ARTICLE IN PRESS

Global Food Security ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs

Improved global cropland data as an essential ingredient for food security

Linda See [a,*], Steffen Fritz [a], Liangzhi You [b,i], Navin Ramankutty [c], Mario Herrero [d], Chris Justice [e], Inbal Becker-Reshef [e], Philip Thornton [f], Karlheinz Erb [g], Peng Gong [h], Huajun Tang [i], Marijn van der Velde [a], Polly Ericksen [f], Ian McCallum [a], Florian Kraxner [a], Michael Obersteiner [a]

[a] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria
[b] International Food Policy Research Institute (IFPRI), Washington DC, USA
[c] The University of British Columbia, Vancouver, Canada
[d] Commonwealth Scientific and Industrial Research Organisation (CSIRO), St. Lucia, QLD, Australia
[e] University of Maryland, College Park, MD, USA
[f] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), International Livestock Research Institute (ILRI), Nairobi, Kenya
[g] Institute of Social Ecology, Vienna; Alpen-Adria-University Klagenfurt, Graz, Austria
[h] University of California, Berkeley, USA; Tsinghua University, Beijing, China
[i] Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, China

ARTICLE INFO

Article history:
Received 8 June 2014
Received in revised form
30 September 2014
Accepted 3 October 2014

Keywords:
Cropland
Land cover
Food security
Crowdsourcing
Data sharing

ABSTRACT

Lack of accurate maps on the extent of global cropland, and particularly the spatial distribution of major crop types, hampers policy and strategic investment and could potentially impede efforts to improve food security in an environment characterized by continued market volatility and a changing climate. Here we discuss the pressing need for the provision of spatially explicit cropland datasets at a global scale and review the strengths and weaknesses of the various approaches used to develop such data.

© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-SA license (http://creativecommons.org/licenses/by-nc-sa/3.0/).

1. Introduction

Ensuring food security from land that is increasingly under pressure is a key challenge of this century. By 2050 the global population will exceed 9 billion (Roberts, 2011), and with the growing wealth of populous low- and middle-income countries, a 60% to 70% increase in annual agricultural output is required (FAO, 2009; Alexandratos and Bruinsma, 2012), a rise unprecedented in human history.

Food security is monitored in near-real time by different organizations and initiatives at the international, regional and national scale, e.g. the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative at the global level and by the agricultural departments of many countries. Along with other sources of information, such as road networks and market prices, forecasts of crop production are needed in order to anticipate production shortfalls. Production is estimated from yield and cropland area, which are often obtained through interviews with farmers or from agricultural surveys, where both methods have problems, e.g. area can simply be estimated as a difference from the previous year, leading to biases over time (Jayne and Rashid, 2010). At a national level, cropland area and yield are needed in order to make decisions about how much food is to be stored, distributed or exported and to make an assessment of food losses along the food supply chain. Hence, wrong trade decisions can lead to unwanted price fluctuations and food shortages. Jayne and Rashid (2010) provide a hypothetical example of how overestimating production by 13% and underestimating consumption by 8% can lead to a potentially disastrous shortfall in food of 21%, which could then lead to sharp rises in food prices if no food aid or trade was present in this situation. The authors then provide a real life example of how overestimates in maize

* Corresponding author.
E-mail address: see@iiasa.ac.at (L. See).

http://dx.doi.org/10.1016/j.gfs.2014.10.004
2211-9124/© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-SA license (http://creativecommons.org/licenses/by-nc-sa/3.0/).

Please cite this article as: See, L., et al., Improved global cropland data as an essential ingredient for food security. Global Food Security (2014), http://dx.doi.org/10.1016/j.gfs.2014.10.004

surpluses reported in Malawi in 2007 led to maize prizes reaching record highs when that forecasted surplus failed to materialize.

At the global level, detailed crop yield and crop extent information can help to identify where investment from large donors might be most effective in terms of boosting agricultural output. At the regional level, this information can be used to help understand the impact of drought and other natural and manmade disasters on food production (Funk and Brown, 2009). At a national and sub-national level, accurate information on cropland can be used to measure trends in agricultural outputs and to evaluate if investments have led to the expected results.

