Keynote Speech

Nepal's Agriculture in the 21st Century: Traditional to Climate Smart Approaches

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Abstract
Nepal is an agrarian country where majority of people rely on farming for their livelihood. Due to small farm sizes and lack of capital, most farmers in high hills and mountains still use traditional approaches and follow subsistence farming. The level of mechanization has increased which is characterised by increasing number of tractors. The use of tractors is mostly limited to Terai region (plain land), whereas low hilly region has adopted two-wheeler tractors. The total GHG emissions of Nepal accounts for 0.09% of the world emissions, however agriculture sector contributes more than half of the nation's GHG emissions. Most of agricultural plans and policies promote sustainable agricultural development through commercial and market oriented economic growth, however the implementation has been unsatisfactory. Climate smart agriculture (CSA) and sustainable agricultural practices have been identified and implemented to improve agriculture production considering climate change and emissions.

Keywords: Agricultural policies, Climate smart agriculture, Emissions, Mechanization, Nepal

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1. Introduction

Nepal is one of the least developed countries in the world, which is located in South Asia between India and China. The country occupies about 0.3% and 0.03% land area of Asia and the world, respectively (CBS, 2019a). Total population in 2018 was estimated to be 28.1 million, of which 80.3% resided in rural areas (World Bank, 2019). The annual population growth rate is estimated at 1.65%. The per capita income in 2018 was reported as USD 1034 per annum.

Land covers about 97.4% of the total area, which is divided into three agro-ecological zones: Hills (rugged terrain), mountains and Terai (flat lowland). Two-third of the land is covered by hills (42%) and mountains (35%), and only 23% is occupied by Terai (Knerr, 2017). Figure 1 shows the nation's land use, of which 28.7% is classified as agricultural area. About 51.3% of agricultural area is classified as arable land, 43.6% as permanent meadows and pastures, and remaining 5.1% is covered by permanent crops.

2. Agricultural practices in Nepal

Agriculture is one of the major means of people's livelihood in Nepal. In 2018, the agricultural sector contributed to 25.3% of total GDP and provided employment to 70.1% of the population (World Bank, 2019). Agriculture is mostly characterized by small scale farms as 76.5% of farm holdings are smaller than two hectares (CBS, 2019b). The average farm size has continued to decrease over the decades (Table 1). Small farm holdings and lack of capital and market have compelled most farmers to adopt subsistence agriculture using traditional tools (Shrestha, 2012).

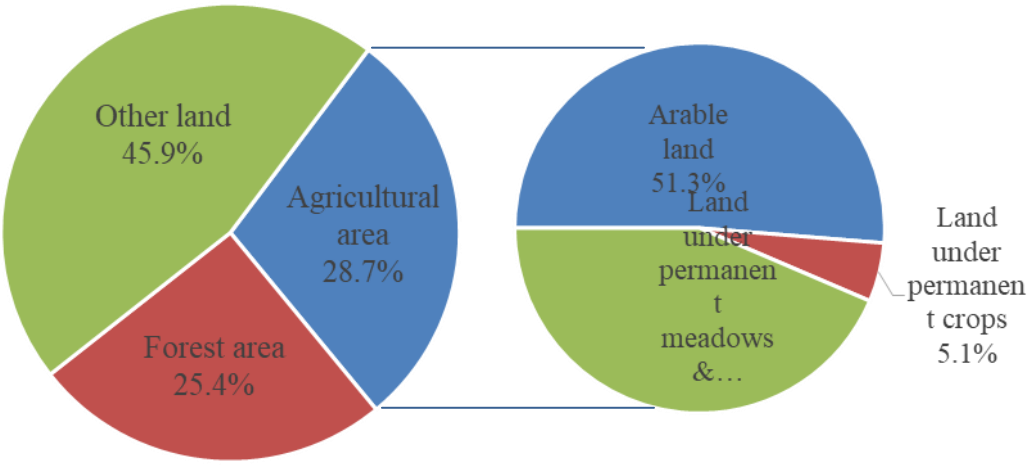

Figure 1. Land use classification of Nepal (FAOSTAT, 2019)

