Greenhouse Gas Mitigation Options for Pakistan: Agriculture Sector

This factsheet provides a summary of the mitigation option analysis in the agriculture sector, for more details on methodology and sources, please refer to the corresponding technical report.

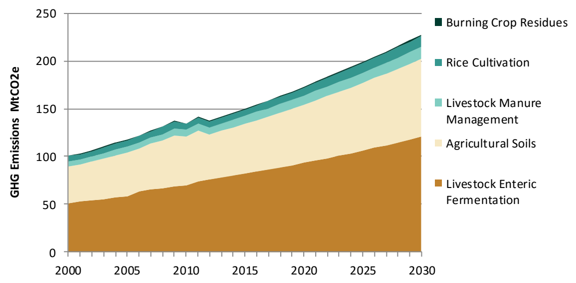
Key Facts

Agriculture contributes more than a fifth of the country's GDP (21.4 per cent) and employs almost half of the country's workforce (45 per cent). There is a minimum expectation of 5 per cent growth per annum for the sector. The sector is also a large driver of the country's emissions contributing nearly 42 per cent of national greenhouse gas (GHG) emissions in 2012.

The challenge for the sector is to be more productive to meet country needs, while coping with increased climate risks. The stability of the sector is threatened by extreme weather as well as temperature changes, both of which can deplete quality of agricultural soil.

GHG Baseline

FIGURE 1: PROJECTED GREENHOUSE GAS EMISSIONS IN AGRICULTURE SECTOR (MT CO_2E)



Projected greenhouse gas emissions from the agriculture sector by source, to the year 2030 are indicated below in Figure 1 and Table 1. **Emissions are projected to rise by 77.2 per cent between 2012 and 2030, or approximately 3.1% per year. Emissions are forecasted to grow from approximately 137 Mt CO_2e in 2012 to approximately 236.6 Mt CO_2e in 2030.**

TABLE 1 PROJECTED GREENHOUSE GAS EMISSIONS IN AGRICULTURE SECTOR (MT CO_2E)

Major Emission Source Category	2012	2015	2020	2025	2030
Livestock Enteric Fermentation	75.8	82.3	93.4	106.1	120.6
Agricultural Soils	47.0	51.8	60.8	71.0	81.8
Livestock Manure Management	7.6	8.3	9.4	10.7	12.2
Rice Cultivation	6.0	6.8	8.3	10.0	11.6
Burning Crop Residues	0.6	0.7	0.9	1.1	1.2

Mitigation Options

Options were identified from a review of existing policies and strategies, independent studies and key agriculture improvements that have demonstrated their success in similar contexts. Options were prioritised based on their commercial and technical viability in Pakistan. The methodology for calculating emissions reductions, as well as more detail on assumptions and figures, can be found in the corresponding technical report for the agriculture sector.

Twelve options were identified based on GHG abatement potential, sustainable development benefits, cost effectiveness, evidence of existing action and barriers to implementation:

- Improve irrigation/water management
- Reduce methane from rice cultivation
- Promote better manure storage & management
- Implement agroforestry practices

- Reduce methane from enteric fermentation
- Introduce genetically modified crops that are more carbon responsive
- Limit and reduce crop burning practices
- Use agricultural and animal wastes to produce biogas and organic fertiliser
- Reduce nitrous oxide release from soils by efficient & targeted use of chemical fertilisers
- Promote no-till farming to improve soil carbon
- Develop and adopt new breeds of cattle which are more productive in terms of milk and meat, and have lower methane production from enteric fermentation
- Use of organic pesticides and fertilisers
- Identify and implement ideal cropping patterns to manage soil nitrogen and reduce needs for chemical fertilisers

Five high priority GHG mitigation options were identified that offer abatement potential, can be implemented immediately without significant barriers and which are cost-effective. All are examined in detail below, with a summary of GHG benefits and costs.

Merits of options such as reducing methane production from enteric fermentation were considered as well, given that more than 60 per cent of agricultural emissions result from it. However, these could not be quantified during the initial screening of options to uncertainties and data availabilities. This does not mean that adopting certain feedstock mixes, for instance, would not have the potential to contribute greatly to reduce emissions. Developing new breeds of cattle that have lower methane production from enteric fermentation could also have the co-benefits of being more productive in terms of milk and meat as well.

