology and food security and nutrition in LMIC.[196]

Climate change and food systems

The sixth IPCC assessment report presented data related to expected climate-induced changes in Asia and South Asia. On a regional level, Asia should expect mean surface temperatures and heat extremes to increase, while cold extremes should decrease.[197] Furthermore, there is high confidence that marine heat waves will continue to increase; average and heavy precipitation will increase; and seasonal snow duration, glacial mass, and permafrost area will decline, while sea level continues to rise. In SA, the report asserts with medium confidence that heat waves and humid heat stress will be more intense and frequent, while annual and summer monsoon precipitation will increase with enhanced interannual variability. Those findings are relevant for this report, also, as the relationship between agriculture and climate change is a complex one. On one hand, emissions from agriculture influence climate change, and on the other, climate change affects agricultural production. Plants and soil involved in agricultural production act as CO_2 reservoirs, and hence, remove it from the atmosphere. At the same time food systems, in general, and agricultural production, in particular, are big sources of emissions. The following sections will present the main emission sources from agriculture, which are dominant in SA countries, and it will present potential solutions and policy measures that can mitigate emissions.

There are two global trends with profound impacts on food systems and emissions from agriculture—the growth of the global population and increasing urbanization rates. It has been estimated that the global population will increase from 7.9 billion in 2021 to 9.7 billion in 2050. At the same time, urbanization rate is expected to increase from 57 percent in 2021 to 68 percent in 2050.[198] More food will be needed to feed the growing population. Additional food can be sourced through reduced food waste and loss as well as increased production. As for production, an increased food demand dictates either expanding food production in new areas or increasing yield in the areas of existing food production. As there is a limited area where food production is possible and economically viable at current food prices, the increase in production will need to be achieved by increasing yield. Urban population, as elaborated in Section 3, has different dietary habits compared to rural counterparts; therefore, the two trends will influence both food supply quantity and composition.

While the globalized world and mass migrations generally diminish the importance of national statistics on population growth and urbanization rates, for the purpose of this report, it is worth exploring those two parameters in the SA region (Table 4.10).

Table 4.10 | POPULATION AND URBANIZATION TRENDS IN SOUTH ASIA

	Population 2021 (million)	Projected population 2050 (million)	Urbanization rate 2021 (%)	Projected urbanization rate 2050 (%)
Afghanistan	38.91	61.93	26.3	41.1
Bangladesh	171.50	201.93	38.9	58.3
Bhutan	0.844	0.994	43	57.6
India	1,397.42	1,658.97	35.4	52.8
Maldives	0.465	0.577	41	53.9
Nepal	30.57	36.11	21	37.4
Pakistan	212.1	306.94	37.4	52.2
Sri Lanka	21.15	20.8	18.9	31.6
South Asia	1,872.959	2,288.251	35.3	52.5

Data source: Our World in Data

[195] Deaconu et al. (2021)
[196] Kerr (2021)
[197] IPCC (2021)
[198] Our World in Data. (How many people will live in urban areas in the future?) https://ourworldindata.org/urbanization#by-2050-close-to-7-billion-people-are-projected-to-live-in-urban-areas

Increase of agricultural production, even if food loss and waste levels reduce substantially, will result in additional emissions from agriculture, if the current agricultural practices continue. At the same time, emissions reduction from agriculture is one of the main preconditions for slowing the rise in global average temperature. The next section will explore effects of climate change on agriculture, what the main sources of emissions from agriculture are, what the existing mitigation strategies are, and which strategies are realistic, suitable, and acceptable in the context of SA.

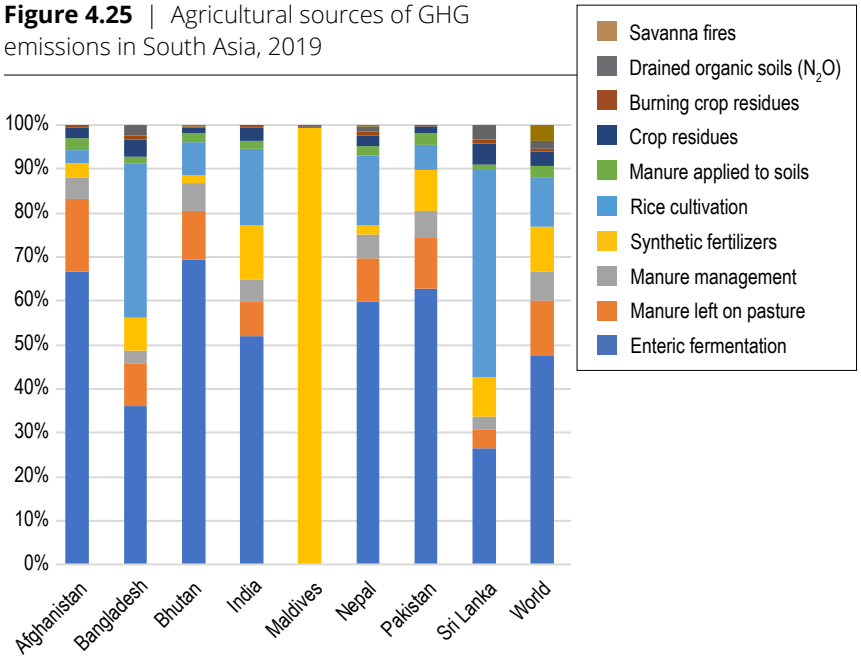
Climate change and agriculture

There is various evidence of the effect of climate change on agriculture; in this context, climate change refers to temperature, precipitation, and integrated metrics that combine with these and other variables.[199] Table 4.11 presents a snapshot from the IPCC6 report. Better data and modeling techniques provide more accurate predictions. As for the yield, a recent study that examined global production found that, compared to research conducted in the past, we should expect more pessimistic outcomes in maize, soybean, and rice yield.[200] Increase in CO_2 is found to negatively affect protein, iron and zinc content.[201] A comprehensive list of impacts of certain climate drivers on food security pillars can be found in the supplementary material section of the IPCC special report on climate change.

Emissions from agriculture

As Figure 4.25 depicts, agricultural emissions in SA come largely from four sources. These are enteric fermentation, rice cultivation, manure left on pasture, and synthetic fertilizers. Enteric fermentation is the largest emissions contributor from agriculture in Afghanistan, Bangladesh, Bhutan, India, Nepal, and Pakistan. In the Maldives, it is synthetic fertilizers, and in Sri Lanka, it is rice cultivation that are the largest emissions contributors. Globally, enteric fermentation and net forest conversion equally contribute to GHG emissions; yet, to enhance comparison with SA countries where forest conversion data is missing, forest conversion on a global level has been excluded.

Figure 4.25 | Agricultural sources of GHG emissions in South Asia, 2019



Data source : FAOstat. FAO definitions of different types of emissions are in Annex (Table A.3).

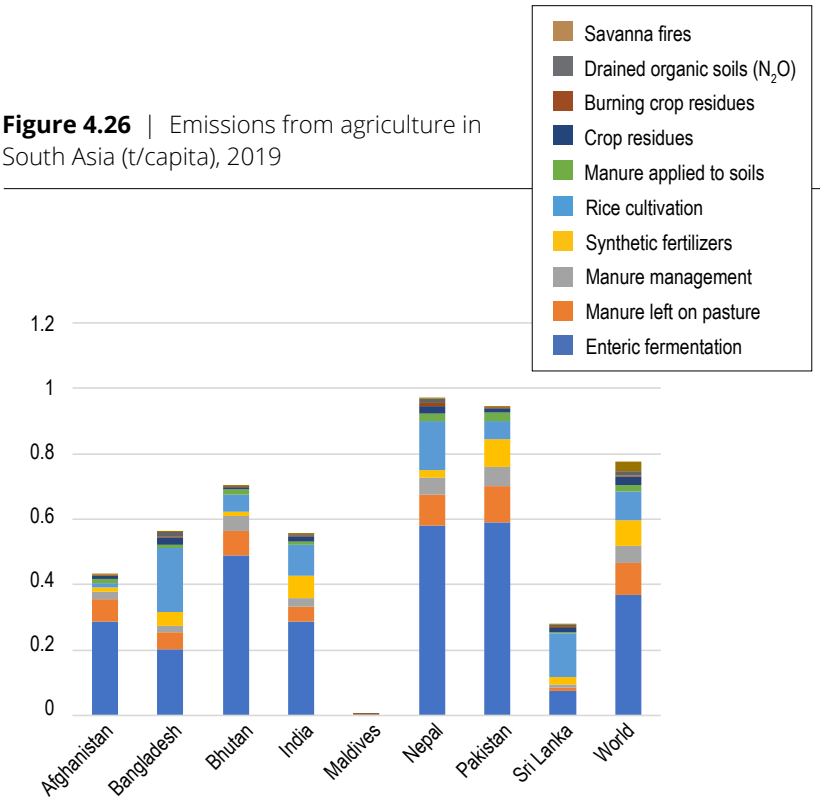
Table 4.11 | EFFECTS OF CLIMATE CHANGE ON AGRICULTURE

Positive effects	Negative effects
Increased yield in higher latitude regions	Lower yield in lower latitude regions
New areas available for production	Loss of areas currently used for production Lower yields in livestock systems Reduced food quality Reduced food safety and nutritional quality Reduced protein, zinc, and iron content

Source: IPCC (2022).