Table 1. Average farm size by agro-ecological zones (CBS, 2006; CBS, 2019b)

Agro-ecological zones	**Average farm size (ha)**			
	1981/82	**1991/92**	**2001/02**	**2011/12**
Mountain	0.62	0.68	0.74	0.65
Hill	0.90	0.77	0.66	0.57
Terai	1.48	1.26	0.96	0.75
National	1.13	0.96	0.80	0.66

The major cereal crops are rice, wheat and maize, and major cash crops are sugarcane, oilseed and potato. Other agriculture products include pulses, fruits and vegetables. Rice is mostly cultivated in Terai and lower part of mid hills, while maize is mostly cultivated in mid hill to lower mountain regions (Gauchan and Shrestha, 2017). Figure 2 presents area harvested and yields of these agricultural products for last five years. Both area and yields have slightly changed over the years. In 2017/18, the yields of rice, maize, wheat, oilseed, pulses, vegetables and potato observed annual increase of 4%, 5%, 6%, 9%, 2%, 2%, and 22%, respectively. However, the yields of sugarcane and fruits declined by 0.4% and 22%, respectively.

Figure 3 presents the annual fertilizers inputs; green line indicates total fertilizer input per hectare of arable land, which shows an increasing trend, however it remained same in 2015 and 2016. Different sources of irrigation are available for the farmers including dam/ reservoir, tube wells/ boring, gravity fed/ pumping through canals/ rivers. About 66.8% of the cultivable area is irrigable, however only 47.5% was irrigated in 2010/11 which increased to 52.7% in 2016/17 (MoAD, 2012; MoALD, 2018).

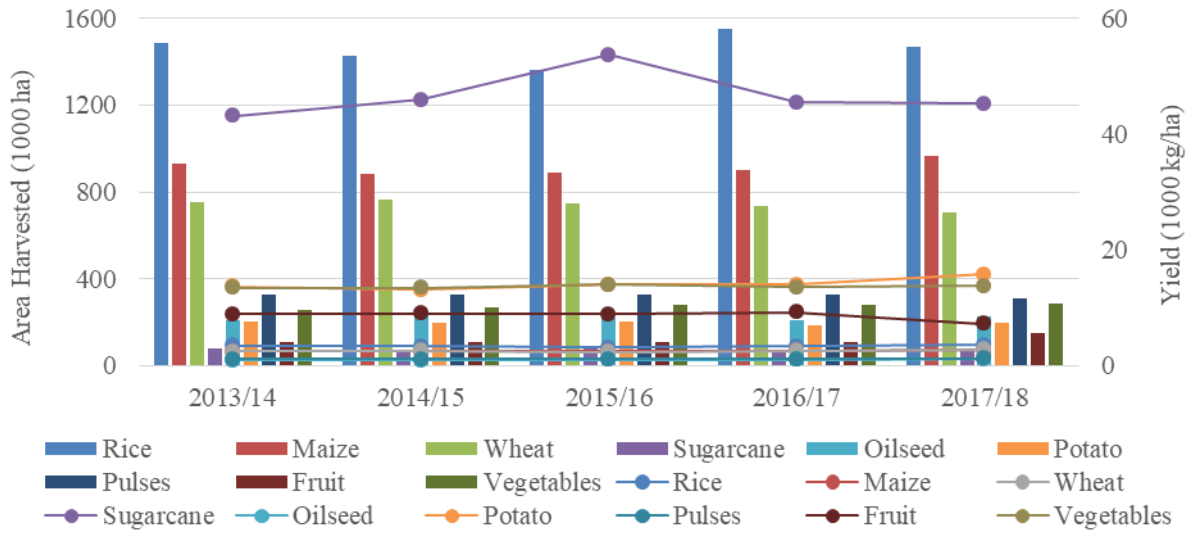

Figure 2. Area harvested and yield of major crops in Nepal (CBS, 2016; CBS, 2018; MoALD, 2018; CBS, 2019c)

