Agroforestry Network

FOUNDED BY VI AGROFORESTRY

Agroforestry and Agroecology

Sustainable and safe alternatives to pesticides for increased biodiversity and human health

Across the globe, small-scale farmers have adopted agroecology and agroforestry as their primary farming methods, which represent innovative ways that, in harmony with nature, provide food and nutritional security. One notable feature of these methods is the minimal use of chemical inputs, such as synthetic fertilizers and pesticides, and instead promote natural solutions for soil nutrient management, pest, disease, and weed control. This choice is often driven by health concerns and financial constraints, as many small-scale farmers lack the resources to purchase and apply chemical inputs. This brief outlines how agroforestry and agroecology can serve as sustainable alternatives to synthetic pesticides, and simultaneously build resilient agri-ecosystems, combat climate change, and empower smallholder farmers and vulnerable communities to adapt to the challenges of a changing climate. This policy brief emphasizes the urgent need to reduce the reliance on synthetic pesticides and phase out the use of particularly hazardous ones. Agroforestry and agroecology are presented as viable alternatives to achieve this objective. The purpose of this paper is to provide information to policy makers on the available science based evidence on synthetic pesticide use and available alternatives. It expounds on how agroecology and agroforestry can support safe agricultural production and give insights on challenges in access to bioinputs. The policy brief can be used to inform policies, make a business case for bioinputs production and distribution as well advancement of research.

Agroforestry and agroecology – good for people and the environment

The current food system, from production to consumption, needs transformation [1][2][3], which requires a systemic agriculture ecosystem approach that builds on the understanding and knowledge of farming practices as part of the ecosystem in harmony with nature [22][24]. Such an approach brings benefits both to farming and to society as a whole [71]. Agroforestry and agroecology emphasize ecosystem health, resilience and the safeguarding of food rights and involves a diverse set of cropping systems and natural pest control methods, all of which improve the environment, soil health, nutrient cycling, fertility, water retention and contribute to mitigating greenhouse gas emission and resilience to climate change. Agroforestry is regarded as a practice within the more holistic agroecology approach. Agroecology looks at the whole food system and builds on 13 principles [2][32] that enhances the resilience and sustainability of food and farming systems, while preserving social integrity. Both promote and increase the share of biological pest control methods (biopesticides and biofertilizers) and they are regarded as environmentally friendly and economically viable. Agroforestry and agroecology practices supply alternatives to the use of synthetic chemicals and contribute to spatial and temporal diversity of crops that sustain greater agrobiodiversity above- and below ground, pollinator species richness and wild pollinator populations [16].

FACTBOX:
AGROECOLOGY
is a science, a practice and a social movement that has gained recognition as the pathway to transform the food system. Agroecology is guided by the 13 principles of agroecology defined by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security (CFS) [2].

AGROFORESTRY
Is a land-use systems and technologies where woody perennials (trees, shrubs, palms, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrange-ment or temporal sequence [72] to attain sustai-nable agricultural production through the positive ecosystem services provided by trees.

Agroforestry and agroecology are practiced by millions of smallholders around the world in diverse landscapes and ecosystems. These approaches contribute to increased biodiversity, providing habitats and foraging resources, nesting or egg laying sites, landscape connectivity, carbon storage in trees and soil [16][18][19]. Three out of four crops across the globe producing fruits or seeds for human use as food depend, at least in part, on pollinators which demonstrate how important the pollinators are for our food system [9][12] [23][29]. The ecosystem services performed by the pollinators add billions of dollars to global crop productivity and contribute significantly to global nutritional security. It has been estimated that insect pollination services to vegetables and fruits are worth 153 billion Euros a year [44].

Can agroecology and agroforestry approaches at least maintain yields of the world's staple crops without the use of synthetic fertilisers and pesticides? The answer is Yes. There is promising evidence [77][78] that many practices promoted in agroecology and agroforestry systems, such as using legumes to fix nitrogen, diversifying crops to better regulate weeds, pests and diseases, recycling manures to fertilize crops and managing crop residues to improve soil quality could contribute to maintaining or increasing yields [51][52]. However, to guide the world's transition to agroecological intensification of food production, more support is required in terms of policies and participatory learning that combines scientific knowledge and indigenous ecological wisdom. This collaborative approach can bring forward winning agroecological principles, such as intercropping, crop rotation, and use of botanical pest control measure [2][3][46].

What does science tell us about pesticides?

