Annex I: Methods and Materials

Food supplies and production data

We analyzed the full set of food crop commodities included in food supplies and production data provided by FAO[25] [for food supplies: calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day); for production systems: production quantity (tonnes), harvested area (ha), and gross production value (million US$)]. National food supply from plants represents national production plus imports plus or minus stock changes over the survey period; minus exports, quantities used for seed, animal feed, and in the manufacture of non-food products, and losses during storage and transport.[2] While food supplies data accounts only for direct human consumption, production data for crops such as maize and soybean is potentially inclusive of livestock and industrial uses as well as human food. In the production analysis we also included agricultural crops indirectly contributing to human food supplies via livestock production (i.e., alfalfa, clover, and vetch). Non-food (e.g., industrial and fibre) crops as well as animal product commodities were not included in the analysis. Plant commodities comprised of the same crop species were aggregated into single commodities representing the crop, e.g., sesame seed oil and sesame seed. After aggregation, 53 crop commodities remained in food supplies data, and 132 crop commodities in production data (Supplementary Table 6). See Table S1 of Khoury *et al.* (2014)[2] for a comprehensive listing of the crop species included in the commodities treated in food supplies data.

For current food supplies and production systems, we analyzed data for each crop commodity per country per measurement over the most recent three years for which sufficient data were available (2009-2011). All (177) countries consistently reported during the time period were included for food supplies variables, as well as for production quantity and harvested area (Supplementary Table 7), covering 98.5% of the world's population. All (141) countries reported for (current million US$) production value were included, covering 94.1% of the world's population.[25]

For the analysis of change in dependence over time, food supplies data were assessed for each year from 1961-2009, and production systems from 1961-2011, utilizing the full set of commodity and country listings, standardized across all years. In order to align all time periods and include as much of the world's population as possible, the current countries formerly comprising the USSR, Yugoslav SFR, Ethiopia PDR, and Czechoslovakia were aggregated into their former countries, with national data summed per year for production measurements, and merged by weighted average based upon the population of the respective states during the respective reporting year for per capita food supplies measurements. Belgium and Luxembourg were reported together during 1961-1999 and therefore recent years listing the countries separately were merged as above. Countries that did not have estimates in every year between 1961 and 2009/2011 were removed from the analysis. The resulting 152 comparable countries treated in food supplies data comprised 98% of the world's population across the study period.[2] The 182 comparable countries covered in production quantity and harvested area data comprised 99.7% of the global population, and the 115 countries covered in (constant 2004-2006 million US$) production value data covered 88.5% (Supplementary Table 7).

Primary regions of diversity of crops

Primary regions of diversity were assigned based upon primary and secondary literature regarding centres of crop diversity, origins of crop domestication, and high species richness of closely related wild plants.[1,16-21,57-60] Regional classifications followed those listed in Annex 2 of the FAO State of the World's Plant Genetic Resources for Food and Agriculture,[30] modified to more accurately represent eco-geographic parameters driving plant species distributions. Specifically, both western and eastern Europe were split into north and south regions to account for temperate versus Mediterranean ecologies; Australia and New Zealand were segregated from remaining (tropical) islands of the Pacific region; and South America was split into Andean, temperate, and tropical regions. A total of 23 eco-geographic regions were delineated (Supplementary Figure 7). Countries whose boundaries included more than one eco-geographic region were included in all appropriate regions in order to be as inclusive as possible and thus avoid overestimations of dependence (e.g., Colombia was assigned both to Andean and to tropical South American regions) (Supplementary Table 7).

Crops whose primary areas of diversity encompassed more than one eco-geographic region were listed in all appropriate regions (e.g., wheat was listed in Central Asia, West Asia, and the South and East Mediterranean). Forty-two of the 53 crop commodities treated in food supplies data, and 116 of the 132 crops in production data, were assignable to primary regions of diversity, with the remaining general commodities which were not clearly attributable to specific crop species listed as "not specified" (Supplementary Table 6).

We constructed circular plots displaying the relative importance of primary regions of diversity as sources of crops comprising current (2009-2011 average) national food supplies and production systems, using methods and code adapted from Abel and Sander (2014).[61] For recipient data, regional food supply values (kcal or g, /capita/day) were formed per variable by deriving a weighted average across countries comprising each region, with national values weighted by population. Regional production values were calculated by summing values across countries comprising each region for each variable.

Dependence on "foreign" primary regions of diversity

We estimated the degree to which a country's food supplies and production systems are dependent upon crops of "foreign" primary regions of diversity by determining the extent to which such supplies/systems are composed of crops whose primary regions of diversity do not coincide with the regions within which that country is located (see Supplementary Table 8 as an example for Colombia). The method was initiated with the assumption that crops within a given country's food supplies/production systems were completely "foreign" (100% dependence). The percent contribution of all crops whose primary regions of diversity were identified as in the same region as the country was then subtracted to estimate a "maximum dependence" metric per country (Equation 1) [modified from Flores-Palacios (1998)].[1] In this metric, those general crop commodities whose regions could not be specified were assumed to be of "foreign" primary regions of crop diversity.