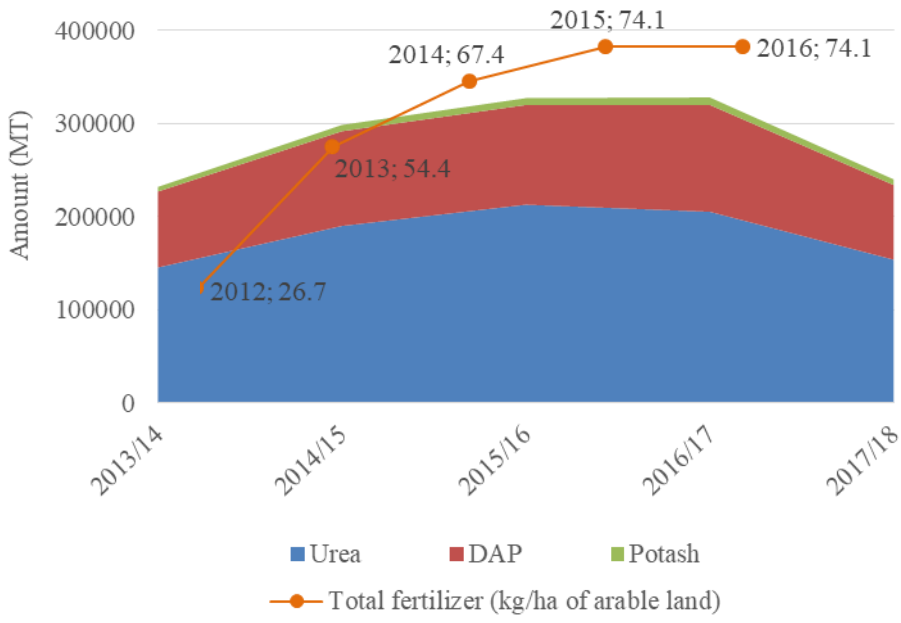

Figure 3. Annual usage of fertilizers (CBS, 2016; CBS, 2018; MoALD, 2018; CBS, 2019c; World Bank, 2019)

Farm mechanization level in the country was used to be low with majority (77%) of farm power needs being fulfilled by human and animal power and only 23% power was being provided by mechanical power. Most of this mechanical power (92%) was concentrated in Terai region (Shrestha, 2012), while most farmers in remote hills and mountain regions relied upon traditional tools. Since 1990, the country has been observing annual growth of number of tractors. Between 1990 to 2000, the number increased significantly from 5000 to 26300, an increase of 462% (World Bank, 2019). In the next decade, the number reached 37425 in the

fiscal year 2011/12 (CBS, 2013), an increase of 42.3%. In 2016, the numbers of tractors were reported to be 47000 (Takeshima, 2017), another increase of 25.6%.

In recent years, Terai region has observed widespread growth of tractors and motorized pumps, and hilly region has started adopting power tillers and mini tillers. Tractors have enabled farmers to intensify production per unit of land and expand cultivated area, reduce labor utilization and increase family income through off-farm activities (Pradhan et al., 2016). The growth of tractors, mainly in Terai region, is due to increase in agricultural production, labor wages, and emigration (Takeshima, 2017), as well as development of market oriented farming. Most of the cultivated area in Terai region can utilize tractors, and growing demand of tractors has played a major role in agricultural transformation in the region. Private sectors and owners are providing custom hiring of tractors, power tillers, combine harvesters, pump sets and other implements. This has benefitted farmers who cannot afford to purchase these implements, and also enabled owners to make additional off-farm income.

Table 2 presents mechanization level of the county, which indicates that there is one tractor and one power tiller (two-wheeler tractor) for every 56 ha and 200 ha of arable land, respectively, compared to one iron plough for every 2.5 ha of arable land. It was reported that about 150 farmers in the Western Terai own combine harvesters (Paudel et al., 2015). These combine harvesters cover 8% of rice and 21% of wheat area, with an average coverage of 200 ha per year.