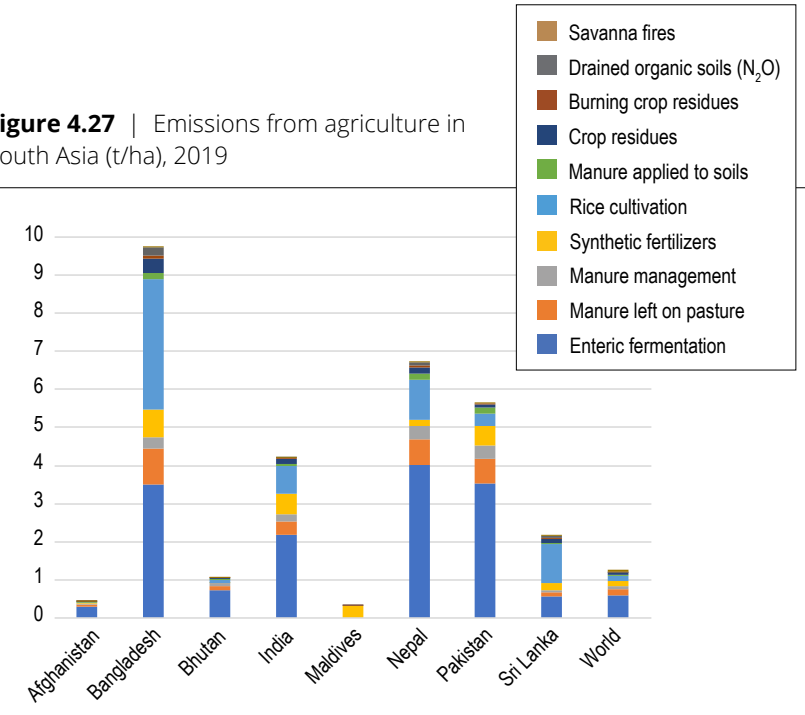
[199] Mbow et al. (2019)
[200] Jägermeyr et al. (2021)
[201] Beach et al. (2019)

Figure 4.26 | Emissions from agriculture in South Asia (t/capita), 2019



Data source: FAOStat

Figure 4.27 | Emissions from agriculture in South Asia (t/ha), 2019



Data source: FAOStat

Comparing emissions from agriculture among South Asian countries can be a challenging task. Since the amount of agricultural land and population vary so greatly among the countries, absolute numbers cannot be compared, and relative numbers could be misleading. Figure 4.26 shows that per capita emissions in Nepal and Pakistan are higher than the global average, while other South Asian countries are below the global average. Emissions per capita in Bhutan are higher than in all South Asian countries, except for Nepal and Pakistan. It should be noted that Bhutan population in 2019 was 763,000, while in Bangladesh it was 163 million and in India, 1.4 billion. If we look at emissions per hectare of agricultural land instead (Figure 4.27), we see the picture differently, that emissions in Bangladesh exceed emissions from other South Asian countries and global emissions. To be able to compare countries, the most suitable approach would be to rely on several indicators, while for deeper analysis, it would be useful to look at each country separately.

In the following section, we will examine two of the highest emitting sources of GHG from agriculture in SA—enteric fermentation and rice cultivation.

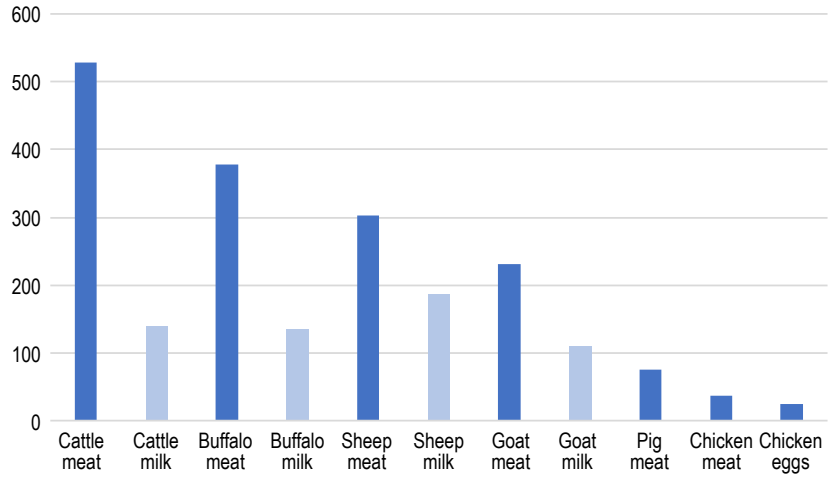
Enteric fermentation

Enteric fermentation, as an GHG emission source, is associated with keeping farm animals, as methane (CH_4) that is produced in the stomachs of ruminants (cattle, goats, sheep, and buffalo) exits mainly from animal's mouth.[202] While enteric fermentation is the most intensive emission source in SA, it is important to note that it is just a part of emissions from the livestock production supply chain. Other emissions from the supply chain originate from feed production, manure management, and post farmgate practices, which include but are not limited to transportation, refrigeration, processing and packaging. Therefore, comprehensive emissions mitigation strategy should aim to address the emission sources along the value chain.

As Figure 4.28 suggests, different animals emit different quantities of emissions per kg of protein, with production of meat from ruminants the most emission intensive. Different agricultural practices, however, contribute differently to overall emissions. For example, in the case of ruminant meat production, a grassland system is more intensive than the production from mixed systems, when one measures emissions per kg of protein.[203] Non-ruminant products, such as pig and chicken meat, as well as eggs have lower emission footprints than ruminant products. Additionally, when analyzing enteric fermentation in SA, it is important to note that some animals are used only as draft animals, and their emissions are, therefore, not reflected in the figure, while some animals are used for two purposes, both power and milk or power and meat. It has been reported that there are around 70 million working animals in India; in Nepal almost all crop cultivation involves animal power; and 90 percent of swamp buffaloes provides power, mainly for rice production systems in Sri Lanka.[204]

The shift from ruminant to aquaculture could be a strategy to reduce GHG emissions and to maintain nutritive values of food consumed. Emissions from aquaculture depend mainly on farming techniques and animals kept, as carbon footprints vary within and across different species. It has been found that emission intensity in bivalves production is similar

Figure 4.28 | Emission intensity from milk, meat, and egg production in South Asia (kg CO_2-eq/kg protein), 2017



Source: FAO GLEAM (2017).
Note: The values include those from Iran

in Latin America and the Caribbean, Western Europe, New Zealand and Australia, North America as well as East Asia (around 2.8 kg CO_2e/kgCW), while the emission intensity varies in shrimp and prawn production – from 6 kg CO_2e/kgCW in Latin America and the Caribbean to 9 kg CO_2e/kgCW in North America, 13 kg CO_2e/kgCW in South Asia and finally 14 kg CO_2e/kgCW in East Asia.[205] As shown in the "Animal Production" section, aquaculture is on the rise in all South Asian countries.

In choosing GHG mitigation strategies both for aquaculture, but also for terrestrial animals, one should look at different emission indicators, such as kg CO_2 eq/unit of interest (kg or t of protein, edible animal, etc.). In addition to CO_2 eq, other indicators can be used, such as m^3 of freshwater used, m^2 of land needed for production of interest, feed conversion efficiency, etc., and the indicators of choice would depend on the most pressing environmental threat in a given context.

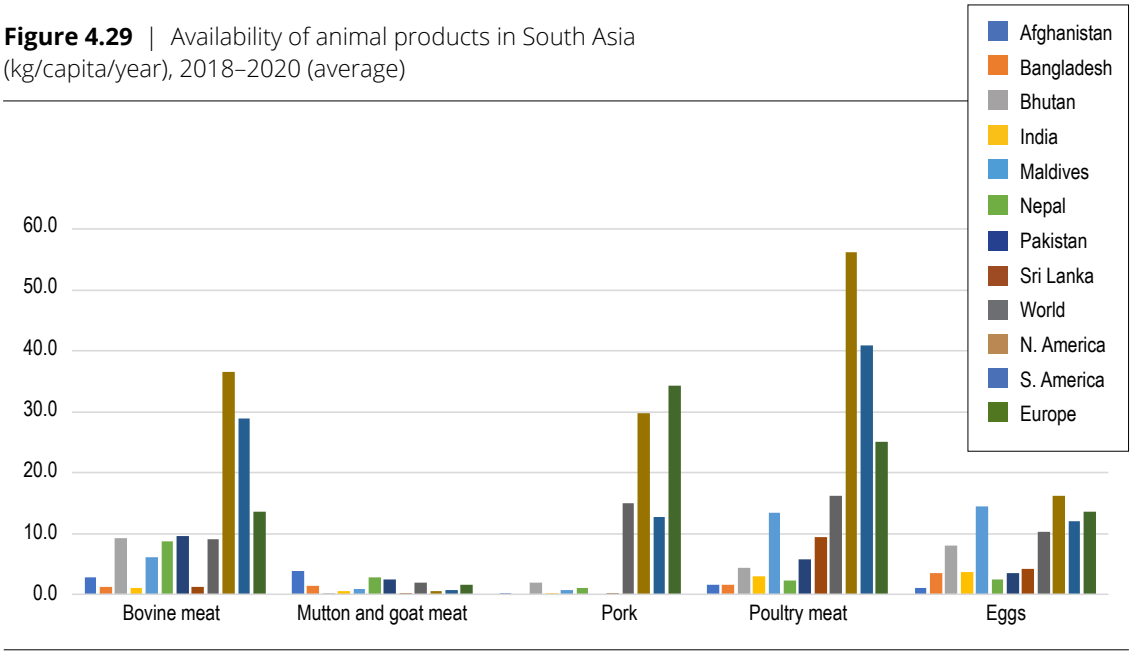
Emission mitigation strategies can be broadly grouped into two main categories—relative and absolute emission reduction. Relative reduction would involve lower emissions per liter of milk, or kg of protein, for example. An absolute reduction would

[202] WRI (2020)
[203] FAO (2017). GLEAM.
[204] FAO (2007)
[205] MacLeod et al. (2020)

entail lower absolute emissions. Additionally, absolute reduction can be achieved by reducing agricultural production—reducing the number of ruminants would be an example, yet one would need to also analyze the impact of this approach to consumption and nutrition outcomes of the affected population. Where productivity per cow is low, replacing those animals with fewer high-production cows would lead to reduction of herd size and associated GHG emissions, but increase in milk production. Absolute reduction could also be achieved by various agricultural techniques that would lead to lower emissions while keeping the output the same—changing the composition of ruminants' fodder might reduce the emissions and keep or even increase production. On a global scale, absolute reduction of emissions from agriculture is necessary, and there is no disagreement on this need. In SA, though, the picture is not as clear.