Scientific research indicates that we are exceeding the planetary boundary for environmental pollutants like pesticides, industrial chemicals, antibiotics and plastics [4][5], leading to negative impacts on both the environment and human health [6][7][8][13][31][37][63] as well as fostering resistance [64] to insecticides and herbicides. Pesticides are important for crop production worldwide and their use increases [53] together with economic growth and many small-scale farmers depend on synthetic pesticides as a solution to crop protection. Synthetic pesticides are also a crucial element to mitigate post-harvest losses which is important both for the environment (land sparing) and food security [70]. However, the overuse and misuse of these synthetic pesticides have negative impact on the environment and cause health problems for both farmers and consumers. It is high time for a shift towards sustainable and resilient farming practices that not only protect crops but also safeguard the well-being of farmers and the planet. There is a growing consensus that the global food system fails to ensure adequate nutrition for all and contributes to climate change, environmental degradation and biodiversity loss [1][2][3].

John Namanya. Uganda Photo: Mark Wahwai.

According to UN Food and Agricultural Organisation (FAO), three out of four crops across the globe depends on pollinators for producing fruits or seeds for human use as food [69]. Recent research presented in Nature Ecology & Evolution 2021 shows that pesticides are important drivers of pollinator decline in all regions in the world, many of the pollinators are threatened with global extinction [9][10][48]. This potentially threatens our entire food system [11]. Insects and other organisms are a vital part of agroecosystems and fulfill more functions than solely food for other organisms, they maintain essential ecosystem services, including leaf litter composting, pollination, and natural pest control functions [12]. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment report 2019 [10], there is evidence that the use of toxic agrochemicals and systemic pesticides in cultivated systems is affecting nonagricultural lands and biodiversity above- and below ground including pollinators and other beneficial organisms [9][45]. Pesticides have also been shown to leach into the groundwater with serious harmful effects on the ecosystems and human health [17][30][54]. Despite the scientific evidence of the dangers of pesticide use to human health and the environment, global pesticide use continues to increase [53][65].

Based on these negative impacts, The High-Level Panel of Experts for Food Security and Nutrition (HLPE), Committee on World Food Security (CFS) recommends promoting the transition to a resilient and diversified sustainable agriculture and food system through the adoption of agroecological principles and alternatives to chemical pesticides [2][3]. Agroecology and agroforestry is promoted by the European Commission's Green Deal and Farm to Fork strategies and the commission has proposed a new partnership on agroecology, The European Partnership on Agroecology [79].

Smallholders and pesticide use

There are many factors that influence small scale farmers' adoption of agricultural practices and use of pesticides. Small scale farmers' decisions whether to use pesticides or not has to be placed into the context depending on agronomical, social, knowledge, geographical, political, economic, or temporal settings. Moreover, different support systems in terms of agricultural extension services, government policies and regulations, financial services, and subsidies impact farmers' decisions. Today, all humans are exposed in some way to pesticides through working with these products or living near agricultural fields, through diet, through products containing pesticides or via the environment. In particular, smallholder farmers are highly exposed to pesticide use and drift-spray exposure of people and environment beyond

Push-pull technology. Photo courtesy of the authors.

target fields. How smallholders are farming matters since about 99% of the 600 million farms globally are managed by a smallholder (<20 hectare), they farm on 22 % of the land and produce 60% of the food we eat [36]. Farmers and farm workers are also the ones suffering the immediate consequences of pesticide use [14][15]. A recent report showed that 385 million cases of pesticide poisoning occur annually world-wide, including around 11,000 fatalities of the world's farming population [7].

Personal protective equipment (PPE) to reduce the risk of exposure is often not accessible and/or affordable for smallholder farmers. Many smallholder farmers in low and lower-middle income countries do not have access to good advisory services, therefore, information about pest management options in these countries is mainly obtained from pesticide shops and other retail outlets [13].

Not to neglect, when used in a responsible manner, synthetic pesticides can play a vital role for small holders in safeguarding seeds and crops against undesired threats such as plants, insects, bacteria, fungi, and rodents. However, it is crucial to recognize that numerous synthetic pesticides can exert adverse environmental effects by contaminating soil, water, and unintended plants and animals, which can lead to a decline in biodiversity and human health.

Help nature help you – Use of environmentally sensitive approaches

Integrated pest management

Across diverse cultures and societies, smallholders commonly employ botanical methods for pests and disease control [16][18][51]. According to FAO, Integrated Pest Management (IPM) is a methodology that carefully takes into consideration all available techniques and measures that can discourage the development of pest population while at the same time reducing risks to the environment and the people. It is a participatory model, involving interactive learning, field observations, experiments, and group discussions among farmers, for managing pests i.e., preventing the buildup, monitoring of any new pest, disease or weed in the field, and applying correct intervention. It uses a variety of methods to prevent pathogens, insects and weeds from causing economic crop losses whilst ensuring cost-effectiveness and preserving the environment. Below, we present a number of eco-friendly methods that can be applied to protect crops and limit harmful agrochemicals and inputs. Other similar methods are early planting, intercropping, crop rotation, use

Photo: Rebecka Lindmark.

of disease tolerant varieties, relay planting, sanitation practices such as pruning and thinning work.