Table 2. Agricultural implements available in Nepal: 2011/12 (CBS, 2013)

Implements	**Total**	**No. of implements per ha of arable land**
Iron ploughs	856283	0,405
Power tillers	10430	0,005
Deep tube well	82009	0,039
Shallow tube well	261975	0,124
Rower pump	36183	0,017
Tractors	37425	0,018
Threshers	51928	0,025
Pumping set/ motor	150304	0,071
Animal drawn cart	159934	0,076
Sprayer	282315	0,134

*Arable land = 2113700 ha

Some farm activities (sowing, weeding, and fertilizer application) are done manually, while some are done using combination of power sources. For instance, during land preparation farmers use tractors for ploughing and animals for levelling. Similarly, both manual and mechanical methods are used in threshing; transportation of harvest is done either manually or using animal-driven carts or tractors.

2.1 Agricultural Emissions

In 2014, greenhouse gas (GHG) emissions including land use change and forestry was estimated to be 44.1 Mt CO_2e, which is 1.13% and 0.09% of South Asia and the world's total, respectively (WRI, 2019). Agriculture sector contributes highest to this emission (Figure 4) adding 52% to the total. About 54% of agricultural emissions is attributed to enteric fermentation, followed by

the emissions from rice cultivation (17%). Emissions from fuel combustion in tractors and pumps, fertilizer production, and waste management contributed to agricultural emissions.