Appropriate emission mitigation strategy should be context-specific. That is, if protein intake in certain areas is lower than daily recommended intake, and if the undernutrition and micronutrient deficiency is high, increasing output per animal would be a more favorable option than reducing consumption of that food. Additionally, the cultural context in South Asian countries prevents increased consumption of certain animal products. A country's mitigation strategy related to animal foods consumption and production could involve import of those products. Although this approach might reduce GHG emissions from the importing country, it could increase GHG emissions from the exporting country. If the exporting country has more efficient and less intensive agricultural production practices, with respect to GHG, this strategy could lead to a net emissions reduction. The import-based mitigation strategy can have a negative impact on the economic development of regions where animal-keeping generates a substantial share of

Figure 4.29 | Availability of animal products in South Asia (kg/capita/year), 2018–2020 (average)



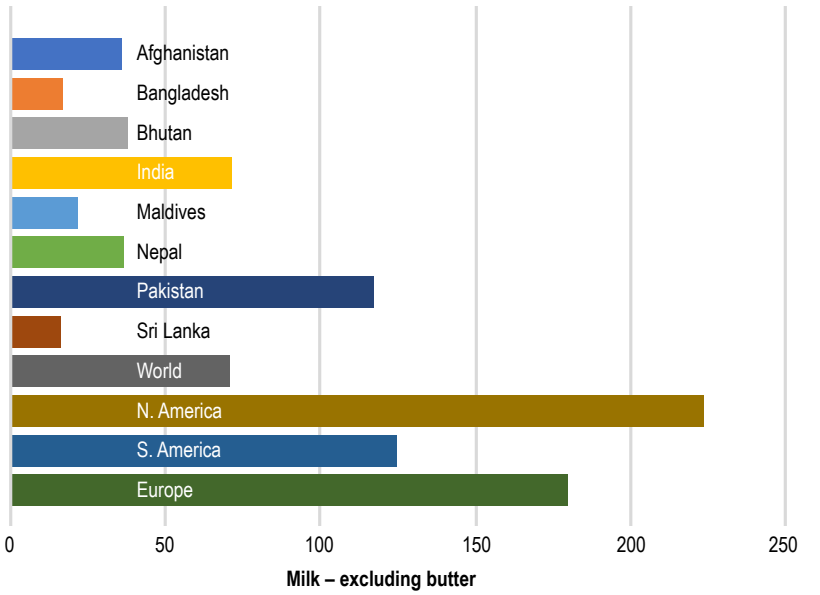
Data source: FAOstat
Note: Availability of animal products in Bhutan presents average value in 2019 and 2020.

income. Therefore, before choosing mitigation strategy, or a balance of different strategies, it is useful to perform ex ante scenario analysis and estimate impacts to food and nutrition security, GHG mitigation potential, impact to farmers' livelihoods, and overall national economy—which will require reliable data and appropriate modeling techniques.

Figures 4.29-4.31 show average animal product availability in the period 2018–2020 in South Asian countries, as well as certain global regions.

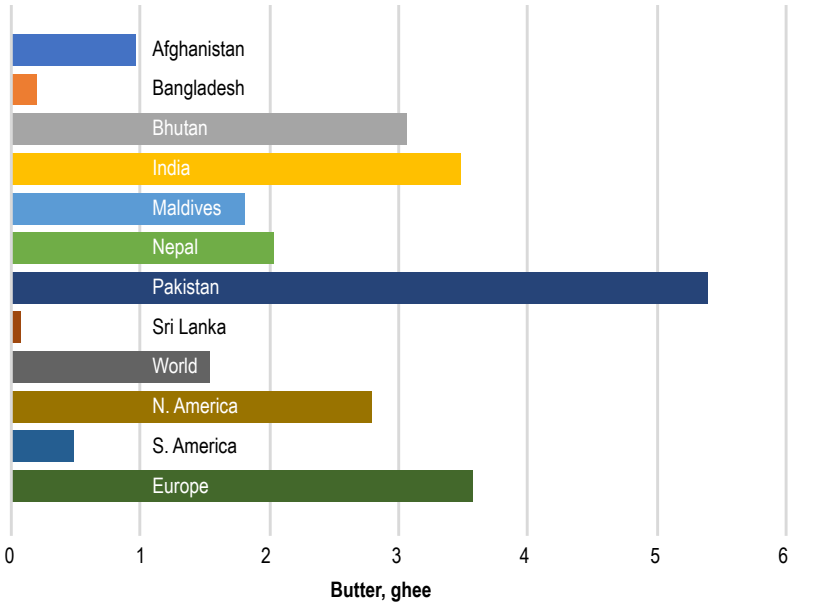
Consumption of bovine meat in Bhutan, Nepal and Pakistan is near the world average but is far below the consumption in North and South America (Figure 4.29). Mutton and goat meat consumption in Afghanistan, Nepal, and Pakistan is higher than the world average and global regions, while pork consumption is almost nonexistent in SA. Poultry meat consumption in the Maldives is around the world average but far below North and South America, as well as Europe, while egg consumption in the Maldives surpass all SA countries, and also the world average. The South Asian picture is very heterogenous with respect to milk and butter consumption (Figures 4.30 and 4.31). Milk consumption In Pakistan is lower than in North America, but very similar to Europe, and higher than in the rest of the world and other South Asian countries. Finally, butter and ghee consumption in Pakistan is more than three times the world average, and it is higher than in North America and Europe.

Figure 4.30 | Milk availability in South Asia and global regions (kg/capita/year), 2018–2020 (average)



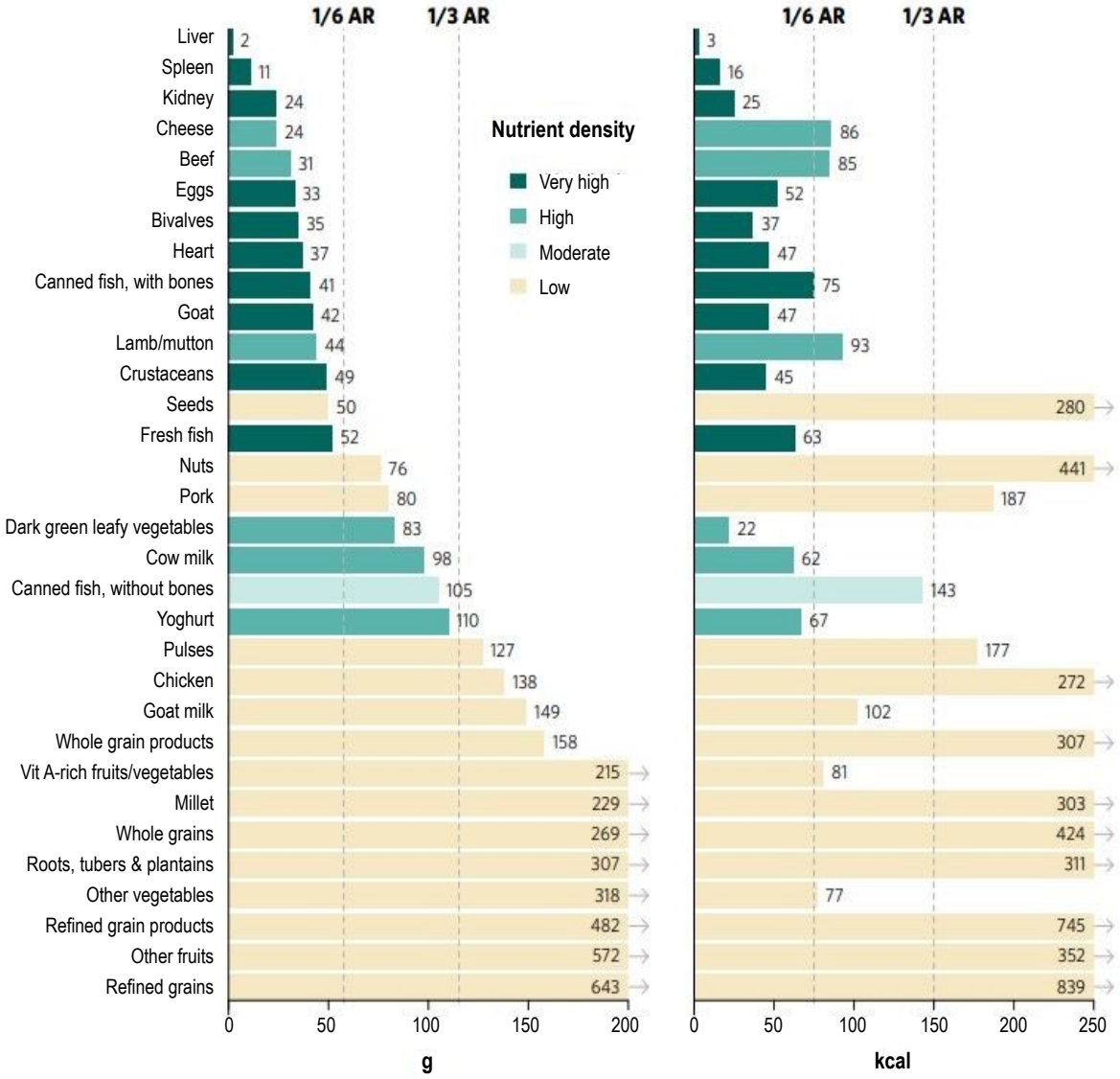
Data source: FAOstat
Note: Availability of animal products in Bhutan presents average value in 2019–2020 period, while in other countries presents average value in 2018–2020 period.

Figure 4.31 | Butter availability in South Asia and global regions (kg/capita/year), 2018–2020 (average)



Data source: FAOstat
Note: Availability of animal products in Bhutan presents average value in 2019–2020 period, while in other countries presents average value in 2018–2020 period.

Figure 4.32 | Nutrient density of different foods



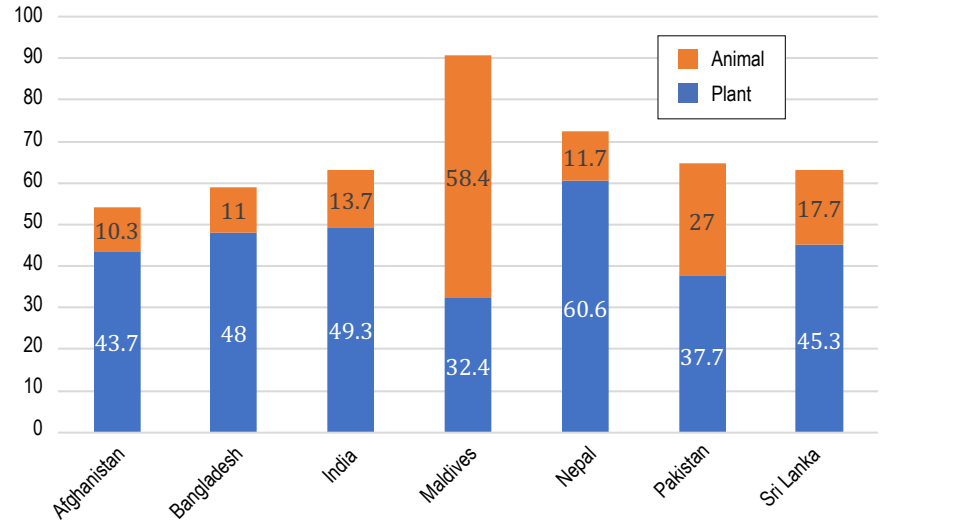
Portion sizes (calories and grams) needed to provide an average of one-third of recommended intakes from complementary foods of vitamin A, folate, vitamin B12, calcium, iron, and zinc for children aged 6–23 months. Each micronutrient's contribution to the aggregate score was capped at 100 percent of recommended intakes. Hypothetical average requirement for mass was obtained by assuming an energy density of 1.3 kcal/g (Ortenzi and Beal 2021).

