Chapter 5
The Critical Role of Smallholders in Ensuring Food Security

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Preamble

There is no consensus or universal definition of the term **smallholder** (Bosc et al. 2013). The term is commonly used to refer to farms less than 2 ha in size.[1] Other authors do not define smallholder farm systems by land area but instead base their definition on other identifiers. Some such identifiers include reliance on family labor, percentage of production consumed on-farm, and quantity of economic output. Smallholder farms can also be distinguished from other farms by the economic size of their farm, a measure derived by scaling farm area by the revenue produced per unit of land, the cost of renting or selling land, or the amount of income derived from an area of land. Economic size can substantially diverge from physical size. We interpret agriculture broadly, to incorporate crops and livestock, but also agroforestry, fisheries, aquaculture, hunting, and resource extraction, which frequently form part of diversified smallholder livelihoods

Much has been written about food security. Several different elements are identified in the most widely accepted definitions (Fig. 5.1).

[1] The term "smallholders" is widely understood to include small farmers who do not own or control the land they farm. In some cases they may have a formal use right. See FAO for a discourse on smallholders and their characteristics. http://www.fao.org/docrep/t0211e/T0211E03.htm

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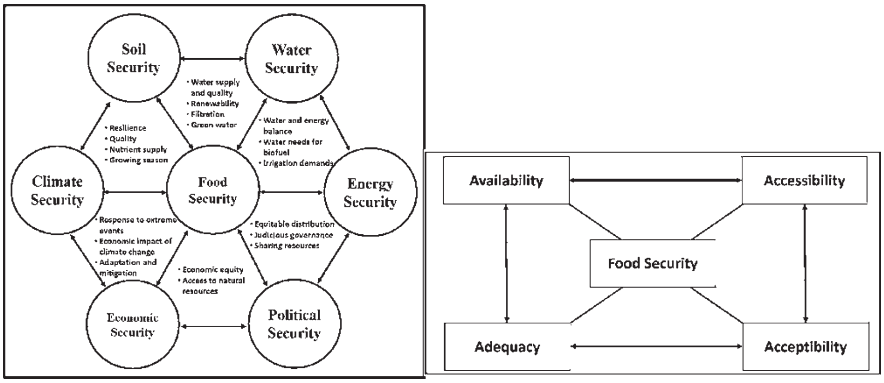


Fig. 5.1 a, b Food security is a multifaceted and multidimensional concept as shown here. Availability Access, Adequacy, Acceptability are key elements in many definitions

But in this chapter we will focus, as our central theme, on basic food security being the "provision of essential food for survival." We are talking about *essential food for a reasonably healthy life*. The defining characteristic of very low food security is that, at times during the year, the food intake of household members is reduced and their normal eating patterns are disrupted because the household lacks money and other resources for food. Food security, following FAO definition and concepts, is achieved when individuals have the food they need to live their lives: it depends on sufficient, adequate food being available; people having access to it; food being well utilized; and on reliable availability and access. Adequate nutrition depends partly on access to food but also on the health environment and level of child care. Undernutrition and "hidden hunger" may well be part of the seasonal variation in food supply and quality. One billion peoples – half of which are small farmers – are hungry. Globally, food security is said to exist for about 4.7 billion persons with another two billion being food insecure in terms of substandard diets and vitamin and micronutrient deficiencies that impair physical and intellectual capacity. Figure 5.2 illustrates the problem using WHO data from Zambia.

To protect the basic nutrition of the most vulnerable and improve food security, social protection and nutrition actions are needed.

If global population stabilizes at around nine billion by 2050 as optimistically predicted, food demands will rise to an equivalent of 12 billion of today's persons due to such factors as affluence-induced food preferences and food wastage in urban supply chains (Braun 2009). And these population projections now look overly optimistic. The vision for food security for all is not achievable from current institutional approaches. No credible prediction of future technologies and policies for food security exists: nevertheless, we may be reasonably sure that a 2050 population of nine billion, mainly in cities, could not be supported from current approaches to food production. With more people now living in cities than rural areas, costs of supplying food (and the extent of food wastage) rise and spawn a new risk, the hungry urban poor. This group can riot and threaten security – hence food security becomes a national security matter (see below). This explains the instructive cases of China and India placing a high priority for food security. Investments such as

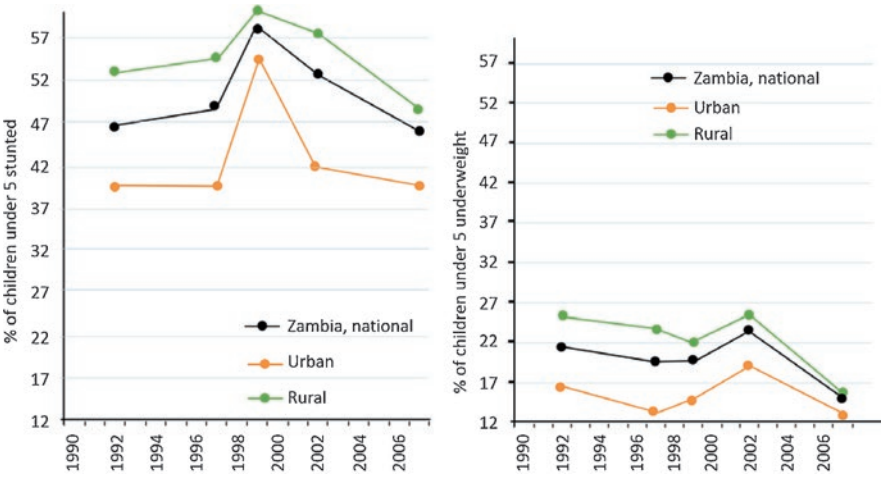


Fig. 5.2 Stunting [A] and underweight[B] children under five, moderate and severe 1992–2012, Zambia. (Source: With data from WHO Global database on Child Growth and Malnutrition)

rural access (infrastructure like roads, railways) and agricultural research have allowed China to feed itself in the face of various predictions to the contrary. Today China is a leader in both farming new and foreign lands (Squires 2018) and in agricultural research, as well as being the world's largest food producer. India has also fed herself but through a different approach based on subsidies of over $25 billion per annum for fertilizer as well as other subsidies for power, water, and food prices and by a priority on domestic stability before export. Both countries intervened in favor of food security by managing emerging risks, such as rising demand for water use efficiency. India's response is through water user's associations, participatory watershed schemes, and community-based rain harvesting, while China relies on incentives for irrigation systems managers. Gulati and Fan (2008) note that both countries accept food self-sufficiency as the key to food security, with liberalized market approaches restricted to surplus-to-security food. Other countries are less organized, and outcomes of this neglect are food shortages in urban areas. The urban poor are no longer just another urban issue but are fast becoming a serious problem.

Social Stability Depends on Food Security

Neglect of a proper food security policy can be a source of civil unrest (Braun 2009). In the past hungry peasants walked in search of food or starved, whereas today hungry urban dwellers readily coalesce into mobs seeking targets on which to vent their anger. Governments' first priority is to forestall such civil unrest. Rising incidence of food protests in more than 60 countries since 2007, of which more than half were violent, seems to follow spiralling grain prices. As the conflict in

Syria has unfolded, experts increasingly point to the nation's drought as a significant underlying factor in the conflict. From 2006 to 2011, severe drought affected over 60% of the land and destroyed the livelihoods of many Syrian farmers. Crop failures of 75–100% were common. By 2010 some one million Syrian farmers were forced into cities already crowded with refugees from Iraq. Observers caution that other nations could experience similar challenges. A study from NASA's Goddard Space Flight Center projected that the Middle East, North Africa, Pakistan, and other desert regions will likely see increased periods without rain as global temperatures increase. As devastating droughts destroy agricultural livelihoods and send farmers fleeing to cities, the world risks repeating crises like that in Syria.