More accurate cropland data are also required to address the multi-dimensional challenges related to global environmental change. To meet the growing demand for food in the future, agricultural land will either expand or production will be intensified in areas where there are current yield gaps or through new innovations. There are environmental impacts and tradeoffs associated with both of these pathways that need to be better understood if the effects are to be minimized (Tilman et al., 2011). Nevertheless, it is generally argued that large expansions of existing cropland are more disadvantageous than intensification, and it is essential to know where and how to increase crop yield on existing cropland areas (Foley et al., 2005; Tilman et al., 2002; Van Wart et al., 2013). Therefore, having accurate data on current cropland extent is critical for undertaking these types of analyses. However, the uncertainties in the available datasets on cropland are currently too high for use in many applications. A recent study showed that current global estimates of the amount of land under crop production vary by 300 Mha, i.e. around 1600 Mha from one global land cover product compared to around 1300 Mha from another (Fritz et al., 2011a). This variation introduces uncertainties in considering how other important drivers of change in agricultural systems, such as biofuel production, rising demand for livestock products, and expanding urban areas, might affect food production. The issue is aptly illustrated in a recent study by Smith et al. (2010), who compared the outputs from a number of integrated assessment models regarding the global change in cropland area as well as other land-use types in 2020 and 2050 under numerous drivers of change. Many of the predictions of cropland change from these models are within the 300 Mha range of uncertainty regarding total cropland area estimates from global land cover maps, some of which are used as inputs to these models. Other studies have shown that model outputs and analyses can vary substantially depending upon which land cover product has been used (Ge et al., 2007; Linard et al., 2010; Quaife et al., 2008). Examples such as these illustrate the need for an improved global spatially explicit cropland map, which is useful at multiple scales from global monitoring and assessment to planning at the national and sub-national levels.

This paper reviews current and emerging approaches for developing global cropland maps including an overview of their strengths and weaknesses. These include a range of options such as the use of satellite imagery, agricultural census and survey statistics, the incorporation of crowdsourcing approaches as well as hybrid methods. We further discuss the need to harmonize definitions of cropland, share data more openly and target new mapping efforts, which could yield substantial benefits for improving food security in the future.

2. Current and emerging approaches for developing global cropland maps

With the recognition that global land use and land cover change is a major driver of global environmental change (Foley et al., 2005), there have been numerous efforts to map land cover and its change globally. We have characterized these into five distinct approaches, where each produces different types of cropland extent information at varying spatial resolutions as outlined in Table 1. We also recognize that these approaches have strengths and limitations and have compared them based on whether they are consistent with FAO statistics, their relative costs, the accuracy of the products, the temporal frequency of production and updating, and any other issues related to these approaches; these are summarized in Table 2 and discussed in the sections that follow.

2.1. Global agricultural census- and survey-based statistics

A frequently used, standard, globally-complete, source of information on cropland extent is the Food and Agriculture Organization's (FAO) compilation of statistics reported by individual countries, which are based on censuses, agricultural samples and questionnaire-based surveys with major agricultural producers (FAO, 1996). These data are publicly available from the FAOSTAT database (http://faostat.fao.org/) from 1961 onward and are reported at the national level. They are frequently updated, often with revisions to the entire time-series. At their best, these data are based on comprehensive agricultural censuses conducted every 5 years and in some countries with conflicts or poor infrastructure, there is a lack of regular censuses. The database reports detailed land cover and land use statistics, and in addition to the extent of cropland, pasture and other land covers, provides land use information such as irrigation extent, fertilizer application rates, and mechanization. Some ongoing efforts aim to compile census and survey based information at the subnational level from individual country statistics/census reports (e.g., The Agro-MAPS project (http://kids.fao.org/agromaps/); Ramankutty et al., 2008; Monfreda et al., 2008). However cropland information at the sub-national scale is even scarcer, plagued by data gaps, and are tedious to compile. Moreover, independent evaluations (FAO, 2006; The World Bank, 2010) have recognized that there are both quality- and quantity-related problems in the agricultural information provided by different reporting countries, particularly those in Africa. Among several pitfalls of relying on national

Table 1
Cropland information that is produced by the five approaches.

Approach	Cropland information produced by the approach
Global agricultural census-and survey-based methods (Section 2.1)	Farm census or sample-survey estimates, reported at the sub-national level (by individual countries) or national level (reported by FAO)
Satellite-based global land cover classification (Section 2.2)	Global maps of presence/absence of cropland or the percentage cropland at resolutions of 30 m to 1 km. National and regional maps are also produced using satellite-based land cover classification.
Blending census and satellite data (Section 2.3)	Maps of presence/absence of cropland or percentage cropland at resolutions of 1 km to 10 km that are calibrated to FAO statistics and other agricultural census data
Use of crowdsourced data (Section 2.4)	Samples of varying resolutions (250 m to 1 km) of percentage cropland (or presence/absence of cropland) which can then be interpolated to create maps of cropland at a resolution that matches the sample size, e.g. 1 km
Synergy map that blends remote sensing, crowdsourcing and census (Section 2.5)	Similar approach to blending the census and satellite data except that existing maps (global, regional and national) are integrated to produce a hybrid product. The input maps are ranked based on correspondence with data collected from crowdsourcing of high resolution imagery.

Please cite this article as: See, L., et al., Improved global cropland data as an essential ingredient for food security. Global Food Security (2014), http://dx.doi.org/10.1016/j.gfs.2014.10.004

Download English Version:

https://daneshyari.com/en/article/7454788

Download Persian Version:

https://daneshyari.com/article/7454788

Daneshyari.com