# Joint environmental and social benefits from diversified agriculture

**Authors:**
Laura Vang Rasmussen*[1], Ingo Grass*[2,3], Zia Mehrabi[4], Olivia M. Smith[5,6], Rachel Bezner-Kerr[7], Jennifer Blesh[8], Lucas Alejandro Garibaldi[9,10], Marney E. Isaac[11], Christina M. Kennedy[12], Hannah Wittman[13], Péter Batáry[14], Damayanti Buchori[15], Rolando Cerda[16], Julián Chará[17], David Crowder[18], Kevin Darras[19], Kathryn DeMaster[20], Karina Garcia[21], Manuel Gómez[22], David Gonthier[21], Purnama Hidayat[23], Juliana Hipólito[24], Mark Hirons[25], Lesli Hoey[26], Dana James[27,28], Innocensia John[29], Andrew D. Jones[30], Daniel S. Karp[31], Yodit Kebede[32], Carmen Bezner Kerr[33], Susanna Klassen[27,28], Martyna Kotowska[34], Holger Kreft[35], Ramiro Llanque[36], Christian Levers[27,37,38], Diego J. Lizcano[39], Adrian Lu[20], Sidney Madsen[13], Rosebelly Nunes Marques[40], Pedro Buss Martins[40], America Melo[39], Hanson Nyantakyi-Frimpong[41], Elissa M. Olimpi[42], Jeb P. Owen[18], Heiber Pantevez[22], Matin Qaim[43], Sarah Redlich[44], Christoph Scherber[45,46], Amber R. Sciligo[47], Sieglinde Snapp[48], William E. Snyder[49], Ingolf Steffan-Dewenter[44], Anne Elise Stratton[26], Joseph M. Taylor[49], Teja Tscharntke[50], Vivian Valencia[51,52], Cassandra Vogel[44,53], Claire Kremen[54]

* These authors contributed equally to this work

**Affiliations:**
[1] Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark.
[2] Department of Ecology of Tropical Agricultural Systems, University of Hohenheim, Stuttgart, Germany
[3] Center for Biodiversity and Integrative Taxonomy (KomBioTa), University of Hohenheim, Stuttgart, Germany
[4] Department of Environmental Studies, Better Planet Laboratory, and Mortenson Center for Global Engineering and Resilience, University of Colorado Boulder, Colorado, USA
[5] Center for Global Change and Earth Observations, Michigan State University, East Lansing, Michigan, USA
[6] Ecology, Evolution, and Behavior Program, Michigan State University, East Lansing, Michigan, USA
[7] Department of Global Development, Cornell University, Ithaca, New York, USA
[8] School for Environment and Sustainability, University of Michigan, Ann Arbor, Michigan, USA
[9] Universidad Nacional de Río Negro, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, Río Negro, Argentina.
[10] Consejo Nacional de Investigaciones Científicas y Técnicas, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, Río Negro, Argentina.
[11] Department of Physical and Environmental Sciences and Department of Global Development Studies, University of Toronto, Toronto, Canada
[12] Global Science, The Nature Conservancy, Fort Collins, Colorado, USA
[13] Centre for Sustainable Food Systems and Institute of Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada
[14] "Lendület" Landscape and Conservation Ecology, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary

[15] Department of Plant Protection, Bogor Agricultural University, Jalan Kamper, Kampus Darmaga, Bogor 16680, Indonesia
[16] CATIE - Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
[17] Center for Research on Sustainable Agricultural Systems (CIPAV), Cali, Colombia
[18] Department of Entomology, Washington State University, Pullman, Washington, USA
[19] EFNO, INRAE, Nogent-sur-Vernisson 45290, France
[20] Department of Environmental Science, Policy, and Management, University of California, Berkeley 94720, USA
[21] Department of Entomology, University of Kentucky, Lexington, Kentucky, USA
[22] Federación Colombiana de Ganaderos (FEDEGAN), Bogotá, Columbia
[23] Department of Plant Protection, IPB University, Bogor, Indonesia
[24] Federal University of Bahia (UFBA), Biology Institute, Salvador, Brazil
[25] Environmental Change Institute, School of Geography and the Environment, University of Oxford, UK
[26] Urban and Regional Planning Program, University of Michigan, Ann Arbor, Michigan, USA
[27] Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada
[28] Centre for Sustainable Food Systems, University of British Columbia, Vancouver, Canada
[29] Department of Agricultural Economics and Business, University of Dar es Salaam, Tanzania
[30] School of Public Health, University of Michigan, Ann Arbor, Michigan, USA
[31] Department of Wildlife, Fish, and Conservation Biology, University of California- Davis, Davis, California, USA
[32] Eco&Sols, Université de Montpellier, IRD, CIRAD, INRAE, Institut Agro, Montpellier, France
[33] University of Toronto, Canada
[34] Department of Plant Ecology and Ecosystems Research, University of Göttingen, Göttingen, Germany
[35] Biodiversity, Macroecology & Biogeography, University of Göttingen, Göttingen, Germany
[36] Consejo de Salud Rural Andino, La Paz, Bolivia
[37] Department of Environmental Geography, Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
[38] Thünen Institute of Biodiversity, Johann Heinrich von Thünen Institute - Federal Research Institute for Rural Areas, Forestry, and Fisheries, Braunschweig, Germany
[39] Latin America North Andes and Central America Region, The Nature Conservancy, Bogota, Columbia
[40] Applied Ecology Graduate Program, “Luiz de Queiroz” College of Agriculture, University of São Paulo, Piracicaba, SP, Brazil
[41] Department of Geography & the Environment, University of Denver, Denver, Colorado USA
[42]Conservation Science Partners, Truckee, California, USA
[43] Center for Development Research (ZEF), University of Bonn, Bonn, Germany
[44] Department of Animal Ecology and Tropical Biology, Biocenter, Julius-Maximilians-University Würzburg, Würzburg, Germany
[45] Leibniz Institute for the Analysis of Biodiversity Change (LIB), Museum Koenig, Centre for Biodiversity Monitoring and Conservation Science, Bonn, Germany
[46] Bonn Institute for Organismic Biology, Faculty of Mathematics and Natural Sciences, University of Bonn, Germany

[47] The Organic Center, Washington D.C., USA
[48] Sustainable Agrifood Systems, International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico
[49] Department of Entomology, University of Georgia, Athens, Georgia, USA
[50] Agroecology, University of Göttingen, Göttingen, Germany
[51] Farming Systems Ecology group, Wageningen University and Research, Wageningen, The Netherlands
[52] Department of Environment, Agriculture and Geography at Bishop's University, Sherbrooke, Canada
[53] Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden
[54] Institute of Resources, Environment and Sustainability, Biodiversity Research Centre and Department of Zoology, University of British Columbia, Vancouver, Canada

**Abstract:** Agricultural simplification continues to expand at the expense of more diverse forms of agriculture. This simplification in the form of, for example, intensively-managed monocultures, poses a risk to keeping the world within safe and just Earth system boundaries. Here, we estimate how agricultural diversification simultaneously affects social and environmental outcomes. Drawing from 24 studies in 11 countries across 2,655 farms, we show how five diversification strategies focusing on livestock, crops, soils, non-crop plantings, and water conservation benefit social (human well-being, yields, food security) and environmental (biodiversity, ecosystem services, reduced environmental externalities) outcomes. We find that applying multiple diversification strategies creates more positive outcomes than individual management strategies alone. To realize these benefits, well-designed policies are needed to incentivize adoption of multiple diversification strategies in unison.

**One Sentence Summary:**

Agricultural diversification strategies can achieve win-win outcomes for both social and environmental dimensions.

## MAIN TEXT:

## Background

Simplification of farming systems continues to grow at the expense of more diversified agriculture, contributing to the crossing of planetary boundaries through excessive use of chemical inputs, greenhouse gas emissions, biodiversity loss and water use(*1*). To address these challenges, a new paradigm for farming systems is needed that focuses on providing food security and nutrition while minimizing negative environmental, health, and social impacts(*2*). This transformation is particularly pertinent as countries in different stages of economic development navigate through distinct challenges. Economically advantaged nations need to reverse simplification to recover from environmental and social damages done whereas lower income nations need to avoid these externalities in their development transition(*3*). Historically, the architects of the Green Revolution were primarily concerned with breeding crops and developing agronomic inputs to increase staple crop yields and respond to food security needs. Yet, unintended focus of Green Revolution policies to simplify agricultural systems came with large negative environmental impacts, such as pollution, as well as social side-effects such as farmer indebtedness, reduction of peoples' dietary diversity, and reduced resilience(*4,5*). This has led to widespread calls for a change in agricultural development policy that addresses the negative side-effects directly, through the action of biologically diversified farming systems.

Biologically diversified farming systems—those which intentionally increase the number of agricultural and non-agricultural crop and livestock species (and their genetic diversity)—are a promising solution to more sustainable food production because in theory they offer an ecological mechanism for higher resource use efficiency, less pollution, improved food sovereignty, and reduced vulnerability to climate change(*6-8*). Much research has examined the empirical effects of agricultural diversification on environmental outcomes(*9-12*). This research includes recent quantitative syntheses demonstrating positive effects of agricultural diversification on biodiversity and ecosystem services, showing that diversification practices increase yields as often or more often than they decrease them(*11-13*). However, while evidence of environmental benefits of agricultural diversification is accumulating, our knowledge of social outcomes beyond yields is limited to studies focusing on selected dimensions of social sustainability such as income(*14*) or employment but with limited attention to other facets such as social networks(*15,16*). Consequently, broad tradeoffs between social and environmental outcomes from agricultural diversification are poorly understood and largely unquantified(*9,17,18*). To determine whether there are advantages to scaling up diversified agricultural systems(*19*), we need evidence that diversification does not privilege certain outcomes (e.g. non-agricultural biodiversity) at the expense of others (e.g. yields)(*20*). Here, we draw on data from 11 countries to take the next step, building on prior syntheses examining how diversification impacts biodiversity, ecosystem services, and yields(*12-14,21,22*) to include other social outcomes such as food security and human well-being.

## Interdisciplinary and participatory data synthesis

We examined environmental and social outcomes resulting from multiple agricultural diversification strategies, separately and in combination. We focus our assessment on five types of diversification strategies: i) livestock inclusion and diversification (including managed mammals, fowl, bees, and fish), ii) temporal crop diversification (e.g., crop rotation, cover crops), iii) soil conservation and fertility management (e.g., compost application), iv) non-crop plantings (e.g., hedgerows), and v) water conservation (e.g., contour farming). We chose these five diversification strategies (Table S2) inductively to classify the wide array of farming practices represented across the 24 datasets (Table S5) included in our analysis. We consider soil conservation practices, such as compost addition, to represent a diversification strategy if they create habitat conditions that enhance biodiversity or trophic complexity belowground(*23*). Likewise, we consider water conservation practices to represent diversification if they affect plant and microtopographic heterogeneity that influences biodiversity(*24*). We investigated how these five strategies can lead to tradeoffs and/or synergies between targeted environmental (non-agricultural biodiversity, regulating ecosystem services such as crop pollination, reduced environmental externalities or harms) and social (yields, human well-being, and food security) outcomes (Table S1-7, Fig S7-10). Our six environmental and social outcomes each measure unique dimensions of sustainability to account for interconnections and assess the overall sustainability of diversified farming from a systems perspective.

We harmonized 24 datasets covering 2,655 farms and various farming types across five continents, including smallholder farming in rural Africa, plantation crops in Southeast Asia, and both small and large-scale farming in North America, Europe, and Latin America (Fig 1). The harmonized dataset combines individual studies to cover a broad range of farming practices, geographies, and environmental and social contexts to develop a synthesis broadly applicable across multiple farming systems. All 24 datasets measured at least one agricultural diversification practice as well as one environmental and one social outcome, and hence are inherently interdisciplinary (mostly collected by ecologists and social scientists working together and merging their ‘ways of knowing’ and methods). Also, each dataset studied farm sites with varying levels of diversification, including farms without any diversification practices. Unlike data synthesis approaches that extract values from published materials, our data synthesis is based on a participatory, iterative process, including multiple group meetings and exchanges with data contributors during all stages of variable selection, data analysis, and result interpretation. While our sample size of 24 studies would be relatively small for a standard meta-analysis, it is ideal for an approach requiring extensive interaction with data contributors working across disparate geographies and farming systems to confirm and contextualize results. For example, Fig S5 provides an example illustration that we used to confirm and contextualize results with data contributors who worked with Malawian smallholders.

We first tested how agricultural diversification strategies affected each of the six targeted social and environmental outcomes. For each of the five diversification strategies, we identified the number of distinct practices adopted by farmers at the field or farm level that were recorded by each study. For example, non-crop diversification included practices such as windbreaks, flower strips, and hedgerows. Also, we recorded the total number of strategies (maximum of five) and the total number of practices recorded by each study (calculated by summing all practices applied within each strategy). For example, a farm with non-crop diversification in the form of hedgerows and flower strips, in combination with soil conservation through application of green manure and biochar, would score 2 for strategies and 4 for practices (Fig S1 shows examples of coverage of agricultural diversification strategies within farms). We then modeled outcome variables as a function of a) the degree of diversification of each strategy (i.e., the number of practices used within each strategy), b) the total number of diversification strategies used, and c) the total number of diversification practices applied across all strategies (linear mixed-effects models with study IDs as a random effect, see Materials and Methods and Table S12-13).

We also examined the effect of landscape composition on diversification outcomes (Fig S2-4). To this end, we re-fitted the same model set described above but allowed the effects of diversification strategies and practices to differ depending on landscape composition (interaction: diversification×composition). We compared effects of diversification for farms situated in cleared, simple, and complex landscapes, using the amount of seminatural habitat in a 3000 m radius as a measure of landscape complexity (cleared: <5% of natural habitat remaining, simple: 5-20%, complex: >20%)(*25*) (Table S8-10). We note that farmers’ adoption of diversification strategies occurred in our study through choices rather than experimental manipulation (Fig S6), and that this is a synthesis of observed associations on real-world farms, not experimental field trials.

## More diversification strategies or practices are better

We found that applying a higher number of diversification strategies or practices had a greater likelihood of beneficial outcomes than using individual strategies or practices. Specifically, we show that combining five diversification strategies or practices had overwhelmingly strong benefits across outcomes with positive effects especially on non-agricultural biodiversity and food security (Fig 2f-g). Farmers who integrated multiple strategies or practices more likely experienced benefits for non-agricultural biodiversity (effect sizes of 0.19 ± 0.05 and 0.26 ± 0.05 for strategies and practices, respectively), moderate increases in human well-being (number of strategies: 0.07 ± 0.03), and comparatively stronger increases in food security (0.24

± 0.03 and 0.35 ± 0.04 for strategies and practices, respectively). Positive effects of diversification strategies and practices on biodiversity were driven by effects on large, but not small, farms (Table S11-12). This may be due to the availability of stronger contrasts in management intensity between large-scale simplified farms and similar-sized farms that have adopted diversification strategies(*26*). We also found that increases in food security were driven by small farms, which might suggest that new market opportunities could be more beneficial than diversification for food security on large farms(*27*).

We note that all results for non-agricultural biodiversity and regulating ecosystem services should be taken with caution as these outcomes were measured by only 11 and 12 studies, respectively (Table S9). We also note that a potential criticism of the type of analysis we report is that hierarchical models place more weight on studies with more observations. Therefore, we also created a weighting scheme whereby we kept the total evidence constant, but artificially up- or down-weighted studies so that all studies were equally represented in the model fitting. In the equalized model, we observed some difference in results for specific outcomes (e.g. ecosystem services) and diversification strategies (e.g. livestock diversification); however, equalizing the influence of each study did not alter the key finding that multiple diversification strategies and practices maximized benefits across environmental and social outcomes (Fig S9). We interpret the results from both model sets to suggest that different outcomes, tradeoffs, and synergies may be more present in different contexts, but the overall best strategy to maximise environmental and social outcomes is to apply multiple diversification strategies and practices in tandem.

## Maximising win-wins, minimising tradeoffs

We further examined the extent to which the five diversification strategies might promote pairs of environmental and social win-win outcomes, and if so, which strategies are particularly promising for achieving paired benefits. Overall, applying a high number of diversification strategies or practices was associated with more potential for win-win outcomes (Fig 3b-c). Livestock diversification and soil conservation were the two strategies that appeared to consistently elicit multiple positive outcomes (Fig 2a,c), especially win-win outcomes of non-agricultural biodiversity and multiple social outcomes (Fig 3c). Half of the farms in our study practiced some form of livestock integration (14 studies surveyed farms with livestock integration). Livestock diversification had the largest positive effect on food security (0.23 ± 0.03), with the effect being more than 4 times as large as the effect on yields. Livestock diversification promoted non-agricultural biodiversity, but with a lower effect size than for food security (0.16 ± 0.04) (Fig 2a). Soil conservation practices also promoted synergies through gains in all three environmental outcomes, accompanied by enhanced human well-being and food security (Fig 3c). Overall, three of the five assessed agricultural diversification strategies offered potential win–win outcomes regarding food security and non-agricultural biodiversity. Contrarily, many national strategies and programmes focusing on agricultural intensification do not achieve win-wins(*28*).

We also observed tradeoffs. Examples include soil conservation practices leading to gains in biodiversity, but potential yield losses, although the latter were not statistically significant (Fig 2c and 3a-c). For non-crop diversification, we did not observe a consistent positive effect on biodiversity (Fig 2d), potentially driven by divergent responses of taxa. Yet, positive effects on food security can readily arise from such practices: having trees on-farm can support peoples' diets by providing edible products, including fruits, nuts, and leaves(*29-33*). Five of our studies (corresponding to 810 farms) used dietary diversity scores (counting the number of food groups consumed) to proxy dietary quality, a key component of food security – and a metric likely to capture effects of having trees on-farm(*34*). The positive effect of non-crop diversification on food security was pronounced (0.21 ± 0.08), and almost twice the size as the negative effect of non-crop diversification on human well-being (Fig 2d). Explanations for this negative effect include longer crop rotations or the implementation of practices such as hedgerows that could lead to a smaller area planted with cash crops, potentially leading to lower production and higher labor demands. Although we did not detect significant effects of single diversification strategies on ecosystem services, several large meta-analyses have shown strong positive effects of diversification practices on many ecosystems services(*12,13*).

## Role of landscape composition for diversification outcomes

The ‘intermediate landscape complexity hypothesis’ states that agricultural diversification is unlikely to result in improvements in cleared landscapes as the regional species pool available to colonize crop fields and provide ecosystem services is limited(*25*). Similarly, in complex landscapes, diversification may not lead to measurable increases in non-agricultural biodiversity and/or ecosystem services on farms because sufficient alternative resources and habitats are already present in the farm surroundings to support these species and services. Instead, the predicted environmental benefits from agricultural diversification strategies are largest in simple landscapes containing 5-20% of seminatural habitats or non-crop areas(*25*). We tested this hypothesis and found that landscape composition (the proportion of seminatural habitats in a landscape) moderated outcomes of agricultural diversification strategies (Fig 4 and Table S10 for sample sizes). We observed that the number of diversification strategies applied had strong positive effects on food security (Fig 4e) and human well-being (Fig 4d) in cleared landscapes, indicating benefits even in landscapes lacking natural habitat. Yet, we also observed positive effects in complex landscapes. For example, livestock diversification showed the strongest positive effects on human well-being in cleared landscapes (Fig 4d). However, while we found positive social outcomes in cleared landscapes, diversification practices in these landscapes did not result in positive environmental outcomes, which accords with the hypothesis. Finally, we observed that the number of diversification strategies and practices applied had positive effects on biodiversity in both simple and complex landscapes (Fig 4a). These results show agreement with the ‘intermediate landscape complexity hypothesis’, but indicate that diversification strategies on farms can be beneficial for biodiversity even in complex landscapes.