TABLE 2: EMISSION MITIGATION MEASURES AND IMPACTS

Emissions Mitigation Measure	GHG Emission Reductions in 2030 ($MtCO_2e$)	GHG Emission Reductions from Sector BAU in 2030 (%)	Marginal Abatement Cost (\$/Tonne CO_2e Reduced)
Improve Irrigation/Water Management	1.58	0.7%	Low (<\$25)
Reduce Methane from Rice Cultivation	1.16	0.5%	Low
Implement Agroforestry Practices	8.4	3.5%	Very low (<\$10)
Promote better manure storage and management	0.14	0.06%	Low
Limit and Reduce Basmati Rice Crop Burning Practices	0.54	0.2%	Low
TOTAL AGRICULTURE SECTOR	**11.82**	**4.96%**	Low

Improve Irrigation/ Water Management

In Pakistan, every year about 50 billion cubic metres of groundwater is pumped for irrigation, which consumes more than six billion kWh of electricity and three to five billion litres of diesel. About 200 000 tube wells are operated by electric motors whereas the remaining one million are run by diesel, which emit approximately 2.4 $MtCO_2e$ a year. By adopting improved irrigation schedules, the amount of groundwater to be pumped, and the fuel required to pump it, could be drastically reduced.

Scenario Definition

This recommendation focuses specifically on increasing irrigation efficiency to reduce groundwater pumping as groundwater use remains highly inefficient. A few reports have found that efficiency could be improved by up to 48 per cent, here we assume improvement of 10 per cent (which could very easily be achieved by adopting improved/more appropriate irrigation schedules).

Emissions reductions were calculated as follows:
tCO_2e = Total fuel consumption * emission factor * % targeted pumps

Emissions Reductions in 2030 (tCO_2e) = 5.931 billion litres * 2663 gCO_2e * 0.1
= 1579 $GgCO_2e$
= 1,579,753 tCO_2e

Benefits and Impacts

Water conservation, reduced costs.

Reduce Methane from Rice Cultivation

There are a number of options in this area regarding water management techniques to control the release of methane from agricultural soils. For example, demo plots were conducted at 25 locations in Pakistan, where the Controlled Irrigation (CI) water saving approach to rice cultivation, or the Alternate Wetting and Drying (AWD) rice management practice and dry seeding have been verified over the last three to four years and are now being practiced in rice-growing areas of Punjab and Sindh.

The total area currently under such cultivation is estimated at 200,000 hectares, and there is scope for further action in the country. AWD technology have also shown that they can have a significant impact on reducing methane emissions from farming: CH_4 emissions on pump-irrigated farms decreased by nearly 70 per cent under AWD technology.

Scenario Definition

Given 2.365 million hectares of rice irrigated, responsible for more than 6 $MtCO_2e$, there is scope for further action. A number of studies found potential for 48 per cent to 70 per cent methane emission reductions with AWD/dry seeding or CI. Here we model 20 per cent of rice-cultivated areas adopting these measures, with 50 per cent improvement in emissions reductions.

Emissions reductions were calculated as follows:
tCO_2e = Baseline Emissions * Reduction potential * % of Hectare Targeted

Emissions Reductions in 2030 (tCO_2e) = 11,566,400 tCO_2e * 0.5 * 0.2
= 1,156,640 tCO_2e

Benefits and Impacts

Aerobic or AWD technology have been shown to increase yields, improve soil quality, decrease water usage and related production costs while reducing methane emissions anywhere between 48 to 80 per cent in regions such as Guranwala, Okara, Kasur and Jhang districts in Punjab and Thatta, and Larkana in Sindh.

Implement Agroforestry Practices

The Government of Pakistan has already expressed its will to increase the forest cover to 6 per cent in the country, which would offer strong and significant mitigation potential through carbon sinks. Each province in the country has already begun running programmes fostering agroforestry practices, most commonly promoting planting eucalyptus, as well as trees such as shishum and kikar.

More than 80 per cent of all farms in Pakistan are less than five hectares and small farmers are concerned of the opportunity cost of planting seeds other than what is required for optimal crop production on such small lands. Yet, studies have shown that it is possible to plant as much as 12 trees per hectare of crop land without having any negative impact on crops.

Scenario Definition

Desk-based research suggested minimal uptake to date because of the number of small farms and the need to prioritise the land for crop production. There is significant potential if a program can be developed to illustrate the many co-benefits. Here, modelled are agroforestry practices on an additional 3 per cent of agricultural land, through plantation of multipurpose and fast growing tree species.