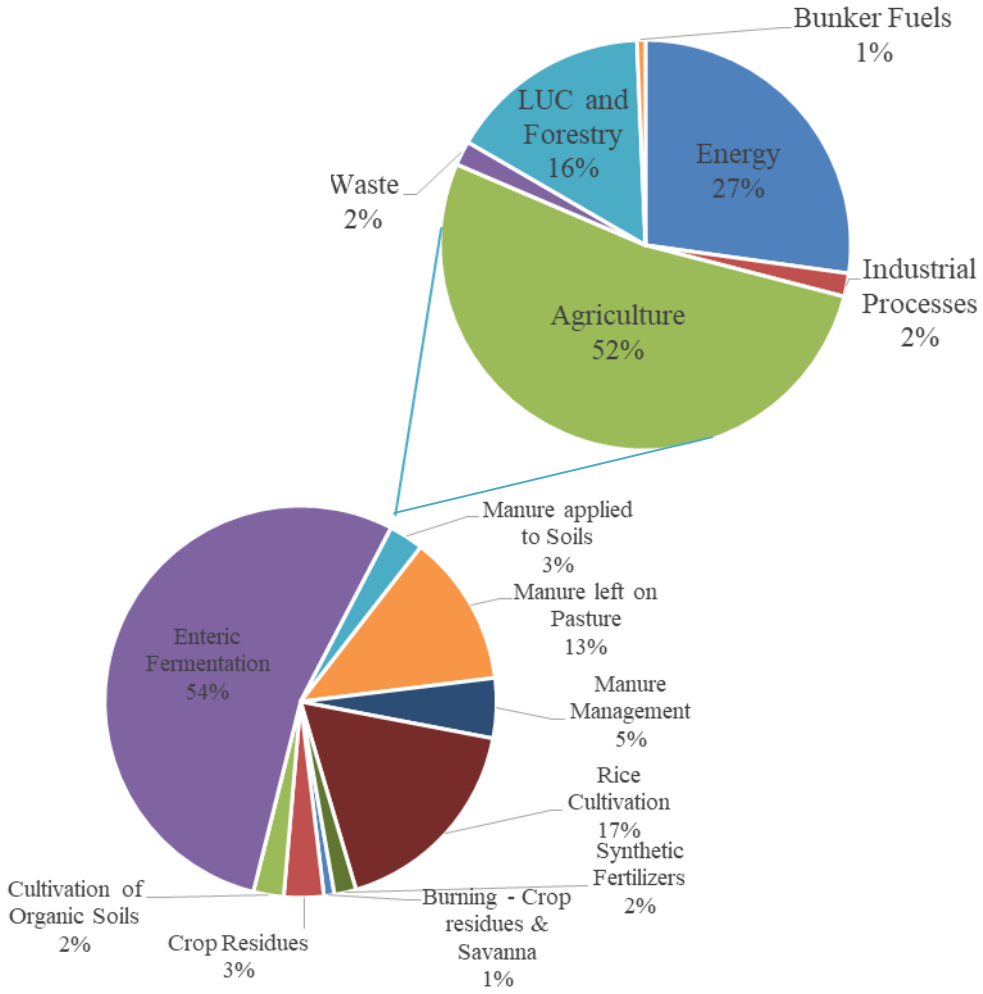

Figure 4. Contribution of Nepalese agriculture on GHG emissions (FAOSTAT, 2019; WRI, 2019)

2.2 Agricultural Policies

Several national policies on agriculture have been adopted, which mostly aim towards sustainable agriculture development, food security, poverty reduction, and promotion of market oriented economic growth in Nepal. Some of the prominent agricultural plans and policies include Agriculture Perspective Plan (APP), 1995/96 – 2014/15; National Seed Policy, 2000; National Fertilizer Policy, 2002; Irrigation Policy, 2003; National Agriculture Policy , 2004; Agribusiness Promotion Policy (AgPP), 2006; Agriculture Bio-diversity Policy, 2007; Trade Policy, 2009; Agriculture Mechanization Policy (AMPP), 2014; Agriculture Development Strategy (ADS), 2015-2035. Most of earlier plans and policies overlooked agricultural mechanization which affected the investment, research and proper implementation of mechanization throughout the country. To address this gap, AMPP was introduced to promote mechanization which is friendly to different agro-ecological regions, climate, and gender (GC et al., 2019).

ADS is the latest long term plan, which was adopted in 2014 with a vision of "*A self-reliant, sustainable, competitive, and inclusive agricultural sector that drives economic growth, and*

contributes to improved livelihoods and food and nutrition security" (MoAD, 2014). ADS included agricultural mechanization as one of thirteen core priority areas, which promotes agricultural mechanization through creation of awareness and financial arrangements, tax regulations, public-private coordination, and institutional mechanism (Takeshima et al., 2016).

Agricultural plans and policies aim to transform farming from subsistence to commercial level through public-private coordination. Majority of policies, however, has not performed satisfactorily as there is a gap between contents and their implementation. Other policy gaps include: (i) lack of policy to regulate or control conversion of productive lands into housing and other infrastructure; (ii) lack of consideration of land consolidation issues; (iii) lack of agricultural legislation to implement NAP; and (iv) lack of information dissemination about agricultural services and cooperative supports to farmers (JICA, 2013).

Ministry of Agricultural Development (MoAD) provides 50% subsidy on imported power trailers and tax exemption for tractors (Takeshima, 2016). The cost of registering these machineries with the Zonal Transportation Division is relatively high, which may have resulted in owners not officially registering their machines (Takeshima, 2017).

2.3 Climate Smart Agriculture

According to the Department of Hydrology and Meteorology (DHM, 2015), annual mean maximum temperature, minimum temperature and precipitation are reported to be 22°C, 10.8°C and 1859 mm, respectively. Analysis of historical data presented an increasing trend of temperatures and precipitation, with an annual increase of 0.037°C in maximum temperature, 0.012°C in minimum temperature and 0.7 mm of precipitation.