## Outlook

At a time when the outlook for simultaneously improving and protecting the environment and social conditions for farmers often seems bleak(*2*), our findings present a promising avenue for shaping global agricultural policy by showing how applying a suite of diversification strategies or practices can create win-win scenarios. Our results support the notion that a ‘diversified farming system’ is often more beneficial than specific diversified farming strategies or practices in isolation(*13,14*). This finding emphasizes the need for more explicit evidence on which combinations of diversification strategies and practices are most complementary in different social and ecological contexts. Most of our findings – based on working farm data – support the growing body of literature that links agricultural diversification strategies with better outcomes for non-agricultural biodiversity and regulating ecosystem services, without compromising yields(*12,13*).

Our study advances existing knowledge about how diversification affects agricultural system sustainability by i) considering how a multitude of diversification strategies, not just crop diversification, may affect sustainability outcomes (including both individual and combined effects of diversification strategies), ii) examining how diversification influences multiple social and environmental outcomes while highlighting tradeoffs and/or synergies within and between environmental and social outcomes, and iii) examining how landscape composition mediates the effects of diversification on environmental and social outcomes. Thereby, we move beyond existing studies that typically assess the effects of diversification strategies in isolation, and on selected output variables(*35-37*), preventing the systemic understanding needed for informing policy debates on how to produce food while maintaining a safe operating space for humanity. By focusing on agricultural working landscapes, our work complements earlier studies that examined environmental and social tradeoffs and/or synergies of protected areas(*38*), to consider working lands conservation approaches affecting a broader area(*39*). Because we include diverse datasets representing multiple world regions, our flexible approach can be replicated and expanded to incorporate additional datasets in the future.

How can and should policymakers and practitioners encourage the adoption of specific types of 'diversified farming systems'? While we recognize the benefits of diversification, it is also critical to acknowledge that many farmers are working 'against the odds'(*8*); structural factors are often the main barrier for adopting diversification practices, such as high land rents, the predominance of short-term leases, stringent food safety regulations, trade agreements exacerbating corporate concentration in global food systems, and other supply chain pressures(*40*). Transitions to 'diversified farming systems' often require financial support because of potential initial yield declines or implementation costs(*8*). Indeed, current policies often lock in simplified, conventional farming rather than enabling durable transitions to diversified farming – and investments are needed to develop appropriate seeds, crop mixes and rotations, and equipment to promote profitability of diversified farms.

Further, effective policies for encouraging adoption of diversification strategies and practices likely vary with cropping system and region, and include incentives, regulations, and combined approaches. The benefits of incentives can, for example, be seen in the European Union where farmers are financially compensated on a per area basis(*41,42*) for some diversification practices such as non-crop plantings. Also, a recent synthesis from Ghana shows that incentivizing non-crop diversification has cascading positive effects on adoption patterns(*43*). Regulatory mechanisms can be used for e.g. soil or water conservation through policies requiring farmers to utilize diversification practices to reduce pollutants on their farms (e.g. for water quality)(*44*). Finally, the benefits of combining incentives with regulatory mechanisms can be seen in California where increasing adoption of diversification practices on larger farms may require supplementing the "pull" of incentives with the "push" of regulatory mandates(*44*).

Our study suggests several contexts in which desirable local outcomes occur most frequently, with a key example being the positive effect on human well-being and food security from applying a high number of diversification practices in cleared landscapes and on small farms (Table S12). Yet, researchers have much more to discover about the variability of outcomes that can occur across different agricultural diversification strategies, landscapes, and social contexts, and future work should use quasi-experimental methods that control for possible underlying differences between farmers that choose more versus fewer diversification strategies.

The future of agriculture faces two great challenges: large increases in demand for agricultural commodities must be met while minimizing agriculture's negative environmental, health, and social impacts(*2*). Our interdisciplinary analysis spanning a wide array of regions provides convincing evidence that agricultural diversification is a promising win-win strategy for providing social and environmental benefits.

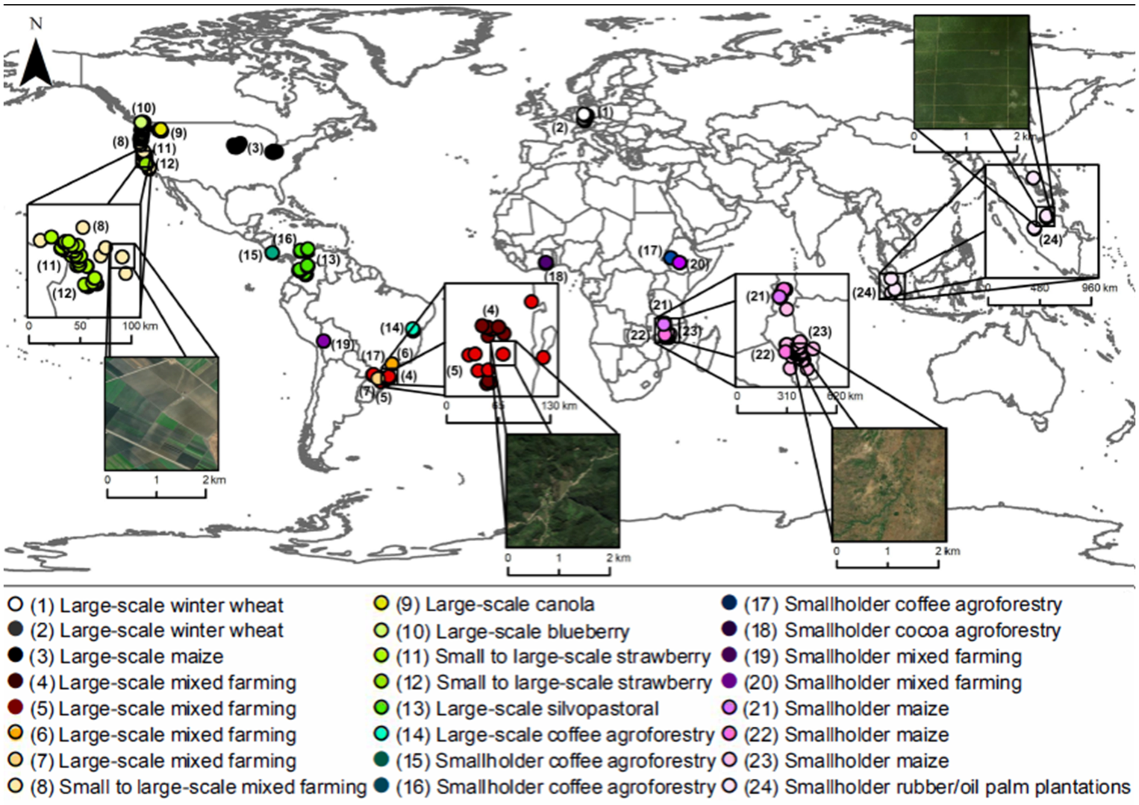

**Figure 1. Geographic distribution of 24 datasets that span five continents and a wide range of landscapes.** Our analysis of agricultural diversification strategies covers 2,655 farms across five continents. Insets depict satellite images of agricultural systems (left to right: Leafy greens in the US West coast, mixed farming in Brazil, smallholder maize in Malawi, and oil palm plantations in Indonesia). Colored dots indicate farm locations within each study. We applied the commonly used 2 ha threshold for differentiating smallholder farming from farming that is less reliant on subsistence (*45*).

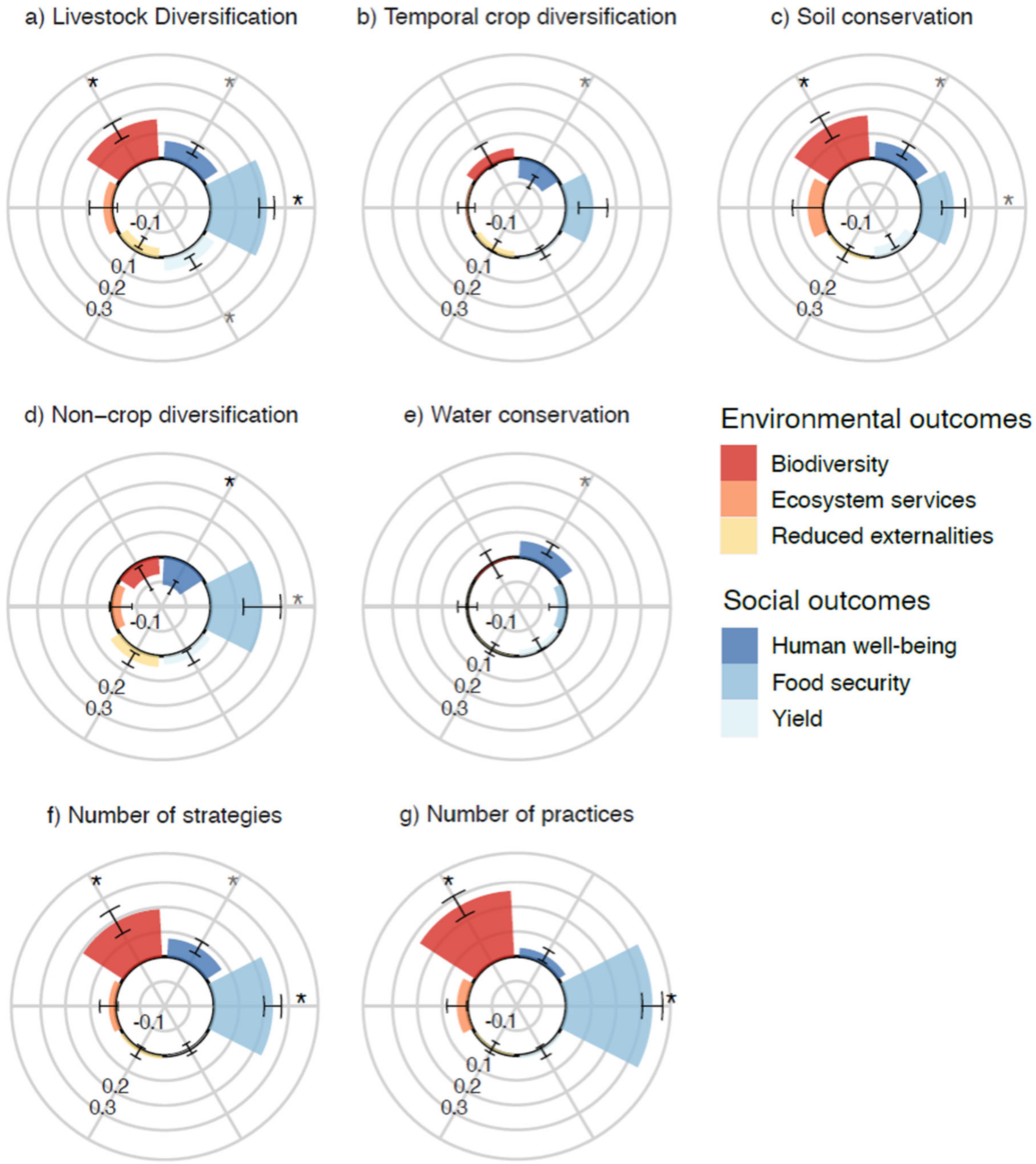

**Figure 2. Effects of agricultural diversification on environmental and social outcomes**. Agricultural diversification strategies include livestock diversification, temporal crop diversification, soil conservation, non-crop diversification, and water conservation. Flower diagrams indicate the effects of diversification strategies on three environmental outcome variables (non-agricultural biodiversity, regulating ecosystem services, reduced environmental externalities) and three social outcome variables (human well-being, food security, yield). Additionally shown are the effects of the total number of diversification strategies (up to a total of 5) and their associated diversification practices (up to a total of 23, excluding livestock diversification) applied (Table S2). Effect sizes are measured in units of standard deviation, with the black circle indicating an effect size = 0.0. The size of the flower petals is proportional to the effect size; error bars indicate ± 1 standard error. Asterisks indicate statistically significant effects of diversification strategies on outcomes (grey asterisks: $p < 0.05$; black asterisks: $p < 0.00119$ using Bonferroni correction for multiple comparisons (42 estimates).

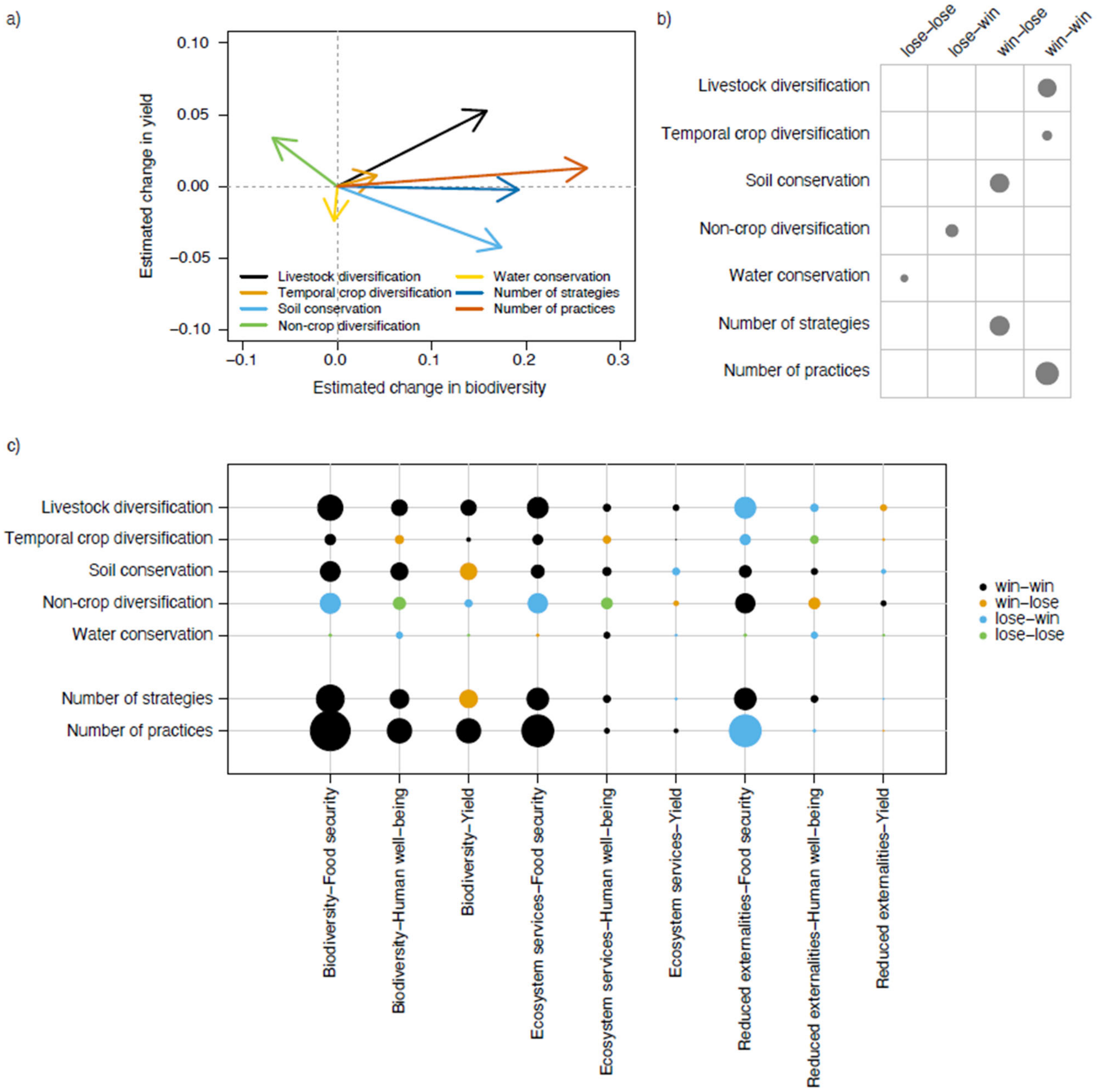

**Figure 3. Synergies and tradeoffs among environmental and social outcomes of agricultural diversification (a, b: methodological approach to identify synergies and tradeoffs based on the example of non-agricultural biodiversity and crop yield; c: synergies and tradeoffs for all pairwise combinations of studied environmental and social outcome variables)**. a) Effects of agricultural diversification strategies on non-agricultural biodiversity and crop yield. Arrow tips are located at the predicted change in non-agricultural biodiversity and crop yield, respectively, with an increase of one standard deviation of a given diversification strategy; the x-y coordinates of the arrow tips are numerically similar to the effect sizes shown in Figure 2. The resulting arrow directions indicate tradeoffs and synergies of diversification strategies, with arrows pointing in the upper right corner indicating win-win outcomes, and arrows pointing in the other quadrants indicating either tradeoffs (lose-win; upper left quadrant; win-lose; lower right quadrant) or lose-lose (lower left quadrant) outcomes. b) Outcomes by diversification strategy. Circle size is proportional to arrow length in panel a, and indicates the effect strength, that is, the conjoined change in non-agricultural biodiversity and crop yield with diversification. c) Colored circles indicate outcome combinations of environmental and social outcome variables (black: win-win; orange: win-lose, blue: lose-win; green: lose-lose). Circle size is proportional to the joint change of the paired environmental and social variables.

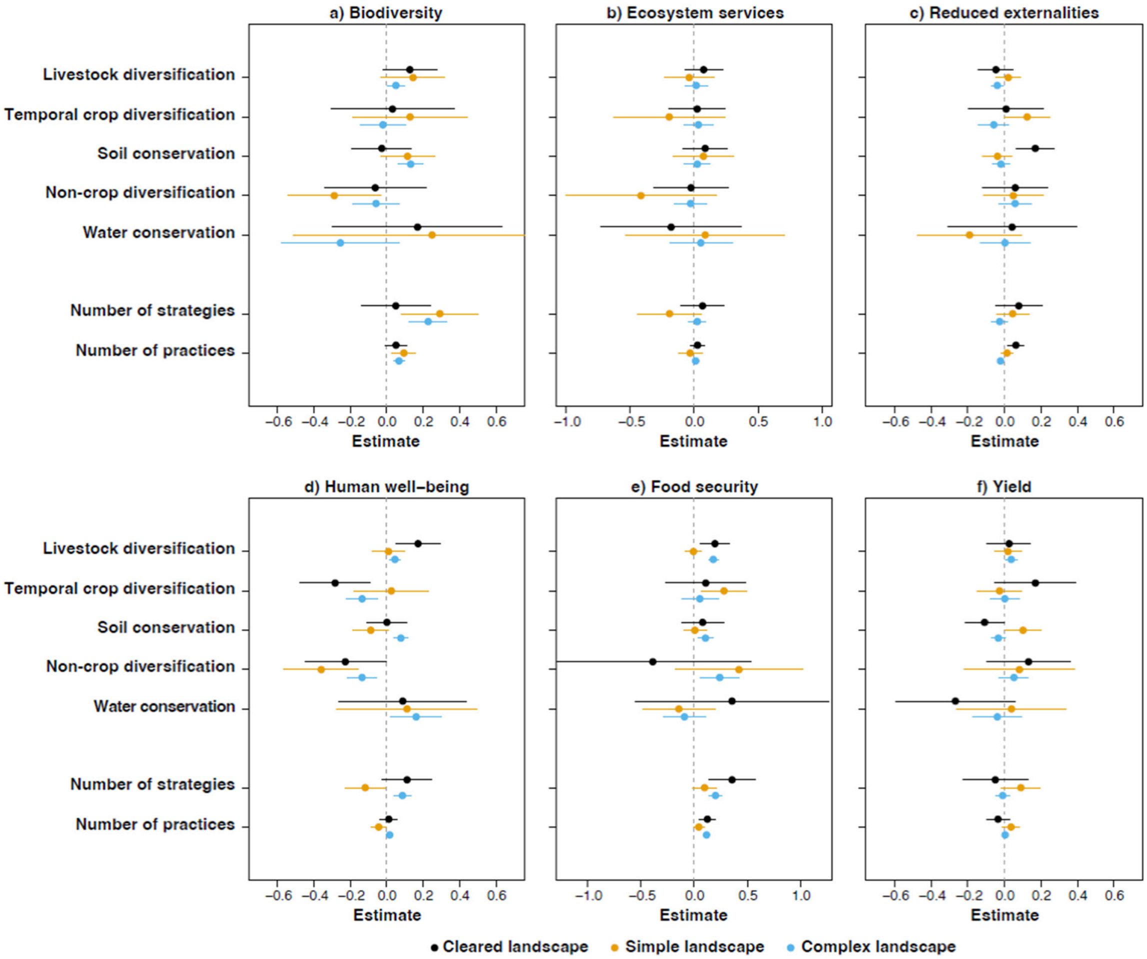

**Figure 4. Landscape composition moderates the outcomes of agricultural diversification strategies.** Shown are standardized effect sizes (means and 95% confidence intervals) of the five diversification strategies and the total number of diversification strategies or practices applied, depending on the proportion of seminatural habitat in a 3000-m radius surrounding farms (cleared: <5%; simple: 5-20%; complex: >20%). When the confidence interval is not overlapping with the 0-line, there is a significant effect in a given landscape.