Although the previous figures do not provide clear evidence as to whether the enteric fermentation emissions and other animal-sourced emissions in SA are too high, they do show that, with a very few exceptions, animal-sourced food consumption in SA is lower, and in some cases, much lower than the consumption of those products in the rest of the world's regions. The only group of animal products that is consistently consumed more across SA than in the rest of the world is mutton and goat meat, with an emission intensity lower than that of cattle and buffalo, but higher than chicken.

From a nutrient perspective, animal foods are sources of protein, vitamin A, folate, vitamin B12, calcium, iron, and zinc (Figure 4.32).[206] Hence, in areas where micronutrient deficiency is significant, decrease in consumption of those foods to reduce GHG emissions can have negative nutrition-related externality. With the exception of the Maldives, protein in SA is mostly derived from plants (Figure 4.33). While the average daily protein requirement is 50g/capita/day, only a share of total protein consumed is digestible, and only a part of that can be utilized. In India, total protein intake is barely sufficient, and the amount that is utilizable is inadequate.[207]

Based on the Figures 4.32 and 4.33, as well as on the micronutrient deficiency information presented in first section of this report, consumption of animal foods should not be discouraged in most SA countries. Instead, different approaches and new techniques should be used to address enteric fermentation emissions—involving relative GHG reduction, such as CO_2 eq/kg protein, or simultaneous production increase and GHG emission reduction.

Figure 4.33 | Supply of plant- and animal-based protein in South Asia (g/cap/day), 2015–2017 (average)



Data source: FAOstat
Note: This figure is similar to Figure 3.9, which represents the 2000–2017 time series; this figure is a snapshot of 2015–2017.

[206] Ortenzi and Beal (2021)
[207] Moughan (2021)

Greenhouse gas mitigation from livestock production

There is a range of greenhouse gas (GHG) mitigation measures that can be used to address enteric fermentation. According to the FAO, there are available feed additives and feeding practices that can help in methane mitigation.[208] Some have high mitigation effects (for example, use of nitrates in feed additives), some have low-to-medium mitigation effects (for example, concentrate inclusion in rations), and some have low effects (grazing management and feed processing). Furthermore, the authors of the FAO report examined whether the proposed practices are environmentally safe or safe for the animal. The report also examined practices and techniques that affect GHG emissions through manure handling and animal husbandry. Another FAO work examined GHG emissions in livestock production, assessing which region(s) and to what animal species certain strategies are applicable, how input intensive the strategies are, and whether there is an interaction between the mitigation practice and other GHG emission sources, as sometimes reducing one GHG can increase another.[209]

GHG mitigation strategies should analyze the impact of the strategy, not only on other GHG emissions on the same farm/field, but also in comparison to emissions in other regions, as well as the impact to agricultural productivity and household income. Another FAO publication presented a modeling exercise that provided evidence that it is possible to reduce enteric fermentation and increase milk production at the same time.[210] The authors not only examined two countries, Bangladesh and Sri Lanka, but they also examined different contexts within these two countries. In Bangladesh, they analyzed mitigation strategies for commercial and subsistence farms, and concluded that not only did the same intervention have different impacts on GHG mitigation and milk production in the two types of farms, but some measures that were appropriate for one type of farm were inappropriate for another (Table 4.12). In the case of Sri Lanka, the authors modeled different mitigation strategies for different parts of the country and proposed different strategies for different regions (Table 4.13). Additionally, cost benefit estimates were performed for each strategy in both countries. This exercise showed that GHG mitigation strategies not only can simultaneously reduce emissions and increase productivity, but they are context-specific and must be carefully tailored for different geographies and production practices.

A potential caveat to the modeling techniques is that sometimes data used for modeling are accurate in the laboratory environment, but change in vivo conditions.

Greenhouse gas emissions from rice cultivation

There are two main GHGs in rice production, methane (CH_4) and nitrous oxide (N_2O). The literature that examines GHG from rice production mainly focuses on CH_4. FAOstat also refers only to CH_4 in the context of GHG from rice production. While CH_4 should remain the focus, it is worth noting that the 100-year global warming potential of N_2O is 10 times higher than of CH_4, and that different growing practices have profound impacts on CH_4 and N_2O. Finally, another source of GHG, related to rice postharvest practices is residue burning,[211] during which CH_4 and N_2O gases are released.[212]

Methane (CH_4) from rice production is emitted when the crops are persistently flooded, which results in organic matter decaying in anaerobic conditions. Then, CH_4, produced by anaerobic bacteria, is mainly transported and released by the plant, from it rhizosphere to surrounding air.

Nitrous oxide (N_2O) is produced in the process of nitrification and denitrification. There is a particular soil moisture window when N_2O emission reaches its peak, and that is when soil is neither completely dry, nor completely saturated. It occurs when irrigation water is released to the field, but the soil has not been completely flooded, and also during field drainage when soil saturation is in decline. Both aerobic and anaerobic conditions are necessary for N_2O to be generated and released. Both synthetic and organic fertilizers are substrates for bacteria that produce N_2O. The difference is that organic fertilizer is a slow release one, and therefore, does not lead to spikes in emissions. Crop residue incorporation is often promoted as a measure to improve soil health. However, direct seeding briefly after harvest when residue has had no time to decompose, at least partially in aerobic conditions , leads to crop residue turning into "feed for bacteria" in flooded areas and then to GHG emissions. Timing, amount, and even quality of residues can affect emissions. Very often, farmers do not have control over those determinants, which is why, despite the benefits, residue incorporation might lead to unintended consequences.

[208] Gerber et al. (2013)
[209] Hristov et al. (2013)
[210] FAO & New Zealand Agricultural Greenhouse Gas Research Centre (2017)
[211] "Non-CO_2 emissions from Cropland Remaining Cropland (particularly CH_4, CO, NO_x and N_2O) are usually associated with burning of agriculture residues, which vary by country, crop, and management system. CO_2 emissions from biomass burning do not have to be reported, since the carbon released during the combustion process is assumed to be reabsorbed by the vegetation during the next growing season" IPCC (2006, 5.24).
[212] Murali et al. (2010)

Table 4.12 | EFFECTS OF GREENHOUSE GAS EMISSIONS MITIGATION STRATEGIES ON MILK PRODUCTION AND EMISSIONS IN BANGLADESH

GHG mitigation interventions	Percentage change in milk production relative to baseline (%)	Reduction in enteric CH_4 emissions intensity relative to baseline (%)
Fodder cultivation	4.4	–5.6
Use of urea molasses multi-nutrient blocks	8.1	–28.2
Balanced feed ration	15	–28.1
Use of prepartum balanced diets	7.2	–5.2
Mastitis prevention and control	11.7	–10.1
Deworming	13.6	–3.7
Heat stress management	11.5	–8.1

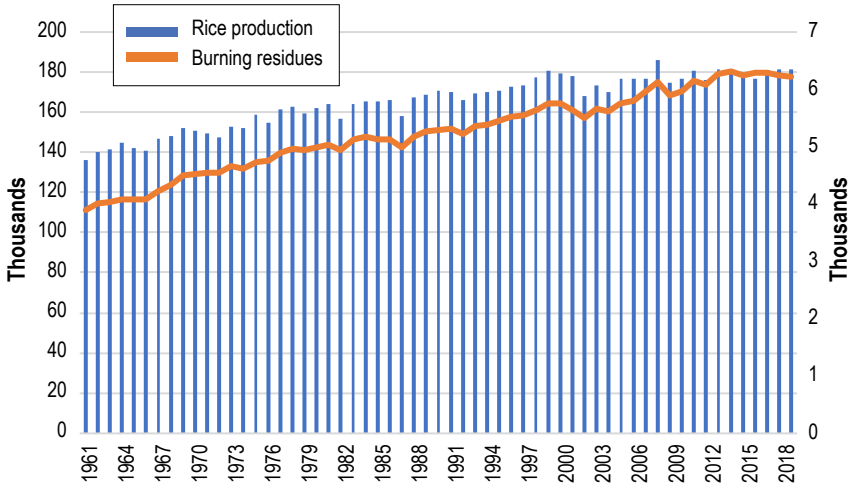
Source: FAO & New Zealand Agricultural Greenhouse Gas Research Centre (2017a). http://www.fao.org/in-action/enteric-methane/participating-countries/south-asia/bangladesh/en/

Table 4.13 | EFFECTS OF GREENHOUSE GAS EMISSIONS MITIGATION STRATEGIES ON MILK PRODUCTION AND EMISSIONS IN SRI LANKA

GHG mitigation interventions	Percentage change in milk production relative to baseline (%)	Reduction in enteric CH_4 emissions intensity relative to baseline (%)
Supplementation with straw	58	–36.4
Use of total mixed ration	48	–19.8
Supplementation (concentrate, fodder trees)	44	–37.9
Supplementation with Gliricidia blocks	106.6	–49.2
Mastitis prevention and control	6	–5.4
Heat stress management	6	–3.7

Source: FAO & New Zealand Agricultural Greenhouse Gas Research Centre (2017b). http://www.fao.org/in-action/enteric-methane/participating-countries/south-asia/sri-lanka/en/

Figure 4.34 | GHG from rice cultivation and residue burning in South Asia (kt CO_2eq), 1961–2019



Data source: FAOstat

In Figure 4.34, GHG emissions from rice production in SA show an increase from 140,000 kt CO_2eq in 1961 to 180,000 kt CO_2eq in 2019. The increase peaked in 2000, and the emissions have been stable for the past 20 years . While the emissions from burning of crop residues are much lower—4,000 kt CO_2eq in 1961 and 6,200 kt CO_2 eq in 2019, their contribution to topsoil degradation, as well as pollution and associated human health conditions, is significant. Notably, the estimates are based on Tier1 methodology, which is not very accurate, and therefore, these estimates should be taken with some caution. More details on "Tier methodology" is following in this section.