Agroforestry methods

Agroforestry methods, for example intercropping of Leucaena and Calliandra (East Africa) in between rows of annual crops such as maize, may introduce a conducive environment for natural enemies and predators, such as birds and parasitoid wasps, that feed on insect pests. Agroforestry systems can also contribute to sustainable pest management by impacting microclimate and thereby limiting their growth or survival while providing optimal growing conditions for the crop. Shade and tree diversity is contributing to pathogen regulation through predation on caterpillars and aphid parasitism rates [16][19][20][21][23].

These agroforestry trees also provide leaves that can be used for mulching and help suppress weeds' growth. They also help with nitrogen fixation, which builds the soil quality. Good soil supports the growth of strong crops capable of resisting pests and diseases. Some pests may also become more attracted to the trees than to the food crops, giving the plants time to mature without destruction.

Research has demonstrated the positive effects agroforestry practices have on pest, disease and weed control. Areas where agroforestry practices were implemented experienced reduced abundance of weeds and increased presence of natural enemies [16].

Mechanical control of pests

Farmers use direct removal of pests or weeds, for instance through hand-picking to remove insects, tilling to remove weeds, setting up barriers to prevent entry to the farm and trapping to catch insects or rodents.

Tephrosia vogelii is used in Uganda by livestock keepers to control ticks.
Photos courtesy of the authors.

Push and pull technique

The method is used mainly to reduce the abundance of insect pests in crops through repelling the pest and allowing the food crop to thrive [25]. This practice uses intercropping of crops with repellant or intercepting plants that either stops or kills the insects. For example, maize is intercropped with Desmodium spp to prevent striga weed and stem borers from attacking the maize. *Desmodium* repels pests, whilst improving soil through nitrogen fixation.

Biological pest control

This entails the use of beneficial organisms such as insects or pathogens to keep pest populations down and the use of biological cycles where farmers are able to adjust planting or harvesting time to either increase capacity of the plants to resist or escape invasion by pests. Farmers use insects such as ladybirds that are 'predator' on mites, beetles and aphids, and hence control their effect on crops.

Tegetes erecta – intercropped or planted around the boundaries to prevent nematodes on crops. Photos courtesy of the authors.

Traditionally, plants have been used for pest and disease management though the extent of utilization remains low as compared to their potential. Research shows that smallholder farmers use indigenous and local knowledge to produce bio-solutions that help with pests and disease control [18]. For example, the use of the Tephrosia vogeliia tropical plant, natively found throughout East Africa, whose leaves extract is used in Uganda by livestock keepers to control ticks [26]. To make the solution, the fresh leaves are pounded and then mixed with water to form a solution that is applied on animals. For insecticides, the solution is left to soak overnight and used to spray crops to eliminate aphids and red spider mites. Several other agroforestry plants such as *Securidaca longepedunculata, Bobgunnia madagasariensis* are used by smallholder farmers as pesticides and are appreciated for being accessible and cost effective [73]. Other research conducted shows that use of neem oil from Azadirachta indica (Neem tree) seeds and powdered leaf has 70% effectiveness in controlling the fall army worms [74] and grounded *Papaya carica* seeds were equally effective [75].

Banned agrochemicals in the past – biopesticides for the future

The ambition of reducing the use of pesticides in the European Union is high, despite recent setbacks by the EU Commission [76], as stipulated in the Green Deal and the Farm to Fork Strategy [27][28] which addresses comprehensively the challenges of sustainable food systems and the links between healthy people, healthy societies and a healthy planet. Despite the high ambition, European States continue to export banned or unapproved pesticides to developing countries [40][55]. This impairs the right to health and right to a clean, healthy and sustainable environment and therefore constitutes a breach by European States of their international human rights obligations [41][42][43] and other multilateral environmental agreements [47].

On a more positive note, there is a growing global concern for healthy diet, pesticide-free food has fueled an increased demand for organic products, resulting in a record-breaking growth of the organic food market in 2020, surpassing 120 billion euros [49]. This surge in demand coupled with the war in Ukraine has created increased interest for bio inputs, such as biopesticides and biofertilizers, hence boosting sustainable agricultural practices based on agroforestry and agroecology. These bio inputs address environmental and health concerns, comply with regulations, and meet consumer preferences for eco-friendly and organic products. As research and development continue to drive innovation in this field, we can expect even more effective and economical bio input solutions to transform modern agriculture [60]. However, current agricultural extension officers have limited knowledge about bio inputs, and their training is not sufficient to provide adequate guidance to farmers.