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**Author contributions:**

LVR, IG, ZM and CK designed the study. LVR, IG, ZM, OS, JB, LAG, MEI, CMK, RBK, HW, CL, and CK developed the code book. IG, ZM, OS, JB, LAG, MEI, CMK, RBZ, HW, PB, RC, JC, DC, KD, KDM, KG, DG, PH, JH, LH, DJ, IJ, AJ, DK, MK, YK, CBK, SK, HK, RL, AL, RNM, PBM, AM, SM, HNF, EMO, JPO, MQ, SR, AS, SS, WES, ISD, AES, JMT, VV, CV and CK contributed to data collection and/or data entry. LVR and IG conducted the data cleaning and data analyses, with assistance from ZM, CS, and CK. LVR and IG wrote the first manuscript draft with contributions by all authors. OS designed Figure 1.

**Competing interests:**

The authors declare no competing interests.

**Data and materials availability:**

The dataset that we compiled based on 24 case studies and comprising 2655 farms is available on Zenodo (*46*). The R code used to generate the results is available in the same Zenodo Repository.

SUPPLEMENTARY MATERIALS:

Materials and Methods
Supplementary Text

Figs. S1 to S10
Tables S1 to S13

References: 1-46
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# Joint environmental and social benefits from diversified agriculture

**Authors:**
Laura Vang Rasmussen*[1], Ingo Grass*[2,3], Zia Mehrabi[4], Olivia M. Smith[5,6], Rachel Bezner-Kerr[7], Jennifer Blesh[8], Lucas Alejandro Garibaldi[9,10], Marney E. Isaac[11], Christina M. Kennedy[12], Hannah Wittman[13], Péter Batáry[14], Damayanti Buchori[15], Rolando Cerda[16], Julián Chará[17], David Crowder[18], Kevin Darras[19], Kathryn DeMaster[20], Karina Garcia[21], Manuel Gómez[22], David Gonthier[21], Purnama Hidayat[23], Juliana Hipólito[24], Mark Hirons[25], Lesli Hoey[26], Dana James[27,28], Innocensia John[29], Andrew D. Jones[30], Daniel S. Karp[31], Yodit Kebede[32], Carmen Bezner Kerr[33], Susanna Klassen[27,28], Martyna Kotowska[34], Holger Kreft[35], Ramiro Llanque[36], Christian Levers[27,37,38], Diego J. Lizcano[39], Adrian Lu[20], Sidney Madsen[13], Rosebelly Nunes Marques[40], Pedro Buss Martins[40], America Melo[39], Hanson Nyantakyi-Frimpong[41], Elissa M. Olimpi[42], Jeb P. Owen[18], Heiber Pantevez[22], Matin Qaim[43], Sarah Redlich[44], Christoph Scherber[45,46], Amber R. Sciligo[47], Sieglinde Snapp[48], William E. Snyder[49], Ingolf Steffan-Dewenter[44], Anne Elise Stratton[26], Joseph M. Taylor[49], Teja Tscharntke[50], Vivian Valencia[51,52], Cassandra Vogel[44,53], Claire Kremen[54]

* These authors contributed equally to this work

**Affiliations:**
[1] Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark.
[2] Department of Ecology of Tropical Agricultural Systems, University of Hohenheim, Stuttgart, Germany
[3] Center for Biodiversity and Integrative Taxonomy (KomBioTa), University of Hohenheim, Stuttgart, Germany
[4] Department of Environmental Studies, Better Planet Laboratory, and Mortenson Center for Global Engineering and Resilience, University of Colorado Boulder, Colorado, USA
[5] Center for Global Change and Earth Observations, Michigan State University, East Lansing, Michigan, USA

[6] Ecology, Evolution, and Behavior Program, Michigan State University, East Lansing, Michigan, USA
[7] Department of Global Development, Cornell University, Ithaca, New York, USA
[8] School for Environment and Sustainability, University of Michigan, Ann Arbor, Michigan, USA
[9] Universidad Nacional de Río Negro, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, Río Negro, Argentina.
[10] Consejo Nacional de Investigaciones Científicas y Técnicas, Instituto de Investigaciones en Recursos Naturales, Agroecología y Desarrollo Rural, Río Negro, Argentina.
[11] Department of Physical and Environmental Sciences and Department of Global Development Studies, University of Toronto, Toronto, Canada
[12] Global Science, The Nature Conservancy, Fort Collins, Colorado, USA
[13] Centre for Sustainable Food Systems and Institute of Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada
[14] "Lendület" Landscape and Conservation Ecology, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary
[15] Department of Plant Protection, Bogor Agricultural University, Jalan Kamper, Kampus Darmaga, Bogor 16680, Indonesia
[16] CATIE - Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
[17] Center for Research on Sustainable Agricultural Systems (CIPAV), Cali, Colombia
[18] Department of Entomology, Washington State University, Pullman, Washington, USA
[19] EFNO, INRAE, Nogent-sur-Vernisson 45290, France
[20] Department of Environmental Science, Policy, and Management, University of California, Berkeley 94720, USA
[21] Department of Entomology, University of Kentucky, USA
[22] Federación Colombiana de Ganaderos (FEDEGAN), Bogotá, Columbia
[23] Department of Plant Protection, IPB University, Bogor, Indonesia
[24] Federal University of Bahia (UFBA), Biology Institute, Salvador, Brazil
[25] Environmental Change Institute, School of Geography and the Environment, University of Oxford, UK
[26] Urban and Regional Planning Program, University of Michigan, Ann Arbor, Michigan, USA
[27] Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, Canada
[28] Centre for Sustainable Food Systems, University of British Columbia, Vancouver, Canada
[29] Department of Agricultural Economics and Business, University of Dar es Salaam, Tanzania
[30] School of Public Health, University of Michigan, Ann Arbor, Michigan, USA
[31] Department of Wildlife, Fish, and Conservation Biology, University of California- Davis, Davis, California, USA
[32] Eco&Sols, Université de Montpellier, IRD, CIRAD, INRAE, Institut Agro, Montpellier, France
[33] University of Toronto, Canada
[34] Department of Plant Ecology and Ecosystems Research, University of Göttingen, Göttingen, Germany
[35] Biodiversity, Macroecology & Biogeography, University of Göttingen, Göttingen, Germany
[36] Consejo de Salud Rural Andino, La Paz, Bolivia
[37] Department of Environmental Geography, Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
[38] Thünen Institute of Biodiversity, Johann Heinrich von Thünen Institute - Federal Research Institute for Rural Areas, Forestry, and Fisheries, Braunschweig, Germany
[39] Latin America North Andes and Central America Region, The Nature Conservancy, Bogota, Columbia
[40] Applied Ecology Graduate Program, "Luiz de Queiroz" College of Agriculture, University of São Paulo, Piracicaba, SP, Brazil
[41] Department of Geography & the Environment, University of Denver, Denver, Colorado USA

[42] Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia, USA
[43] Center for Development Research (ZEF), University of Bonn, Bonn, Germany
[44] Department of Animal Ecology and Tropical Biology, Biocenter, Julius-Maximilians-University Würzburg, Würzburg, Germany
[45] Leibniz Institute for the Analysis of Biodiversity Change (LIB), Museum Koenig, Centre for Biodiversity Monitoring and Conservation Science, Bonn, Germany
[46] Bonn Institute for Organismic Biology, Faculty of Mathematics and Natural Sciences, University of Bonn, Germany
[47] The Organic Center, Washington D.C., USA
[48] Sustainable Agrifood Systems, International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico
[49] Department of Entomology, University of Georgia, Athens, Georgia, USA
[50] Agroecology, University of Göttingen, Göttingen, Germany
[51] Farming Systems Ecology group, Wageningen University and Research, Wageningen, The Netherlands
[52] Department of Environment, Agriculture and Geography at Bishop's University, Sherbrooke, Canada
[53] Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden
[54] Institute of Resources, Environment and Sustainability, Biodiversity Research Centre and Department of Zoology, University of British Columbia, Vancouver, Canada

Corresponding author: lr@ign.ku.dk

**The PDF file includes:**

## Materials and Methods

### *Data overview*

As a first step to identify relevant datasets, participants of the SESYNC working group 'Can Enhancing Diversity Help Scale Up Agriculture's Benefits to People and the Environment?' were identified that had studied farm sites with varying levels of diversification in different parts of the world. Our goal was to encompass a wide range of farming systems across geographic latitudes, from subsistence to commercial farming, while also considering the geophysical landscape context of agricultural diversification outcomes (Fig 1). As a second step to obtain sufficient representation of various geographic regions as well as types of agricultural diversification strategies, the group identified additional data contributors with relevant datasets (done through a broader solicitation request for data) as potential collaborators.

We had three inclusion criteria for datasets. That is, datasets should have recorded at least: 1) one agricultural diversification practice, while also including control study sites without or with less diversification, 2) one environmental outcome variable, and 3) one social outcome variable. We compiled 24 datasets that cover 11 countries from 5 world regions: Brazil (5); Malawi (3); Costa Rica (2); Ethiopia (2); Germany (2); Bolivia (1); Canada (1); Colombia (1); USA (5); Ghana (1); and Indonesia (1) (Fig 1). The number of data points (corresponding to fields and/or farms, referred to as "farm" in main text for simplicity) per study ranged from 15-484.

While most studies to date have focused on the spatial (e.g., polyculture) or temporal (e.g., crop rotation) diversity of crops or livestock at the field or farm level (*47*), we acknowledge that agricultural diversification strategies go far beyond on-farm species selection, as it encompasses a wide range of strategies, such as the integration of livestock into mixed farming systems, the integration of non-crop habitats or plantings at field and farm levels (e.g., hedgerows, scattered trees), and soil and water conservation measures (*10,48*). We grouped diversification practices into five broad strategies: i) temporal crop diversification, ii) non-crop diversification, iii) soil conservation and soil fertility management, iv) livestock diversification, and v) water conservation strategies (Table S2). These corresponded to the specific diversification strategies covered across our 24 datasets (see Supplementary material (text section) for description of practices included in each of the five strategies). We consider some soil conservation practices (e.g. organic nutrient sources) to represent agricultural diversification strategies because they can create conditions and resources below ground that affect the below-ground trophic chain (*23*). Likewise, we consider some water conservation practices to represent diversification strategies because water conservation practices can affect plant and microtopographic heterogeneity influencing biodiversity (*24*).

We developed an integrated approach that allowed us to standardize and aggregate the study-specific variables into three broad social outcome categories (food security, human well-being, yield) and three broad environmental outcome categories (non-agricultural biodiversity, regulating ecosystem services, reduced environmental externalities). All subcategories of outcome variables are listed in Table S1. After an initial round of coding, additional subcategories were added and existing subcategories refined to ensure that all the indicators that data contributors had used to assess our six aggregated outcome categories were sufficiently captured. For example, the 20 subcategories of human well-being were identified through an iterative approach accounting for all subcategories used to assess well-being across our 24 datasets. Yields and food security obviously overlap, but yield metrics measure agricultural outputs arising directly from farming, whereas food security metrics measure food access and acquisition (see Table S1 for additional overlaps). However, we note that some of the subcategories of human well-being, such as education, may not only act as outcomes of agricultural diversification but also precursors of whether farmers adopt diversification strategies in the first place (*8*). As such, we make no claims about causality. We also note that because researchers in each study location independently chose which outcomes to measure, there is a risk that they may have chosen to study the outcomes most likely to be positively affected by the practices in that site.

Compared to a situation in which all outcomes were systematically collected across all sites, the likelihood of win-win situations might therefore be overstated in our study.

Human well-being was most frequently recorded (21 datasets), whereas yield observations, reduced externalities, regulating ecosystem services (Table S3), non-agricultural biodiversity, and food security metrics were included in 20, 18, 13,11, and 8 datasets, respectively (Table S4). As such, the 24 datasets varied in which social and environmental outcomes they covered, with only one dataset (Study ID 24, Table S4) measuring all six social and environmental outcome variables.

Because we include diverse datasets representing multiple world regions, our flexible approach can be replicated and expanded to incorporate additional datasets in the future.

### Computing z-scores and averaging across outcome subcategories

We combined the 24 datasets by standardizing within each dataset by computing *z*-scores for each data point (field and/or farm) across the subcategories of social and environmental outcome variables. Subsequently, we averaged across computed scores for each of the six aggregated outcome variables. For example, if food security had been measured through two variables, such as the number of hungry months and a dietary diversity score, we first standardized data for each of these two variables within the dataset using z-scores, and then averaged the z-scores to obtain the final value for the aggregate food security outcome variable for that data point within that study. We used the same standardization procedure whether data were entered by data contributors as a binary variable or continuous variable, by transforming binary data entries to 0/1 values before computing *z*-scores. For example, one indicator used to assess human well-being was men's/women's participation in networks. Participation was recorded by some data contributors as a binary variable of participation/no participation whereas other data contributors recorded the actual number of networks that men/women engaged in. For all binary data entries, we transformed these. For some variables such as the number of hungry months as an indicator for food security, the direction was reversed with higher values indicating lower food security. We transformed these variables by multiplying by -1 before computing *z*-scores. For a full list of variables with reversed directionality see Table S6 – and we note that the directionality of variables was defined individually by each data contributor thereby accounting for the context in which it was measured. Our approach to compute *z*-scores across the subcategories of our six social and environmental outcomes necessarily implies that each subcategory is equally important. As such, our aggregate outcome categories might mask heterogeneity in the importance of different subcategories across contexts. For example, farmer networks have been a key part of agricultural diversification processes in Malawi (*8*) whereas other subcategories of well-being are of greater importance elsewhere. Despite this imperfect nature of our aggregated *z*-scores, our approach is reasonable because 1) subcategories were developed through an iterative process with data providers to be as inclusive as possible meaning that all metrics considered relevant across studies and contexts were included, and 2) it allows for comparison of variables measured in different units which is key for broad-scale harmonization efforts.

Data could be entered into the codebook by data contributors both at the field level or the farm level, depending on their study design. For seven datasets, data were recorded at both levels, with human well-being and food security typically recorded at the farm level and yield, non-agricultural biodiversity, reduced environmental externalities, and regulating ecosystem services recorded at the field level. When a given farm had, for example, food security measured at the farm level and non-agricultural biodiversity recordings from multiple fields, the same farm level food security value would be entered against multiple field level biodiversity values.

### Social and environmental outcome variables

#### Food security

To assess food security, we used five subcategories of indicators: number of hungry months, the household food insecurity access scale, the FAO Food Insecurity Experience Scale, dietary diversity scores, and other indicators (e.g., a food consumption score and food expenditures per month). We then calculated one compound food security variable per farm by averaging *z*-scores of up to five of the food security variables measured in each study. We did not lump food security into human well-being as we were interested in obtaining a detailed understanding of the effects of agricultural diversification on each of these outcomes separately. For example, major international policy agendas such as the SDGs do not lump food security (SDG2) and well-being (SDG3), recognizing that these are synergistic but not synonymous.

### *Human well-being*

For human well-being, we included 20 subcategories of indicators (Table S1), including, for example, the total value of agricultural production, level of income satisfaction, and education. These 20 variables were typically measured at the farm level. The human well-being compound variable was created by averaging *z*-scores of all subcategories measured by each study.

We acknowledge that other dimensions of well-being might be relevant, but our chosen approach ensured that all subcategories originally measured to assess well-being across our 24 independent datasets could be included in the analysis. These dimensions represent elements considered by each study's authors to be important for well-being across these highly diverse contexts. We compared our subcategories against the Millennium Ecosystem Assessment (MEA) constituents of well-being (*49*) and the IPBES Good Quality Life (GQL) (*50*) groupings, finding that our compilation of subcategories covers all groupings, except for the MEA 'Security' and the crosscutting 'Freedom of choice and action' (Fig S10).

Because our human well-being outcome variable potentially includes tradeoffs between the 20 subcategories included – and to avoid overstating findings based on subcategories measured by only a few studies—we also ran a series of robustness checks. Specifically, we constructed three additional configurations of our human well-being composite score: 1) focusing on total value of agricultural production only, 2) excluding the three labour subcategories (Women's participation in agriculture, Number of hired workers, Number of family member workers), and 3) excluding seven subcategories measured by only one or two studies (Level of income satisfaction, Women's empowerment in agriculture Index, Other measures of social support (Men), Other measures of social support (Women), Employment satisfaction, Women's participation in agriculture, Other measures of labour productivity).

When using only the value of agricultural production as an indicator of human well-being (n=13 studies and 1211 farms/fields), we found similar effects of livestock diversification and the number of diversification strategies applied as for our compound human well-being outcome (Fig S8). However, relative to our compound variable, we observed shifts in this sole indicator of human well-being for non-crop diversification (negative to positive), the number of diversification practices applied (neutral to positive), soil conservation (positive to negative), temporal crop diversification (negative to neutral), and water conservation (positive to neutral). These changes are not surprising since the total value of agricultural production is a more limited aspect of human well-being.

Four of the 13 studies that measured the total value of agricultural production used agricultural net income whereas nine studies used other indicators such as gross agricultural income. We thus ran an additional model predicting the total value of agricultural production as a function of the interaction between the type of diversification and the way in which the total value of agricultural production was measured (a factor with two levels: (1) net agricultural income or (2) another metric such as gross agricultural income without deducting costs). As there was no significant interaction with the factor variable (Table S13), our results on the effects of diversification on total value of agricultural production (Fig S8) remain robust as to whether total value of agricultural production was measured as net income or not.

When excluding the three labour subcategories from our human well-being compound (n=21 studies and 2002 farms/fields remaining), we found similar effects of temporal crop diversification, soil conservation, and number of diversification strategies applied as for our compound human well-being outcome. However, for the number of practices applied we found effects to shift from neutral to positive, for non-crop diversification effects shifted from negative to neutral, and for water conservation and livestock diversification effects shifted from positive to neutral.