There are various factors which affect GHG emissions from rice production, and they depend on water management practice, fertilizer application, temperature effects, rice varieties, and wider production practices.[213] The next section will briefly cover the importance of rice in consumption among peoples of SA, as well as the main rice production systems, to help us understand which GHG mitigation practices are suitable for the SA region.

Advances in agricultural production brought by the Green Revolution in Asia contributed to reduction in poverty and hunger for millions of people.[214] Most of the effect is related to HYV of rice and accompanying technology. In 2019, paddy rice was globally produced on over 160 million hectares in 2019, of which 85 percent of the production was in Asia, and almost half of Asian production is in SA—more than 60 million hectares.[215] In South Asian countries that rely on rice consumption, rice-sourced calories ranged between 645 kcal/day in India to 1,700 kcal/day in Bangladesh, with values in Nepal and Sri Lanka between India and Bangladesh.[216] In all four countries, rice consumption was relatively stable; in India, it started decreasing slightly after 1991, while in Sri Lanka around the same time, rice consumption started to increase. During the same period, the area of rice harvested increased by around 30 percent in Bangladesh, India, and Nepal, and almost doubled in Sri Lanka.[217] The data show how important rice production is from a consumption perspective, but also from a farm income perspective. Sixty-year trends in harvested area and rice consumption suggest that rice will probably remain a very significant crop in SA, both for household income and caloric sufficiency, and GHG mitigation interventions will need to consider that significance.

For rice production systems, one of the production categorizations is based on the landscape position and drainage characteristics where rice is produced—upland, lowland, deep water, and whether it has been irrigated or rainfed. Seventy-five percent of global rice production is under an irrigated lowland production system, where rice is being flooded under anaerobic conditions.[218] Even irrigated rice in SA is commonly subject to periodic drainage. The main reason why rice flooding is a widespread practice is because it is an efficient and cost-effective weed control measure. In rainfed, lowland production systems, the fields are flooded for at least a part of the season, while in upland production systems, mostly involve aerobic production.[219]

Rice can be grown under continuous flooding (CF) conditions or alternate wetting and drying (AWD). In some regions, where irrigation infrastructure is in place, and where water drainage is well established and fields are leveled, farmers might be in position to choose the water management practice. Very often, though, there are infrastructural or physical constraints that dictate the practice, and most farmers have limited control over water, especially in monsoon climates.

As for the sowing method, rice can be directly seeded, or rice seedlings can be prepared in the nursery and then transplanted to the field. Direct seeding can further be divided into dry-seeded rice, wet-seeded rice, and water-seeded rice.[220]

[213] Khalil and Aslam (2009); Win (2021); WRI (2020)
[214] Pingali (2012)
[215] FAOstat (2023)
[216] FAO (2001)—Food Balance Sheets.
[217] Harvested area is counted twice in double-cropping systems. Increase in areas harvested under rice, to a large extent, is driven by multi-cropping systems, and to a smaller extent, by expansion of agricultural land.
[218] Rao et al. (2017)
[219] Rao et al. (2017)
[220] Rao et al. (2017)
[221] Kim et al. (2018)

Finally, fertilizers used in rice production can be mineral fertilizers, of which nitrogen-based ones have a significant impact on GHG emissions, or organic fertilizers that can be of plant or animal origin. Rate, time, and type of fertilizer used depend on the soil condition, water management, and sowing method, among other factors, and all combined have differentiated effects for GHG emissions. Notably, both inorganic and organic nitrogen from fertilizers are subject to the same environmental loss pathways.

Additionally, it has been found that different rice crop varieties have different effects on GHG emissions, which is partly explained by morphological differences—the transverse section and aerenchyma areas.[221] Another variety-related trait, which influences GHG emission is vegetation period, where varieties of longer growth duration have higher cumulative CH_4 emissions than varieties with shorter growth duration,[222] which assumes differences in flood duration.

GHGs emission mitigation strategy for rice production should be based on three factors—data, constraints, and externalities. As for **data**, it is important to have an accurate picture of emissions from different rice production practices. A better understanding of underlying mechanisms that lead to different levels of emissions from different production practices would also be helpful. To determine emission levels, countries can use the United Nations Framework Convention on Climate Change (UNFCCC) Tier methodology, for which the total emission from a single source is calculated by using local data and emission factors. The emission factors can fall under Tier1, Tier2, or Tier3, in which Tier1 factors rely on global default factors and are the least accurate. Tier3 factors rely on data collected on the ground and are repeated over time, and therefore, are the most accurate. Ideally, all countries should aim to use Tier3 factors for relevant emission sources, but that process is very data demanding.[223] In case of Japan, Tier3 methodology was used to calculate emissions from rice production, and in that process, the following data have been used: physical and chemical soil properties, field drainage, meteorological data, field management information, and amount of organic matter application. In the case of calculating emissions from rice cultivation in SA, Bangladesh, India, and Sri Lanka relied on Tier2 factors, while Afghanistan, Bhutan, Nepal, and Pakistan relied on Tier1 factors. Although the Tier3 approach is what all countries in SA should aim for, it is questionable whether this is realistic in the context of LMIC, so a robust Tier2 approach might be an appropriate way for now. More information about GHG emissions from agriculture and Tier factors used for the calculation in SA can be found in the Annex (Table A.4).

Regarding **constraints**, one should first analyze what it would take for farmers to adopt a change in their rice production. In a scenario in which farmers do not pay for causing emissions from their operations, any production-related expenditure that would lead to the same or lower rice yield would probably not be an option. Another determining factor is whether farmers are ready to adopt a new technology or rice variety, even if it does not come at an additional cost to them. Furthermore, some measures cannot be implemented simply because of plot size, field, and soil physical constraints, or inability to control irrigation, for example. For promotion and support of new measures, a region should have physical infrastructure in place, but also institutional support, such as effective extension service.

Finally, before a mitigation strategy is implemented, their **externalities** must be considered. Mitigating one GHG can increase emission of another GHG, and while net emission is important, this should be calculated in advance, as not all GHG are equally potent. Although the impact of a mitigation strategy on rice yield has been widely examined, research on the impact on rice nutritive composition may be lacking. For example, a mitigation strategy which involves introduction of certain "lower methane-emitting" hybrids, instead of the "higher methane-emitting" ones, could have nutritional consequences for the consumers, if the two hybrids have different nutritional characteristics.

Greenhouse gas mitigation from rice production

As in the case of GHGs from enteric fermentation, emission mitigation strategies can be broadly grouped into two main categories—relative and absolute reduction. Relative reduction involves strategies that promote higher output per hectare, thus lowering emissions per output unit. As for absolute reduction, these are strategies which aim to reduce demand—reduced consumption of rice. As income rises, populations' diets tend

[222] Win et al. (2021)
[223] Greenhouse Gas Inventory Office of Japan and Ministry of the Environment (2021)

to diversify and move away from staples toward fruit, vegetables, and meat. From this perspective, reduction of GHG from rice production will naturally occur in SA.

Specific mitigation interventions are increasing yield, which indirectly reduces emissions by preventing future expansion of areas under rice and leaving that land to act as a carbon sink; breeding lower-methane rice varieties; removing rice straw; reducing flood periods, including dry seeding, single midseason water drawdown, alternate wetting and drying, and aerobic rice production; reduced tillage; certain fertilization practices, such as urea deep placement;[224] and other measures.

Although all practices mentioned here have roles in GHG emission mitigation, water management was the most studied, because rice is still mostly grown in flooded conditions, which has a significant impact both on CH_4 emissions and on water availability. As noted, flooded rice fields create anaerobic conditions, which facilitate CH_4 emissions. Hence, the mitigation practices seek to reduce flooding time, thus reducing the anaerobic conditions. To that end, water is being drawn down once or multiple times, and every time that happens, CH_4 emissions decrease. Although this seems to be an obvious solution to rice methane emissions, not every farmer can apply this practice, as it involves leveled fields and the ability to fully regulate irrigation. Another effect of creating aerobic conditions by water drawdown is that it typically results in increased N_2O emissions. Therefore, by reducing one GHG, this mitigation practice increases another. It is important to calculate net emissions, to see whether the cumulative impact of N_2O emissions is higher or lower than the impact achieved by CH_4 removal. Current research shows mixed results.[225] In addition, it has been argued that organic fertilizers could lead to increased CH_4 production, while mineral nitrogen fertilizers would produce more N_2O.[226] Finally, the same research argues that increasing soil temperature stimulates both methanogenic and methanotrophic bacteria, and this process can lead to both net reduction and net increase of methane.

There are many competing processes occurring in rice production, and while some of them stimulate GHGs emission, others are having the opposite effect. For that reason, it is important to carefully examine emissions processes in a given region and tailor region-specific GHG mitigation measures.

4.6 Agriculture–Environment Policy Work

In this report, we show that agriculture has a profound impact on soil, water, air, and biodiversity. When this impact is negative, it can affect not only yields, but also animal and human health, and farmers' welfare. Therefore, it is very important to design an appropriate policy mix that would prevent negative impacts from agriculture. Some measures might help farmers achieve high environmental standards. One such measure could be subsidies for efficient irrigation equipment. Not only could this measure slow down depletion of groundwater—the irrigation source—but it could also help prevent water erosion, facilitate better use of fertilizers, and help to reduce methane emissions in the case of alternate wetting and drying practice. These are environmentally related effects produced by the measures. Other effects include higher yields and farm income, and indirectly better nutrition. To successfully implement such measures, there must be an enabling environment, entailing reliable irrigation infrastructure, training in using new irrigation techniques, and higher irrigation water price.

For pollution from overuse of fertilizers, pesticides, and burning crop residues, a policy mix should include either financial penalties or denial of access to agricultural subsidies for a certain number of years.

Part of the policy mix should also support acquiring varieties and breeds, which not only secure higher yields, but also those that are resistant to climate and environmental stress. This acquisition could increase production and farm income and also contribute to relative reduction of GHG emissions. In addition, there are low-emission rice varieties, which could lead to GHG emission reduction in absolute terms. The IPCC special report on climate change provides an extensive list of food-related adaptation and mitigation options.[227]

Supporting agrivoltaics, in which land is also used for agriculture and solar photovoltaic energy generation is another intervention that has potential to provide farmers with agricultural output and additional income from power generation.

A policy mix also includes measures that do not directly target agricultural production. Education on negative effects of agriculture might motivate consumers to require environmentally friendly food products. Agricultural and food producers, who are interested in being integrated in the markets, might respond by applying more environmentally friendly practices. To succeed, an enabling environment is necessary, too, including trust between policymakers, farmers, and consumers, which can be enhanced through introduction of certain standards and certifications.