Agenda 2030

The Agenda 2030 has set out ambitious targets in the Sustainable Development Goals (SDGs) that relate to the food system and the reduction of the use of pesticides, which can have many positive effects in relation to health and environment.

Agroecological and agroforestry app-roaches support the transition to a sustai-nable food system free from harmful pesticides that can feed the world population with nutritious food and is resilient to climate change.

The TYFA (Ten Years for Agroecology) scenario [52] shows it is possible that a large-scale agroecological transition in the EU could feed all EU citizens by 2050. Global hunger is still far above pre-pandemic levels. It is estimated that between 690 and 783 million people in the world faced hunger in 2022 [11]. The 2023 Global Hunger Index shows that hunger is at "serious" or "alarming" levels in 43 countries [50].

Production and consumption of healthy and nutritious food free from harmful pesticides will substantially reduce the number of deaths and illnesses emanating from poor consumption habits and from use of hazardous chemicals affecting air, water and soil contamination [63].

Agroecology and agroforestry approaches use water more sustainably, through improved soil and water management and by reducing pollution of groundwater [17][30][54], eliminating dumping and minimising release of hazardous pesticides that can prevent serious harmful effects on the ecosystems and our health. Read more in our brief on Agroforestry and water for resilient landscapes [68].

Agroecology and agroforestry can provide a growing global population with healthy and diversified diets from sustainable food systems. Read more in our brief on Agroforestry, food security and nutrition [67].

Several recent international surveys have shown that people are worried about pesticides in their food [66]. A report from Route to Food Initiative show that 88% of the consumers in Kenya are concerned about pesticide residues in food. The report also emphasize the importance of producing sustainable and healthy food and to achieve the climate, biodiversity, zero pollution and public health goals are fundamental to Kenyans [38].

The use of pesticides has severe negative impacts on biodiversity above- and below ground and results in decline in insect population [48], insects that are critical for pollination of our food crops [12]. According to IPBES, many of the insect pollinators are threatened with global extinction [10]. The drivers are multiple and land use changes as a result of agricultural expansion and intensification together with the extensive use of pesticides that kill pollinators are the main reasons [23][29][63].

Agricultural expansion is also driving almost 90 percent of global deforestation [33] which results in increased use of pesticides. This land-use change responds to multiple underlying drivers, including poverty and unsustainable production practices and consumption patterns and requires a multitude of responses including food system transformation [1]. Agroecology and agroforestry approaches can significantly reduce the degradation of natural habitats, halt the loss of biodiversity, and thus restore damaged ecosystems [10][13][63].

Photo: Katie O'Sullivan.

Recommendations

Business sector/Market actors

- **Support the development of the market for agricultural low-risk pesticides and bio inputs.** The growing interest and implementation of agroecology and agroforestry requires the development of a market for bio inputs. Consequently, a growing market for bio inputs, including biopesticides and biofertilizers, is a positive sign that will boost sustainable agroecology and agroforestry practices [60]. It addresses environmental and health concerns, aligns with regulatory pressures, and fulfills consumer demands for eco-friendly and organic products. As research and development continue to drive innovation in this field, we can expect even more effective and economical bio input solutions to transform modern agriculture. In this regard farmers should have access to adequate extension services including digitally enabled tools, training, peer-to-peer learning and participatory research.

- **Ensure that traders and operators of pest control products are trained and certified** in IPM and biocontrol. Developing guidance and knowledge of products that are appropriate for effectiveness of inspections and enforcement of pesticide-related activities during manufacturing, importation, distribution, sales, disposal and counteract the use of counterfeit and illegal pesticides [39]. Ensure government regulators, the private sector, civil society and other stakeholders comply with best practice in managing pesticides throughout their lifecycle [61].

- **Support and develop the value chain for organically certified products from agroecology and agroforestry practices to catalyse their greater adoption and commercialisation.** This requires development of knowledge among extension services, market actors and consumers. Incentivize development of organic markets whereby farmers can be fairly compensated for what they produce and receive a price premium for organically produced products. According to IFAD, small-scale farmers receive only about 6 cents for every $1 worth of food they produce [34][62].

Consumers

- **Raise awareness among the general public about environmental and health risk from pesticide use.** Consumers are increasingly concerned about pesticide residues in their food [38][66]. Raising consumers' awareness about the threat pesticide use poses to the environment and human health, and the ways such risks can be minimized is important. This will increase consumers' consumption patterns and willingness to pay for environmentally friendly and chemical free products from agricultural systems based on agroecology principles and agroforestry.