Finally, when excluding the seven subcategories measured by only one or two studies (n=21 studies and 2245 farms/fields remaining), we found similar effects of temporal crop diversification, non-crop diversification, soil conservation, water conservation and number of strategies applied as for our compound human well-being outcome. Only the effects of livestock diversification shifted from positive to neutral.

### *Yield*

Yield data could be entered both at the field level as well as the farm level, depending on how data contributors had recorded it. For example, yield could be entered for each crop grown on each field or as a total yield per crop per farm – and in the unit used by data contributors during data collection. For silvopastoral systems, yields were entered as stocking rate and milk productivity. We computed *z*-scores within the same crop type for each study and when multiple crops were cultivated in the same field, total yield per field was calculated by taking the sum of the crop *z*-scores.

### *Non-agricultural biodiversity*

For the non-agricultural biodiversity variables, data providers entered the following information per field: number of replicates, description of what a replicate is, sampling method, month(s) of data collection, taxon, and richness (non-crops). Across the 24 datasets, the following taxa and functional groups were represented: birds, butterflies, plants, beetles (e.g., carabids, rove beetles), spiders, detritivores, herbivores, pollinators, predatory arthropods/parasitoids, and bees. Data collaborators entered aggregate values per field or farm. We note that the mentioned taxa and functional groups are not mutually exclusive as birds or butterflies, for example, can be pollinators. Yet, we did not 'double-count' as we first generated *z*-scores for the richness of each taxa and functional group recorded within studies (Table S1). We then aggregated per field (or farm when data were entered at the farm level) by averaging across taxa and functional groups.

### *Ecosystem services*

Instead of using a predefined list of variables as was the case for our five other outcome variables, we allowed data contributors to enter any regulating ecosystem service that they had measured as well as the indicator used to assess it (see Table S3 for a full list of the ecosystem service indicators used across the 24 datasets). This practice permitted inclusion of the wide variety of outcome variables that different researchers had utilized to assess one or more ecosystem service(s) in their studies. If ecosystem disservices (e.g., % crop damage) were measured, we reversed the sign when appropriate (see Table S3 for a full list of ecosystem services or disservices with reversed directionality). We did not include food production as an ecosystem service due to including yield as a key social outcome variable.

Ten of the 13 studies assessing regulating ecosystem services recorded one ecosystem service and *z*-scores were computed for each data point (field or farm). For the three studies measuring multiple ecosystem services, we averaged across *z*-scores computed for each ecosystem service to derive one value per field/farm.

### *Reduced environmental externalities*

To create a metric of reduced environmental externalities, data contributors were asked to enter whether or not pesticides and/or synthetic fertilizers were applied on each field (or farm). If data on application amounts had been collected rather than just a binary of application/no application (entered as 1 vs 0), actual amounts were entered. To ease data interpretation, we then reversed the directionality when computing *z*-scores so that higher values indicate lower usage of pesticides and/or synthetic fertilizers.

### *Landscape composition classification*

Data contributors also provided coordinates for each field surveyed when they supplied their data. We calculated the percent natural land cover based on the 2015 ESA-CCI land cover product (300-m resolution) (*51*) (see Table S8) using a 1, 3, and 5 km radius buffer from each provided coordinate using the "landscape metrics package" (*52*) in R software (R Core Team 2021). Landscapes in our study ranged from 0–99% natural land cover (Fig S2). The farms with 99% natural land cover in their surroundings were primarily found in the mixed maize and agroforestry systems in Brazil. The percentages of natural land cover were highly correlated across the 1, 3, and 5 km radius buffer sizes (Fig S3). We note that we did not receive exact locations for four studies (see Supplementary text for further details on calculation of landscape composition variables for these studies).

### *Statistical analysis*

We first tested how agricultural diversification strategies affected each of the six targeted social and environmental outcomes. For this, we modeled outcome variables as a function of each of the five diversification strategies, with the number of specific practices applied per strategy to quantify the degree of diversification. Also, we modeled outcome variables as a function of the total number of diversification strategies applied on a given farm as well as the total number of diversification practices applied. The total number of strategies had a maximum of five, whereas the total number of practices was calculated by summing all practices applied within each strategy. For example, a farm applying non-crop diversification in the form of hedgerows, beetle banks and flower strips as well as soil conservation in the form of green manure and biochar would score 2 for total number of strategies and 5 for total number of practices. For each of the six outcome variables and five diversification strategies (as well as the total number of diversification strategies and practices), we fitted a linear mixed-effects model, with number of diversification practices as predictors and study ID as a random effect. Before modeling, for each diversification strategy, we standardized the number of practices (zero mean and unit variance) to allow for direct comparisons of effect sizes among the 42 estimates. To further examine whether results varied across small vs large farms (using a 2 ha threshold for differentiating smallholder farming from farming that is less reliant on subsistence (*45*)), we reran all models for a) small farms only (n=1742) and b) large farms only (n=913) (see Table S11 for sample sizes and Table S12-13 for model results).

To test whether the datasets with more observations might be driving our results, we ran a sensitivity analysis in which we created a weighting scheme whereby we kept the total evidence constant, but up or down-weighted studies so they were equally represented in the model fitting. Weighting of studies was achieved by calculating for each study the proportion of observations (of the study) on all observations (across all studies) for a given response variable. Next, we calculated how much this proportion differed from a situation where each study contributed equally to the total number of observations. Studies that had more observations (a larger sample size) than expected with an equal distribution were down-weighted, while studies with fewer observations than expected from an equal distribution were up-weighted so that all studies could contribute equally to the model estimation regardless of their sample size. The equalized model influenced outcomes of specific diversification strategies, e.g. effects of livestock diversification and soil conservation on biodiversity shifted from positive to neutral. Importantly, we found the weighting scheme not to influence the key result of the paper on the necessity for multiple diversification strategies and practices to maximise across environmental and social outcomes (Fig S9); if anything, it strengthened this result since the effects of number of strategies and number of practices on reduced externalities shifted from neutral to positive.

Moreover, to improve interpretation of model results and accommodate situations where data contributors felt that models did not match their knowledge of study sites, we ran separate models for selected studies that were discussed with data contributors (see Fig S5 for an example).

Next, we identified whether diversification strategies resulted in synergies or tradeoffs for the studied social and environmental outcomes on average. Here, we focused on all possible pairwise combinations of the three social and three environmental outcome variables. For each pair, we used the standardized model estimates of the diversification effects on the social and the environmental variable from the mixed-effects models described above. Depending on the directionality of the estimates, we then identified whether a given diversification practice resulted in a win-win outcome (both estimates positive), win-lose (estimate of first outcome positive, estimate of second outcome negative), lose-win (negative, positive) or a lose-lose outcome (both estimates negative). In addition, we identified the joint effect strength of diversification on the paired outcomes as the square-root of their additive squared components (Pythagorean theorem: conjoined effect strength = square-root (first $\text{estimate}^2$ + second $\text{estimate}^2$).

Finally, we tested whether landscape composition moderated diversification outcomes. For landscape composition, we created a factor with three levels according to the amount of seminatural habitat in a 3000 m radius surrounding the center of our study plots: cleared landscapes with <5% natural habitat remaining, simple landscapes (5-20%), and complex landscapes (>20%). We chose 3000 m as in Schmidt et al. (*53*), but note that the percentages of natural land cover were highly correlated across the 1, 3, and 5 km radius buffer sizes (Fig S3).

To test how the effects of the diversification practices (and number of strategies or practices applied) might differ depending on the landscape composition, we included interaction terms between diversification practices and landscape composition. To estimate the parameters for the interaction between diversification measures and landscape composition (including their 95% confidence interval), we used the "marginaleffects" function from the R package "marginaleffects" (*54*). This function uses a given linear model object as an input. In case of categorical explanatory variables, the function calculates the mean contrasts for each given term in the model object, plus confidence intervals around these estimates. To avoid including a baseline category, the intercept was removed from the input model (so that the model summary already contains the estimates for the three landscape complexity classes). Based on this model, the "marginaleffects" function was then used to compute the contrast mean values for all combinations of diversification and landscape complexity, including their confidence intervals. Confidence intervals were estimated using the *delta method*. Let Xß be the (input) model matrix X, multiplied with the coefficient vector ß. A predicted value P for a one-unit change in a categorical explanatory variable X can be estimated as a *Taylor series expansion* of $\text{Link}^{-1}(X_1\beta - X_2\beta)$. The *variance* of the predicted value P(Xß) is then estimated using the Jacobian matrix (a matrix of partial derivatives) of the inverse link function, multiplied with its own inverse ($J^{-1}$) and the variance-covariance matrix of the parameter estimates, ß. This variance estimate is then used to calculate the 95% confidence interval around the coefficient of interest (e.g. for "complex" landscapes and temporal crop diversity). The important point to note is that the standard errors calculated using the delta method (and partial derivative) approaches are necessarily different from standard errors derived using the predict() method with se.fit=T.

To reduce the Type 1 error rate, we used a conservative Bonferroni correction to account for multiple testing, with $p=0.00119$ for our main 42 estimates of diversification effects (Table S12). Finally, we assessed whether our studies had a potential selection bias of which farms participated in diversified practices. Almost half of the included studies applied random or partial random sampling of farmers. The studies that did not use a random sampling strategy were evenly split between whether or not the focus on diversification was revealed (Fig S6). When looking at the number of farms sampled, 27% of farms were selected randomly and an additional 40% with a partial random sampling strategy.

We then compared our effect sizes with two existing meta-studies on outcomes of diversification (*12,13*). Although these meta-analyses did not estimate effects on human well-being and food security, we can observe that our estimates are not signaling bias towards positive outcomes for biodiversity, yield, and ecosystem services but that our estimates fall well within the range of values that can be expected from these meta-analyses (Fig S7). Although there is no existing meta-analysis reporting on the magnitude of social effects beyond yields, we can qualitatively compare our estimates on human well-being with McElwee et al.'s (*55*) assessment of how different types of land management, including agricultural diversification, affect SDG3 (Good health and well-being). The authors find medium positive impacts - albeit described as categories of effects (i.e., small, medium, or large impacts) instead of actual magnitude. Again, our estimates are not signaling bias towards overly positive estimates as we find small positive effects on human well-being of livestock diversification, soil conservation, water conservation, and number of diversification strategies applied– and we even find small negative effects on human well-being of temporal crop diversification and non-crop diversification (Fig 2).

## Supplementary Text

### *Construction of five agricultural diversification strategies*

We identified five broad categories of agricultural diversification strategies during a workshop with data contributors as well as other diversification experts. These strategies included temporal crop diversification, non-crop diversification, soil conservation, livestock diversification, and water conservation. These five categories were based on previous classifications and selected to cover the full suite of diversification practices found across the 24 datasets and study sites. Table S2 lists the diversification practices considered within each diversification strategy, and further information is also provided below. Across the total sample of 2655 farms, 168 farms (6%, from 5 studies) did not apply any diversification strategies (see Table S9 for the gradient per study). While some practices might serve multiple purposes (for example, a hedgerow might also function as a windbreak), data contributors were asked to code farmland features so that they only fitted into one practice category and diversification strategy. They recorded the types of agricultural diversification practices present on each farm or field within each of the five diversification strategies. Fig S1 showcases examples of the coverage of two agricultural diversification strategies (livestock diversification and non-crop diversification) and their corresponding practices across selected farms in the US.

### 1. Temporal crop diversification

Each farm or field can score between 0 and 3 points. One point is obtained for each of the following practices present on the farm/field:

1. There is a rotation
2. The rotation includes >2 crops
3. There is cover cropping (i.e., non-harvested crops in rotation with primary crops)

### 2. Non-crop diversification

Each farm or field can score between 0 and 6 points. One point is obtained for each of the following practices present on the farm/field:

1. Hedgerows
2. Windbreaks
3. Flower strips
4. Beetle banks
5. Forage strips
6. Other non-crop practices are adopted (e.g. shade trees)

### 3. Soil conservation

Each farm or field can score between 0 and 9 points. One point is obtained for each of the following practices present on the farm/field:

1. Use of manure
2. Use of compost
3. Use of green manure (legume N sources/legumes in rotation)
4. Use of inoculants
5. Use of biochar

6. Use of crop residues (as opposed to residue removal)
7. Use of mulching
8. Use of nutrient mobilizing plants
9. Other soil amendment practices (e.g., nitrogen-fixing trees)

## 4. Livestock diversification

Each farm or field can score points according to each additional livestock species present, including animals such as cattle, goats, sheep, pigs, horses, fowls, fish, and managed bees. That is, we do not account for the number of animals present on-farm.

## 5. Water conservation

Each farm or field can score between 0 and 5 points. One point is obtained for each of the following practices present on the farm/field:

1. Terracing
2. Continuity of cover/roots
3. Bunds
4. Contour farming
5. Other water conservation practices (e.g., trees on farm)

### *Construction of landscape composition variables for studies without exact locations*

For four of the 24 studies, we did not receive exact locations. One study (ID 7) had no locational information so was excluded from analyses that included landscape metrics. One study (ID 18) surveyed 104 farms from five communities in Ghana. The authors were unable to provide exact locations for the study but provided coordinates for community centers. The closest communities were 2.74 km apart, the furthest were 57.7 km, and the average distance between communities was 30.0 km. The region was primarily agricultural. To extract random points to estimate landscape composition, we created a 5 km radius buffer around each community center. We then randomly placed 15 points, with a minimum distance of 2 km from other points, centered in a crop cover class. We estimated landscape composition for this study by averaging the landscape values across the 15 random points (Fig S4A). Percent natural cover in a 1 km radius ranged from 0–8.8% (coefficient of variation = 1.56), suggesting the landscape was fairly homogenous and our estimate provided a good index.

Another study (ID 16) surveyed 15 fields in Costa Rica. Six plots were in the CATIE Experimental Farm, and exact locations were provided. The remaining nine sites were private farms whose locations were unable to be shared due to a privacy agreement in participants' informed consent form. Therefore, we repeated our procedure described above for the Ghana (ID 18) study, using nearby landmarks shared by the authors (min distance = 0.11 km; max distance = 13.5 km) to create a 5 km radius buffer and randomly assigned 15 points, with a minimum distance of 2 km from other points (Fig S4B). Percent natural cover in a 1 km radius ranged from 61.1–97.3% (coefficient of variation= 0.13), again suggesting the landscape was fairly homogenous and our estimate provided a good index.

Study ID 22 surveyed 430 farms from three communities in Malawi. The authors were unable to provide exact locations for the study but provided coordinates for community centers. The closest communities were 11.2 km apart, the furthest were 387.4 km, and the average distance between communities was 261.4 km. We repeated our random point allocation procedure described above. Percent natural cover in a 1 km radius ranged from 0–93.8% (coefficient of variation = 0.81). We used the average landscape values for the northern sites (Fig S4C) and southern sites (Fig S4D) for farms in those areas, respectively.

Some studies (*n*=5 studies) provided incomplete coordinates. For farms/fields with missing coordinates (*n*=106 farms/fields), we used the average values for the landscape for that study.

*Datasets without published papers/data or published papers/data cover part of the data*
Table S5 provides references for most of the 24 datasets. For those datasets which do not yet have published papers/data or published papers only cover part of the data, descriptions are provided below.

### *Study ID 6: Large-scale mixed farming*

A case study was conducted at the municipality of Iperó, state of Sao Paulo, southeastern Brazil. This study visited and interviewed 34 farmers from October to December 2019. The main levels of analysis were the rural household and the local landscape (taken as the municipal/local agrarian system). Data for each farm was collected according to an indicator-based framework, which categorized the functions of agroecosystems into three dimensions, according to the function's relationship/contribution to: 1) farmers' well-being and socioeconomic reproduction; 2) ecological sustainability, and 3) society well-being, cohesion and reproduction. Dimension 1 groups the functions of income generation, work, personal satisfaction, residence, family food security, food autonomy and intergenerational continuity. Dimension 2 includes the functions of soil, water, and agrobiodiversity conservation. Dimension 3 aggregates societal food security, food quality, educational opportunities, leisure and recreation opportunities, work and employment, rural viability, and contribution to social capital functions.

### *Study ID 10: Large-scale blueberry*

This study collected data between September 2015 and February 2016 in the Lower Fraser Valley in Southern British Columbia. A total of 33 structured interviews were conducted with growers at the location of their choice, which was often on their farms or in their homes. Two interviews were conducted by phone. The data collection instrument consisted of a mixture of structured and open-ended questions, and covered a variety of topics related to food sovereignty, including agroecological management, land access, economic context of farming, and working conditions for farmworkers. There were 33 blueberry growers and their farms included in this study, representing a range of scales and modes of production. This sample of 33 growers accounts for 4% of the grower population in the province (there are an estimated 800 growers in BC), and the total acreage represented in this sample accounts for nearly 8% of the province's blueberry acreage. The sampling strategy was purposive to target farms and growers that represented the diversity in production types present in the industry.

### *Study ID 11 and 12: Small to large-scale strawberry*

**Diversification practices.** Use of diversification practices was recorded on each farm through direct observation and conversation with the farmer.

**Socio-economic indicators and context.** Semistructured interviews were conducted by the same interviewer (KdM) with the head of operations at each farm in 2015 or 2016 to provide information on marketing (percent of production to direct sales, community-supported agriculture, farmer's markets, big box stores, wholesale or U-pick); mental well-being and job satisfaction; farmer training (whether training was by family, apprentice, agricultural school, self-trained, peer-to-peer, etc.) and highest level of education; participation in extension services, farmer networks and social supports, and aspects of labor (difficulty in obtaining, inclusion of family members).

**Ecosystem services**. At each site, 50 strawberry plants were surveyed on three separate transects of 20 m in 2015, and on 20 plants per transect in 2016 (Study ID 11, (*56*)) and 2018 (Study ID 12, (*57*)). Each ripe berry was scored for damage from pests (described in Olimpi et al. (*57*)) or powdery mildew. Pest and disease control were then calculated as one minus the proportion of berries damaged from each source of damage, across all of the berries measured per farm. Pollination services were also measured in Study ID 11 in 2015. We marked open flowers and measured the proportion of total flowers that produced a marketable fruit (defined in Sciligo et al.(*58*)) as our indicator of pollination services.

**Biodiversity**. Bird communities were surveyed at point counts as described for Study ID 11 ((*59*)) and Study ID 12 (*60*). In Study ID 11, bee communities were also surveyed in 2015, using 18 pan traps filled with soapy water. Six sets of blue, white and yellow pans were opened for four hours on six 25 m transects arrayed across the farm (three within the focal strawberry field and three outside of the focal field), following protocols similar to Sciligo et al. (*58*). Two net surveys of 15 minutes were also conducted along the transects within the focal strawberry field. Pan and net sampling was only conducted during good weather (as defined in Sciligo et al. (*58*)).

**Yield**. Using a Monte Carlo error propagation method that incorporated uncertainty across three measurements (berry weight, number of berries per plant, proportion of marketable berries per plant), we estimated a site-specific measure of the weight of ripe, marketable berries for each site. We conducted the Monte Carlo procedure 100 times for each site and took the mean value as our measure of yield. Berry weight data was obtained from ripe berry harvests on 3 plots per farm obtained weekly over 12 weeks on 6 farms in 2015 (Study ID 11, (*59*)) and 8 weeks for 20 farms in 2018 (Study ID 12, (*57*)). This combined dataset was utilized to inform the normal distribution used within the Monte Carlo routine to select berry weights. For each farm site, site-specific measures of number of berries per plant and proportion of marketable berries per plant were used to inform a Poisson distribution and binomial distribution respectively.

