Spatially explicit database on crop-livestock management, soil, climate, greenhouse gas emissions and mitigation potential for all of Bangladesh

Tek B. Sapkota\textsuperscript{a,}\textsuperscript{*}, Fahmida Khanam\textsuperscript{b}, Gokul Prasad Mathivanan\textsuperscript{c,d}, Sylvia Vetter\textsuperscript{e}, Sk. Ghulam Hussain\textsuperscript{b,f}, Anne-Laure Pilat\textsuperscript{b}, Sumona Shahrin\textsuperscript{b}, Md. Khaled Hossain\textsuperscript{b}, Nathu Ram Sarker\textsuperscript{g}, Timothy J. Krupnik\textsuperscript{b}

\textsuperscript{a} International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico \\
\textsuperscript{b} International Maize and Wheat Improvement Center (CIMMYT), Dhaka, Bangladesh \\
\textsuperscript{c} International Maize and Wheat Improvement Center (CIMMYT), New Delhi, India \\
\textsuperscript{d} Thünen Institute of Climate-Smart Agriculture, Braunschweig, Germany \\
\textsuperscript{e} Institute of Biological & Environmental Sciences, School of Biological Sciences, University of Aberdeen, Cruickshank Building, St. Machar Drive, Aberdeen AB24 3UU, United Kingdom \\
\textsuperscript{f} Bangladesh Agricultural Research Council, Dhaka 1215, Bangladesh \\
\textsuperscript{g} Bangladesh Livestock Research Institute, Savar, Dhaka 1341, Bangladesh

\textbf{A R T I C L E I N F O}

\textbf{Article history:}
Received 31 May 2021 \\
Revised 10 June 2021 \\
Accepted 11 June 2021 \\
Available online 14 June 2021

\textbf{Keywords:}
Crop \\
Livestock \\
Greenhouse gas \\
Mitigation \\
Climate smart agriculture

\textbf{A B S T R A C T}

This data article provides spatially explicit data on greenhouse gas (GHG) emissions and mitigation potential at various administrative levels for the whole of Bangladesh. The results arising from analysis of this database are presented in research article “Quantifying opportunities for greenhouse gas emissions mitigation using big data from smallholder crop and livestock farmers across Bangladesh” [1]. We collected crop and livestock management data and associated soil and climatic data from variety of primary and secondary sources outlined below in our methodology. The datafiles on crops and livestock contain model outputs for three greenhouse gases (CO$_2$, CH$_4$ and N$_2$O) and their...
Specifications

| Subject | Agriculture, Environmental Sciences |
|---------|-------------------------------------|
| Specific subject area | Climate change, greenhouse gas emissions, mitigation |
| Type of data | Spreadsheet |
| How data were acquired | We collected crop and livestock management data and associated soil and climatic data from variety of primary and secondary sources outlined below in our description of data collection. The detailed description and source of these datasets can be found in the associated manuscript [1] |
| Data format | Crop and plot identifier Model output (spatial) District-wise mitigation potential segregated by crop/animal types and mitigation options (Analyzed) |
| Parameters for data collection | The crop model requires all management information from planting to harvesting including plot-specific soil and climatic information to estimate GHG emissions from production. To estimate livestock production related GHG emissions, the number of livestock within each district, segregated by animal type (e.g. ruminants, small ruminants, etc.), age, breed, sex, body weight and other management practices (e.g. stall-fed, grazing or mixed management) under particular agro-climatic conditions were considered. |
| Description of data collection | Crop management data taken from Bangladesh Integrated Household Survey (BIHS) [2]. Location specific analysis of cropping systems and irrigation map developed by Gumma et al. [3]. District-wise crop area: Yearbook of Agricultural Statistics 2015 [4]. Livestock data: Bangladesh Bureau of Statistics, 2010 [5], expert surveys, 2019 Soil data: database compiled for pedo-transfer function validation, 2017 [6] Climatic region and specific climate categories identification: Analysis of 30 years of climate data from the Bangladesh Meteorological Department and those reported by Maclean et al. [7] and Yan et al. [8]. Greenhouse gas emissions for baseline, business-as-usual and mitigation scenarios were estimated using CCAFS’ Mitigation Options Tool (CCAFS-MOT) [9] for crops and using the approach developed by Herrero et al. [10]. Mitigation potential was determined as difference in emissions between business-as-usual scenario and mitigation scenario for respective years. |
| Data source location | Spatially explicit data on crop and livestock segregated by crop/livestock types and management practices together with associated soil and climatic information is available for the whole country (Bangladesh). |
| Data accessibility | https://data.mendeley.com/datasets/cnwsb8hdn/1[11] |

(continued on next page)
Value of the Data

- The dataset is useful for bottom-up and data-driven approaches to GHG accounting from agricultural activities in Bangladesh.
- The database is a valuable source of information for Bangladesh’s national GHG inventory and to update the country’s nationally determined contributions (NDC) and monitor progress against NDC targets.
- Spatially explicit data on GHG emissions segregated by each crop and livestock types together with their mitigation potential will be helpful for government of Bangladesh to better prioritize their mitigation work in ways consistent with food production goals.
- Bangladesh can make use of the data to demonstrate the mitigation potential of various technological and agricultural management options to better negotiate for the environmental services, for example the Green Climate Fund or other mitigation funds.
- Jurisdiction-wise emissions and mitigation potential by crops/livestock can help in the design of agricultural research and development interventions at administrative levels consistent with food production and environmental goals.
- The database will be useful to research for development communities in the area of agriculture, environment and natural resources management.