Eseri Gaalya Mayuge, Uganda
Photo: Joseph Lubega Mukaawa.

Beehives are essential for our food systems.

Governments

- **Lobby national governments and the EU Commission to propose provisions that ban the export of chemicals banned in the EU to countries outside the union.** Such provisions should be part of an EU regulation, to be binding for all member states. European companies must end the production and export of EU banned pesticides to countries outside the union [40][41][42] where they are banned because it's a break against human rights and poses unacceptable risks to human health and the environment.

- **Increase the share of investment in research and development (R&D) for agroecology and agroforestry approaches in the government public spendings.** African Union decided in the Maputo declaration 2003 that 10% of national budgetary resources should be allocated to agriculture [56]. Only a few countries are close to 10 % but most countries spend only around 5%, mostly directed to conventional agriculture [57] and not development of agroecology and agroforestry. A greater share of R&D in tackling post-harvest losses would have a positive effect both on environment and human health.

- **Redirect economic incentives (subsidies and taxes) that are associated with the use of harmful pesticide towards the incentivize the support to agroecological principles and agroforestry approaches.** Subsidies in richer countries have put small scale farmers from lower-income countries at a significant competitive disadvantage in both domestic and international markets. According to OECD, the Agricultural Policy Monitoring and Evaluation Report 2022 shows that 54 countries provided USD 817 billion in support to agriculture annually over the 2019-21 period [58][59].

- **Increase investments in government or private extension services** is crucial to increase training and the use of personal protective equipment (PPE) as a risk reduction measure when using pesticides and promote integrated pest management (IPM) to avoid the use of pesticides through the training of agronomists, extension agents, input distributors and farmers [35][36].

- **Development of national policies and strategies to support pollinator conservation** through a reduced use of harmful pesticides and direct support for agroecology and agroforestry practices [32][44]. Pollinators are declining in numbers and diversity, which potentially threatens our food system.

ODA and Civil Society

- **Governments, donors and CSOs should direct more investments into agroecology and agroforestry from their official development assistance (ODA) budgets.** ODA and civil society have a very important role in supporting agroecology and agroforestry. Unfortunately, today only a marginal part of the ODA is targeting the agricultural sector. As little as $0.04 of every $1 of Overseas Development Aid go to agriculture (IFAD) [62] and out of the 4 % only a fraction is directed to agroecology and agroforestry.