*Study ID 23: Smallholder maize*

The data were obtained from a panel of households from Central Malawi as part of the Africa Research in Sustainable Intensification (SI) for the Next Generation (Africa RISING) project. The project aimed to improve food security, farmer livelihoods, and agroecological indicators of system health through the SI. The sampled households (324) consisted of three categories of farmers: those who participated (intervention farmers) in the Africa RISING research project and local and distant control farmers. Sites were visited repeatedly over 5 years (2015–2019), more than one time a year in some cases. Collected data included household level characteristics, farmer preferences, detailed plot management and soil and crop performance. Using a comprehensive list of households within each village cluster obtained from local authorities, the intervention and local control households were randomly selected, while the distant control groups were chosen using a "Y-sampling frame". In all cases, two of the larger plots cultivated per household were monitored, which were primarily used to grow maize. The two plots were considered the "representative plots" of the household practices that provided information on the SI technologies employed by the households.

Figs. S1 to S10

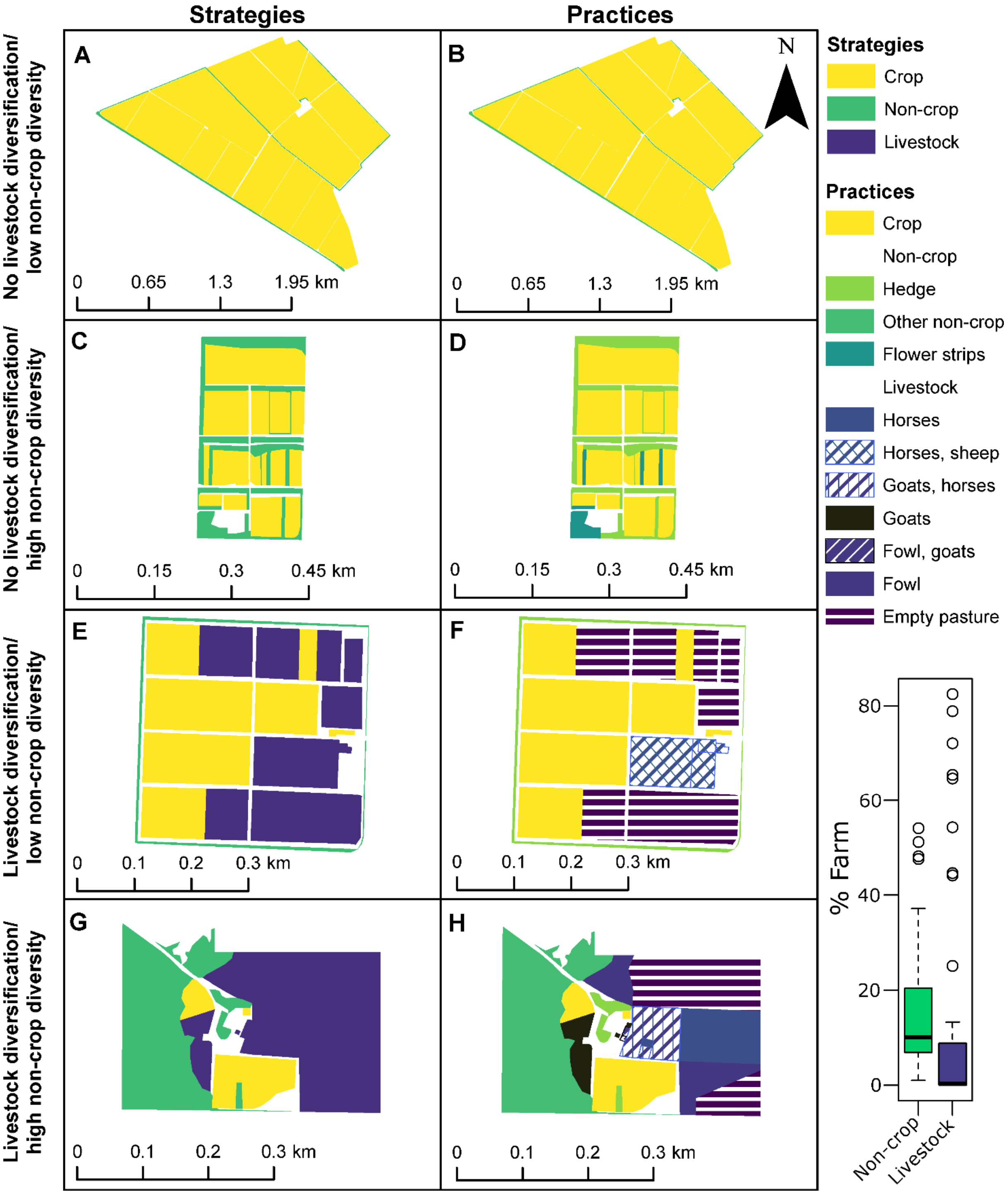

**Figure S1. Example farms showcasing the coverage of two agricultural diversification strategies (livestock diversification and non-crop diversification) and the corresponding practices.** The four farms are located in the US (Study ID 8, Small to large-scale mixed farming).

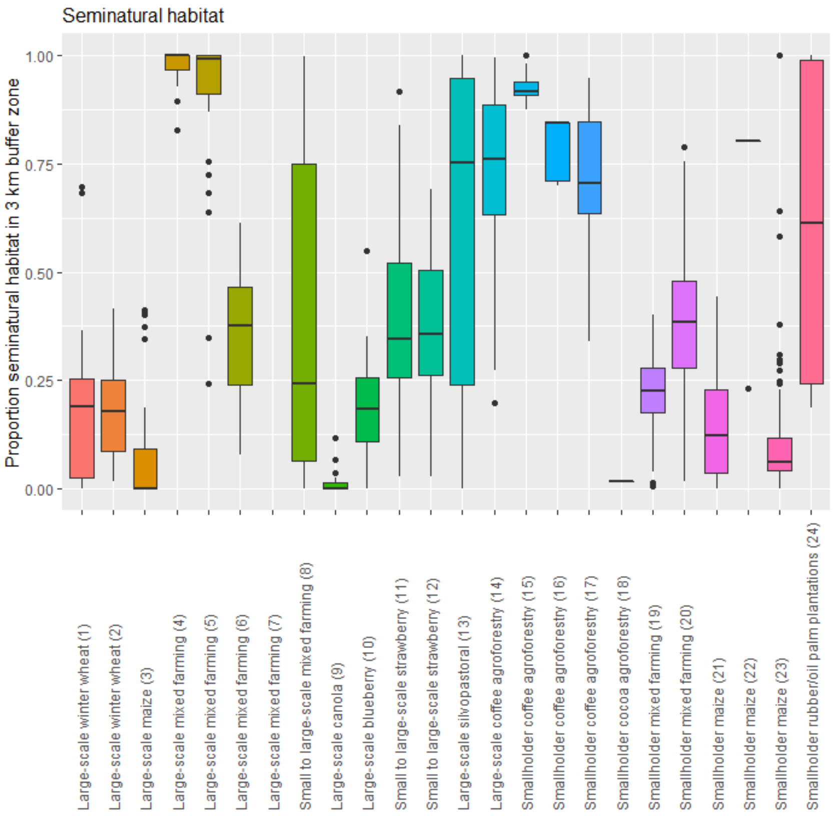

**Figure S2. Landscape composition in study areas.** Boxplots of the proportion of seminatural habitat in 3 km buffer zones around each data point. Boxplot denotes median (solid line), 25th and 75th centiles (box edges), and 5th and 95th centiles (whiskers). n=2655 farms/fields and 23 datasets (Large-scale mixed farming (ID 7) did not include GPS coordinates).

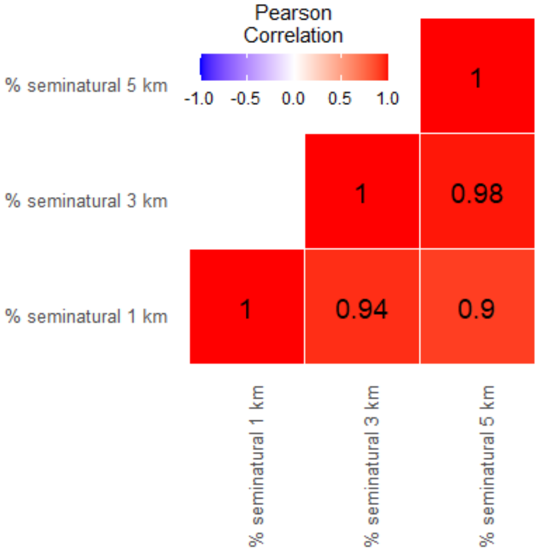

**Figure S3. Correlation plot for landscape variable (% seminatural habitat) with different buffer sizes (1 km, 3 km, and 5 km radius buffer zones).** n=2655 farms/fields and 24 datasets

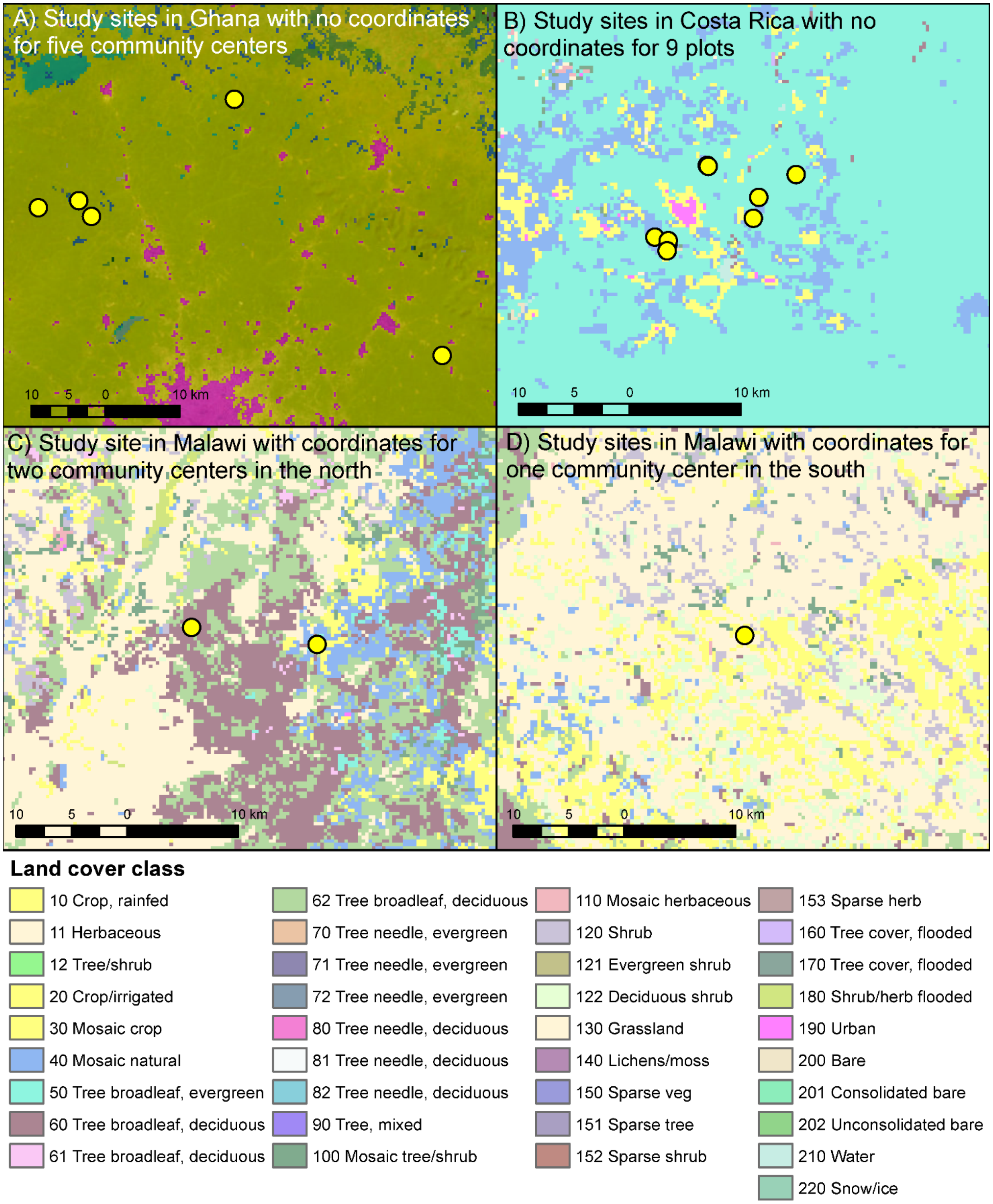

**Figure S4. Construction of landscape variables for studies without exact locations.** Land cover classes are based on the 2015 ESA-CCI land cover product (300-m resolution) (*51*) (see Table S8 for full code labels)

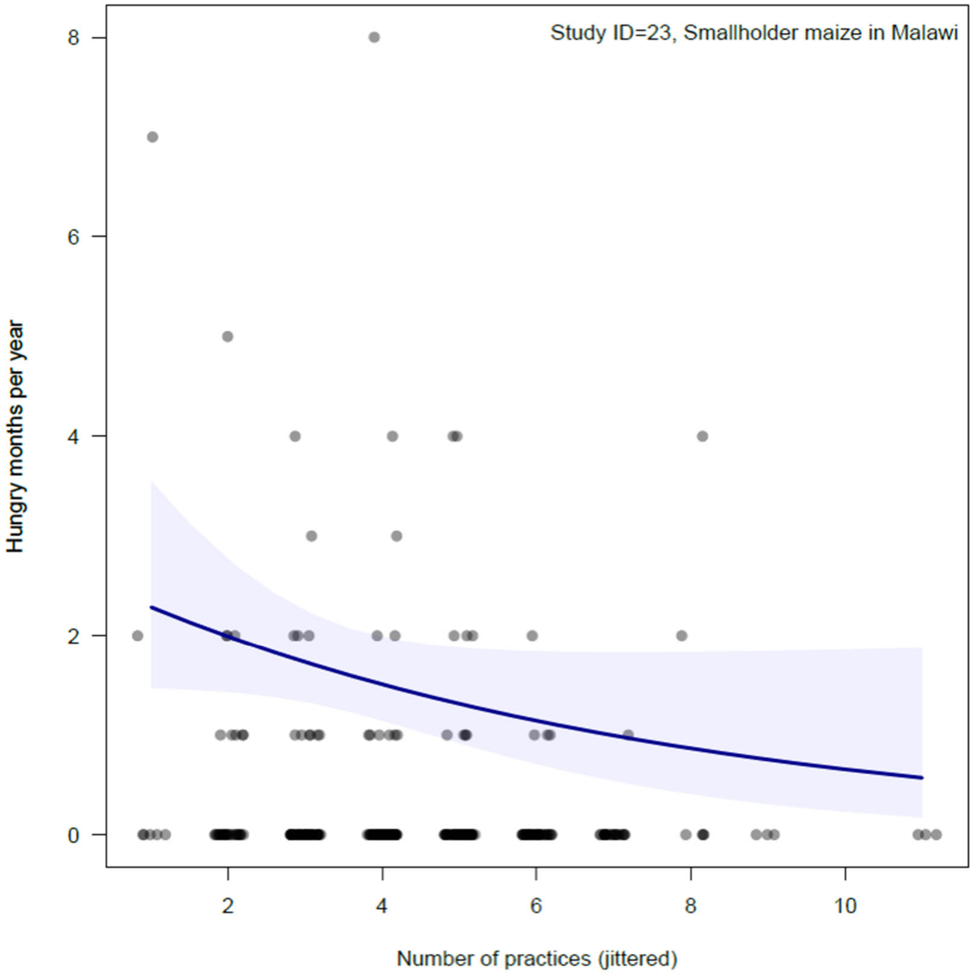

**Figure S5. Agricultural diversification enhances food security of Malawian smallholders.** Shown are the number of hungry months vs the number of applied agricultural diversification practices (N = 308 smallholder households; grey dots) and model predictions (blue line) with 95% confidence interval (blue shaded area). Model prediction is from a generalized linear model with zero-inflated Poisson distribution. Note that dots are slightly jittered across the x-axis to better discern individual data points.

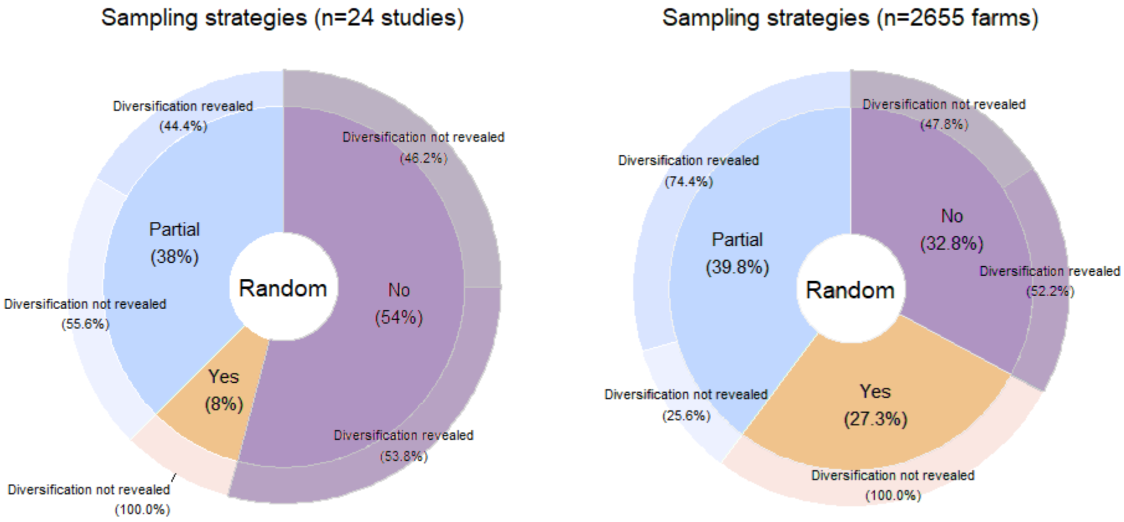

**Figure S6. Sampling strategies applied across the 24 studies and 2655 farms.** Almost half of the 24 studies applied either a random or partial random sample of farmers. When looking at the farms surveyed (n=2655), 60% were identified either through a random or partial random sampling strategy. Of the studies using (and the farms identified through) a non-random sample, they spread relatively equally as to whether or not the focus on diversification was revealed to farmers. Studies with either a non-random sample or a partial random sample used 1 or more of the following additional identification strategies: 1) Existing list or database supplied by an agency or non-profit organization, 2) Worked with extension agents or other knowledgeable personnel (including other researchers) to generate farmer list, 3) Contacted farmers suggested by other farmers, 4) Contacted farmers that the team had worked with in the past, and 4) Other (such as purposively selecting farms along a diversification gradient, a farm size gradient, or a forest cover gradient).