Supplementary Table 8. Food supply of Colombia as measured in calories (kcal/capita/day) (2009-2011 average), with primary regions of diversity of contributing crops.

COMMODITY	CALORIES (KCAL/ CAPITA/ DAY)	% OF TOTAL	PRIMARY REGIONS OF DIVERSITY	ASSIGNMENT
SUGAR	347.7	16.7%	South Asia, Southeast Asia, Europe, South and East Mediterranean	Foreign
RICE	296.7	14.3%	East Asia, South Asia, Southeast Asia, Central Africa, West Africa	Foreign
MAIZE	258.7	12.5%	Central America and Mexico	Foreign
WHEAT	235.0	11.3%	Central Asia, West Asia, South and East Mediterranean	Foreign
PALM OIL	228.0	11.0%	Central Africa, West Africa, Central America and Mexico, Tropical South America	Native
SOYBEAN	136.3	6.6%	East Asia	Foreign
BANANAS & PLANTAINS	127.7	6.1%	South Asia, Southeast Asia	Foreign
CASSAVA	91.0	4.4%	Tropical South America, Central America and Mexico	Native
POTATOES	60.7	2.9%	Andean South America	Native
BARLEY	48.3	2.3%	Central Asia, West Asia, South and East Mediterranean	Foreign
FRUITS, OTHER	32.0	1.5%	Not specified	Not specified
BEANS	30.3	1.5%	Central America and Mexico, Andean South America	Native
BEVERAGES, ALCOHOLIC	19.0	0.9%	Not specified	Not specified
YAMS	17.3	0.8%	West Africa, South Asia, Southeast Asia	Foreign
PEAS	16.0	0.8%	East Africa, West Asia, Southern Europe, South and East Mediterranean	Foreign
PULSES, OTHER	16.0	0.8%	Africa, South Asia, West Asia, South and East Mediterranean	Foreign
VEGETABLES, OTHER	13.3	0.6%	Not specified	Not specified
SUNFLOWER	12.0	0.6%	North America	Foreign
CITRUS, OTHER	11.3	0.5%	Not specified	Not specified
ONIONS	10.3	0.5%	Central Asia, West Asia	Foreign
COCONUTS	7.7	0.4%	South Asia, Southeast Asia, Tropical Pacific region	Foreign
TOMATOES	7.3	0.4%	Andean South America	Native
ORANGES & MANDARINS	6.0	0.3%	East Asia	Foreign
PINEAPPLES	6.0	0.3%	Tropical South America	Native
RAPE & MUSTARD	5.3	0.3%	Southern Europe, South and East Mediterranean	Foreign
COCOA BEANS	5.0	0.2%	Central America and Mexico, Tropical South America	Native
COTTONSEED OIL	4.3	0.2%	East Africa, Southern Africa, Caribbean, Central America and Mexico, Tropical South America	Native
GROUNDNUT	4.0	0.2%	Tropical South America	Native
SPICES, OTHER	4.0	0.2%	Not specified	Not specified
GRAPES	3.3	0.2%	North America, East Asia, West Asia, South and East Mediterranean	Foreign
ROOTS, OTHER	3.0	0.1%	Caribbean, Central America and Mexico, Tropical South America, South Asia, Southeast Asia, Tropical Pacific region	Native
APPLES	2.7	0.1%	Central Asia, East Asia, Europe	Foreign
SWEETENERS, OTHER	2.0	0.1%	Not specified	Not specified
COFFEE	1.3	0.1%	Central Africa, East Africa, West Africa	Foreign
MISCELLANEOUS	1.3	0.1%	Not specified	Not specified
OLIVES	1.3	0.1%	East Africa, West Asia, Southern Europe, South and East Mediterranean	Foreign
LEMONS & LIMES	1	0.0%	East Asia, South Asia	Foreign
OATS	1	0.0%	Northern Europe	Foreign
SESAME	1	0.0%	East Africa, South Asia, West Asia	Foreign
TREENUTS	1	0.0%	Not specified	Not specified

Equation 1: Metric of maximum dependence = 100% - Σ% crops for which the country forms part of a primary region of diversity

The sum of the percent contribution of these non-specified general crop commodities was then subtracted, resulting in a "minimum dependence" metric which assumes that all non-specified crop commodities possess primary regions of diversity within the same region as the country (Equation 2).

Equation 2: Metric of minimum dependence = 100% - Σ% crops for which the country forms part of a primary region of diversity - Σ% crop commodities not specified to regions

Mean dependence in food supplies and production systems per country was estimated using an interval censoring method, where the response variable (the calculated dependence value in each country in each year) was bounded between the minimum and maximum dependence estimates for each observation. A model of this type allows the uncertainty around an observation to be incorporated into the parameter estimates for the parameter of interest. For estimates of current dependence, we modelled the mean of the most recent three years (2009-2011). For estimates of change in dependence from 1961-2009/2011, intercepts and slopes per country were modelled as random effects, where the mean hyper-parameter for the random slopes represented the estimated slope (change in dependence over time) across all countries. We allowed a correlation between country-level intercepts and slopes to account for the fact that countries with high dependence have weaker dependence-time relationships than countries with low dependence.[62] The interval-censored models were implemented using a Bayesian framework in JAGS (v. 3.4.0) called from R (v.3.1.1), using the packages rjags and R2jags. Non-informative ("flat") priors were used for all coefficients. Convergence was assessed using the Gelman-Rubin diagnostic[63] and by visual inspection of trace plots. Dependency values reported in the text represent the model-estimated coefficient, ± the standard deviation. Credible intervals for each parameter are reported in Supplementary Tables 2-4.