References

1. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Garnett T, Tilman D, DeClerck F, Wood A, Jonell M, Clark M, Gordon LJ, Fanzo J, Hawkes C, Zurayk R, Rivera JA, De Vries W, Majele Sibanda L, Afshin A, Chaudhary A, Herrero M, Agustina R, Branca F, Lartey A, Fan S, Crona B, Fox E, Bignet V, Troell M, Lindahl T, Singh S, Cornell SE, Srinath Reddy K, Narain S, Nishtar S, Murray CJL. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019 Feb.
2. HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.
3. The Policy Recommendations on Agroecological and Other Innovative Approaches were endorsed by the Committee on World Food Security (CFS) at its 48th plenary session in June 2021.
4. Persson L, Carney Almroth BM, Collins CD, Cornell S, de Wit CA, Diamond ML, Fantke P, Hassellöv M, MacLeod M, Ryberg MW, Søgaard Jørgensen P, Villarrubia-Gómez P, Wang Z, Hauschild MZ. Outside the Safe Operating Space of the Planetary Boundary for Novel Entities. Environ Sci Technol. 2022 Feb. https://pubs.acs.org/doi/pdf/10.1021/acs.est.1c04158
5. Planetary boundaries – Stockholm Resilience Centre
6. IPCC, 2023: Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, (in press)
7. Boedeker W, Watts M, Clausing P, Marquez E. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health. 2020 Dec 7;20(1):1875. Doi: 10.1186/s12889-020-09939-0. PMID: 33287770; PMCID: PMC7720593.
8. Trasande, L., R. T. Zoeller, U. Hass, A. Kortenkamp, P. Grandjean, J. P. Myers, J. DiGangi, et al. 2016. "Burden of Disease and Costs of Exposure to Endocrine Disrupting Chemicals in the European Union: An Updated Analysis." Andrology 4 (4) (March 22): 565–572. Doi:10.1111/ andr.12178.
9. Dicks, L.V., Breeze, T.D., Ngo, H.T. et al. A global-scale expert assessment of drivers and risks associated with pollinator decline. Nat Ecol Evol 5, 1453–1461 (2021). https://doi.org/10.1038/s41559-021-01534-9
10. IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673
11. FAO, IFAD, UNICEF, WFP and WHO. 2023. The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum. Rome, FAO. https://doi.org/10.4060/cc3017en
12. Ollerton, J., Winfree, R. and Tarrant, S. (2011), How many flowering plants are pollinated by animals?. Oikos, 120: 321-326. https://doi.org/10.1111/j.1600-0706.2010.18644.x
13. United Nations Environment Programme (2022). Synthesis Report on the Environmental and Health Impacts of Pesticides and Fertilizers and Ways to Minimize Them. Geneva. https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/38409/pesticides.pdf
14. Damalas CA, Koutroubas SD. Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention. Toxics. 2016 Jan 8;4(1):1. doi: 10.3390/toxics4010001. PMID: 29051407; PMCID: PMC5606636.
15. de-Assis MP, Barcella RC, Padilha JC, Pohl HH, Krug SBF. Health problems in agricultural workers occupationally exposed to pesticides. Rev Bras Med Trab. 2021 Feb 11;18(3):352-363. doi: 10.47626/1679-4435-2020-532. PMID: 33597986; PMCID: PMC7879472.
16. Pumariño, L., Sileshi, G. W., Gripenberg, S., Kaartinen, R., Barrios, E., Muchane, M. N., Midega, C. and Jonsson, M. (2015) Effects of agroforestry on pest, disease and weed control: a meta-analysis. Basic and Applied Ecology, 16 (7). pp. 573-582. ISSN 1439-1791
17. Zhu, X., Liu, W., Chen, J. et al. Reductions in water, soil and nutrient losses and pesticide pollution in agroforestry practices: a review of evidence and processes. Plant Soil 453, 45–86 (2020). https://doi.org/10.1007/s11104-019-04377-3
18. Agroecology case study: Using Pesticidal Plants for Pest Management in Africae, AFSA, 2019. https://afsafrica.org/wp-content/uploads/2019/04/using-pesticidal-plants-for-pest-management-in-africa.pdf
19. Akoutou Mvondo Etienne, Ndo Eunice Golda Danièle, Bidzanga Nomo Lucien, Ambang Zachée, Bella Manga Faustin, Cilas Christian. 2022. Tree diversity and shade rate in complex cocoa-based agroforests affect citrus foot rot disease. Basic and Applied Ecology, 64 : pp. 134-146. Tree diversity and shade rate in complex cocoa-based agroforests affect citrus foot rot disease - Agritrop (cirad.fr), https://doi.org/10.1016/j.baae.2022.08.003
20. Guenat, Solène. 2014. Assessing the effects of agroforestry practices on biological control potential in kale (Brassica oleracea acephala) plantations in Western Kenya. https://stud.epsilon.slu.se/7256/
21. Kvick Nastaj, Nadja. 2020. The role of agroforestry tree species in biocontrol of the cabbage pest Plutella xylostella. https://stud.epsilon.slu.se/16057/
22. Lewis, W. J., et al. "A Total System Approach to Sustainable Pest Management." Proceedings of the National Academy of Sciences of the United States of America, vol. 94, no. 23, 1997, pp. 12243–48. JSTOR, http://www.jstor.org/stable/43890. Accessed 1 June 2023.
23. Bentrup, G.; Hopwood, J.; Adamson, N.L.; Vaughan, M. Temperate Agroforestry Systems and Insect Pollinators: A Review. Forests 2019, 10, 981. https://doi.org/10.3390/f10110981
24. Sietz, D., Klimek, S. & Dauber, J. Tailored pathways toward revived farmland biodiversity can inspire agroecological action and policy to transform agriculture. Commun Earth Environ 3, 211 (2022). https://doi.org/10.1038/s43247-022-00527-1
25. Erdei, A., Aneth, D., Eleni, S., Vaida, D., Advaith, C., & Teun, D. (2022). The push-pull intercrop Desmodium does not repel, but intercepts and kills pests. BioRxiv.
26. ICRAF. (n/d). PESTICIDAL PLANT LEAFLET; Tephrosia vogelii.Hook. f. N/A: ICRAF. Doi:ISBN 978-92-9059-346-1
27. EU, 2020, Farm to Fork Strategy, https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf ,
28. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX-%3A52020DC0381
29. Holzschuh, A., Steffan-Dewenter, I., & Tscharntke, T. (2008). Agricultural Landscapes with Organic Crops Support Higher Pollinator Diversity. Oikos, 117(3), 354–361. http://www.jstor.org/stable/40235312
30. Beketov, M. A., Kefford, B. J., Schäfer, R. B., & Liess, M. (2013). Pesticides reduce regional biodiversity of stream invertebrates. Proceedings of the National Academy of Sciences, 110(27), 11039–11043. https://doi.org/10.1073/pnas.1305618110
31. Dudley, Nigel, Simon J. Attwood, Dave Goulson, Devra Jarvis, Zareen, Pervez Bharucha, and Jules Pretty. "How Should Conservationists Respond to Pesticides as a Driver of Biodiversity Loss in Agroecosystems?" Biological Conservation 209 (Mai 2017): 449–53. https://doi.org/10.1016/j.biocon.2017.03.012
32. Belmain, S., Tembo, Y., Mkindi, A., & Stevenson, P. (2021). Practice Bridge: Elements of agroecological pest and disease. Elem Sci Anth.
33. FAO. 2022. The State of the World's Forests 2022. Forest pathways for green recovery and building inclusive, resilient and sustainable economies. Rome, FAO. https://doi.org/10.4060/cb9360en
34. Why farmers are getting less and less of every dollar Americans spend on food – The Washington Post
35. Laborde, D., Murphy, S., Parent, M., Porciello, J. & Smaller C. (2020). Ceres2030: Sustainable Solutions to End Hunger – Summary Report. Cornell University, IFPRI and IISD.
36. IFAD, 2021. "IFAD RURAL DEVELOPMENT REPORT 2021 – Transforming food systems for rural prosperity," IFAD Research Series 313753, International Fund for Agricultural Development (IFAD)