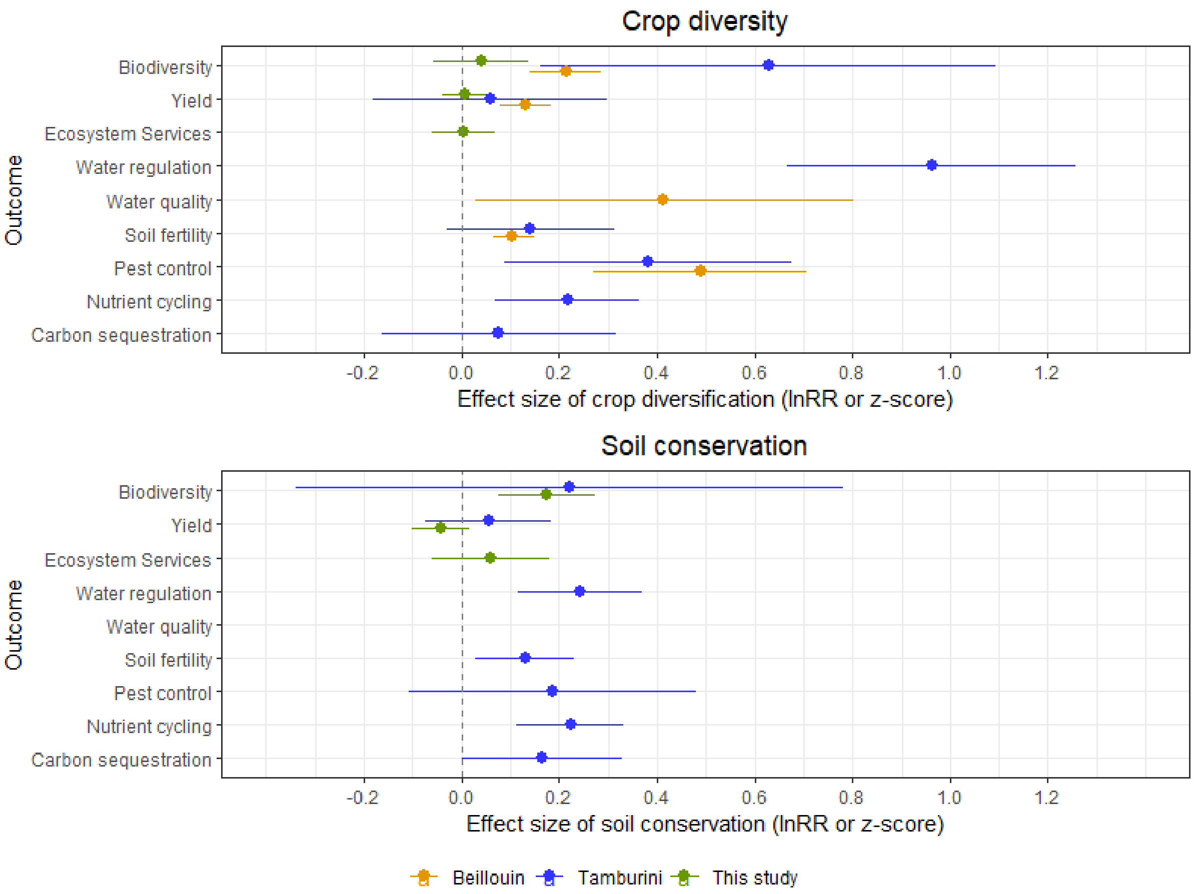

**Figure S7**. **Comparison of our estimated effect sizes with existing meta-analyses**. Effect sizes are shown in lnRR for the two second-order meta-analyses and z-scores for our study. For regulating ecosystem services, Tamburini et al. (*13*) and Beillouin et al. (*12*) estimated effects on individual ecosystem services (e.g., water regulation, water quality, soil fertility, pest control, nutrient cycling, carbon sequestration) whereas our study shows the combined effect size across measured ecosystem services.

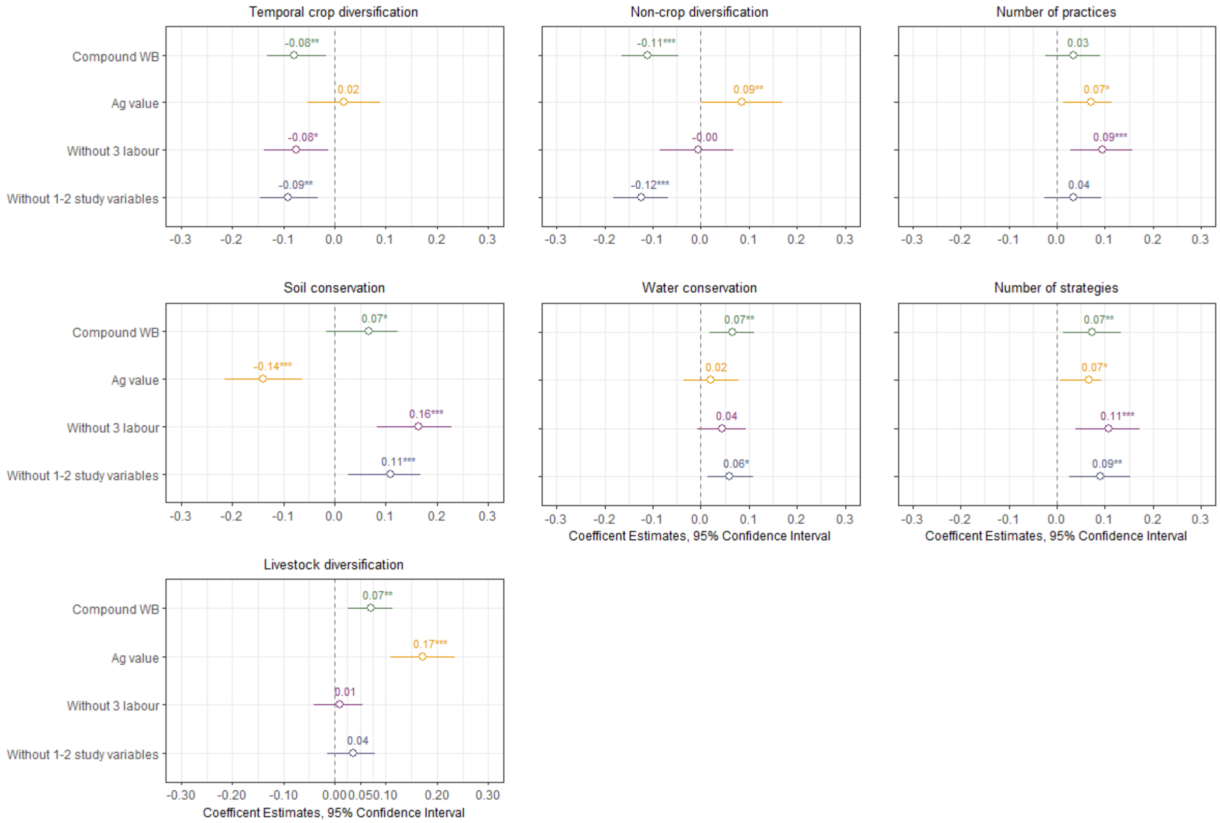

**Figure S8. Model coefficients for different configurations of the human well-being outcome for linear mixed-effects model, with diversification type as a predictor and study ID as a random effect.** Coefficients are shown for the five agricultural diversification strategies (as well as the total number of diversification strategies and practices). We standardized the number of practices (zero mean and unit variance) to allow for direct comparisons of effect sizes among the models. n=2245 farms/fields for human well-being compound (including 20 subcategories), n=1211 farms/fields when focusing on total value of agricultural production only, n=2002 farms/fields when excluding 3 labour categories (Women's participation in agriculture, Number of hired workers, Number of family member workers), and n=2245 farms/fields when excluding 7 subcategories measured by 1-2 studies only (Level of income satisfaction, Women's empowerment in agriculture Index, Other measures of social support (Men), Other measures of social support (Women), Employment satisfaction, Women's participation in agriculture, Other measures of labour productivity).

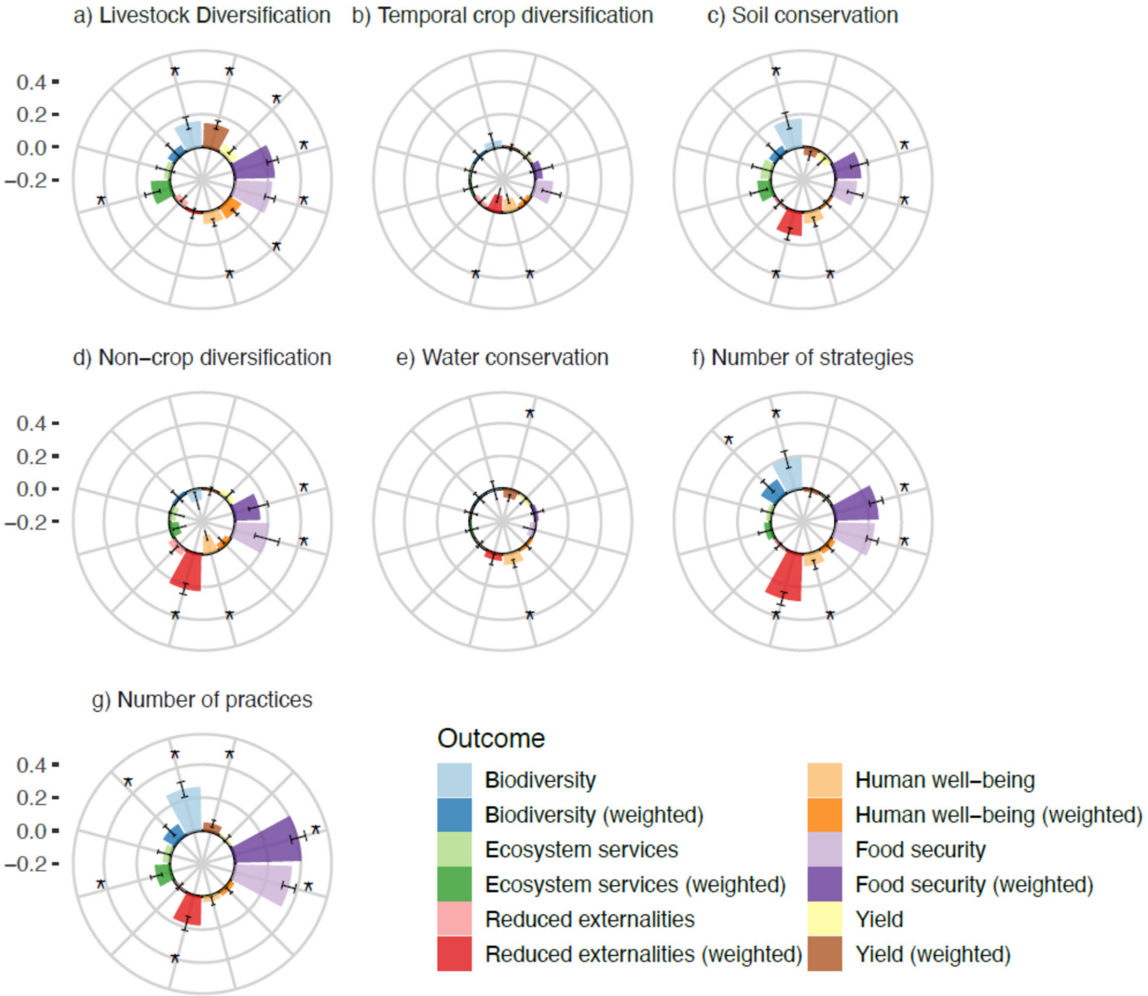

**Figure S9. Comparison of effects of agricultural diversification with and without a weighting scheme.** With the weighting scheme, the total evidence is kept constant, but studies are up or down-weighted so that they are equally represented in the model fitting. Flower diagrams indicate the effects of diversification strategies on three environmental outcome variables (non-agricultural biodiversity, regulating ecosystem services, reduced environmental externalities) and three social outcome variables (human well-being, food security, yield). Additionally shown are the effects of the total number of diversification strategies (up to a total of 5) and their associated diversification practices (up to a total of 23, excluding livestock diversification) applied (Table S2). Effect sizes are measured in units of standard deviation, with the black circle indicating an effect size = 0.0. The size of the flower petals is proportional to the effect size; error bars indicate ± 1 standard error. Asterisks indicate statistically significant effects of diversification strategies on outcomes ($p < 0.05$).

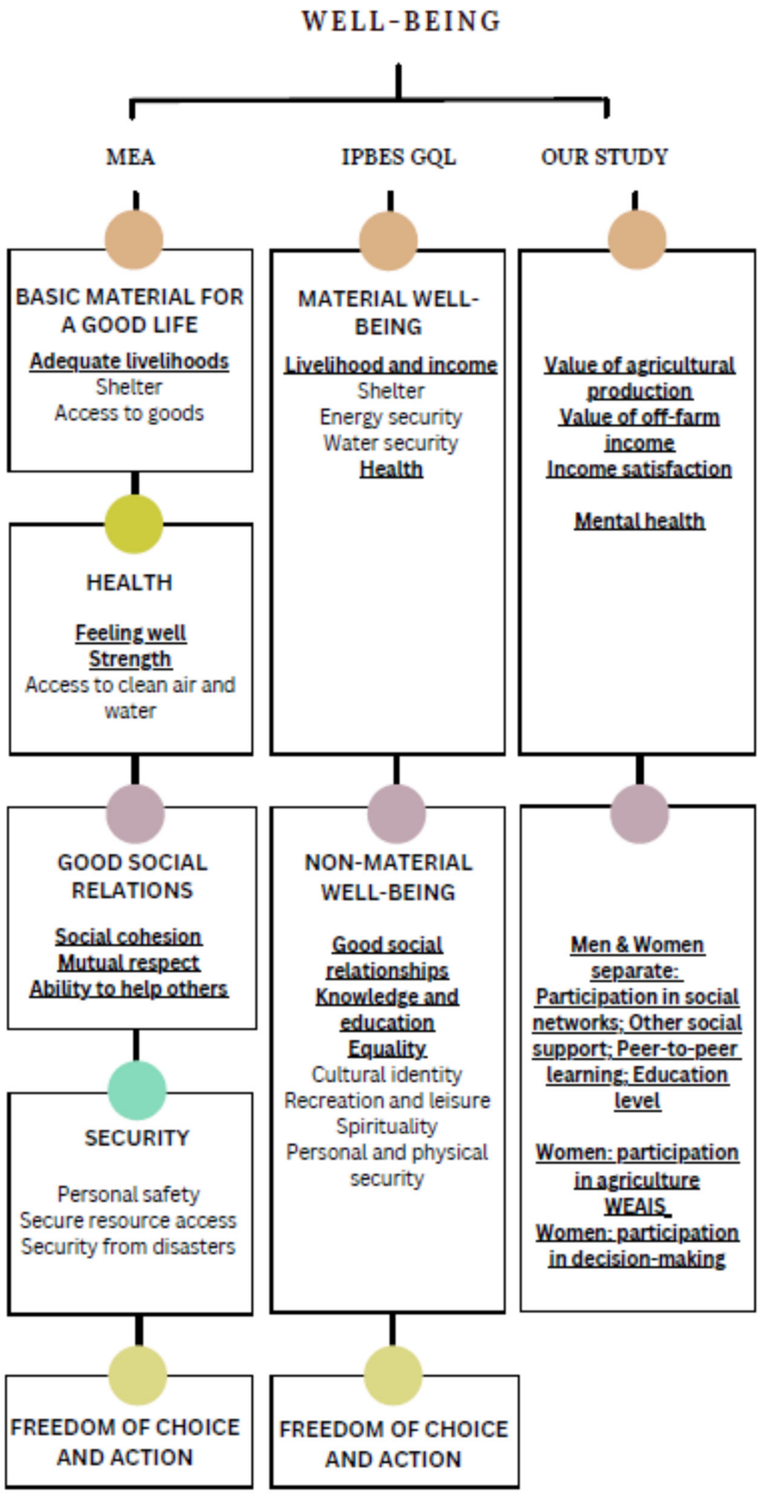

**Figure S10. Comparison of which of the Millenium Ecosystem Assessment (MEA) Constituents of human well-being and IPBES Good Quality of Life (GQL) dimensions that our human well-being subcategories address.** Addressed dimensions are underlined and in bold – with our corresponding subcategories listed in the right column. Food security is not included as we assessed that separately.

| Social and environmental outcome categories | List of subcategories | N | Examples of overlaps between outcomes |
|---|---|---|---|
| Food Security | Number of hungry months per year<br>HFIAS (The Household Food Insecurity Access Scale)<br>FAO FIES (Food Insecurity Experience Scale)<br>Dietary diversity score<br>Other indicators used to proxy food security | 3 studies, 372 farms<br>2 studies, 475 farms<br>1 study, 53 farms<br>5 studies, 810 farms<br>4 studies, 829 farms | Effects might reflect 'Yield"<br><br>Note that because metrics are computed at the farm level, broader-scale food security metrics (e.g. export-related) are not included - nor measured by any of the 24 studies |
| Human well-being | Total value of agricultural activities ($)<br><br>No. of hired workers<br>No. of family member workers<br>Women: Participation in agriculture<br><br>Women's Empowerment in Agriculture Index (WEAI)<br>Level of income satisfaction<br>Other measures of labor productivity<br>Employment satisfaction<br>Women: Other measures of social support/knowledge access<br>Men: Participation in institutions/social networks<br><br>Total value of off-farm income sources ($)<br>Mental health<br>Women: Peer-to-peer learning (Y/N)<br>Women: Level of education<br>Men: Peer-to-peer learning (Y/N)<br>Men: Level of education<br>Participation in Extension services<br>Women: Participation in institutions/social networks<br>Men: Other measures of social support/knowledge access<br>Women: Participation in decision making | 13 studies, 1311 farms<br><br>8 studies, 482 farms<br>6 studies, 536 farms<br>2 studies, 242 farms<br><br>1 study, 428 farms<br>1 study, 177 farms<br>2 studies, 292 farms<br>2 studies, 79 farms<br>2 studies, 636 farms<br>2 studies, 674 farms<br><br>8 studies, 1520 farms<br>3 studies, 507 farms<br>7 studies, 850 farms<br>8 studies, 527 farms<br>8 studies, 855 farms<br>9 studies, 953 farms<br>12 studies, 1024 farms<br>9 studies, 935 farms<br>10 studies, 938 farms<br>3 studies, 172 farms | Effects on subcategories such as mental health might reflect 'Food Security' levels<br><br>Effects on subcategories such as 'Total value of agricultural activities' might reflect 'Yield'<br><br>Note that no human health metrics (beyond mental health) were measured by the 24 studies |
| Yield | Yield (for each crop per field or farm). When multiple crops were cultivated in the same field, total yield per field was calculated by taking the sum of the crop *z*-scores | 20 studies, 1906 farms/fields | |
| Regulating ecosystem services | Water infiltration; Potential for N loss from field (nutrient leaching or N losses as a gas (e.g., nitrous oxide)); Carbon sequestration; Soil Carbon stock; Soil nutrient cycling; Pollination; Diseases; Pest control; Pest damage.<br>Directionality was reversed when disservices were measured (e.g., % pest damage) | 11 studies, 694 farms/fields | Effects might be related to level of use of pesticides and fertilizers in 'Reduced environmental externalities' |
| Reduced environmental externalities | Application of chemical pesticides; Application of synthetic fertilizers.<br>Directionality was reversed to have higher values indicating positive outcomes (less pesticides and fertilizers) | 17 studies, 1935 farms/fields | |
| Non-agricultural Biodiversity | Taxa and functional groups: Birds, butterflies, plants, beetles (e.g., carabids, rove beetles), spiders, detritivores, herbivores, pollinators, predatory arthropods/parasitoids, and bees.<br>0-4 taxa and functional groups were recorded per study. When multiple groups were recorded, biodiversity was calculated by averaging across the taxa and functional group *z*-scores | 11 studies, 526 farms/fields | |