History informs us that most cities arose in fertile valleys and deltas close to their food supplies. Continued expansion of cities has produced the almost unbelievable situation where the area of the combined cities of the world covering the best farmland is the equivalent of half the area of China. Good food policy allows both small and large farmers to innovate. The world needs all the food that it can produce. Added to the increased food demand is that of changing dietary habits. The so-called affluent diets seem to have only minimal effect so far but retain the potential to skew demand as they have done in urban areas of China (Squires et al. 2015). It is projected that at current levels of crop yields, increases in land and water requirements for affluent diets could rise in East Asia by 47–70% and in South Asia by 30–57%. Of course, such additional resources do not exist. That is why increased yields and efficiency in water delivery and on-farm use are imperative. Hence, China's emphasis on food grain production in the face of other market demands, and its apparent willingness to move toward treating non-essential foods under an open policy trade.

More critical to food security, since it is affected by both climate and urban competition, is water. Grain is produced under mainly rainfed conditions, as in the five major global exporters. But the success of Asia to feed itself and export surplus relies on irrigation. This means that the largest food production area in the world is faced with increased competition for water from the most populous cities of the world. Quarantining water for food production will require strong governance. Such variables as these have never before been faced simultaneously. It is one thing to say that "the challenge is great," but that tends to lead to more of the same interventions as in the past.

Now that food security has become a primary focus for many governments of food-marginal countries, multiple strategies will become essential, including food reserves. As Falvey (2010) reminds us, food reserves around the world have been allowed to decline over recent decades. This has been done in a managed way in China as a cost-saving measure. At the same time, China has increased yields, production, and cultivated area by huge research investments and political might and investment. Smaller nations cannot do this, and neither do they have China's diversity of environments. Hence they will need to consider reestablishing and maintaining reserves. It must be remembered that in many Asian, African, and Latin American countries the vast majority of food is consumed in its country of production. Figure 5.3 shows the ratio of rice produced and proportion for local consumption as well as the level of self-sufficiency. It is significant that many of ASEAN countries depend on smallholders to produce food for their populous and for export.

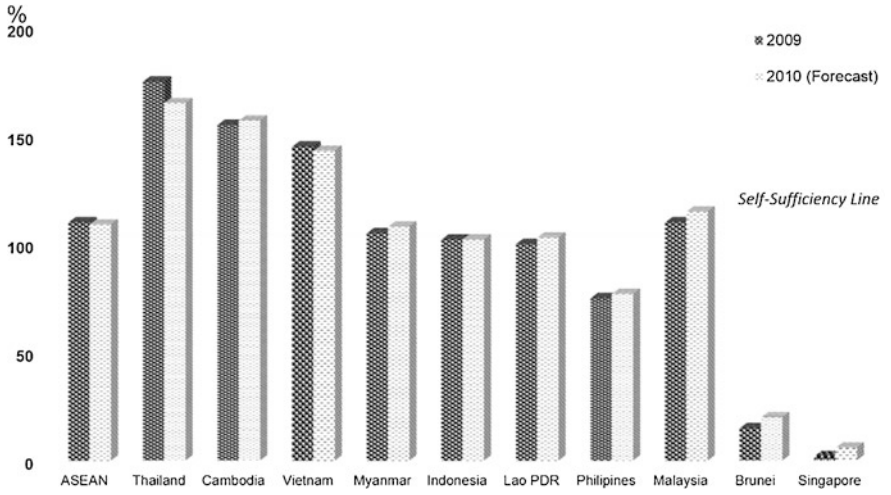


Fig. 5.3 Ratio of rice produced to local consumption in selected ASEAN countries

Smallholders Play a Vital Role in Ensuring the Basic Level of Food Security

In reality smallholders, especially small farmers, feed the world. IFAD and FAO put the number of small farmers at about 530 million (85% of all farms across the world). These are supported by two billion persons – about one third of the world's population – most whom are feeding themselves, some of them produce a surplus (Samberg et al. 2016). Smallholder farmers are also estimated to represent half of the hungry worldwide and probably three-quarters of the hungry in Africa (Sanchez and Swaminathan 2005). Consequently, the fate of smallholder farmers will largely determine whether or not the world succeeds in reducing poverty and hunger worldwide and meeting the Millennium Development Goals. Of the world's 530 million farms, FAO records 85% as less than 2 hectares (ha), 12% between 2 and 10 ha, 2.7% between 10 and 100 ha, and only 0.6% of more than 100 ha (Samberg et al. 2016). The small farm sector of poor countries involves some two billion people – it feeds them and provides surplus for non-producers in towns and cities. Most small farmers live in poor countries (where most of the world's population live anyway). Smallholders have a significant role to play in the world food production system and in the overall economy (Fig. 5.4).

India and China with their huge and diverse populations have large numbers of smallholders. Some live in the drier agropastoral zones and even in the deserts; but most are tilling pocket handkerchief-sized farms and feeding their families. Some are landless (see below). The average farm size in most poor countries continues to decline (Figs. 5.5 and 5.6).

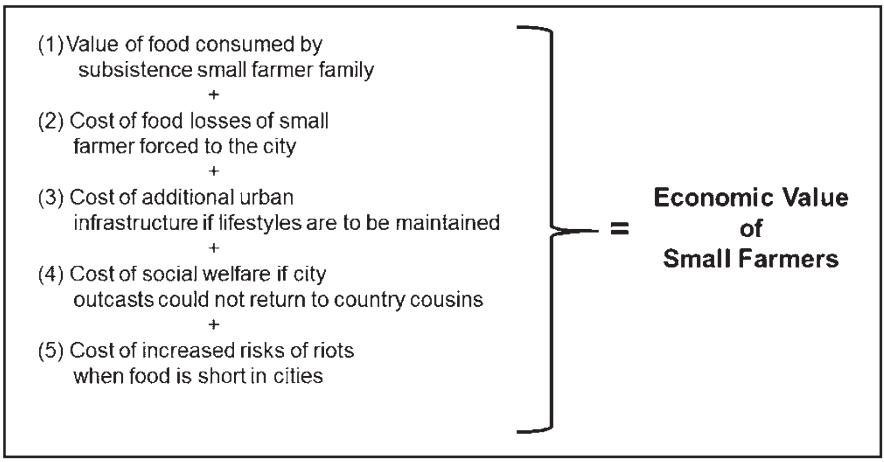


Fig. 5.4 The economic value of smallholders must take into account five distinct roles

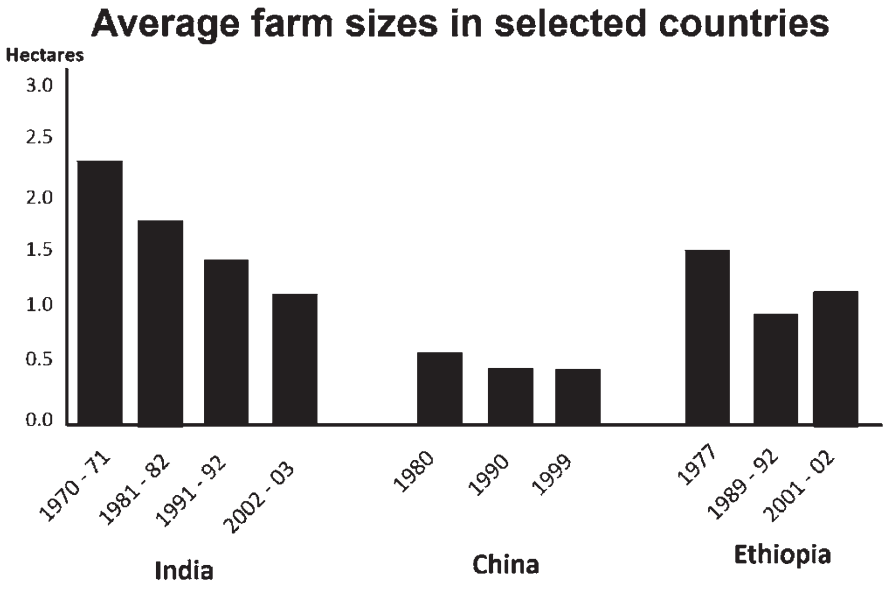


Fig. 5.5 Average farm size has fallen dramatically in India and Ethiopia, largely in response to population pressure. China started off from a low base and is constrained in further subdivision. Part of the decline is attributed to land lost by urbanization and infrastructure development