We used Simpson's diversity index to correlate the degree of contributing crop diversity in current (2009-2011 mean) national food supplies/production systems with dependence on crops of "foreign" primary regions of diversity under the same time period. The diversity-dependence relationship was modelled using a simple linear model with both linear and quadratic terms, using the vegan package in R (v. 3.1.1). We also correlated dependence with national Gross Domestic Product (GDP) per capita purchasing power parity, using a mean GDP value across 2009-2011 for 169 available countries.[64]

Importance of food crops

Crops were assigned importance individually for each food supplies and production systems variable into 10% quantiles, from 1 (low importance) to 10 (high importance), based upon their global aggregate (food supplies) and total global production values. A combined assessment was performed on (136) unique crop commodities covered in food supplies and production systems data (Supplementary Table 5). Thirty-seven of these commodities possessed both food supplies and production systems data and were directly compared. An additional 92 crop commodities with production systems values were embedded within 12 general commodities in food supplies data (i.e., cereals, other; fruits, other; oilcrops, other; oranges & mandarins; pulses, other; rape & mustard; roots, other; spices, other; sugar; tea; treenuts; and vegetables, other). Food supplies values for most of the individual commodities were estimated by dividing their total general commodity values equally across listed crops. For the sugar commodity, sugarcane was assigned 70% and sugar beet 30% of the total value; for the tea commodity, tea [*Camellia sinensis* (L.) Kuntze] was assigned 80%, mate 10%, and "not elsewhere specified" (nes) tea 10%. Three additional production systems crop commodities (alfalfa, clover, and vetches), which are livestock feed/forage crops and therefore are not recorded in food supplies data, were assessed through quantile values derived solely from production systems variables. Four general food supplies commodities (beverages, alcoholic; beverages, fermented; miscellaneous; and sweeteners, other) were not recorded in production systems variables, thus these commodities were assessed through quantile values derived solely from food supplies variables. Coverage of each crop in the MLS, i.e., Annex 1 of the Plant Treaty was assessed, listing crops as covered, partially covered (often in the case of general crop commodities, in which some portion of the crops within the commodity are covered in the MLS and others not), or not covered. The extent of geographic importance of crops was additionally documented by counting the number of countries listing each commodity (>0) for each variable, as well as listing the plant commodities by decreasing importance until the total contribution equaled 90% of each country's food supply/ production for each variable, a threshold which is inclusive of major contributors to supply/ production systems and exclusive of commodities contributing very small quantities.[2,65] The total count of countries including each crop commodity as important was then derived per crop commodity (Supplementary Table 5).

Data limitations and uncertainties

In this analysis we included all pertinent available variables for both food supplies and production systems that permit a globally comparable evaluation across countries. This said, a number of constraints to the data exist. First, food supply data is not directly equivalent to consumption, as food losses at the household level are not measured. The aggregation of numerous crops into several general commodities particularly in food supplies data, constrains the ability to assign all crop commodities to primary regions of diversity and thus to derive more specific dependence estimates without substantial degrees of uncertainty (i.e., between minimum and maximum dependence). In addition, such aggregation causes uncertainty within a number of crop commodities that are associated to regions, e.g., sugar in food supplies data, which may contain both sugarcane and sugar beet. Although both these crops may be associated to primary regions of diversity, the accurate assignment of dependence of any particular country's food supply in regard to the contribution of sugar is limited by the inability to disaggregate the specific contribution of each of these crops within the commodity. The assignment of crops and countries to regions also results in a degree of generalization due to the lack of accounting for natural variation within such regions. Iceland, for instance, was counted within north Western Europe, but the crops of primary diversity within this region are largely not indigenous to that island nation.

The range of crops covered in this analysis is not fully inclusive of all foodstuffs produced and consumed in national food systems, and thus an underestimation and/or overgeneralization of diversity is assumed, particularly in regard to plants primarily encountered in home gardens and local markets, seasonally important foods, and culinary herbs, spices and other crops consumed in relatively small quantities.[2,65] Although accounting for food weight, which may indirectly elucidate the importance of crops for essential nutrients other than calories, protein, and fat, food supply data does not specifically report statistics in regard to micronutrients, where a larger number crops contributing relatively small quantities individually may be of particular importance.[66]

In sum, the aggregation of some crop commodities, the generality of the defined eco-geographic regions, uncertainty for some crops as to their primary regions of diversity, and the subjective nature of the boundaries of such regions, lead to a degree of uncertainty in dependence metrics. Acknowledging these limitations, the results are a very strong indication of the extent of globalization of food systems and the resulting interdependence among nations on plant genetic resources. We also note that production data, which included a much more comprehensive list of crop commodities than food supplies data, resulted in equivalently high dependence values globally.