Majority of farming is still climate-sensitive, hence climate change poses a huge challenge to Nepalese agriculture. The climate change may result in droughts/ floods, which may affect crop yield of rain-fed agriculture. In order to respond to climate change through agriculture, climate smart agriculture (CSA) was initiated in collaboration with multiple stakeholders. CSA aims to develop and implement agricultural technologies and practices to achieve food security and economic growth under a changing climate (CIAT, World Bank, CCAFS and LI-BIRD, 2017; Paudel et al., 2017). CSA has three pillars: productivity (yield), adaptation (income, water, soil, risks) and mitigation (energy, carbon and nitrogen). Multiple institutions (local agencies, ministries, NGOs and INGOs) are involved in carrying out activities related to these pillars.

Some of CSA technologies and activities include precision nutrient management, improved water and irrigation management, soil conservation techniques, crop intensification technique, improved planting and management of crops, use of modern technologies, and use of ICT to disseminate climate information. Figure 4 and Table 3 provide CSA options and activities based on their suitability to different agro-ecological zones of Nepal.

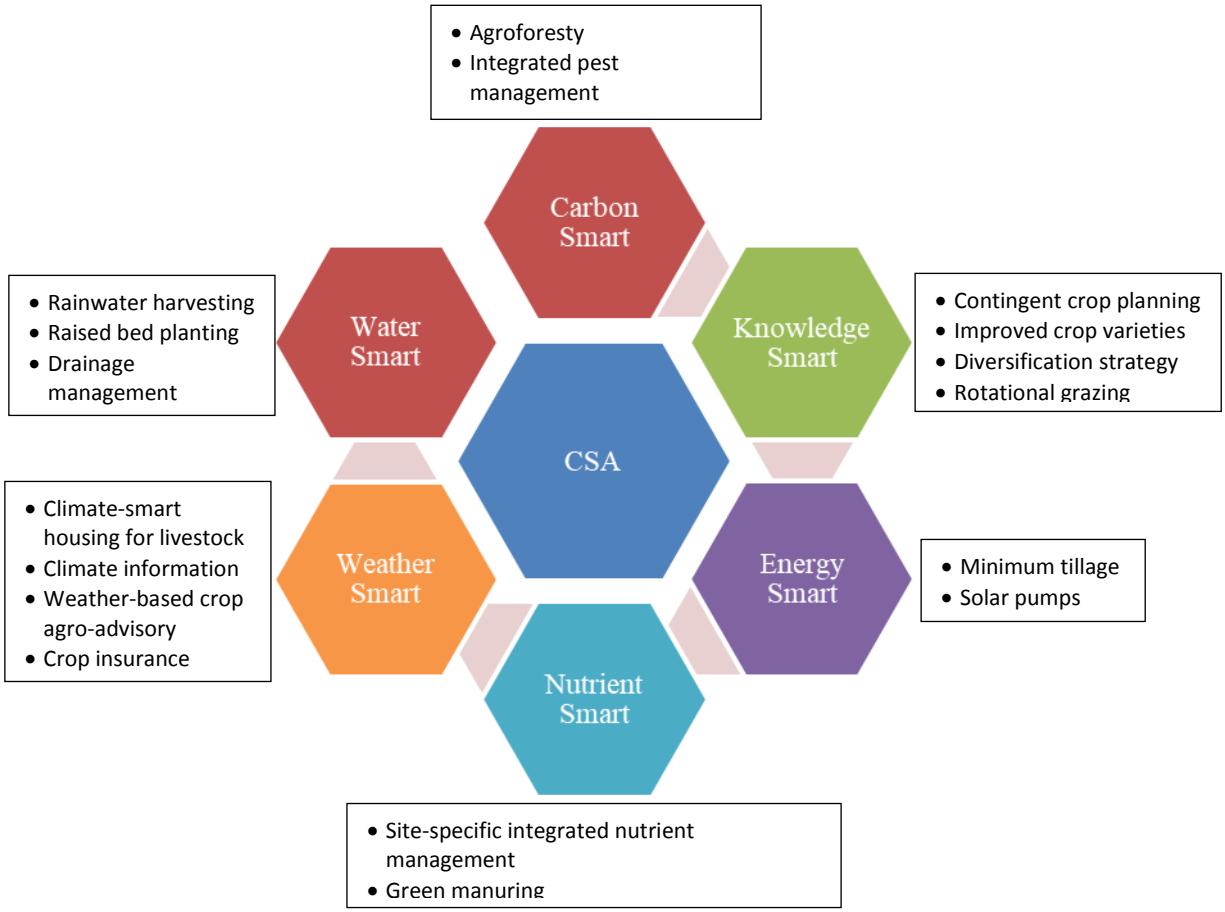

Figure 4. CSA categories applicable to Nepal (adapted from Paudel et al., 2017)

Table 4. CSA techniques for different agro-ecological zones of Nepal (adapted from Paudel et al., 2017)

CSA Techniques	Smartness	Agro-ecological Zone
New crops, seed varieties, etc.	Weather and knowledge smart	High and mid hills; Terai
Home garden	Weather and knowledge smart	High and mid hills; Terai
Mixed farming (legume integration)	Nutrient and weather smart	High and mid hills; Terai
Community seed banks	Knowledge smart	High and mid hills; Terai
Small hand-tools/ machines	Energy smart	High and mid hills; Terai
Agriculture insurance	Weather smart	High and mid hills; Terai
ICT based agro-advisory	Weather and knowledge smart	High and mid hills; Terai
Cattle-shed improvement	Nutrient and carbon smart	High and mid hills
Plantation and agroforestry	Carbon smart	High and mid hills

Plastic house	Weather and water smart	Mid hills
Plastic pond	Water smart	Mid hills
Water harvesting ponds, water source protection	Water smart	Mid hills
Drip irrigation	Water smart	Terai
Solar based irrigation	Water and energy smart	Terai
Conservation agriculture (zero tillage)	Carbon, water and weather smart	Terai
Rice intensification system	Water smart	Terai

2.4 Challenges and Opportunities