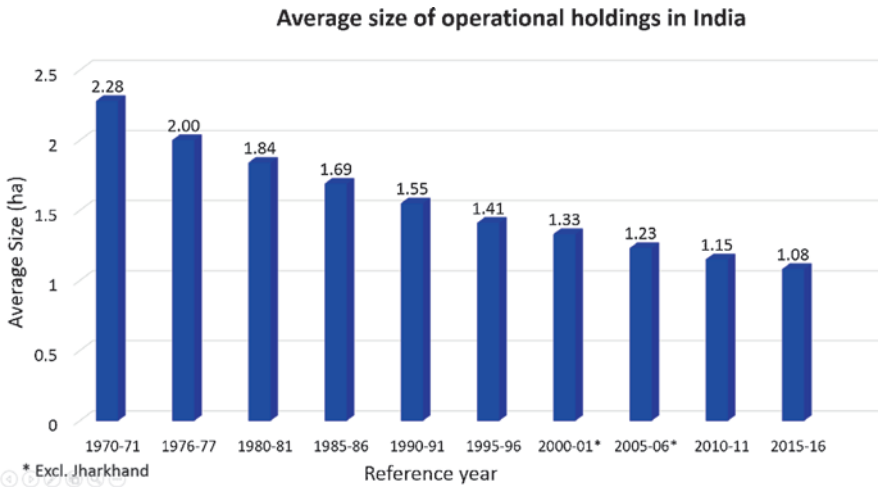


Fig. 5.6 Trends in farm size per household in India since the census of 1970–1971

China has the remarkable distinction of feeding its huge population from the smallest area of arable land per capita in the world. Farm size in China was trending downward, but of late there has been policy reform away from small individual plots under the household contract responsibility system[2] introduced in the 1980s. Land consolidation, usually as result of the pooling of land and water resources within farmer cooperatives, has seen a statistically significant rise in the reported farm size. In India, for example, farm size has fallen from 1.41 ha to 1.08 ha in the past 20 years (Fig. 5.4). As much as 67% of India's farmland is held by the marginal farmers with holdings below 1 hectare. The average size of the holding has been estimated as 1.15 hectare. The average size of these holdings has shown a steady declining trend over various agriculture censuses since 1970–1971.

A similar trend in reduced size of farms has occurred in Ethiopia. Few countries in the world are more synonymous with starvation and famine than Ethiopia. The Ethiopian highlands are highly agrarian and densely populated relative to its fragile natural resource base. Farm sizes are generally very small in the Ethiopian highlands (Fig. 5.6) and declining over time (Headey et al. 2014). The average farm size varies with the agroecological region. For example, the average is 0.49 ha in the Southern Nations, Nationalities, and Peoples' (SNNP) Region where the percentage of farmers with less than 0.5 ha is highest (61.7%) to Oromia and Tigray where farm size is near 1 ha and the percentage of farms with less than 0.5 ha is less than 30%.

[2] HCRS Since the mid-1980s under this policy, all livestock and rangeland resources (except the land itself) that originally belonged to the State and were used communally in collectives were distributed to each householder according to family size, at that time. There was a contract between the government and the householder to produce a quota of produce. Surplus, above the quota, would accrue to the householder. It provided incentive to produce, whereas before there was none.

Fig. 5.7 Frequency distribution of average area of cultivated land per holder in the Ethiopian highlands. More than 57% of holders have <0.5 ha. (Source: Headey Dereje and Taffesse, 2014)

Nationally, average farm sizes declined from an estimated 1.4 ha per holding in the 1977 agricultural census to just below 1.0 ha in recent times. Farmers below the age of 38 have farm sizes that are almost 0.2 ha smaller than farmers aged 50 years and about 0.3 hectare smaller than those aged 60 years. Young rural households face particularly severe land constraints (Fig. 5.7).

India has many people, little arable land, and burgeoning populations, so a brief analysis of what the situation is in India could be very instructive. India has made great strides since independence, but there are a few major reasons which still keep it among the league of developing nation. These are teeming population, over-dependency of rural population (about 70%) on agriculture, fragmentation of land holdings, decreasing growth in agricultural production due to depleting natural resources (particularly land productivity and water resources), and weak implementation of various developmental programs aimed to promote sustainable development. Food security is the major issue among all these problems, as it impedes the development of the people as well as the country.

Problems of Food Production

Small and fragmented land holdings, land degradation (due to soil and water erosion) resulting in depletion of land productivity, improper use of water resources, old-fashioned agricultural production technologies, and absence of required infrastructure for postharvest management and marketing of agriculture produce are responsible for lower yield and income of farmers.

The Indian Green Revolution worked very well particularly in Punjab, Haryana, and parts of Uttar Pradesh and parts of Rajasthan, where lands were well developed and fertile, water for irrigation was readily available, and farmers were keen to increase their farm productivity and income. Generous support was extended by the government to develop the necessary infrastructure for individual farmers as well as for building common infrastructural facilities. As a result, the area under crop production increased from 115.58 Mha in 1960 to 127.84 Mha in 1990. It generated employment for everyone, i.e., landholders as well as landless, while ensuring food security for the country. The positive impacts of Green Revolution continued for over 30 years till the 1990s. However in 1990s, the growth in the agricultural sector started facing stagnation.

Growth in Food Grain Production in India

India's food grain production increased five times over six decades, according to 2016 government data. But with the average Indian farm now half as large as it used to be 50 years ago and yields among the lowest in developing economies, both the agriculture sector and farmers have been driven to the brink. Output of food grains in India (Table 5.1) increased from 50.82 million tonnes in 1950–1951 to 252.22 mil-

Table 5.1 Growth in food grain production in India

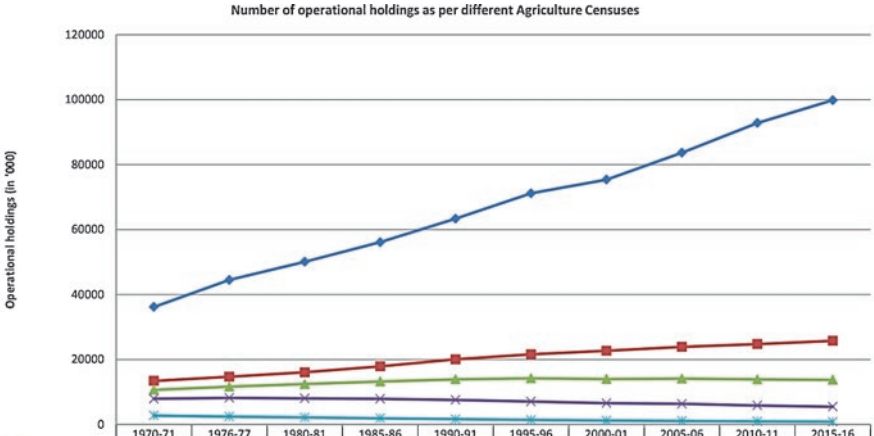
	Food crop production (million tons)				
Year	Rice	Wheat	Coarse cereals	Pulses	Total food grains
1950–1951	20.58	6.46	15.38	8.41	50.82
1960–1961	34.58	11	23.74	12.7	82.02
1970–1971	42.22	23.83	30.55	11.82	108.43
1980–1981	53.63	36.31	29.02	10.63	129.59
1990–1991	74.29	55.14	32.7	14.26	176.39
2000–2001	84.98	69.68	31.08	11.07	196.81
2002–2003	71.82	65.76	26.07	11.13	174.77
2003–2004	88.53	72.15	37.60	14.91	213.19
2004–2005	83.13	68.64	33.46	13.13	198.36
2005–2006	91.79	69.35	34.06	13.39	208.60
2006–2007	93.35	75.81	33.92	14.20	217.28
2007–2008	96.69	78.57	40.76	14.76	230.78
2008–2009	99.18	80.68	40.03	14.57	234.47
2009–2010	89.09	80.80	33.55	14.66	218.11
2010–2011	95.98	86.87	43.68	18.24	244.78
2011–2012	105.30	94.88	42.01	17.09	259.29
2012–2013	105.24	93.51	40.04	18.34	257.13
2013–2014	106.65	95.85	43.29	19.25	265.04
2014–2015	105.48	86.53	42.86	17.15	252.02
2015–2016	104.32	93.50	37.94	16.47	252.22

Source: Directorate of Economics & Statistics, DAC&FW, Government of India

lion tonnes in 2015–2016 (*Agriculture Statistics at a Glance, Government of India, 2016).* Also yield increased from 522 kg per hectare (ha) in 1950–1951 to 2056 kg ha^{-1} in 2015–2016. The increase during the first 30 years of the Green Revolution was mainly due to increase in the area under crop production and introduction of improved varieties with recommended cultivation practices. The increase in food production during 1990–2010 can be attributed to improved efficiency and increased use of agri-inputs (particularly insecticides and other pesticides) which also increased the cost of production.