1. Data Description

The crop data files i.e. “Crop_Baseline_2014–15.csv”, “Crop_BAU2030.csv”, “Crop_BAU2050.csv”, “Crop_MITI2030.csv” and “Crop_MITI2050.csv” contains location-specific information on greenhouse gases (CO₂, CH₄ and N₂O) emissions and global warming potential estimated using CCAFS-MOT [9] for base-year (2014–15 crop year), business-as-usual (BAU) scenario 2030, BAU 2050, mitigation scenario 2030 and mitigation scenario 2050, respectively. The corresponding location-specific information on crop management, soil and climatic conditions as well as management practices are given in supplementary data S1 (Input_data_crop) of associated manuscript [1]. Units of input and output variables are indicated in variable names and they are introduced briefly in “metadata.csv”. No emission values in some cases (i.e. blank columns) are due to non-application of the associated production inputs/practices.

The livestock data file i.e. “Livestock.csv” contains input and output data related to livestock production. This data file contains information on livestock numbers at district level segregated by livestock type, breed, age, sex and management system. It also contains data on GHGs arising from enteric fermentation and manure management, and GHG mitigation potential from various mitigation options, as well as total annual mitigation potential by 2030 and 2050. All the variables in the datafile are explained in detail in “metadata.csv”.

The data files on mitigation potential by options i.e. “Mitigation_options&potential_2030.csv” and “Mitigation_options&potential_2050.csv” contain district-level annual GHG mitigation potential and associated abatement costs for different mitigation options, by 2030 and 2050, respectively. Similarly, data files on mitigation potential by crop/livestock type i.e. “Mitigation_potential_by_crop&livestock_type_2030.csv” and “Mitigation_potential_by_crop&livestock_type_2050.csv” contain district-level annual GHG mitigation potential segregated by crop and livestock categories together with their 95% margin of error. These files also contains crop,
livestock and crop-livestock total annual mitigation potential by administrative district. All the variables in these datafiles are also explained in detail in “metadata.csv”.

2. Experimental Design, Materials and Methods

Analytical framework starting from data sources to estimation of emissions for base-year, business-as-usual scenarios (2030 and 2050) as well as mitigation scenarios (2030 and 2050) and determination of mitigation potential for short-term (2030) and long-term (2050) is explained in detail in the related manuscript [1]. Briefly, we obtained crop management information from the “Bangladesh Integrated Household Survey” (BIHS) [2] and livestock related information from the Bangladesh Bureau of Statistics, 2010 [5]. We took plot-specific soil information from a database compiled for pedo-transfer function validation of Bangladesh soil, 2017 [6]. We determined rice water management by analyzing the rice irrigation maps developed by Gumma et al. [3]. Finally, we performed a telephonic survey of farmers and owners of farm tractors and irrigation pumps to gather information about crop residue management and fuel consumption per tillage or irrigation event. The proportion of these animals by breed, age, sex, body weight, feed consumption and livestock management system (i.e. stall feeding, grazing or mixed management system) were determined through expert opinion. The district-wise area under each of the eight crop types by season in 2014–15 were obtained from Yearbook of Agricultural Statistics 2015 [4]. Greenhouse gas emissions for baseline, business-as-usual and mitigation scenarios were estimated using CCAFS’ Mitigation Options Tool (CCAFS-MOT) [9] for crops and using the approach developed by Herrero et al. [10] for livestock. Mitigation potential was determined as difference in emissions between business-as-usual scenario and mitigation scenario for respective years.

Ethics Statement

Data compiled in this database were gathered from various sources available publicly and these sources are properly acknowledged. See the “Specification Table” and the “Experimental Design, Material & Methods” section for details of data sources and source citations. Telephonic surveys were conducted with the proper consent of the respondents. Following statements i.e. “This study is conducted anonymously. You will only be identified through code numbers. Your identity will not be stored with other information we collect about you. Your responses will be assigned a code number, and the list connecting your name with this number will be kept in a locked room and will be destroyed once all the data has been collected and analysed. Any information we obtain from you during the research will be kept strictly confidential” were read before start of the telephonic interviews and respondents were informed that they are free to withdraw their consent and discontinue participation in this study at any time.