Numerous challenges exist with the development of agriculture in the country, for instance population growth (1.65%), poverty (25.2%) and inequality (GINI index of 32.8), literacy rate (60%), low investment, subsistence farming, slow pace of research and technology development, lack of subsidy on farm equipment, lack of trained human resources, and lack of implementation of agricultural policies. However, agriculture sector can benefit from the adoption of sustainable agricultural practices. Technologies can be modified to suit agro-ecological zones of Nepal, for instance, improved water mills for hills and mountains, wind mills, solar powered pumps, hand power tillers, etc.

3. Conclusion

Agriculture is one of major livelihood of Nepal, which contributes towards one-fourth of the nation's GDP. In last decades, agriculture sector has progressed as indicated by increased production and adoption of tractors, however it is slow and not satisfactory. Agriculture contributes highest to GHG emissions, but it is still low compared to South Asia and the World. Government has adopted several agricultural plans and policies, but the implementation is unsatisfactory. Investment on infrastructure, implements, public-private partnership, technologies for varying topography, and transformation of subsistence farming to commercial farming are important for agricultural development in the country. Climate smart agriculture (CSA) initiatives has identified several practices and techniques suitable for different agro-ecological zones to address food security and economic growth under a changing climate. Renewable energy based technologies and practices are needed to be explored to lower GHG emissions due to agriculture sector.

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References

CBS. (2006). Monograph – Agricultural Census Nepal, 2001/02. Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal.

CBS. (2013). National Sample Census of Agricultural Nepal 2011/12. National Report, Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CBS. (2016). 2015 Statistical Year Book of Nepal. Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CBS. (2018). 2017 Statistical Year Book of Nepal. Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CBS. (2019a). Nepal in Figures 2018. Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CBS. (2019b). Statistical Pocket Book of Nepal 2018. Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CBS. (2019c). Statistical Pocket Book of Nepal 2018. Central Bureau of Statistics, National Planning Commission, Government of Nepal.