**Table S1. Social and environmental outcomes used to assess the effects from agricultural diversification strategies.** We standardized all subcategories within each dataset by computing *z*-

scores for each data point (field and/or farm), meaning that all measurement units were replaced with number of standard deviations. Studies were conducted at both the farm and field-levels, but we used "farm" to refer to the unit of replication hereafter for conciseness. We consider human well-being as multidimensional (*61*), including indicators related to mental health, education, and governance that go well beyond income. While this is not an exhaustive list of well-being indicators, the list represents a useful set of measures.

| **Diversification strategy** | **List of practices** | **Score range for each farm** | **Number of farms/fields applying strategy** |
|---|---|---|---|
| Temporal crop diversification | Rotation<br>Rotation including > 2 crops<br>Cover cropping | 0-3 | 1414 |
| Non-crop diversification | Hedgerows<br>Windbreaks<br>Flower strips<br>Beetle banks<br>Forage strips<br>Other non-crop diversity | 0-6 | 1282 |
| Soil conservation | Manure application<br>Compost application<br>Green manure application<br>Inoculant application<br>Biochar application<br>Residue incorporation<br>Mulching<br>Nutrient mobilizing plants<br>Other beneficial soil amendment practices | 0-9 | 2124 |
| Livestock diversification | Number of livestock species, including e.g., cattle, horses, pigs, goats, sheep, fowls, donkeys, fish, and managed bees | 0-n species | 1244 |
| Water conservation | Terracing<br>Continuity of cover/roots<br>Bunds<br>Contour farming<br>Other beneficial water conservation practices | 0-5 | 558 |

**Table S2. Farm diversification strategies and practices.**

| *Ecosystem service* | *Indicator* |
|---|---|
| Water infiltration | Flood control |
| Potential for N loss from field (i.e., "nutrient leaching") | Partial nitrogen mass balance (Sum of N inputs from fertilizers, legumes, manure minus N removed in harvested crops) |
| Carbon sequestration | Above Ground Carbon in shade canopy (kg per $100m^2$) |
| Carbon sequestration | Ton $CO_2$ Equivalent |
| Soil carbon stock | Total soil organic carbon to 20-cm depth |
| Soil nutrient cycling | Mineralizable carbon |
| Soil nutrient cycling | Mineralizable nitrogen |
| Soil quality | pH, phosphorous, potassium, Soil Organic Carbon, carbon and nitrogen content |
| Pollination | Seeds per fruit set |
| Pollination | Marketability |
| Reduced externalities | Reduced externalities indicator (*62*) |
| Disease | Reduction of berry damage due to powdery mildew |
| Disease | Fruit damage |
| Pest control | Reduction of proportion berries damaged by vertebrates and invertebrates |
| Pest control | % crop damage |
| Pest damage on beans | Damage by leaf chewing pests (i.e. leaf beetles) |
| Pest damage on maize | Damage by leaf chewing pests (in particular fall armyworm and African stemborer) |

**Table S3. Indicators used across the 24 datasets to measure regulating ecosystem services**

| Study ID | Farm system | Yield | Food security | Human well-being | Non-agricultural biodiversity | Ecosystem Services | Reduced Externalities |
|---|---|---|---|---|---|---|---|
| 1 | Large-scale winter wheat | X |  | X | X |  | X |
| 2 | Large-scale winter wheat | X |  |  | X |  | X |
| 3 | Large-scale maize | X |  | X |  | X | X |
| 4 | Large-scale mixed farming | X |  | X |  | X | X |
| 5 | Large-scale mixed farming | X |  | X |  |  |  |
| 6 | Large-scale mixed farming |  |  | X |  |  | X |
| 7 | Large-scale mixed farming |  | X | X |  | X | X |
| 8 | Small to large-scale mixed farming | X |  | X | X |  | X |
| 9 | Large-scale canola | X |  | X | X |  |  |
| 10 | Large-scale blueberry | X |  | X |  |  | X |
| 11 | Small to large-scale strawberry | X |  | X | X | X | X |
| 12 | Small to large-scale strawberry | X |  |  | X | X |  |
| 13 | Large-scale silvopastoral | X |  | X | X | X | X |
| 14 | Large-scale coffee agroforestry | X |  | X | X | X | X |
| 15 | Smallholder coffee agroforestry | X |  | X |  | X | X |
| 16 | Smallholder coffee agroforestry | X |  | X | X | X |  |
| 17 | Smallholder coffee agroforestry | X | X | X |  | X |  |
| 18 | Smallholder cocoa agroforestry |  |  | X |  | X |  |
| 19 | Smallholder mixed farming | X | X | X |  |  | X |
| 20 | Smallholder mixed farming | X | X | X |  | X | X |
| 21 | Smallholder maize |  | X | X | X | X | X |
| 22 | Smallholder maize | X | X | X |  |  | X |
| 23 | Smallholder maize | X | X |  |  |  | X |
| 24 | Smallholder rubber/oil palm plantations | X | X | X | X | X | X |

**Table S4. Social and environmental variables measured by each of the 24 datasets.** We applied the commonly used 2 ha threshold for differentiating smallholder farming from farming that is less reliant on subsistence (*45*).

| **Study ID** | **Farm system** | **Reference** |
|---|---|---|
| 1 | Large-scale winter wheat | (*63*) |
| 2 | Large-scale winter wheat | (*64*) |
| 3 | Large-scale maize | (*65*) |
| 4 | Large-scale mixed farming | (*17,66*) |
| 5 | Large-scale mixed farming | (*67*) |
| 6 | Large-scale mixed farming | See Supplementary Text |
| 7 | Large-scale mixed farming | (*68,69*) |
| 8 | Small to large-scale mixed farming | (*70-72*) |
| 9 | Large-scale canola | (*73*) |
| 10 | Large-scale blueberry | See Supplementary Text |
| 11 | Small to large-scale strawberry | (*59*) |
| 12 | Small to large-scale strawberry | (*57,60*), See also Supplementary Text |
| 13 | Large-scale silvopastoral | (*74,75*) |
| 14 | Large-scale coffee agroforestry | (*76*) |
| 15 | Smallholder coffee agroforestry | (*77-79*) |
| 16 | Smallholder coffee agroforestry | (*80*) |
| 17 | Smallholder coffee agroforestry | (*81-84*) |
| 18 | Smallholder cocoa agroforestry | (*85*) |
| 19 | Smallholder mixed farming | (*86*) |
| 20 | Smallholder mixed farming | (*87,88*) |
| 21 | Smallholder maize | (*89*) |
| 22 | Smallholder maize | (*90*) |
| 23 | Smallholder maize | (*91*), See also Supplementary Text |
| 24 | Smallholder rubber/oil palm plantations | (*92*) |

**Table S5. References for the 24 datasets.** Those datasets without published papers/data or with only part of the data published are described in detail in the Supplementary Text.

| *Variable* |
|---|
| Food security: Number of hungry months |
| HFIAS (The Household food insecurity access scale) |
| Food security: Other food insecurity metrics |
| Human well-being: Mental health |
| Ecosystem services: Fruit damage |
| Ecosystem services: Pest and disease damage |
| Ecosystem services: Reduced externalities(*62*) |
| Ecosystem services: Partial nitrogen mass balance |

**Table S6. Variables that were transformed before standardization due to reversed directionality.** The directionality of variables was defined individually by each data contributor thereby accounting for the context in which it was measured (and theoretically allowing for different directionality in the same variable between studies although this was not the case).

| | OUTCOME VARIABLES | % MISSING OBSERVATIONS |
|---|---|---|
| *ENVIRONMENTAL VARIABLES* | Non-agricultural biodiversity | 80 |
| | Regulating ecosystem services | 74 |
| | Reduced Environmental Externalities | 27 |
| *SOCIAL VARIABLES* | Compound Food Security | 39 |
| | Compound Human well-being | 15 |
| | Total yield | 28 |

**Table S7. Percentage of missing observations for broad categories of environmental and social outcome variables.** N = 2655 farms/fields (24 studies).

| ESA-CCI Code | Class description | Reclassification |
|---|---|---|
| 0 | No data | 9999 |
| 10 | Cropland, rainfed | 1 |
| 11 | Herbaceous cover | 1 |
| 12 | Tree or shrub cover | 2 |
| 20 | Cropland, irrigated or post-flooding | 1 |
| 30 | Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%) | 1 |
| 40 | Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%) | 2 |
| 50 | Tree cover, broadleaved, evergreen, closed to open (>15%) | 2 |
| 60 | Tree cover, broadleaved, deciduous, closed to open (>15%) | 2 |
| 61 | Tree cover, broadleaved, deciduous, closed (>40% | 2 |
| 62 | Tree cover, broadleaved, deciduous, open (15-40%) | 2 |
| 70 | Tree cover, needleleaved, evergreen, closed to open (>15%) | 2 |
| 71 | Tree cover, needleleaved, evergreen, closed (>40%) | 2 |
| 72 | Tree cover, needleleaved, evergreen, open (15-40%) | 2 |
| 80 | Tree cover, needleleaved, deciduous, closed to open (>15%) | 2 |
| 81 | Tree cover, needleleaved, deciduous, closed (>40%) | 2 |
| 82 | Tree cover, needleleaved, deciduous, open (15-40%) | 2 |
| 90 | Tree cover, mixed leaf type (broadleaved and needleleaved) | 2 |
| 100 | Mosaic tree and shrub (>50%) / herbaceous cover (<50%) | 2 |
| 110 | Mosaic herbaceous cover (>50%) / tree and shrub (<50%) | 2 |
| 120 | Shrubland | 2 |
| 121 | Evergreen shrubland | 2 |
| 122 | Deciduous shrubland | 2 |
| 130 | Grassland | 1 |
| 140 | Lichens and mosses | 2 |
| 150 | Sparse vegetation (tree, shrub, herbaceous cover) (<15%) | 2 |
| 151 | Sparse tree (<15%) | 2 |
| 152 | Sparse shrub (<15%) | 2 |
| 153 | Sparse herbaceous cover (<15%) | 2 |
| 160 | Tree cover, flooded, fresh or brackish water | 2 |
| 170 | Tree cover, flooded, saline water | 2 |
| 180 | Shrub or herbaceous cover, flooded, fresh/saline/brackish water | 2 |
| 190 | Urban areas | 3 |
| 200 | Bare areas | 3 |
| 201 | Consolidated bare areas | 3 |

| | | |
|---|---|---|
| 202 | Unconsolidated bare areas | 3 |
| 210 | Water bodies | 2 |
| 220 | Permanent snow and ice | 3 |

**Table S8. Reclassification table for ESA-CCI land cover product.** Reclassification: 9999 = no data, 1 = agriculture, 2 = seminatural, 3 = other.

|  |  | Environmental outcomes (# observations) |  |  | Social outcomes (# observations) |  |  | Diversification practices (Min and Max values) |  |  |  |  |  |  |  |  |  | Landscape in 3 km radius (Min and Max values) |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Study* | *study* | *Non-agricultural biodiversity* | *ES* | *Reduced Externalities* | *Yield* | *Food Security* | *HH well-being* | *Crop Diversification* |  | *Non-crop Diversification* |  | *Livestock diversification* |  | *Soil Conservation* |  | *Water Conservation* |  | *% Seminatural habitat* |  |
| 1 | Large-scale winter wheat | 36 | NA | 40 | 40 | NA | 28 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.70 |
| 2 | Large-scale winter wheat | 28 | NA | 28 | 28 | NA | NA | 2.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 2.00 | 0.00 | 0.00 | 0.02 | 0.42 |
| 3 | Large-scale maize | NA | 55 | 55 | 53 | NA | 55 | 2.00 | 3.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 5.00 | 0.00 | 2.00 | 0.00 | 0.41 |
| 4 | Large-scale mixed farming | NA | 15 | 18 | 18 | NA | 18 | 0.00 | 3.00 | 0.00 | 4.00 | 0.00 | 12.00 | 0.00 | 6.00 | 0.00 | 2.00 | 0.83 | 1.00 |
| 5 | Large-scale mixed farming | NA | NA | NA | 73 | NA | 243 | 0.00 | 3.00 | 0.00 | 3.00 | 0.00 | 2.00 | 4.00 | 6.00 | 0.00 | 0.00 | 0.35 | 1.00 |
| 6 | Large-scale mixed farming | NA | NA | 34 | NA | NA | 34 | 0.00 | 2.00 | 0.00 | 1.00 | 0.00 | 7.00 | 0.00 | 5.00 | 0.00 | 0.00 | 0.08 | 0.61 |
| 7 | Large-scale mixed farming | NA | NA | 75 | NA | 75 | 48 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 10.00 | 0.00 | 2.00 | 0.00 | 0.00 | NA | NA |
| 8 | Small to large-scale mixed farming | 218 | NA | 188 | 55 | NA | 218 | 1.00 | 2.00 | 1.00 | 2.00 | 0.00 | 11.00 | 0.00 | 5.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 9 | Large-scale canola | 30 | NA | NA | 30 | NA | 30 | 2.00 | 2.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.12 |
| 10 | Large-scale blueberry | NA | NA | 35 | 29 | NA | 35 | 0.00 | 0.00 | 0.00 | 3.00 | 0.00 | 2.00 | 0.00 | 6.00 | 0.00 | 1.00 | 0.00 | 0.55 |
| 11 | Small to large-scale strawberry | 53 | 53 | 53 | 52 | NA | 53 | 1.00 | 3.00 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.03 | 0.92 |
| 12 | Small to large-scale strawberry | 20 | 20 | NA | 20 | NA | NA | 1.00 | 2.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.69 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Large-scale silvopastoral | 35 | 32 | 38 | 38 | NA | 38 | 0.00 | 0.00 | 1.00 | 4.00 | 1.00 | 6.00 | 0.00 | 5.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 14 | Large-scale coffee agroforestry | 24 | NA | 26 | 26 | NA | 26 | 0.00 | 0.00 | 0.00 | 2.00 | 0.00 | 1.00 | 1.00 | 2.00 | 0.00 | 0.00 | 0.20 | 0.99 |
| 15 | Smallholder coffee agroforestry | NA | 51 | 51 | 50 | NA | 51 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.87 | 1.00 |
| 16 | Smallholder coffee agroforestry | 15 | 15 | NA | 15 | NA | 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.70 | 0.84 |
| 17 | Smallholder coffee agroforestry | NA | 241 | NA | 241 | 241 | 241 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 0.34 | 0.95 |
| 18 | Smallholder cocoa agroforestry | NA | 104 | NA | NA | NA | 104 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 2.00 | 2.00 | 0.00 | 0.00 | 0.02 | 0.02 |
| 19 | Smallholder mixed farming | NA | NA | 484 | 484 | 484 | 484 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 7.00 | 0.00 | 3.00 | 0.00 | 1.00 | 0.01 | 0.40 |
| 20 | Smallholder mixed farming | NA | 33 | NA | 33 | 29 | 29 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 4.00 | 1.00 | 2.00 | 0.00 | 0.00 | 0.02 | 0.79 |
| 21 | Smallholder maize | 43 | 51 | 50 | NA | 47 | 47 | 1.00 | 2.00 | 0.00 | 1.00 | 0.00 | 6.00 | 0.00 | 4.00 | 0.00 | 2.00 | 0.00 | 0.44 |
| 22 | Smallholder maize | NA | NA | 428 | 289 | 428 | 428 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 5.00 | 0.00 | 5.00 | 0.00 | 1.00 | 0.23 | 0.80 |
| 23 | Smallholder maize | NA | NA | 308 | 308 | 308 | NA | 1.00 | 2.00 | 0.00 | 0.00 | 0.00 | 7.00 | 0.00 | 4.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| 24 | Smallholder rubber/oil palm plantations | 24 | 24 | 24 | 24 | 19 | 20 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 1.00 |

**Table S9. Characterization of collected variables at the study level (24 studies).** See Table S2 for min/max range possible for each diversification practice. Data contributors reported food security and human well-being at the farm level, while all other variables in most cases were entered at the field level.

| **A** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | Cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 47 | 51 | 193 | 148 | 18 | 407 | 105 | 249 | 419 | 100 | 227 | 700 | 30 | 175 | 443 | 185 | 182 | 885 |
| 1 | 41 | 3 | 21 | 1 | 6 | 16 | 61 | 85 | 122 | 54 | 88 | 105 | 38 | 86 | 93 | 42 | 31 | 126 |
| 2 | 7 | 17 | 20 | 7 | 6 | 13 | 28 | 83 | 232 | 24 | 65 | 175 | 24 | 68 | 207 | 6 | 35 | 250 |
| 3 | 5 | 7 | 32 | 2 | 7 | 26 | 14 | 38 | 205 | 9 | 29 | 165 | 9 | 36 | 190 | 6 | 17 | 217 |
| 4 | 7 | 2 | 13 | 6 | 2 | 12 | 12 | 18 | 89 | 9 | 16 | 71 | 10 | 16 | 80 | 8 | 8 | 91 |
| 5 | 4 | 3 | 12 | 4 | 0 | 4 | 5 | 8 | 42 | 2 | 5 | 34 | 4 | 5 | 25 | 4 | 6 | 42 |
| 6 | 2 | 0 | 8 | 1 | 3 | 2 | 2 | 4 | 13 | 0 | 1 | 5 | 1 | 4 | 5 | 2 | 3 | 13 |
| 7 | 0 | 0 | 13 | | | | 1 | 1 | 18 | 1 | 1 | 4 | 1 | 1 | 4 | 0 | 0 | 18 |
| 8 | 0 | 0 | 14 | | | | | | | 0 | 0 | 14 | | | | 0 | 0 | 14 |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | | | | 0 | 0 | 1 |
| 11 | 0 | 0 | 3 | | | | 0 | 0 | 3 | | | | | | | 0 | 0 | 3 |
| 12 | | | | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | | | | 0 | 0 | 1 |

| **B** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 6 | 4 | 88 | 111 | 8 | 381 | 16 | 176 | 569 | 17 | 178 | 794 | 6 | 161 | 697 | 121 | 181 | 854 |
| 1 | 50 | 29 | 96 | 3 | 3 | 21 | 127 | 190 | 422 | 89 | 169 | 342 | 79 | 156 | 334 | 46 | 47 | 560 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 55 | 41 | 118 | 42 | 28 | 52 | 72 | 109 | 117 | 82 | 74 | 101 | 32 | 74 | 16 | 73 | 51 | 216 |
| 3 | 2 | 9 | 27 | 13 | 3 | 28 | 13 | 11 | 37 | 11 | 11 | 38 | 6 | 161 | 697 | 13 | 3 | 31 |

| **C** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 41 | 24 | 119 | 30 | 11 | 286 | 45 | 69 | 127 | 73 | 58 | 337 | 11 | 43 | 256 | 58 | 40 | 354 |
| 1 | 8 | 22 | 71 | 6 | 9 | 124 | 33 | 156 | 304 | 32 | 148 | 335 | 24 | 126 | 237 | 11 | 97 | 341 |
| 2 | 8 | 11 | 27 | 108 | 11 | 39 | 58 | 172 | 225 | 54 | 166 | 220 | 50 | 161 | 210 | 116 | 99 | 236 |
| 3 | 21 | 7 | 41 | 14 | 5 | 10 | 47 | 53 | 161 | 26 | 46 | 96 | 29 | 50 | 119 | 26 | 18 | 159 |
| 4 | 26 | 10 | 46 | 2 | 5 | 5 | 31 | 25 | 193 | 7 | 12 | 125 | 3 | 11 | 128 | 28 | 17 | 214 |
| 5 | 9 | 9 | 25 | 9 | 1 | 13 | 14 | 10 | 130 | 7 | 1 | 141 | 0 | 0 | 97 | 14 | 10 | 288 |
| 6 | | | | 0 | 0 | 5 | 0 | 1 | 5 | 0 | 1 | 21 | | | | 0 | 1 | 69 |