The reason for the low yield is excessive dependence – 52% of India's farmland is not irrigated – on the erratic, uneven, and unpredictable monsoons. The dominance of small and marginal holdings makes this situation highly volatile even more troublesome, as small and marginal farmers are highly vulnerable to adverse climatic conditions. Small and marginal farmers cannot afford to adopt modern techniques of irrigation and production. They also find it hard to use modern machinery on smaller plots. They are stressed and burdened by indebtedness due to successive crop failures and low yields. The impact of these multiple problems is that the agriculture sector's share in India's economy is declining. It contributed 17.5% to the country's gross value added (current price 2011–2012 series) in 2015–2016, down from 18.2% in 2012–2013, 18.6% in 2013–2014, and 18% in 2014–2015. This is expected to decline further (Fig. 5.8).

About 67% of agricultural land in India is held by marginal farmers with farm size less than 1 hectare, while farmers with large holdings (having more than 10 hectares) constitute less than 1%. The area of their holdings that is operated by marginal farmers is low compared to their holdings, but large farm holders get access to a land area



	1970-71	1976-77	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2010-11	2015-16
Marginal	36200	44523	50122	56147	63389	71179	75408	83694	92826	99858
Small	13432	14728	16072	17922	20092	21643	22695	23930	24779	25777
Semi-Medium	10681	11666	12455	13252	13923	14261	14021	14127	13896	13776
Medium	7932	8212	8068	7916	7580	7092	6577	6375	5875	5485
Large	2766	2440	2166	1918	1654	1404	1230	1096	973	831

Fig. 5.8 Farm size is changing and the area classified as marginal is increasing. (Source: Agriculture Census 2015–2016, DAC&FW, Government of India)

that is ten times their holdings, indicating the stress marginal farmers face in the country. The average size of the Indian farmland has shrank by over 6% between 2010–2011 and 2015–2016, with operational holding in the country dropping to 1.08 hectares from 1.15 hectares in 2010–2011. With land holding getting smaller, the share of small and marginal holdings in the country (between 0 and 2 hectares) has risen to 86.21% of total operational holding in 2015–2016, which comes to around 126 million, as against 84.97% in 2010–2011. On the other hand, the share of semi-medium and medium operational holdings (2–10 hectares) in total land holdings dropped from 14.29% to 13.22%, while that of large holding (10 hectares and above) fell from 0.71% in 2010–2011 to 0.57% in 2015–2016. This also means the number of small holdings in the country has grown in 5 years, due to fragmentation of land, while that of medium and large holdings have gone down. Total operated area, which includes both cultivated and uncultivated, provided part of it is put to farm use, fell from 159.59 Mha in 2010–2011 to 157.14 Mha in 2015–2016.

The highest number of operational holders belonged to UP – out of the 146 million, around 23.82 million was in UP, followed by Bihar (16.41 million), Maharashtra, Madhya Pradesh, and Karnataka.

Marginal Farmers Most Indebted

About 52% of India's agricultural households are indebted, with an average outstanding loan of Rs 47,000, according to Agricultural Statistics 2016 based on the National Sample Survey Office – Assessment Survey of Agricultural Households (Jan–Dec 2013). The indebtedness varies across states, from 93% in Andhra Pradesh to 2.4% in Meghalaya. Agricultural households with marginal holdings are the most indebted (64%) compared to just 0.6% of households holding large farms. Nearly 70% of India's 90 million agricultural households spend more than they earn on average each month, pushing them toward debt; it was reported in mid-2017 (Mallapur 2017).

About 62.6 million households spending more than they earn had land holdings of 1 hectare or less. In contrast, 0.39% households owning more than 10 hectares of land had an average monthly income of Rs 41,338 and consumption expenditure of Rs 14,447, thereby maintaining a monthly surplus of Rs 26,941 (Fig. 5.9).

Impact of Slow Growth in Agricultural Production

Reduction in the rate of growth in food production has several adverse effects on the farmers, particularly the poor. The per capita availability of food grains has declined after 1990 (Table 5.2). While the availability of rice and wheat marginally declined, there was a drastic reduction in the availability of coarse cereals and pulses. This had a direct impact on the supply of protein and minerals, which accelerated the incidences of malnutrition particularly among pregnant women and children.

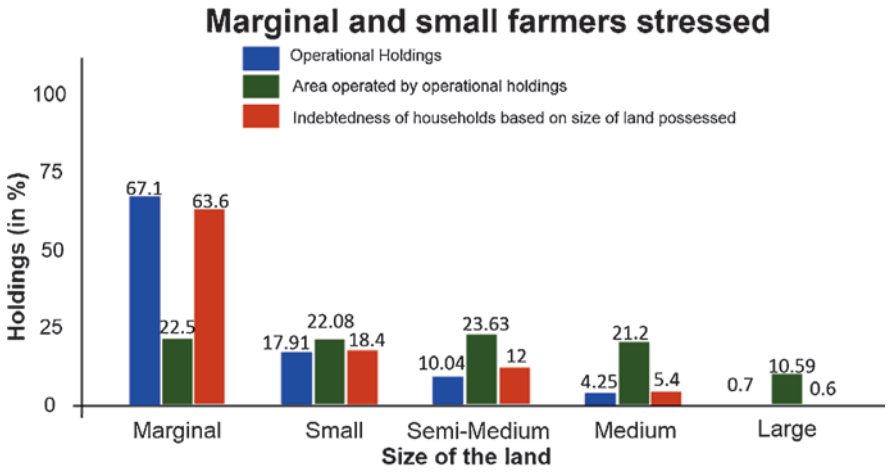


Fig. 5.9 Land fragmentation is a factor in the increasing number of marginal holdings. (Source:Agriculture Census 2010–2011)

Table 5.2 Per capita availability of food grains in India (Kg per capita per year)

Year	Rice	Wheat	Other cereals	Pulses	Food grains
1951	58.0	24.0	40.0	22.1	144.1
1961	73.4	28.9	43.6	25.2	171.1
1971	70.3	37.8	44.3	18.7	171.1
1981	72.2	47.3	32.8	13.7	166.0
1991	80.9	60.0	29.2	15.2	186.2
2001	69.5	49.6	20.5	10.9	151.9
2002	83.5	60.8	23.1	12.9	180.4
2003	66.2	65.8	17.1	10.6	159.7
2004	71.3	59.2	25.3	13.1	159.9
2005	64.7	56.3	21.7	11.5	154.2
2006	72.3	56.3	22.1	11.8	162.5
2007	71.8	57.0	20.8	10.7	160.4
2010	64.0	53.0	19.7	15.3	159.2
2011	66.3	59.7	23.9	15.7	170.9
2012	69.4	57.8	21.9	15.2	169.3
2013	72.1	66.8	19.2	15.8	179.5
2014	72.3	66.8	22.8	16.9	178.6
2015	67.9	61.3	28.4	16.0	169.8
2016	67.2	72.9	26.1	15.9	177.9
2017	69.3	70.1	30.0	19.9	184.7

Source: https://eands.dacnet.nic.in/PDF/PerCapita-FoodGrains.pdf

Stagnation in agricultural production has also been suppressing the employment opportunities in this sector. As a result, contribution of agriculture to the national GDP has come down drastically from 58% in 1951 to 35% in 1991 and to 17% in 2009. However, the population dependent on agriculture in the country reduced marginally from 70% in 1951 to 60% in 2009. This has been affecting the income of the rural families and their capacity to purchase food. Thus, the per capita food consumption in rural India has been decreasing significantly over the last 25 years and threatening food security. Landless, small, and marginal groups are facing vulnerability.