Policymakers might eventually decide to address environmental externalities of agricultural production, which would lead to environmentally friendly practices being more competitive. For this to occur, there must be a global consensus on the mechanism to achieve this ambitious goal; otherwise, global markets might punish those who adhere to high environmental standards.

[224] WRI (2020); Islam et al. (2020); Islam et al. (2018); Singh et al. (2022).
[225] WRI (2020)
[226] Khalil and Aslam (2009)
[227] Mbow et al. (2019)

5 Policymakers' Corner

There are many factors that influence one's diet and the associated nutritional outcomes, such as undernutrition, overweight, or macronutrient deficiency. Some of the factors are very intuitive and obvious—income, for example—and some are less so, such as international trade. We unpack some of these factors, in the context of agriculture-dominated economies—where the agricultural sector employs a high share of the population and significantly contributes to national GDP.

An Indian farmer tends to his millet crops.
(Photo by Thana Ram/Shutterstock)

A farmer carries grain on her back in rural Bhutan. ***(Photo by Mark Dozier/ Shutterstock)***

Agricultural production is a very important source of income and food for people engaged in the production. Higher agricultural productivity should lead to higher disposable income, which can be used for obtaining diverse nutritious foods, education, and investments in water, sanitation, and refrigeration, which all lead to better nutritional outcomes.

The environment affects and is affected by agricultural production. Irresponsible agricultural practices, whether caused by lack of knowledge or lack of disincentives, can negatively affect land, water, air, and biodiversity. If prolonged, these practices lead to a reduction in output, and eventually, to lower agricultural productivity. As noted in the previous section (Figure 4.22), this would very likely lead to worsening of nutritional outcomes.

Indian King fish at auction at Cochi Port in Kerala, India. ***(Photo by Abhijeet Khedgikar/ Shutterstock)***

Like the case of the natural environment, changes in climate patterns and agricultural production affect each other. While increased emissions from agriculture negatively influence the rise in global average temperature and climate change, the relationship in the opposite direction is more complex. Specifically, agriculture in some global regions will benefit from global warming, and in some, will lose, and the SA region is in the latter group. Global warming will not only negatively affect yield and productivity, but also nutritional content of the crops, causing dual negative effects to nutritional outcomes.

International trade can provide fresh and nutritious foods throughout the year, and thus, it can help a country to achieve food and nutritional security. Also, competitive producers would have an economic benefit. International trade can also negatively affect the livelihoods of the farmers who are not competitive enough, and who live in areas without off-farm opportunities, as it would negatively affect their income, and thus, nutritional outcomes. Additionally, international trade can also bring foods with very low nutritional quality, which could in the long run result in increased prevalence of overweight, directly undermining public health efforts and negatively affecting health expenditures. Therefore, the same intervention—opening the economy to global market—may have very different consequences for different countries or different groups within the population.

Although there are many more factors that can influence nutritional outcomes, the examples given here illustrate the complexity of relationships within food systems. This can partially explain why undernutrition and overnutrition coexist, and the poor nutritional outcomes are so challenging to eradicate. It is often argued that policy coherence can be an answer to these sustained challenges. Yet, it remains to be seen whether cross-departmental policy coherence is just a "holy grail." The example of water policy showed us that a policy that leads to reduction of excessive underground water withdrawal also leads to increased air pollution. In this case, the policy instrument failed to identify and address the externalities, even within the same subject area—the environment. Therefore, can we expect the policymakers to address the negative effects which extend across different subject areas—the environment, public health, agricultural productivity, etc.?

There are some steps that may help policymakers move in the right direction. Efficient and effective policy instruments must be based on credible scientific evidence. To achieve this, academia must rely on well-trained researchers, accurate and timely data, appropriate methodology, access to the latest scientific and technological achievements, and unbiased research free from any influence. Governments can play a very important role in most of these preconditions, especially with respect to data availability, which is scarce in SA. Additionally, researchers whose research outcomes in the future will be used for design of food systems policy instruments cannot operate in isolation from other researchers whose work will also be used, as this could lead to creation of conflicting policy instruments. On the contrary, the researchers should work together across disciplines, or at least understand how their own research fits into much larger "food systems puzzle" and take that into consideration in their work.

The next step would be increasing policymakers' institutional capacities, so that they can translate research into policy instruments. For this to occur, it is necessary to assess current institutional capacities and to address the shortcomings at the central, regional, and local levels. Capacity assessment should also be done impartially and free from any influence and interests.

With these two preconditions in place, it is possible to work on policy coherence across departments. In practice, policy coherence would entail maximization of synergies between policy instruments and minimizing their trade-offs. This is certainly easier said than done. It is necessary to identify and quantify relationships among policy instruments. It is important to understand that the nature and strength of those relationships are time- and location-specific, and while it may be possible to replicate a certain successful policy instrument from one SA country to another, this cannot be taken for granted. Appropriate modeling techniques and timely and credible data are invaluable in the creation of an effective policy instrument. Models that are designed to include different elements of food systems are quite complex and could require additional training of those involved in modeling.

The final step in the policy process is effective implementation of a policy instrument. There are numerous factors that can prevent policy implementation, and these are policy-specific. However, some are farmers' low adoption rate, shortage of trained extension workers, corruption, powerful interest groups, among others. Power dynamics among food systems participants could also have a negative impact on policy implementation. The nature of disproportion of access to financial resources might lead to multinational companies steering the policy design process to favor their own interests.

In this report, we discussed and analyzed different policies. Some are related to nutritional outcomes, others to consumption or agricultural production. Also, some are simple and directly address an issue, such as vitamin A supplementation, while others are more complex and address underlying issues, such as poverty. To effectively address challenges related to nutritional outcomes, consumption, agriculture, and everything that is between and around these three areas, SA countries will need to rely on a carefully designed bundle of policy instruments, which might differ from country to country. Also, it is important to note that design and implementation of complex policy instruments require time, and that the policies should be designed based on the expected food systems scenarios and conditions 5, 10, or 15 years in the future.

Table 5.1 presents some of the policy options to address challenges in nutritional outcomes, consumption, and agriculture. The list is not exhaustive, and what might prove effective in one country does not necessarily need to be in another. Therefore, before any policy instrument is implemented, a comprehensive ex ante evaluation must be performed, especially in regard to unintended consequences. Also, it should be noted that policy instruments that lead to increased agricultural productivity might also lead to increases in household income, and ultimately, to improved nutritional outcomes. This is particularly prominent where producers are well integrated into markets.

To make this extensive list relatively easy to follow, we have structured the policy measures based on their place in a food supply chain.

A hen eats grain next to a child in Kathmandu, Nepal. *(Photo by Nicram Sabod/Shutterstock)*

Table 5.1 | POLICY INTERVENTIONS ALONG THE SUPPLY CHAIN

PRODUCTION STAGE

Production Element	Policy Instrument	Issues to Consider
Seeds/seedlings	*Enable purchase of seeds and seedlings that are: local, HYV, resilient to pests/extreme climate conditions/high soil salt content, and developed for local conditions.* For example, subsidies for HYV seeds (where crops are used both for human and animal consumption); subsidies for biofortified seeds/seedlings with increased micronutrient content (where the micronutrient deficiency in the population exists); subsidies for planting material for seaweeds and other aquatic plants; financially supporting national institutes to increase human capacities and to improve local varieties; cooperation with national and international organizations to develop seeds suitable for local conditions and markets.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability; affordability of expenditures associated with adoption of the seed (mechanization, irrigation, plant protection chemicals); marketability of crops. **Environment** – Effects on biodiversity; water, air, and soil pollution, as well as land degradation, resulting from growing new seeds. **Health** – Effects on human health (nutritive value of a product); if chemical use is needed, what are effects to human health in case of overuse? **Social** – adoption capacity (Are producers willing to try it? Is the product culturally acceptable?).
Breeds	*Enable purchase of animal breeds that are: local, resilient to diseases and local climate conditions.* For example, subsidies for purchase of particular breeds; subsidies for artificial insemination, using sex-sorted semen to improve genetic material and productivity; financially supporting national institutes to increase human capacities and to improve local breeds; cooperation with national and international organizations to develop breeds suitable for local conditions and markets.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability; affordability of expenditures associated with adoption of the breed (mechanization, storage facilities); uninterrupted accessibility to safe, nutritious, and affordable feed; marketability. **Environment** – Effects on biodiversity; water, air and soil pollution, as well as land degradation, resulting in keeping new breeds. **Health** – Effects on human health (nutritive value of a product); if antibiotic use is needed, what are effects on AMR; exposure to poultry feces. **Social** – Adoption capacity (are producers willing to try? is the breed culturally acceptable?); animal choice to consider women's time constraints and is it "women friendly."
Fertilizers	*Enable use of synthetic and organic fertilizers and optimal application.* For example, subsidies for fertilizers (with or without added micronutrients); subsidies/no cost to determination of fertilization requirement (soil or plant testing); subsidies for training in organic fertilizer production and application; subsidies for trainings in appropriate fertilizer application; subsidized fertilizer to those who complete the training.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability; costs associated with fertilizer application. **Environment** – Effects on pollution in the case of excessive use; if chemical fertilizers completely replace organic fertilizers, effect on soil organic matter. **Social** – For organic fertilizer, consideration of which household members would be involved in the activity, and how would it affect their other daily activities.

Production Element	Policy Instrument	Issues to Consider
Irrigation	*Enable irrigation to producers.* For example, assessment of regional and subregional irrigation potential; developing capital infrastructure projects; subsidies for efficient irrigation and fertigation equipment and solar pumps; subsidies for trainings in appropriate irrigation and water management practices; performing water quality tests.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability. **Environment** – Effects on soil (soil structure, leaching, qualitative characteristics); effects on underground water levels; pollution effects of diesel pumps. **Health** – Effects on human and animal health (if water is contaminated). **Social** – Different irrigation systems require different time use—avoid adding more work to women; competing interests of different regions over water supply.
Animal-keeping facilities	*Enable construction of animal-keeping facilities.* For example, subsidies for the construction of animal-keeping facilities (including investments in aquaculture); adoption of equitable planning regulations, which are simple to follow and adhere to.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability; sustainability of the investments. **Environment** – Effects on biodiversity and pollution. **Health** – Effects of feces on human health.
Protection from climate shocks	*Facilitate protecting production from extreme climate events (adaptation measures).* For example, infrastructure investments to reduce damage from floods, droughts, hail; enabling and promoting insurance market and subsidizing insurance premiums.	**Economic** – Accessibility, affordability, and viability of insurance premiums to small-scale producers
Postharvest practice	*Enable easier access to machinery and infrastructure for decreasing postharvest loss.* For example, subsidies for efficient grain harvesters, subsidies for milk coolers, etc.; subsidized storage capacities; subsidized trainings in appropriate storage to prevent quality and quantity loss and to improve food safety.	**Economic** – Accessibility and affordability to small-scale producers; profitability; availability; sustainability of the investments; access to service centers.