| **D** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 45 | 32 | 102 | 37 | 20 | 253 | 150 | 414 | 486 | 171 | 409 | 662 | 106 | 376 | 556 | 77 | 207 | 647 |
| 1 | 25 | 16 | 60 | 123 | 21 | 183 | 33 | 35 | 504 | 15 | 19 | 474 | 11 | 15 | 491 | 131 | 38 | 693 |
| 2 | 40 | 34 | 153 | 6 | 0 | 26 | 41 | 35 | 132 | 10 | 2 | 98 | | | | 41 | 35 | 223 |
| 3 | 1 | 1 | 6 | 1 | 1 | 7 | 2 | 2 | 9 | 1 | 2 | 27 | | | | 2 | 2 | 84 |
| 4 | 2 | 0 | 8 | 2 | 0 | 13 | 2 | 0 | 14 | 2 | 0 | 14 | | | | 2 | 0 | 14 |

| **E** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 0 | 72 | 76 | 139 | 27 | 380 | 195 | 436 | 716 | 150 | 387 | 921 | 106 | 349 | 712 | 195 | 249 | 1218 |
| 1 | 1 | 41 | 7 | 26 | 13 | 99 | 29 | 48 | 426 | 46 | 43 | 352 | 11 | 42 | 334 | 54 | 31 | 440 |
| 2 | 2 | 0 | 0 | 4 | 2 | 3 | 4 | 2 | 3 | 3 | 2 | 2 | 0 | 0 | 1 | 4 | 2 | 3 |

| **F** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 0 | 0 | 16 | 0 | 0 | 153 | 0 | 8 | 21 | 0 | 8 | 157 | 0 | 8 | 154 | 0 | 8 | 156 |
| 1 | 6 | 5 | 39 | 20 | 4 | 126 | 29 | 116 | 138 | 29 | 115 | 233 | 8 | 106 | 193 | 28 | 109 | 227 |
| 2 | 26 | 38 | 99 | 112 | 11 | 73 | 53 | 168 | 328 | 63 | 157 | 348 | 29 | 116 | 247 | 128 | 92 | 364 |
| 3 | 36 | 16 | 85 | 20 | 16 | 96 | 98 | 150 | 199 | 99 | 136 | 242 | 68 | 138 | 101 | 51 | 41 | 445 |
| 4 | 37 | 21 | 83 | 9 | 3 | 27 | 40 | 36 | 278 | 8 | 16 | 169 | 4 | 16 | 179 | 38 | 25 | 288 |
| 5 | 8 | 3 | 7 | 8 | 8 | 7 | 8 | 8 | 181 | 0 | 0 | 126 | 8 | 7 | 173 | 8 | 7 | 181 |

| **G** | **Samples per variable combination** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BIODIVERSITY | | | ECOSYSTEM SERVICES | | | REDUCED EXTERNALITIES | | | YIELD | | | FOOD SECURITY | | | HUMAN WELL-BEING | | |
| # of practices | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex | cleared | simple | complex |
| 0 | 0 | 0 | 16 | 0 | 0 | 153 | 0 | 8 | 21 | 0 | 8 | 157 | 0 | 8 | 154 | 0 | 8 | 156 |
| 1 | 6 | 5 | 29 | 0 | 2 | 111 | 11 | 52 | 81 | 11 | 51 | 172 | 4 | 46 | 146 | 5 | 48 | 168 |
| 2 | 3 | 6 | 43 | 20 | 3 | 51 | 28 | 97 | 106 | 28 | 97 | 135 | 10 | 81 | 79 | 26 | 72 | 125 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 16 | 23 | 45 | 108 | 10 | 59 | 32 | 97 | 167 | 43 | 87 | 149 | 21 | 68 | 90 | 119 | 65 | 173 |
| 4 | 25 | 14 | 25 | 7 | 6 | 22 | 32 | 79 | 96 | 47 | 76 | 97 | 21 | 67 | 78 | 26 | 29 | 96 |
| 5 | 3 | 1 | 19 | 3 | 1 | 22 | 28 | 42 | 104 | 27 | 43 | 101 | 25 | 42 | 86 | 3 | 4 | 110 |
| 6 | 13 | 2 | 19 | 4 | 2 | 19 | 30 | 39 | 80 | 19 | 37 | 74 | 18 | 38 | 69 | 16 | 10 | 104 |
| 7 | 9 | 2 | 12 | 2 | 2 | 7 | 17 | 21 | 109 | 8 | 17 | 102 | 6 | 18 | 86 | 11 | 6 | 178 |
| 8 | 18 | 5 | 23 | 6 | 6 | 5 | 22 | 14 | 99 | 4 | 8 | 76 | 1 | 12 | 71 | 21 | 7 | 162 |
| 9 | 2 | 8 | 16 | 6 | 4 | 7 | 7 | 13 | 89 | 5 | 5 | 63 | 2 | 4 | 72 | 6 | 11 | 116 |
| 10 | 1 | 11 | 13 | 3 | 0 | 4 | 3 | 12 | 75 | 1 | 0 | 50 | 1 | 0 | 62 | 3 | 12 | 81 |
| 11 | 4 | 5 | 8 | 4 | 5 | 9 | 5 | 11 | 43 | 1 | 2 | 43 | 5 | 7 | 34 | 4 | 9 | 103 |
| 12 | 12 | 0 | 30 | 5 | 0 | 4 | 12 | 0 | 34 | 5 | 0 | 40 | 2 | 0 | 18 | 12 | 0 | 48 |
| 13 | 1 | 1 | 11 | 1 | 1 | 3 | 1 | 1 | 14 | 0 | 1 | 8 | 1 | 0 | 2 | 1 | 1 | 14 |
| 14 | 0 | 0 | 16 | 0 | 0 | 1 | 0 | 0 | 18 | 0 | 0 | 3 | | | | 0 | 0 | 18 |
| 15 | 0 | 0 | 1 | | | | 0 | 0 | 1 | | | | | | | 0 | 0 | 1 |
| 16 | | | | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | | | | 0 | 0 | 2 |
| 18 | 0 | 0 | 3 | | | | | | | | | | | | | | | |
| 20 | | | | 0 | 0 | 1 | | | | 0 | 0 | 1 | | | | | | |

**Table S10. Characterization of number of samples per variable combination: type of diversification strategy, number of diversification practices, and landscape composition in a 3 km radius around observations.** A: Livestock diversification, B: Temporal crop diversification, C: Soil conservation, D: Non-crop diversification, E: Water conservation, F: Total number of diversification strategies, G: Total number of diversification practices

| | **Small farms only (n=1742)** | **Large farms only (n=913)** |
|---|---|---|
| # of observations | | |
| BIODIVERSITY | 82 | 444 |
| ECOSYSTEM SERVICES | 519 | 175 |
| REDUCED EXTERNALITIES | 1345 | 590 |
| YIELD | 1444 | 462 |
| FOOD SECURITY | 1495 | 75 |
| HUMAN WELL-BEING | 1358 | 397 |
| Min and Max values for diversification practices | | |
| TEMPORAL CROP DIVERSIFICATION | 0-3 | 0-3 |
| NON-CROP DIVERSIFICATION | 0-4 | 0-4 |
| LIVESTOCK DIVERSIFICATION | 0-7 | 0-12 |
| SOIL CONSERVATION | 0-5 | 0-6 |
| WATER CONSERVATION | 0-2 | 0-2 |

**Table S11. Number of observations across small farms and large farms for the six outcome variables (24 studies).** See Table S2 for min/max range possible for each diversification practice.

| | | **Full dataset<br>(N = 2655)** | | | **Small farms only<br>(N = 1742)** | | | **Large farms only<br>(N = 913)** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Estimate | SE | P | Estimate | SE | P | Estimate | SE | P |
| **Biodiversity** | (Intercept) | 0.08 | 0.08 | 0.3255 | 0.05 | 0.22 | 0.8320 | **0.15** | **0.09** | **0.0866** |
| | Temporal crop diversity | 0.04 | 0.05 | 0.4057 | -0.18 | 0.16 | 0.2650 | 0.09 | 0.06 | 0.1172 |
| | Non-crop diversity | -0.07 | 0.05 | 0.1948 | 0.16 | 0.12 | 0.2060 | -0.11 | 0.07 | 0.1172 |
| | Livestock diversification | **0.16** | **0.04** | **<0.0001*** | 0.26 | 0.18 | 0.1490 | **0.21** | **0.05** | **<0.0001*** |
| | Soil conservation | **0.17** | **0.05** | **0.0006*** | -0.09 | 0.23 | 0.7050 | **0.25** | **0.06** | **0.0001*** |
| | Water conservation | 0.00 | 0.06 | 0.9522 | 0.07 | 0.11 | 0.5100 | -0.02 | 0.06 | 0.7187 |
| | **Number of strategies** | **0.19** | **0.05** | **0.0003*** | 0.21 | 0.15 | 0.1510 | **0.22** | **0.05** | **<0.0001*** |
| | **Number of practices** | **0.26** | **0.05** | **<0.0001*** | 0.05 | 0.08 | 0.5520 | **0.31** | **0.05** | **<0.0001*** |
| | | | | | | | | | | |
| **Ecosystem services** | (Intercept) | 0.05 | 0.05 | 0.3290 | 0.02 | 0.09 | 0.8040 | 0.04 | 0.13 | 0.7405 |
| | Temporal crop diversity | 0.00 | 0.03 | 0.8860 | 0.00 | 0.10 | 0.9960 | 0.01 | 0.08 | 0.9464 |
| | Non-crop diversity | -0.04 | 0.05 | 0.4320 | 0.00 | 0.05 | 0.9410 | -0.13 | 0.09 | 0.1493 |
| | Livestock diversification | 0.03 | 0.06 | 0.5520 | -0.03 | 0.10 | 0.7460 | 0.19 | 0.11 | 0.0885 |
| | Soil conservation | 0.06 | 0.06 | 0.3260 | 0.13 | 0.10 | 0.1820 | 0.04 | 0.11 | 0.6936 |
| | Water conservation | 0.00 | 0.04 | 0.9900 | 0.01 | 0.07 | 0.8590 | -0.01 | 0.05 | 0.8727 |
| | **Number of strategies** | 0.03 | 0.04 | 0.4850 | 0.04 | 0.05 | 0.3760 | -0.03 | 0.07 | 0.6220 |
| | **Number of practices** | 0.04 | 0.04 | 0.2850 | 0.04 | 0.05 | 0.4690 | 0.05 | 0.07 | 0.4830 |
| | | | | | | | | | | |
| **Reduced externalities** | (Intercept) | 0.02 | 0.02 | 0.5300 | 0.03 | 0.03 | 0.2384 | 0.04 | 0.05 | 0.3238 |
| | Temporal crop diversity | -0.02 | 0.02 | 0.3170 | 0.01 | 0.03 | 0.7522 | -0.03 | 0.04 | 0.4982 |
| | Non-crop diversity | 0.04 | 0.03 | 0.1220 | **0.07** | **0.04** | **0.0647** | 0.02 | 0.05 | 0.7434 |
| | Livestock diversification | -0.04 | 0.02 | 0.1080 | **-0.05** | **0.03** | **0.0702** | -0.04 | 0.04 | 0.3115 |
| | Soil conservation | 0.01 | 0.03 | 0.7430 | **-0.08** | **0.04** | **0.0317** | **0.13** | **0.06** | **0.0247** |
| | Water conservation | 0.00 | 0.02 | 0.9230 | -0.03 | 0.03 | 0.4209 | 0.06 | 0.04 | 0.1175 |
| | **Number of strategies** | 0.01 | 0.02 | 0.6000 | -0.03 | 0.03 | 0.2390 | **0.09** | **0.04** | **0.0074** |
| | **Number of practices** | -0.01 | 0.02 | 0.8300 | **-0.08** | **0.03** | **0.0116** | **0.07** | **0.04** | **0.0657** |
| | | | | | | | | | | |
| **Yield** | (Intercept) | 0.00 | 0.02 | 0.8582 | 0.00 | 0.03 | 0.9690 | 0.02 | 0.05 | 0.6722 |
| | Temporal crop diversity | 0.01 | 0.02 | 0.7422 | 0.00 | 0.03 | 0.9070 | 0.03 | 0.04 | 0.5183 |
| | Non-crop diversity | 0.03 | 0.03 | 0.2436 | 0.00 | 0.03 | 0.9230 | 0.05 | 0.06 | 0.4284 |
| | Livestock diversification | **0.05** | **0.03** | **0.0365** | 0.02 | 0.03 | 0.4000 | **0.11** | **0.06** | **0.0420** |
| | Soil conservation | -0.04 | 0.03 | 0.1485 | -0.02 | 0.04 | 0.5320 | -0.08 | 0.06 | 0.1596 |
| | Water conservation | -0.02 | 0.02 | 0.3090 | 0.01 | 0.03 | 0.8300 | **-0.09** | **0.04** | **0.0193** |
| | **Number of strategies** | 0.00 | 0.02 | 0.9180 | 0.01 | 0.03 | 0.8430 | -0.04 | 0.04 | 0.4140 |
| | **Number of practices** | 0.01 | 0.02 | 0.5980 | 0.00 | 0.03 | 0.9360 | 0.04 | 0.04 | 0.4220 |
| | | | | | | | | | | |
| **Food security** | (Intercept) | 0.08 | 0.12 | 0.5070 | -0.04 | 0.13062 | 0.7373 | -0.63 | 0.42 | 0.1300 |
| | Temporal crop diversity | 0.11 | 0.06 | 0.0610 | **0.08** | **0.04494** | **0.0623** | NA | NA | NA |
| | Non-crop diversity | **0.21** | **0.08** | **0.0060** | **0.12** | **0.04364** | **0.0068** | NA | NA | NA |
| | Livestock diversification | **0.23** | **0.03** | **<0.0001*** | **0.2** | **0.0279** | **<0.0001*** | **0.37** | **0.18** | **0.0380** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Soil conservation | **0.13** | **0.05** | **0.0066** | **0.11** | **0.03837** | 0.0040 | -0.33 | 0.46 | 0.4730 |
| | Water conservation | -0.03 | 0.04 | 0.3530 | -0.04 | 0.03701 | 0.3300 | NA | NA | NA |
| | **Number of strategies** | **0.24** | **0.04** | **<0.0001*** | **0.27** | **0.03948** | **<0.0001*** | 0.28 | 0.64 | 0.6700 |
| | **Number of practices** | **0.35** | **0.04** | **<0.0001*** | **0.31** | **0.03691** | **<0.0001*** | 0.42 | 0.26 | 0.1200 |
| | | | | | | | | | | |
| **Human well-being** | (Intercept) | 0.03 | 0.03 | 0.4520 | -0.04 | 0.07 | 0.5700 | 0.03 | 0.06 | 0.6610 |
| | Temporal crop diversity | **-0.08** | **0.03** | **0.0043** | **-0.10** | **0.05** | **0.0500** | **-0.13** | **0.04** | **0.0052** |
| | Non-crop diversity | **-0.11** | **0.03** | **0.0002*** | **0.08** | **0.04** | **0.0500** | **-0.23** | **0.05** | **<0.0001*** |
| | Livestock diversification | **0.07** | **0.02** | **0.0020** | **0.07** | **0.03** | **0.0100** | **0.08** | **0.04** | **0.0313** |
| | Soil conservation | **0.07** | **0.03** | **0.0200** | **0.10** | **0.04** | **0.0200** | 0.08 | 0.05 | 0.0970 |
| | Water conservation | **0.07** | **0.02** | **0.0100** | **0.09** | **0.04** | **0.0200** | 0.00 | 0.04 | 0.9751 |
| | **Number of strategies** | **0.07** | **0.03** | **0.0100** | **0.11** | **0.03** | **0.0010*** | -0.02 | 0.04 | 0.6000 |
| | **Number of practices** | 0.03 | 0.03 | 0.1900 | **0.15** | **0.04** | **<0.0001*** | **-0.07** | **0.04** | **0.0710** |

**Table S12. Model coefficients for linear mixed-effects models, with number of diversification practices as predictors and study ID as a random effect.** Coefficients are shown for each of the six outcome variables (Non-agricultural biodiversity, regulating ecosystem services, reduced externalities, yields, food security, and human well-being) and the five agricultural diversification strategies (as well as the total number of diversification strategies and practices), resulting in 42 estimates of diversification effects. We standardized the number of practices (zero mean and unit variance) to allow for direct comparisons of effect sizes among the 42 estimates. We applied the commonly used 2 ha threshold for differentiating smallholder farming from farming that is less reliant on subsistence (*45*). Bold values represent significant results. * denotes significance after Bonferroni correction for multiple comparisons (42 estimates), threshold for significance of p=0.00119.

| | **Outcome: Total value of agricultural production (N = 1211 farms/fields across 13 datasets)** | | |
|---|---|---|---|
| | Estimate | SE | P |
| Intercept | -0.0034 | 0.0306 | 0.9106 |
| Factor: Income measured as net agriculture income (Yes) or in another way (e.g., gross agriculture income) (No) | 0.0221 | 0.1401 | 0.8745 |
| Temporal crop diversification | 0.0184 | 0.0352 | 0.6008 |
| Non-crop diversification | 0.0943 | 0.0432 | 0.0289* |
| Livestock diversification | 0.1774 | 0.0323 | <0.0001*** |
| Soil conservation | -0.1264 | 0.0379 | 0.0009*** |
| Income::Temporal crop diversification | 0.0847 | 0.1980 | 0.6687 |
| Income::Non-crop diversification | -0.0719 | 0.2951 | 0.8076 |
| Income::Livestock diversification | -0.0762 | 0.1866 | 0.6828 |
| Income::Soil conservation | 0.0143 | 0.1820 | 0.9373 |
| | | | |
| Intercept | -0.0938 | 28.460 | 0.9974 |
| Factor: Income measured as net agriculture income (Y) or in another way (e.g., gross agriculture income) (N) | -2.5550 | 122.30 | 0.9833 |
| Number of strategies | 51.740 | 22.910 | 0.0239* |
| Income::Number of strategies | -38.170 | 111.20 | 0.7314 |
| | | | |
| Intercept | 0.0176 | 0.0355 | 0.6209 |
| Factor: Income measured as net agriculture income (Yes) or in another way (e.g., gross agriculture income) (No) | -0.0397 | 0.1295 | 0.7589 |
| Number of practices | 0.0882 | 0.0308 | 0.0042** |
| Income::Number of practices | -0.1202 | 0.1202 | 0.3171 |

**Table S13: Model coefficients for linear mixed-effects models with total value of agricultural production as the outcome variable.** Diversification practices are predictors and study ID is included as a random effect. An interaction was included between the type of diversification and the way in which the total value of agricultural production was measured (a factor with two levels: (1) net agricultural income or (2) another metric such as gross agricultural income without deducting costs). Four of the 13 studies measured net agricultural income. As there was no significant interaction with the factor variable, our results on the effects of diversification on total value of agricultural production (Fig S8) remain robust as to whether total value of agricultural production was measured as net income or not. Water conservation is not included due to few observations. Significance levels: *<0.05; **<0.01; ***<0.001

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