Small Farms Are Very Efficient

Despite their small size (maybe partly because of it), efficiency levels are high. Worldwide, and especially in the developing world, the production of food has increased ahead of population growth for most of the last 50 years. Much of this increase in availability has come from small-scale family farms, particularly in Asia. Taking Asia as an example, we can see that 90% of the rice, 40% of other cereal grains, and 40% of the meat is produced there – most of it by smallholders. Smallholders in Africa, Asia, and Latin America focus on real food security for survival. Smallholders play a critical role in such food security in the poor world. They feed themselves and their families and in some cases sell their surplus to feed rural towns and even peri-urban markets.

The report of Lerman and Sedick (2011) for FAO *Policy studies on rural transition 2003-9 in Central Asian agriculture* demonstrates higher productivity of small farms, especially household plots. Falvey (2010) notes that "the Asian smallholder has consistently fed Asia, generated exports and accepted technological innovations while feeding himself and enjoying less social protection (price support/subsidies) than his compatriots." This is quite a compliment! And they are very efficient. Small farmer yields under these intensive conditions are often higher than under the extensive broad acre systems common in rich countries. The advantages of small farms over larger ones (Table 5.3) is well documented (Braun 2009). Smallholder production offers specific skills that may not be accessible in broad acre agriculture, such as

Table 5.3 Some comparisons related to transaction costs of small and large farms*. (Modified from Global Donor Platform for Rural Development, https:/www.donorplatform.org/)

Small farms	Large farms
– Close supervision of farm household labor – Detailed farm knowledge down to small areas, plants, and animals – Feeding the family on fresh produce direct from the farm – Empathy with livestock and high levels of animal welfare	– Sourcing and managing skilled labor – Access to technologies and markets – Deals on inputs, credit, contracted and bulk sales, government favors – More secure tenure over land – Possible quality assurance (QA) of produce across the supply train

preprocessing on the farm, orientation to specific markets including organic produce, and maintaining competitive cost structures. A review by the Australian Centre for International Agricultural Research (ACIAR) presents some instances in which smallholder initiatives produced higher returns than alternatives such as:

- The shift from plantation tea to small farm tea production in Sri Lanka
- Sulawesi cocoa growers who receive an unprecedentedly high 80% of the world price at their farm gate from an industry started by their own initiative
- Vietnam cassava growers who have graduated from being price-takers for bulk carbohydrate raw material by seeking new varieties to service 60 new local starch factories and are now considering expansion to produce biofuel that does not conflict with food production

These examples relate to cash crops, but the same applies to home food production. Table 5.3 shows that there are different transaction cost advantages that apply to small and large farms.

Small farms are vibrant interactions between diverse plants and animals, including the farmer and his family. It is easy to elicit the virtues of small farms in comparison to broad acre farms, but this pits broad acre farms against small farms when the world is not only big enough for both but urgently needs both. It needs to accommodate each in its own niche in social, humanitarian, environmental, and commercial terms. All sizes of farms and variations on labor use are necessary to meet the total food requirements of the world. But it is the neglected small farms that benefit more people. As we have said before, smallholders feed half of the world's population. As suggested by Wiggins and Keats (2013), smallholder agriculture can potentially affect food security and nutrition through the following pathways:

1. Making food available through production.
2. Reducing the real cost of food, by increasing the supply of food. The composition of production also matters, since this affects the availability and prices of different foods with their varying nutrients.
3. Generating incomes for farmers and, for those working the land as laborers, gives access to food and, through this, employment opportunity.
4. Providing incomes to others in the rural economy from linkages in production and consumption that create additional activity and jobs.

Box 5.1 Existing Technologies Are a Starting Point for Adaptation to Climate Variability

Many technologies already exist that could facilitate adaptation by smallholder farmers when customized for local conditions and made available and affordable. Examples include the following: Change varieties or species of crops, or rear different breeds or species of livestock (or fish in aquaculture), including neglected crops and breeds. Varieties or breeds with different environmental optima may need to be adopted or those with broader environmental

(continued)

Box 5.1 (continued)
tolerances. Increase diversification of crops to hedge against risk of individual crop failure. Make use of integrated systems involving livestock and/or aquaculture to improve resilience. *ƒ* Change planting dates for food crops, feeds, and forage. *ƒ* Change irrigation practices to reduce water use. Make more use of rainwater harvesting. In some areas, increased precipitation may allow rainfed agriculture in places where previously it was not possible. *ƒ* Use reduced tillage to lessen water loss. *ƒ* Incorporate manures and compost. *ƒ* Plant cover crops to increase soil organic matter and improve water retention. *ƒ* Alter animal diets and stocking rates. Prepare for increased frequency of extreme events, including putting in place water conservation measures in times of drought, increasing soil organic matter to help store water after storms, and improving drainage and farm design to avoid soil loss and gullying. Farms in coastal areas may need to adapt to increased frequency of saltwater intrusions and those in dryer areas to more frequent wildfires. *ƒ* Adopt integrated management strategies as pest, weed, and diseases respond to climate change. Recognize that the natural regulation of potential pests by their natural enemies may be disrupted by a changing climate. *ƒ* Engage with other food producers to share best practice and experience so as to enhance community-based adaptation. *ƒ* Recognize that where wild plants and animals supplement diets, climate change will alter their availability in ways difficult to predict. Farmers with larger holdings tend to be more mechanized, use more tillage, and rely predominantly on cultivation of single crops. For climate resilience they should explore low- and no-till options; improve management of the resources applied, including nutrients and water, to support soil health; diversify crop production; and rotate crops.

Source: HLPE 2012.

Box 5.2 Reducing Postharvest Losses Can Help Combat Food and Nutrition Insecurity in the Face of Climate Change
In the developing world, on-farm, postharvest food loss is substantial. Sources of loss include harvesting methods, handling techniques, type or availability of storage, and contamination from pests and pathogens. Climate change could increase the losses. Many new programs to reduce postharvest losses are under way. Two are highlighted here.

Burkino Faso
In Burkino Faso, USAID and Catholic Relief services supported the development and distribution of tripled-lined storage bags that are airtight, warding off pests and eliminating the need for chemicals to protect the contents. These bags increase storage life, improve food quality and safety, and allow farmers to sell produce when prices are higher.

(continued)

Box 5.2 (continued)
Nigeria
Postharvest loss is also being combated in Nigeria where smallholder cassava growers struggle to process cassava roots quickly before they deteriorate. USAID, the International Institute of Tropical Agriculture, and the Shell Petroleum Development company created the Cassava Enterprise Development project, which provides smallholder farmers with tools such as industrial root washers, peelers, and graters to facilitate postharvest processing.

Source: The World Bank 2013; USAID 2013; Integrated Cassava Project 2014.

Barriers and Limits to Adaptation for Smallholders

The impacts of climate change are experienced locally, and therefore, geographic variability in climate impacts emphasizes the need for "place-based" approaches to climate vulnerability analysis and adaption. The term "place-based" refers to a spatially distinct group of biophysical and social conditions, which can, in principle, occur at any scale but tend to focus at local scales where local drivers manifest themselves in particular ways.

Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting non-climatic changes. Closely related to the need of adaptation is the concept of vulnerability. This is the case, because factors like adaptive capacity or sensitivity have effects on vulnerability and adaptation mainly seeks to reduce vulnerability. Adaptation and adaptive capacity have the potential to reduce vulnerability.

Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities. Generally defined, barriers to adaptation are challenges, obstacles, constraints, or hurdles that impede adaptation. Barriers are defined here as obstacles that can be overcome with concerted effort, creative management, change of thinking, prioritization, and related shifts in resources, land uses, institutions, etc. Only a small subset of all suggested adaptation measures will be implemented due to technical and physical limits as well as to differences in objectives.