Table 5.1 | POLICY INTERVENTIONS ALONG THE SUPPLY CHAIN, continued

PRODUCTION STAGE

Production Element	Policy Instrument	Issues to Consider
Policy instruments irrespective of production type and element	*Make production predictable.* For example, guaranteed land rights; uninterrupted access to inputs and access to markets; efficient labor market to prevent labor shortage; access to loans. *Capacity building.* For example, subsidies for trainings; providing state-sponsored extension service and facilitating emergence of private extension service; women-centered extension services or investment in peer to-peer networks for accessing inputs, credit, and information. *Facilitating economy of scale.* For example, introducing regulations that lead to land consolidation; subsidized creation and operation of producer organizations. *Lowering production and transactional costs to small-scale farmers to access markets.* For example, investments in physical infrastructure; supporting farmers in product standardization; supporting FPOs to market their products (priority can be given to nutritiously dense products). *Supporting farmers in risk management.* For example, support farmers throughout the process of production diversification. *Technology dissemination.* For example, promoting agritech solutions (precision agriculture, use of mobile devices, etc.) where preconditions for it exist. *Changing cropping structure.* For example, creating environment conducive for the production of nutrient-dense crops that would replace some areas under staples. The environment needs to include both supply and demand side.	**Economic** – For any subsidy measure, strong controlling mechanism must be in place. **Social** – Trainings to be organized in inclusive rather than exclusive way (not during the peak season or when women must stay at home for some reason); subsidy measures must be inclusive, gender sensitive, and culturally appropriate; land consolidation cannot involve smallholder-forced displacement nor interfere in family relations (inheritance regulations granting all land to one child); land consolidation might lead to deeper wealth gap; land consolidation can lead to even deeper gender inequality; scaling solutions and technology dissemination to take into consideration small-scale farmers

TRANSPORT STAGE

Transport Element	Policy Instrument	Issues to Consider
Means of transportation	*Promote vehicles that prevent food and nutrient loss and food spoilage.* For example, subsidizing purchase of temperature-controlled vehicles for FPOs; enabling, promoting, and backing agricultural loans to FPOs.	**Economic** – Preventing monopoly abuse by companies selling temperature-controlled vehicles.
Transport infrastructure	*Enable physical infrastructure.* For example, investments in road, rail, and waterways, as well as communication infrastructure.	**Environmental** – Effects of capital infrastructural work on environment. **Economic/Social** – Market price compensation to farmers, who lose their land due to infrastructural projects.
Transport and food product packaging	*Promote using appropriate transport packaging.* For example, subsidies for plastic or wooden crates for F&V transport.	**Environmental** – Plastic pollution.

Table 5.1 | POLICY INTERVENTIONS ALONG THE SUPPLY CHAIN, continued

PROCESSING STAGE

Processing Element	Policy Instrument	Issues to Consider
Product quality	*Improve qualitative product characteristics.* For example, encourage or mandate fortification of certain foods (wheat, salt, milk); banning processing practices that include unhealthy substances (trans fats); subsidies for solar drying facilities.	**Economic** – Uninterrupted supply of fortifying agents; banning certain practices can negatively affect certain businesses. **Social** – Adoption capacity (Are consumers willing to try? Is the product culturally acceptable?).
Product safety	*Improving food safety.* For example, training in food handling in processing facilities; testing water used in food washing for contaminants; promotion of packaging that prevents food damage and spoilage.	
Shelf life	*Promote technologies that extend product shelf life.* For example, investments in R&D of packaging/coating materials that are not harmful for health or environment, and which extend shelf life.	

Shoppers by producer at a busy market in Sri Lanka. *(Photo by Andrea Chiozzi/ Shutterstock)*

RETAIL STAGE

Retail Element	Policy Instrument	Issues to Consider
Product quality	*Promote healthy and discourage unhealthy options.* For example, nonessential food taxes (SSB, etc.); banning "buy one, get one free" for unhealthy food; removing confectionary from check-out aisles, and placement on the shelves above toddlers, preschool and school age children's eye levels; restricting all cartoon characters on primary and secondary food packages of unhealthy foods; food packages labeling and front-of-package initiatives that warn against unhealthy products; placing fruits and vegetables to the front of a shop; lowering taxes on unequivocally healthy products; publicly praising of companies promoting healthy options.	**Economic** – Taxing certain products can lead to decrease in tax revenues, in case of growth of illegal trade. **Health** – Taxing certain products might lead to increase in counter-feit products, which can be harmful for human health. **Social** – Consumers might feel overwhelmed by the amount of information and mixed messages they are receiving about healthy options.
Product safety	*Maintain high-level standards.* For example, trainings and promotion of importance of food products safety and risks of food poisoning; clear standards on sell by/best buy dates.	
Advertising	*Promote healthy and discourage unhealthy options.* For example, ban on advertising junk foods targeted at children.	

Table 5.1 | POLICY INTERVENTIONS ALONG THE SUPPLY CHAIN, continued

CONSUMPTION STAGE

Consumption Element	Policy Instrument	Issues to Consider
Product quality	*Promote healthy and discourage unhealthy options.* For example, influencing consumer behavior (media strategy – a mix of media components: press conference, performances, public campaign…); education from preschool age throughout school-age; engaging role models from sport, arts, and other spheres who can influence young people's behavior. For example, vending machines in schools and office space being stocked with healthy foods, while vending machines that offer drinks to be replaced by water filling stations; school and hospital meals to contain fresh fruits and vegetables, while range and quantity of ultra-processed foods to be limited; For example, portion size control in restaurants. For example, food transfer programs to be as nutritious and diverse as possible and to rely on local supply where possible (PDS, WIC, SNAP).	**Social** – Healthy eating campaigns should not shame overweight people.
Product safety	*Promote best practice.* For example, educating school-age children on food safety and how to recognize unsafe foods; providing food refrigeration to underserved parts of the population.	
Other elements	*Reduce food waste.* For example, informing on the difference between sell by and best by date; informing on all negative effects of food waste; informing on ways to use food leftovers in a safe way, either for consumption or for composting.	

ALL STAGES

Element	Policy Instrument	Issues to Consider
Women-sensitive measures	*Empowering women.* For example, mandatory education for all children (years of schooling very context-specific); childcare provisions and other measures that result in women having more time for economic activities instead, not in addition to daily commitments. For example, support women in obtaining collateral, lifelong education, and contracting power in the market. For example, financial inclusion of women through providing higher proportion of women with mobile money accounts. For example, cash transfers.	**Social** – Some of the measures can cause disturbances in a society; hence, they must be context-specific and culturally acceptable; cash transferred might eventually reach men. **Infrastructural** – Implementation of cash transfer measure might be negatively affected by lack of bank accounts, access to banks.
Education	*Continuous identification of skills gap in a society.* For example, identification of missing skills for successful implementation of any of the aforementioned measures throughout the supply chain and organizing trainings, including trainings for policymakers.	
Private sector	*Involvement of private sector.* For example, create environment in which private sector can take the lead in certain spheres or share the market with the state (credit providers, input providers, extension service, commodity-specific processing, storage, and marketing facilities).	**Economic** – State monopolies cannot be replaced by private sector monopolies.
Water, sanitation, and hygiene (WASH) and health care facilities	*Providing appropriate WASH and health care services to as many people as possible.* For example, investments in large-scale infrastructural projects; subsidizing household-level WASH investments.	

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Table A.1 | PROGRESS TOWARD MEETING GLOBAL NUTRITION TARGETS IN SOUTH ASIA

	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
Anemia in women of reproductive age (WRA)	No progress/ worsening	No progress/ worsening	No progress/ worsening	No progress/ worsening	No progress/ worsening	No progress/ worsening	No progress/ worsening	No progress/ worsening
Low birthweight	No data	Some progress	Some progress	No data	Some progress	Some progress	No data	Some progress
Exclusive breastfeeding	On course	Some	Some	On course	On course	No progress/ worsening	On course	On course
Under-5 stunting	Some progress	Some progress	On course	On course	Some progress	On course	Some progress	Some progress
Under-5 wasting	Some progress	Some progress	No data	No progress/ worsening	No progress/ worsening	No progress/ worsening	Some progress	No progress/ worsening
Under-5 overweight	On course	Off course	On course	On course	On course	Off course	On course	On course
Adult female obesity	Off course	Off course	Off course	Off course	Off course	Off course	Off course	Off course
Adult male obesity	Off course	Off course	Off course	Off course	Off course	Off course	Off course	Off course
Adult female diabetes	Off course	Off course	Off course	Off course	Off course	Off course	Off course	Off course
Adult male diabetes	Off course	Off course	Off course	Off course	Off course	Off course	Off course	Off course

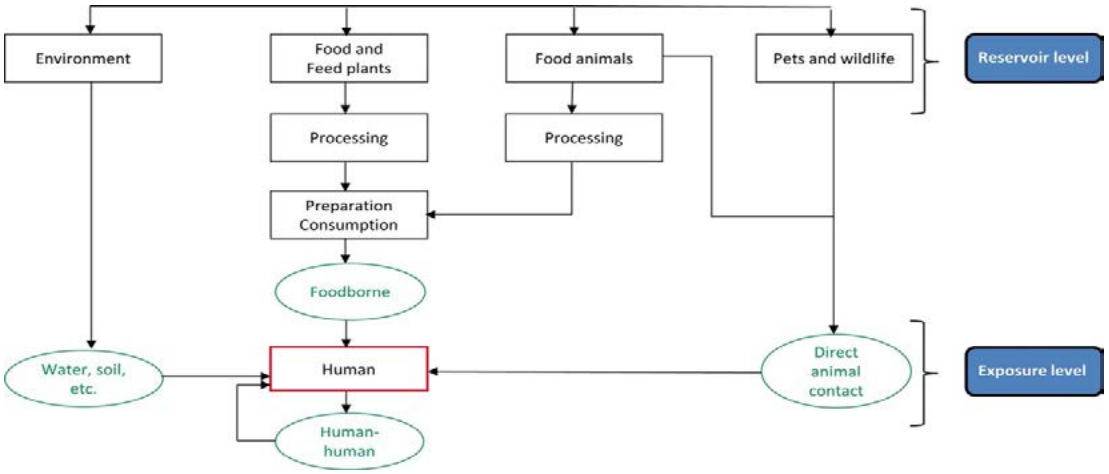
Source: Development Initiatives. 2020. 2020 Global Nutrition Report
Note: Global nutrition targets for 2025 were proposed by the WHO/UNICEF Technical Expert Advisory Group on Nutrition Monitoring.