CIAT, World Bank, CCAFS and LI-BIRD. (2017). Climate-Smart Agriculture in Nepal. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture (CIAT); The World Bank; CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); Local Initiatives for Biodiversity Research and Development (LI-BIRD). Washington, D.C., 26 p.

DHM. (2015). Study of Climate and Climatic Variation over Nepal. Department of Hydrology and Meteorology, Ministry of Science, Technology and Environment, Government of Nepal.

FAOSTAT. (2019). Selected Indictors of NEPAL. Food and Agriculture Organization (FAO). Retrieved from http://www.fao.org/faostat on December 24, 2019.

Gauchan, D., and Shrestha, S. (2017). Agricultural and Rual Mechanisation in Nepal: Status, Issues and Options for Future. In *Rural Mechanisation. A Driver in Agricultural Change and Rural Development.* Institute for Inclusive Finance and Development (InM), Dhaka, Bangladesh, pp. 97-118.

GC, A., Yeo, J.H., and Ghimire, K., (2019). Determinants of Farm Mechanization in Nepal. *Turkish Journal of Agriculture – Food Science and Technology,* 7 (1), pp. 87-91.

JICA. (2013). Preparatory Survey on JICA's Cooperation Program for Agriculture and Rural Development in Nepal: Food Production and Agriculture in Terai. Japan International Cooperation Agency.

Knerr, B. (2017). *International Labor Migration and Livelihood Security in Nepal: Considering the Household Level*. Kassel University Press.

MoAD. (2012). Statistical Information on Nepalese Agriculture 2011/12. Agri Statistics Section, Agri-Business Promotion and Statistics Division, Ministry of Agriculture Development, Singh Darbar, Kathmandu, Nepal.

MoAD. (2014). Agricultural Development Strategy (ADS), 2014. Ministry of Agricultural Development, Singhdurbar, Kathmandu, Nepal.

MoALD. (2018). Statistical Information on Nepalese Agriculture 2016/17. Ministry of Agriculture and Livestock Development, Singh Darbar, Kathmandu, Nepal.

Paudel, B., Khanal, R.C., KC, A., Bhatta, K., and Chaudhary, P. (2017). Climate-smart Agriculture in Nepal: Champion Technologies and their Pathways for Scaling up. LI-BIRD; CCAF.

Paudel, G., McDonald, A, Justice, S. Adhikari, S., Devkota, M.K., Sherchan, D.P. (2015). Conservation Agriculture: A Resilient Way to Exterminate Trade-offs in Combine Harvesters Use and Residue Burning in Rice-Wheat Systems of Nepal. International Conference on "Open Burning of Agricultural Residue" in the Himalayas Region, February 20-21, 2015, ICIMOD, Kathmandu, Nepal.

Pradhan, A., Jayasuriya, H.P.W., and Mbohwa, C. (2016). Status and Potentials of Agricultural Mechanization in Sunsari District, Nepal. *Applied Engineering in Agriculture,* 32 (6), pp. 759-768.

Shrestha, S. (2012). Status of Agricultural Mechanization in Nepal. United Nations Asian and Pacific Center for Agricultural Engineering and Machinery (UNAPCAEM).

Takeshima, H., Shrestha, R.B., Kaphle, B.D., Karkee, M., Pokhrel, S., and Kumar, A. (2016). Effects of Agricultural Mechanization on Smallholders and their Self-selection into Farming: An Insight from the Nepal Terai. Discussion Paper 01583, Development Strategy and Governance Division, South Asia Office, International Food Policy Research Institute.

Takeshima, H. (2017). Overview of the Evolution of Agricultural Mechanization in Nepal: A Focus on Tractors and Combine Harvesters. Discussion Paper 01662, International Food Policy Research Institute, Washington DC.

World Bank. (2019). World Development Indicators: Nepal. Washington, D.C.: The World Bank. Retrieved from https://data.worldbank.org/ on December 24, 2019.

WRI. (2019). CAIT Climate Data Explorer. World Resources Institute, Washington, DC. Retrieved from http://cait.wri.org on December 26, 2019.