Vulnerability of Smallholders to Global (Including Climate) Change

Across the world, smallholder farmers already face numerous risks to agricultural production. But despite their direct contribution to food production, small-scale farmers and their households are disproportionately vulnerable to hunger and to

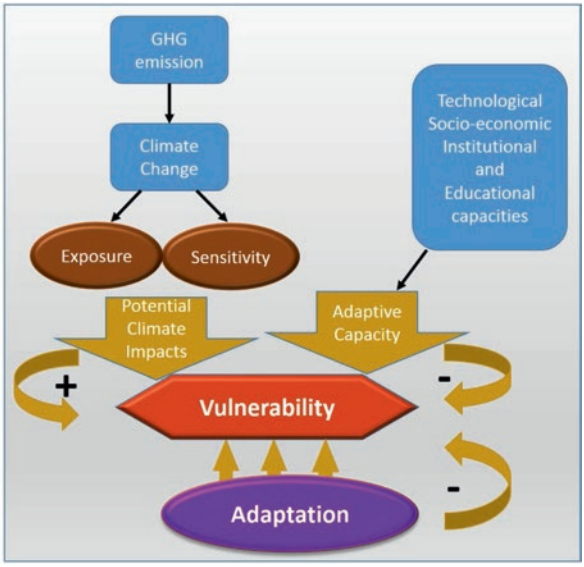


Fig. 5.10 Climate change influences both exposure and sensitivity and therefore creates potential climate impacts, which in turn increase vulnerability. Adaptation and adaptive capacity have the potential to reduce vulnerability

malnutrition. Interventions to promote smallholder well-being should be developed to recognize smallholders as a dynamic group with potential future livelihoods on their own farms, in other rural sectors, and in cities near and far (see Fig. 5.10).

Climate Change Poses Risks to Global Food Security

Climate change will further increase food- and agriculture-related conflicts. The impacts of climate change include increased water and heat stress, damaged ecosystems, and rising sea levels. The actual effects are heterogeneous and region specific. Yet, in most cases, the harmful effects outweigh the benefits and disproportionately hurt the poorest, who have the least capacity for adaptation. By the 2050s, for example, there will be twice as many areas with increasing water stress due to climate change than there will be areas with decreasing water stress. In addition, heat stress may reduce grain yields in Asia by 15–20% by 2050. And the effects of climate change are expected to further increase the number of undernourished people in sub-Saharan Africa. All of these impacts are likely to increase food- and agriculture-related conflicts as well.

Climate change is expected to disproportionately affect smallholder farmers and make their livelihoods even more precarious. Many smallholders are vulnerable to climate change in ways that other farmers are not. The production risks posed by climate shocks may interact with other stressors, including infectious diseases, nutritional deficiencies, natural resource degradation, and insecure land tenure to compound risks to smallholder livelihoods. Hundreds of millions of the world's

poorest people directly depend on smallholder farming systems. These people now face a changing climate and associated societal responses. Smallholder farming systems will become a critical fulcrum between climate change and sustainable development (Cohn et al. 2017). Because smallholder farmers typically depend directly on agriculture for their livelihoods and have limited resources and capacity to cope with shocks, any reductions to agricultural productivity can have significant impacts on their food security, nutrition, income, and well-being.

Farmers are particularly vulnerable to any shocks to their agricultural system owing to their high dependence on agriculture for their livelihoods, chronic food insecurity, physical isolation, and lack of access to formal socioeconomic safety nets. Farmers are frequently exposed to pest and disease outbreaks and extreme weather events (particularly cyclones), which cause significant crop and income losses and exacerbate food insecurity.

As Falvey (2010) points out, if sea levels rise by 300 mm as the majority of the models predict, the fertile river deltas of Asia and Africa will be at risk, of increased saltwater intrusion (as is already happening in the Nile Delta), river siltation, and course change, flooding, and damage from more frequent and severe storms, tidal surges, etc. Loss of lives and property, that is, small holder's lives and farms will be lost to climate change. This is serious for two reasons: first, much of the world's food comes from such low lying deltas, and second, broad acre farming has already significantly displaced smallholders on many non-delta lands leaving delta farmers as a last and now vulnerable repository of advanced small farming innovation. If sea levels rose by 1 meter – the worst case scenario – it has been calculated that this would displace some six million people from 13% of arable land in Egypt, some 13 million producing 16% of rice in Bangladesh, and some 72 million from unspecified large areas of China. These deltas are very expensive to protect, but the value to the many societies is significant.

According to Falvey (2010), the practical response is to use realistic predictions in survival food security policies as a guide for major technology development oriented to smallholders in deltas. Such technology would build on the past innovations of the farmers themselves. For example, smallholders have evolved tide-driven irrigation schemes in the Mekong Delta, acid sulfate soil flushing technologies in the serai of Vietnam, natural soil renewal management systems in the Nile Delta, and highly integrated ecosystem agriculture in the Chinese river deltas. Retention of this knowledge, coupled with means of continuing to use what has been the world's most productive agricultural land, is the task of policy and research. Policies that promote low-input sustainable agriculture should be favored. Any analysis of the cost-effectiveness of traditional delta user agriculture would favor continued investment in delta regions using the smallholder model. Smallholder's attention to individual plants and animals, intensive pest, and nutrient management maximizes use of such valuable land. By contrast, simplistic engineering solutions for large cities such as piping sewage far away from productive agricultural areas reduces food production. Yet major cities arose from deltas with harvested nutrients returned to agriculture. Technologies for healthily recycling solids and wastewater allow a

return to seminatural processes. Once again, China reminds us that millions of tons of pig and human waste used on small farms reduces the need for chemical fertilizers and enhances food crop production. The general approach of nutrient tracking and recycling can be applied to all food production systems.

A different kind of risk to survival food security is the genetic erosion that is hidden in homogenized agriculture and the narrowing of the genetic base of food plants and the loss of indigenous breeds of livestock, especially poultry. Erosion of genetic diversity in agriculture is a problem. It is only recently that fields restricted to single species and varieties have become common. The introduction of modern varieties and breeds has almost always displaced traditional varieties and breeds. The twentieth century saw the loss of some 75% of the genetic diversity of agricultural crops. Only about 150 plants species are now cultivated, of which just three supply almost 60% of calories derived from plants. Such erosion of genetic diversity in agriculture represents a major threat to the food security of the majority of the region's producers. Modern, uniform crop varieties will only reach their potential if the environment is also uniform, which means high-quality land where the fertility and water status have been evened out with the use of fertilizers and irrigation. In areas where mono-cropping is prevalent, diseases and pests can spread quickly and cause devastation. While improved methods of controlling animal and crop diseases are now available, the costs of these services have become increasingly prohibitive for the farmer. This narrowing is making vast areas of agricultural land vulnerable to specific diseases or pests. Thankfully smallholders choose varieties, genotypes that differ from the mainstream for such reasons as flavor, ease of intensive crop management, or just availability of seed or other necessities. Family poultry (village chickens) are case in point (Wong et al. 2019).

Farmers of traditional and low-input agricultural systems have long favored crop diversity. Even today, there are still a huge variety of crop combinations cultivated, including cereals, legumes, root crops, vegetables, and tree crops. Cereals may be intercropped, producing, in some cases, highly complex patterns, with up to ten species grown in close proximity. In very variable conditions, farmers rarely standardize their practices. They maintain diversity, develop a variety of strategies, and so spread risk. Mixtures of crop and varieties clearly provide farmers with a range of outputs and also represent a logical approach to coping with variable environments. Mixed crops can also be less variable in time and space, and combined yields are often greater, particularly if differences in root and shoot geometry allow the crops to use light, nutrients, and water more efficiently Intercropping can reduce weed problems, so influence labor requirements, returns to labor can be increased, and erosion and runoff may be reduced because of the greater ground cover given by the mixture. Crop genetic diversity provides security for farmers against pests, disease, and unexpected climatic conditions. In the highly variable environments of Asia, Africa, and Latin America, crop genetic diversity can help small-scale farmers obtain higher yields than they could with monocropping. Higher yields are obtained from a mixture of crops and crop varieties, each one specifically adapted to the microenvironment in which it grows. Genetic diversity also provides farming communities with a range of products with multiple uses and

value. Some varieties of a particular crop may be good for immediate consumption, for example, while others are better for long-term storage.