37. Mew EJ, Padmanathan P, Konradsen F, Eddleston M, Chang SS, Phillips MR, Gunnell D. The global burden of fatal self-poisoning with pesticides 2006-15: Systematic review. J Affect Disord. 2017 Sep;219:93-104. Doi: 10.1016/j.jad.2017.05.002. Epub 2017 May 12. PMID: 28535450.

38. Food safety in Kenya, a consumer perspective. Consumer Grassroots Association. Food-safety-in-Kenya-Digital.pdf (routetofood.org).

39. Production of fake pesticides on the rise in the EU, Production of fake pesticides on the rise in the EU | Europol (europa.eu)

40. The Export of Banned Pesticides to Africa and Central America: Legal Opinion, Center for International Environmental Law (CIEL), Sep 2022. https://www.ciel.org/wp-content/uploads/2022/09/Legal-Analysis_Exports-of-Banned-Pesticides_FINAL.pdf

41. The right to a clean, healthy and sustainable environment: non-toxic environment Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment. 2022. A/HRC/49/53, G2200448.pdf (un.org)

42. Report of the Special Rapporteur on the right to food.2017. A/HRC/34/48, 1701059 (un.org)

43. United Nations Environment Programme (2023). 30 Foresight Briefs: Early Warning, Emerging Issues and Futures - Special Edition 2017-2022. https://wedocs.unep.org/20.500.11822/41662.

44. Foresight_Brief_No_011.pdf (unep.org)

45. Bijleveld van Lexmond, Maarten & Bonmatin, Jean-Marc & Goulson, Dave & Noome, Dominique. (2014). The Worldwide Integrated Assessment of the Impact of Systemic Pesticides on Biodiversity and Ecosystems (WIA), http://www.tfsp.info/assets/WIA_2015.pdf

46. M. M. Kansanga, I. Luginaah, R. Bezner Kerr, E. Lupafya & L. Dakishoni (2020) Beyond ecological synergies: examining the impact of participatory agroecology on social capital in smallholder farming communities, International Journal of Sustainable Development & World Ecology, 27:1, 1-14, DOI: 10.1080/13504509.2019.1655811

47. Multilateral Environmental Agreements (MEAs) (europa.eu)

48. Wagner, D. L., 2020, Insect declines in the Anthropocene, Annual Review of Entomology 65(1), pp. 457-480 (DOI: 10.1146/annurev-ento-011019-025151).