Emissions reductions were calculated as follows:
tCO_2e = Reduction potential * Total Agricultural Land * % of Hectare Targeted

Emissions Reductions in 2030 (tCO_2e) = 8.06 tCO_2e/ha * 34,890,000 ha * 0.03
= 8,436,402 tCO_2e

Benefits and Impacts

Potential positive impacts and co-benefits of agroforestry are quite numerous. They include: improved soil quality, increased amount of nutrients in the soil and reduced erosion and pests. Agroforestry practices can also provide an additional, and local, source of income, fuel and/or timber to farmers and their local communities. Residues can also be utilised as fodder for cattle. There is significant potential that could be harnessed both for mitigation and co-benefits if a programme could be developed that would illustrate the many benefits that could be reaped by the farmers themselves.

Promote Better Manure Storage and Management

Better manure storage and management could turn manure into two significant resources that would not only reduce emissions from this specific source, but would also provide local fertiliser and/or an energy source harnessed in the form of biogas. As a fertiliser, it is estimated that about 1.5 million tonnes of nutrients are available from farmyard manure in Pakistan. Further, studies in China found that adding manure to crop fields significantly enhanced soil organic carbon stocks (SOC) of land with the potential to improve sequestration capacity. A second study found that adding manure increased carbon sequestration by 4.4 to 5.1 per cent.

Scenario Definition

There is 652 million kg of manure produced daily from cattle and buffalo alone in Pakistan and desk-based review suggests almost 50 per cent of dung remains uncollected. Manure is responsible for 7 MtCO_2e (95 per cent as Methane, 5 per cent as Nitrous oxide). Promoting better manure storage and management can reduce emissions by 25 per cent. A focus on practices for improved application, timing, storage and distribution of manure provides low cost mitigation options. There are few incentives for farmers to adopt these practices, and no cost savings for them, so anticipated are low participation rates, 10 per cent by 2030, resulting in .14 MtCO_2e per year by 2030).

Emissions reductions were calculated as follows:
tCO_2e = Baseline Emissions * Achievable potential * % of Farm Manure Targeted

Emissions Reductions in 2030 (tCO_2e) = 10,994,884 tCO_2e * 0.125 * 0.1
= 137,436 tCO_2e

Benefits and Impacts

Co-benefits may include some displacement of chemical fertiliser and/or energy costs and increased crop yield.

Limit and Reduce Basmati Rice Crop Burning Practices

Burning crop residues is the most common way in Pakistan to remove rice residue from fields where wheat will then be grown next season. Farmers will resort to burning residues from either one of the crop yields (wheat residues in March, rice residues in October) to accelerate turn over between harvests and planting new crops. Approximately 60 per cent of farms observed in Punjab, for instance, were burning rice residues completely after harvesting. Burning crop residues creates black carbon, which is second only to carbon dioxide as a contributor to global warming.

Scenario Definition

In 2015, burning crop residues in Pakistan is estimated to have released 0.73 MtCO_2e in the atmosphere. This is projected to almost double by 2030, reaching 1.24 MtCO_2e that year, making the reform of burning crop residues an important action to strengthen Pakistan's effort at reducing its GHG emissions.

A progressive ban on burning of basmati rice crop residues could realistically cover 80 per cent of residues burned from that specific crop yield by 2030, reducing GHG emissions by 0.54 MtCO_2e that year. The reduction in emissions would be achieved even as rice crop yields steadily go up in Pakistan from approximately 6.3 Mt in 2015 to 10.7 Mt in 2030.

The ban would be implemented only very progressively from 2018 onwards. The assumption is that the ban would reduce burning of basmati rice crop residues by 5 per cent in 2018 and would peak at 80 per cent in 2030.

Emissions reductions were calculated as follows:
tCO_2e = Emission Factor * Total Basmati Rice Residue * Ban Penetration Rate

Emissions Reductions in 2030 (tCO_2e) = 60,41 kgCO2e/t * 11,102,037 * 0.8
= 536,539,244 kgCO2e
= 536, 539 tCO_2e

Benefits and Impacts

A ban on burning of basmati rice crop residues that is implemented alongside targeted subsidy-measures and distribution of technology, such as tilling machines that allow for returning residues into the soil, would have several benefits for farmers. Not only would it save them time by eliminating the need to remove residues from the field, it would also have the benefit of cutting expenses. Accelerating and increasing the rate of penetration could be realised relatively quickly and efficiently. Limiting burning would also improve local air quality, and reduce smoke, haze, soot and black carbon, the latter two of which are shown to contribute to melting glaciers.

**The Climate and Development Knowledge Network ("CDKN") is funded by the Department for International Development and the Dutch Ministry of Foreign Affairs and is led and administered by PricewaterhouseCoopers LLP. PricewaterhouseCoopers LLP is assisted in the management of CDKN by an alliance of organisations comprising the Overseas Development Institute, Fundación Futuro Latinoamericano, South-South-North, LEAD International, and INTRAC*