The mixed farm of the smallholder can be an almost closed system, making little impact on the outside world: crop residues are fed to livestock or incorporated in the soil; manure is returned to the land in amounts that can be absorbed and used; legumes fix nitrogen; trees and hedges bind the soil and provide valuable fodder and fuel wood and habitats for predators of pests. The components of the farm are thus complementary in their functions, with little distinction between products and by-products. Both flow from one component to another, only passing off the farm when the household decides they should be marketed. It is also important to keep in mind that, in some circumstances, modern agriculture undermines food security and health by putting the rural poor at a disadvantage, threatening their land tenure, and degrading basic resource such as water and soil.

Small Farms with Irrigation – A Miraculous Combination

The most productive lands outside small farms in deltas are small farms with irrigation. The volume of food produced in poor countries is miraculous. From regions destined for mass starvation, huge increases in population have been exceeded by greater increases in food production. Today the two most populous countries in the world are food exporters. Smallholder initiative has filled the gap. For an example that relates to irrigation in Asia where 70% of the world's 277 Mha or irrigated land covers 34% of Asia's arable land, that produces 60% of its food grains, mostly from small farms. Smallholders have found ways of complementing or even bypassing state-built irrigation schemes. They have done this, for example, by innovatively pumping from aquifers and rivers and building on-farm storages. Such measures supply a significant amount of irrigation water for small farms across large areas of South, East, Central, and Southeast Asia. It is clearly impossible to support creation of centrally designed irrigation schemes that ignore the specific water needs of smallholders. The same smallholders who have been innovative in accessing water have increased crop yields at the same time. Of course unregulated groundwater pumping has led in places to massive drawdown and resource depletion. The practical response is not to ban pumping but to look to the priorities expressed by the smallholders' decisions, which in this case would suggest that past water delivery schemes have met neither the scheme's nor the smallholders' objectives. Practical, smallholder-focused policy would be integrated with development of further irrigation potential. Potential still exists, despite conservative reports to the contrary. The two major food producers, India and China, provide examples. India claims it has potential of 113 million irrigable hectares compared to its current total of 57, while China's 58 million irrigable hectares is said to be expandable to 64. Even in Southeast Asia, the current 17 million irrigable hectares could potentially be expanded to 44 Mha. Expansion of irrigation in many areas is only possible by

increased water use efficiency, an approach taken by China's development in its water-saving technologies in parallel with institutional innovations and the spread of water user associations (Xu et al. 2014). Water use efficiency has been essential to success everywhere, and this has been driven by research on agronomy and more investment in infrastructure (roads in particular). Adaptive research that might show how advances in science and technology (including climate-smart agriculture) might benefit smallholders is poorly funded.

Between 1980 and 2004 in China, there was a 25% rise in irrigated area. This occurred without a significant increase in water requirements: irrigated area increased by 5.4 Mha and food production by some 20 million tons, thereby allowing 200 million more people to become food secure. It is from such practical experience that other countries will develop their food security, using their smallholder production bases. Indonesia in its *Water Resources Law* acknowledges water rights for small-scale agriculture. The *Law* says "regardless of the financial questions, there is strong case for protecting the water rights of smallholders, particularly in areas where development change is expected, to ensure that their interests are fully recognized in any change process."

Farmers of the Sea

Likewise, the small farmers' cousins of the sea, small-scale artisanal fishers, have millennia-old traditions to husband community fish resources. These are now subject to commercial encroachment, piracy, and pollution; such artisanal fishers and their care of the basic resources are being lost, and a rear guard action is being vainly fought to legislate protection of remaining marine breeding resources to counter clearing of mangroves to make way for aquaculture (fish farms). Regulation of dredging of waterways to allow larger ships to traverse and measures to reduce turbidity of waters that comes from larger ship propellers, etc. need to be implemented. The marine situation mimics that on the hinterland, with declines in small fisher numbers and concomitant risks to future production. The capture production of fish has been declining, with aquaculture making up the difference, which is about half of all consumption with the same narrowing of diversity that characterizes other farmed food production. The potential for technological development remains high as the whole field has been neglected compared to land-based food production. But the promotion of policy initiatives that are firm on resource and small fisher protection within the overall staple food security policy as reflected in strong regulations and determined policing are yet to formulated.

Beyond the delta, seas, and irrigated areas at the other end of the environmental water regime are the 40% of the rural population in developing countries who live in less favorable agricultural areas – mainly drylands (Squires and Ariapour 2018). These dryland areas vary markedly and cover 41% of the earth's land surface (about 6 billion ha) and support, according to FAO, about two billion people (Squires and

Gaur 2019). In some cases, innovations allow profitable crop or livestock production. Technologies and social systems that encourage improvements to smallholding subsistence animal husbandry and crop agriculture in these regions are poorly represented in research and development programs (Squires and Bryden 2019).

Food Security in Drylands Uunder Global Climate Change

Pastoral production systems are the mainstay of livelihoods in drylands. They are found in climatic zones as different as deserts, dry plains, savannahs, steppes, tundra, and high-altitude mountain ranges, but all have in common the exploitation of ephemeral concentrations of resources (Behnke et al. 2011; Asner et al. (2004) estimate that about 26 million km^2 of land in these biomes worldwide are under managed-grazing systems, which is more than the combined areas of USA, China, and the European Union. Rass (2006) estimates that there are about "120 million pastoralists/agro-pastoralists worldwide," 50 million of which are in sub-Saharan Africa, 31 million in West Asia and North Africa, 25 million in Central Asia, 10 million in South Asia, and 5 million in Central and South America.

Besides using strategic mobility and livestock feeding selectivity, pastoralist smallholders interface the instability of their operating conditions with a high degree of diversity within the production system itself. A common strategy is keeping a variety of livestock species with different feed requirements and providing different products and functions to the household (e.g., small stock for covering small expenses and large stock for milk production and annual sales).

Data recently published by the FAO indicate that human-edible protein from livestock is produced much more efficiently in countries where the sector is dominated by pastoralism, with protein input/output ratios between 1:4 and 1:21 in India, Sudan, Mongolia, Ethiopia, and Kenya compared with those of intensive livestock systems where the ratios are well below or around 1:1 in Saudi Arabia, USA, Germany, China, the Netherlands, and Brazil. This also highlights the comparative advantage for livestock production in pastoral systems over intensive systems with regard to the dependence on fossil fuels (as pastoralism is a low-carbon production system) and the limited use of cultivated fodder or competition with food crops (Steinfeld et al. 2010).

Climate change is a global phenomenon, but the impacts of related food crises are expected to be greater in Asia, particularly in the context of the region's industrial structure, population structure, and food culture. Climate change directly impacts agro-ecosystems that are at the heart of efforts to ensure food security (Figs. 5.10 and 5.11).

Postharvest losses (see Box 5.1 and 5.2) must be minimized. In the long term, it will be necessary to actively and proactively respond to future food crises at the national and international levels. It is necessary to address food security in its broadest sense and integrate it in the development of agriculture worldwide. "Climate-smart agriculture" can be built up by improving technology and management systems to achieve global food security (Wheeler and Braun 2013).