Table A.2 | EXPOSURE ROUTES INCLUDED IN THE EXPERT ELICITATION

Hazard	Food	Animal contact (domestic or wild)	Human-to-human contact	Water	Soil	Air	Paint	Cookware, pottery, or or glassware	Toys	Other
Campylobacter spp.	x	x	x	x	x	na	na	na	na	x
Non-typhoidal *Salmonella* spp.	x	x	x	x	x	na	na	na	na	x
Shiga toxin-producing *E. coli*	x	x	x	x	x	na	na	na	na	x
Brucella spp.	x	x	na	x	x	na	na	na	na	x
Shigella spp.	x	na	x	x	x	na	na	na	na	x
Enteropathogenic *E. coli*	*x*	*x*	*x*	*x*	*na*	*na*	*na*	*na*	*na*	*x*
Enterotoxigenic *E. coli*	x	x	x	x	na	na	na	na	na	x
Cryptosporidium spp.	x	x	x	x	na	na	na	na	na	x
Giardia spp.	x	x	x	x	na	na	na	na	na	x
Salmonella Typhi	x	na	x	x	na	na	na	na	na	x
Vibrio cholerae	x	na	x	x	na	na	na	na	na	x
Entamoeba histolytica	x	na	x	x	na	na	na	na	na	x
Norovirus	x	na	x	x	na	na	na	na	na	x
Hepatitis A virus	x	na	x	x	na	na	na	na	na	x
Toxoplasma gondii	x	x	na	x	x	na	na	na	na	x
Echinococcus granulosus	x	x	na	x	x	x	na	na	na	x
Echinococcus multilocularis	x	x	na	x	x	x	na	na	na	x
Ascaris spp.	x	x	x	x	x	na	na	na	na	x
Lead	x	na	na	x	x	x	x	x	x	x

Source: Hald et al. (2016)

Figure A.1 | Major transmission routes of human foodborne diseases illustrating two points of attribution: The reservoir level and the exposure level



Source: Hald et al. (2016)

Table A.3 | FAO DEFINITIONS OF EMISSION SOURCES

Emission source	Definition
Rice cultivation	Agricultural practice for growing rice seeds. GHG emissions from rice cultivation consist of methane gas from the anaerobic decomposition of organic matter in paddy fields.
Synthetic fertilizers	Inorganic material of synthetic origin added to soil to supply one or more plant nutrients essential to the growth of plants. GHG emissions from synthetic fertilizers consist of the addition of nitrous oxide gas to managed soils.
Manure left on pasture	Animal waste left on managed soils from grazing livestock. GHG emissions from manure left on pasture consist of nitrous oxide gas.
Enteric fermentation	Digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal. GHG emissions from enteric fermentation consist of methane gas.

Source: FAOStat, http://www.fao.org/faostat/en/#data/GT

Figure A.2 | Global overconsumption and underconsumption of food groups

Source: Graphic conceptualized by Hazel Healy and Christina Hicks for New Internationalist's Food Justice files. Co-published with Information is Beautiful. https://newint.org/features/2021/09/21/where-does-all-food-go-fif

Table A.4 | UNFCCC TIER1–3 (T1–3) USED TO ESTABLISH EMISSION FACTOR

	India (2016)			Nepal (2011)			Pakistan (2015)		
GHG source and sink category	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
A. Enteric fermentation		T1/T2			T1			T1	
B. Manure management		T1	T1		T1	T1		T1	T1
C. Rice cultivation		T2			T1			T1	
D. Agricultural soils			T2						T1
E. Prescribed burning of savanna									
F. Field burning, agricultural residues		T1	T1					T1	T1
G. Other (urea application)				T1					

	Afghanistan (2017)			Bangladesh (2018)			Bhutan (2015)		
GHG source and sink category	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
A. Enteric fermentation		T1/T2			T1/T2			T1	
B. Manure management		T1/T2	T1		T1/T2	T1/T2		T1	T1
C. Rice cultivation		T1			T1/T2			T1	
D. Agricultural soils		T1	T1						
E. Prescribed burning of savanna									
F. Field burning, agricultural residues		T1	T1						
G. Other (urea application)	T1								

	Sri Lanka (2016)		
GHG source and sink category	CO_2	CH_4	N_2O
A. Enteric fermentation		T1	
B. Manure management		T1	T1
C. Rice cultivation		T2	
D. Agricultural soils			T1
E. Prescribed burning of savanna			
F. Field burning, agricultural residues	T1	T1	T1
G. Other (urea application)			

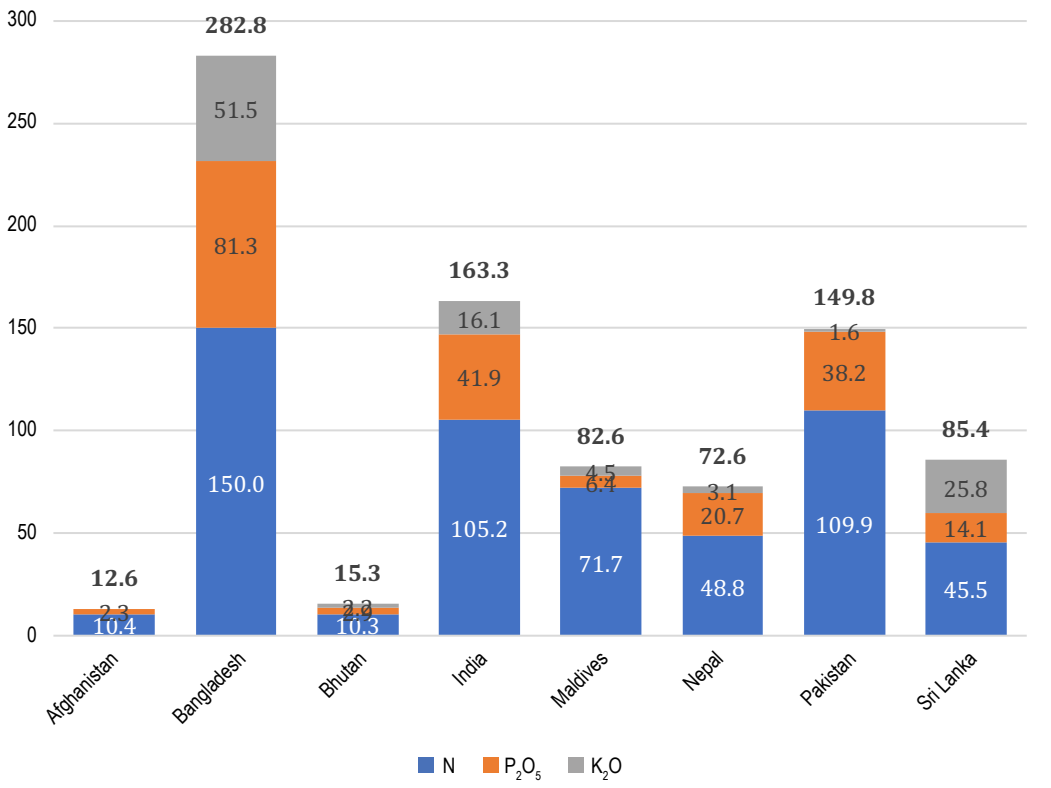
*Source: UNFCCC (2023). National Inventory Report (NIR) of the Islamic Republic of Afghanistan; Third National communication of Bangladesh; Third National Communication to the UNFCCC of Bhutan; India Third Biennial Update Report to the UNFCCC; Nepal Third National Communication to the UNFCCC; Pakistan GHG Second National Communication on Climate Change to the UNFCCC; Sri Lanka's Second National Communication on Climate Change to the UNFCCC; *(YYYY) denotes year in which GHG are calculated, not year of the publication.*

Table A.5 | SHARE OF FARMS GROUPED BY SIZE IN SOUTH ASIA (%)

Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		Sri Lanka	
< 1 ha	25	< 1 ha	84	<1.2 ha	56	< 1 ha	68	< 1 ha	80	< 1 ha	43.5	< 0.1 ha	45
1–5 ha	44	1–3 ha	14	1.2–2 ha	16	1–2 ha	18	1–2 ha	15	1–2 ha	21	0.1–8 ha	54
5+ ha	31	3+ ha	2	> 2 ha	15	2+ ha	14	2+ ha	5	2+ ha	35	>8 ha	0.2

Source: Various sources

Figure A.3 | Fertilizer use in South Asia (kg/ha), 2017–2019



Source: FAOstat

Table A.6 | USE OF NITROGEN FERTILIZER AND CEREAL YIELD IN SOUTH ASIA, 2002, 2017

Country	N_2 fertilizer use (kg/ha), 2002–2017	Cereal Yield (t/ha), 2002–2017
Afghanistan	3.16 ↗ 17.80 (+463%)	1.67 ↗ 2.03 (+21%)
Bangladesh	123.28 ↗ 144.45 (+17%)	3.40 ↗ 4.71 (+39%)
Bhutan	6.02 ↗ 7.50 (+25%)	1.55 ↗ 3.37 (+118%)
India	61.57 ↗ 100.08 (+63%)	2.19 ↗ 3.16 (+45%)
Maldives	0.82 ↗ 50.72 (+6085%)	1.67 ↗ 2.67 (+59%)
Nepal	8.90 ↗ 39.40 (+343%)	2.17 ↗ 2.80 (+29%)
Pakistan	74.80 ↗ 107.71 (+44%)	2.26 ↗ 3.18 (+41%)
Sri Lanka	98.29 ↘ 47.71 (–51%)	3.41 ↘ 3.05 (–11%)
World	56.21 ↗ 69.80 (+24%)	3.10 ↗ 4.12 (+33%)

Data source: Our World in Data

Farmland in Bihar, India.
(Photo by TCI)

Food, Agriculture, and Nutrition in South Asia