CRediT Author Statement

Tek B. Sapkota: Conceptualization, Methodology, Supervision, Investigation, Formal analysis, Writing – reviewing & editing; Fahmida Khanam: Investigation, Data curation, Writing – reviewing & editing; Gokul Prasad Mathivanan: Investigation, Formal analysis, Writing – reviewing & editing; Sylvia Vetter: Investigation, Formal analysis, Writing – reviewing & editing; Sk. Ghulam Hussain: Investigation, Data curation, Writing – reviewing & editing; Anne-Laure Pilat: Writing – reviewing & editing, Investigation, Data curation; Sumona Shahrin: Investigation, Data curation; Md. Khaled Hossain: Investigation, Data curation, Data Analysis, Writing – reviewing & editing, Nathu Ram Sarker: Writing – reviewing & editing; Timothy J. Krupnik: Conceptualization, Methodology, Supervision, Writing – reviewing & editing.
Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

Acknowledgments

The International Maize and Wheat Improvement Center (CIMMYT) carried out this work with support of the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) and the Climate Services for Resilient Development (CSRD; https://ccafs.cgiar.org/research/projects/climate-services-resilient-development-south-asia) for South Asia project supported by USAID. This work was also supported by the USAID and Bill and Melinda Gates Foundation (BMGF) supported Cereal Systems Initiative for South Asia (CSISA; https://csisa.org) CCAFS’ work is supported by CGIAR Fund Donors and through bilateral funding agreements. For details please visit https://ccafs.cgiar.org/donors. The views expressed in this paper cannot be taken to reflect the official opinions of CCAFS, USAID, or BMGF, and shall not be used for advertising.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107225.

References

[1] T.B. Sapkota, F. Khanam, G. Prasad, S. Vetter, S. Ghulam, A. Pilat, S. Shahrin, K. Hossain, N. Ram, T.J. Krupnik, Quantifying opportunities for greenhouse gas emissions mitigation using big data from smallholder and livestock farmers across Bangladesh, Sci. Total Environ. 786 (2021) 147344, doi:10.1016/j.scitotenv.2021.147344.
[2] IFPRI, Bangladesh Integrated Household Survey (BIHS) 2015, IFPRI Dataverse, 2015 https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BXSYEL.
[3] M.K. Gumma, P.S. Thenkabail, A. Maunahan, S. Islam, A. Nelson, Mapping seasonal rice cropland extent and area in the high cropping intensity environment of Bangladesh using MODIS 500m data for the year 2010, ISPRS J. Photogramm. Remote Sens. 91 (2014) 98–113, doi:10.1016/j.isprsjprs.2014.02.007.
[4] BBS, Yearbook of Agricultural Statistics-2015, 27th Series, Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, Dhaka, Government of the People’s Republic of Bangladesh, 2016, pp. 52–167 http://203.112.218.65:8008/WebTestApplication/userfiles/Image/LatestReports/Yearbook_2015.pdf.
[5] BBS, Census of Agriculture 2008. Structure of Agricultural Holdings and Livestock Population, Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, Dhaka, Government of the People’s Republic of Bangladesh, 2010, pp. 127–465 http://www.fao.org/fileadmin/templates/ess/ess_test_folder/World_Census_Agriculture/Country_info_2010/Reports/Reports_3/BGD_ENG_REP_2008.pdf.
[6] M.H.K. Shiragi, M.M. Rahman, M.M.U. Miah, S. Akhta, Pedotransfer function of bangladesh soils. annex xi: second annual progress report of the project on modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh., 2017.
[7] J.L. Maclean, D.C. Dawe, B. Hardy, G.P. Hettel, Rice Almanac: Source book For The Most Important Economic Activity On Earth, CABI Publishing, Wallingford, UK, 2002.
[8] X. Yan, K. Yagi, H. Akiyama, H. Akimoto, Statistical analysis of the major variables controlling methane emission from rice fields, Glob. Chang. Biol. 11 (2005) 1131–1141, doi:10.1111/j.1365-2486.2005.00976.x.
[9] D. Feliciano, D.R. Nayak, S.H. Vetter, J. Hillier, CCAFS-MOT-A tool for farmers, extension services and policy-advisors to identify mitigation options for agriculture, Agric. Syst. 154 (2017) 100–111, doi:10.1016/j.agsy.2017.03.006.
[10] M. Herrero, P. Havlík, H. Valin, A. Notenbaert, M.C. Rufino, P.K. Thornton, M. Blümmel, F. Weiss, D. Grace, M. Obersteiner, P. Havlík, H. Valin, A. Notenbaert, M.C. Rufino, P.K. Thornton, M. Blümmel, F. Weiss, D. Grace, M. Obersteiner, Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems, Proc. Natl. Acad. Sci. USA 110 (2013) 20888–20893, doi:10.1073/pnas.1308149110.
[11] T.B. Sapkota, F. Khanam, G.P. Mathivanan, S. Vetter, S.G. Hussain, A.L. Pilat, S. Shahrin, M.K. Hossain, N.R. Sarker, T.J. Krupnik, Spatially explicit database on crop-livestock management, soil, climate, greenhouse gas emissions and mitigation potential in Bangladesh, Mendel. Data V2 (2021), doi:10.17632/cnwdsh8hdm.2.