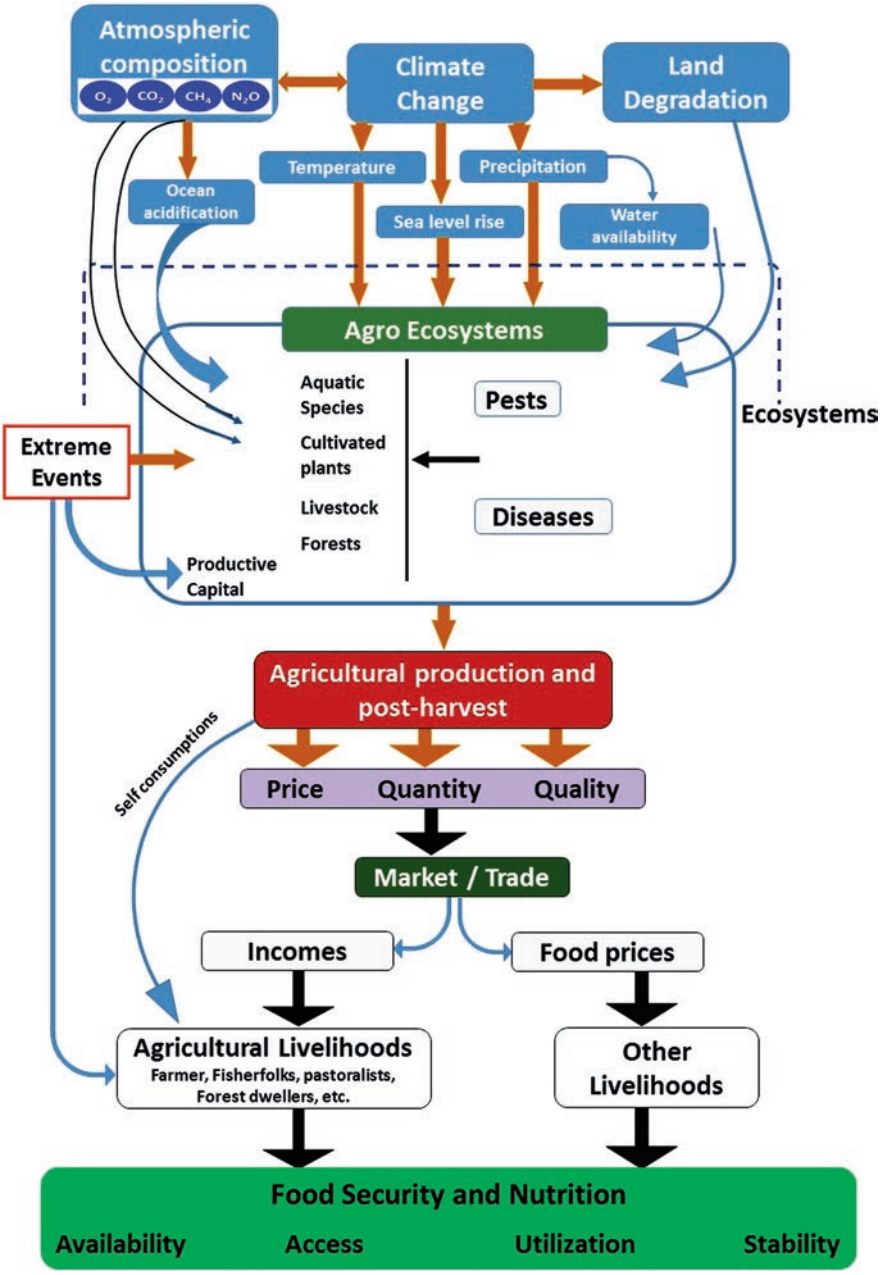


Fig. 5.11 Climate change impacts agroecosystems and exacerbates the problems of ensuring food security

Food Production Under Conditions of Environmental Instability

Livestock provides more food security than growing crops in many arid and semi-arid areas. Comparing nutritional status of children from nomadic and sedentary population groups in Mali, Pedersen and Benjaminsen (2008) conclude that farming appears to be a poorer adaptation than nomadic pastoralism in arid environments such as the northern Sahel. Mobile pastoral systems in both West and East Africa were found to perform better than sedentary systems under the same conditions. Sulieman and Young (2019) found that "in almost every production parameter, the performance of the former is superior to that of the latter." In Niger, nomadism was found to increase productivity by 27% compared with sedentary livestock systems and by 10% compared with transhumant systems.

One of the most critical analyses of the environmental impact of the livestock sector – 'Livestock's Long Shadow – found that "If properly managed, nomadic pastoral livestock production is potentially the most environmentally compatible agricultural activity in this ecosystem [drylands]" (Steinfeld et al. 2006, p. 260).

Increasing the productivity and resilience of smallholder farming systems is a huge challenge that will require significant and sustained technical, financial, and political support and action at both the national and local levels. However, a handful of low-cost and local approaches – such as revitalizing farmer extension services, implementing small-scale local infrastructure projects with farmers, strengthening informal safety nets, and safeguarding natural ecosystems – could go a long way toward beginning to address this critical challenge and improving the livelihoods of smallholder farmers

A priority for policymakers is to safeguard the natural ecosystems that smallholder farmers use as safety nets. Forests, wetlands, rivers, and other natural areas provide critical ecosystem services to smallholder farmers, including the provision of firewood and charcoal, water, wild foods, and materials for house construction, among others. These services are important year-round but particularly following catastrophic events when farmers turn to the forests for food and materials to rebuild their damaged homes. Efforts that conserve, restore, or sustainably manage these natural ecosystems are therefore crucial for sustaining farmer livelihoods.

Particular attention must be paid to raising agricultural productivity, as this could make a significant difference in food insecurity and poverty levels, both by increasing the total food availability to households and improving household income generation (Sanchez and Swaminathan 2005). Agricultural growth has been shown to be 2.2 times as effective at reducing poverty as growth in nonagricultural sectors indicating the critical role that improving agricultural productivity should play in development strategies.

Women and Food Security

Women play a major role in agriculture and food security and thus need to be equal partners in dealing with the challenges of climate change. Women are involved in food production as farm managers and laborers, they earn income that helps their families grow and (sometimes) purchase food, and they are largely responsible for preparing food within the household. In developing countries, on average women make up more than 40% of the agricultural workforce, ranging from 20% in Latin America to 50% in parts of Asia and Africa. Yet there is a substantial gender gap in access to agricultural inputs, with serious implications for agricultural productivity (Elham 2019). There are limited systematic gender-disaggregated data on land ownership, but the few studies that exist point to large gaps in land holdings, with women owning as little as 5% of agricultural land in West Asia and North Africa. In West Asia and North Africa, less than 5% of agricultural land holders are women; in sub-Saharan Africa, women hold approximately 15% of agricultural land. A recent study in the state of Karnataka in India found that women held 9% of the land.

For female-headed households that do own land, plots are usually smaller than those of male-headed households on average. Women also own fewer livestock and have inferior access to productive inputs and services, including credit, technology, equipment, extension services, fertilizers, water, and agricultural labor. These constraints as well as others directly affect women's farm productivity. According to the FAO, by addressing the gender gap in agriculture, developing countries could experience gains in GDP of 2.5–4% with an associated decline of 12–17% in undernourished people. These inequities must be taken into account, and efforts to adapt to climate change must address them to take full advantage of the contributions women can make. Women have varying roles in food systems in different parts of the world. Effective planning for adaptation should anticipate the consequences on gender-specific workloads and effects on existing inequalities between men and women both within households and communities. Institutional and social changes are often essential elements of adaptation.

Although farmers use a variety of risk-coping strategies, these may be insufficient to prevent them from remaining food insecure. Few farmers have adjusted their farming strategies in response to climate change, owing to limited resources and capacity. At the same time, smallholder farmers have myriad adaptive capacities, including knowledge, networks, and management practices that have long enabled smallholder systems to cope with both environmental and socioeconomic change under a changing climate. It is likely that these adaptive capacities will manifest differently from adaptive capacities employed in other farming systems.

Smallholders face many barriers to adaptation, including limited economic and financial resources, lack of access to usable information, unavailability of appropriate technologies for different users, credit constraints, lower socioeconomic and educational status of users, and limited access to social networks (96–100). These constraints can lead smallholders to have lower levels of risk tolerance compared to other farmers, which also influences adoption of new ideas technologies, etc.

Summing Up

Many of the rural poor are subsistence farmers or landless people seeking to sell their labor. They depend on agriculture for their earnings, either directly, as producers or hired workers, or indirectly, in sectors that derive from farming. For example, trading, transportation, and processing involve large numbers of small entrepreneurs and are necessary for agriculture, but, at the same time, such entrepreneurs depend on farming activities for their survival. Food-insecure people neither consistently produce enough food for themselves nor have the purchasing power to buy food from other producers. During times of famine, food may simply not be available at any price. Fortunately, few places experience famine, but many suffer from food insecurity. In the developing countries, 70–75% of the poor and hungry live in rural areas. Farming is, therefore, at the heart of their livelihood strategies. The International Fund for Agricultural Development (IFAD 2001) and the new World Bank Rural Development Strategy (FAO 2002: 8) have reiterated the importance of farming as worsening standards of living in rural areas drive desperate people to the cities, thereby exacerbating urban poverty and a further decline of agriculture and the rural sector.

Smallholders are here to stay for the foreseeable future. Not only that, they are essential as a key to the best possible scenario of providing basic food for reasonably healthy survival of the majority of the world's poor, including two billion of themselves.

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