49. Willer, Helga, Bernhard Schlatter and Jan Trávní ek (Eds.) (2023): The World of Organic Agriculture. Statistics and Emerging Trends 2023. Research Institute of Organic Agriculture FiBL, Frick, and IFOAM – Organics International, Bonn. Online Version 2 of February 23, 2023

50. Global Hunger Index, 2023, 2023 Global Hunger Index: The Power of Youth in Shaping Food Systems

51. MacLaren, C., Mead, A., van Balen, D. et al. Long-term evidence for ecological intensification as a pathway to sustainable agriculture. Nat Sustain 5, 770–779 (2022). https://doi.org/10.1038/s41893-022-00911-x

52. Poux, X., Aubert, P.-M. (2018). An agroecological Europe in 2050: multifunctional agriculture for healthy eating. Findings from the Ten Years For Agroecology (TYFA) modelling exercise, Iddri-AScA, Study N°09/18, Paris, France, 74 p

53. Pesticides use, pesticides trade and pesticides indicators, 2022, Global, regional and country trends, 1990–2020, FAOSTAT Analytical Brief 46

54. Syafrudin M, Kristanti RA, Yuniarto A, Hadibarata T, Rhee J, Al-Onazi WA, Algarni TS, Almarri AH, Al-Mohaimeed AM. Pesticides in Drinking Water-A Review. Int J Environ Res Public Health. 2021 Jan 8;18(2):468. doi: 10.3390/ijerph18020468. PMID: 33430077; PMCID: PMC7826868.

55. Banned in Europe: How the EU exports pesticides too dangerous for use in Europe, https://www.publiceye.ch/en/topics/pesticides/banned-in-europe

56. The Comprehensive African Agricultural Development Programme | African Union (au.int)

57. 3rd_CAADP_Biennial_Review_Report_final.pdf (au.int)

58. OECD (2022), Agricultural Policy Monitoring and Evaluation 2022: Reforming Agricultural Policies for Climate Change Mitigation, OECD Publishing, Paris, https://doi.org/10.1787/7f4542bf-en.

59. Agricultural Policy Monitoring & Evaluation 2022: Reforming Agricultural Policies for Climate Change by OECD – Issuu

60. Draft final report: Assessment of the market in East Africa for biological inputs and alternative technologies that increase climate resilience and biodiversity (21/001668), 2023, FCG.

61. WHO & FAO, 2014, The International Code of Conduct on Pesticide Management, Code of Conduct (fao.org)

62. IFAD13 REPLENISHMENT A NEW DAY IS POSSIBLE. 2022. 17b627ed-ceec-e679-8182-1d095b9f42bf (ifad.org), https://www.ifad.org/en/ifad13/

63. How pesticides impact human health and ecosystems in Europe, EEA, 2023, How pesticides impact human health and ecosystems in Europe – European Environment Agency (europa.eu)

64. Antibiotic and pesticide susceptibility and the Anthropocene operating space | Nature Sustainability, Jørgensen et al. Living with Resistance project. Antibiotic and pesticide susceptibility and the Anthropocene operating space. Nat Sustain 1, 632–641 (2018). https://doi.org/10.1038/s41893-018-0164-3

65. Crop Protection Chemicals Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2023-2028 (researchandmarkets.com)

66. EFSA, Special Eurobarometer - April 2019, “Food safety in the EU” Report, Eurobarometer 2019_Food safety in the EU_Report_final (europa.eu)

67. Agroforestry Network, Agroforestry, food security and nutrition, 2020, Agroforestry Network, Nutritionfood-security_web.pdf.

68. Agroforestry Network, Agroforestry and water for resilient landscapes, 2020,

69. FAO, 2018, Why bees matters - The importance of bees and other pollinators for food and agriculture, Why bees matter (fao.org)

70. Stathers, T., Holcroft, D., Kitinoja, L. et al. A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia. Nat Sustain 3, 821–835 (2020). https://doi.org/10.1038/s41893-020-00622-1

71. One Health theory of change, One Health High Level Expert Panel (OHHLEP), 7 November 2022, Technical document, ohhlep--one-health-theory-of-chance.pdf (who.int)

72. Agroforestry (fao.org)

73. Grzywacz, David et al. “Biological pesticides for Africa: why has so little of the research undertaken to date resulted in new products to help Africa’s poor?” Outlooks on Pest Management 20 (2009): 77-81.

74. Silva, M.S., Broglio, S.M.F., Trindade, R.C.P., Ferrreira, E.S., Gomes, I.B., and Micheletti, L.B. (2015). Toxicity and application of neem in fall armyworm. Comunicata Scientiae 6, 359–364.

75. Figueroa Brito, Rodolfo et al. “Nitrogen fertilization sources and insecticidal activity of aqueous seeds extract of Carica papaya against Spodoptera frugiperda in maize.” Ciencia E Investigacion Agraria 40 (2013): 571-580.

76. Black Day for Health and Biodiversity: EU Commission withdraws proposal for Pesticide Reduction | PAN Europe (pan-europe.info).

77. Poux, X. & Aubert, P-M. 2018. An agro-ecological Europe: a desirable, credible option to address food and environmental challenges. IDDRI Issue Brief No 10/18.

78. D’Annolfo, R., Gemmill-Herren, B., Graeub, B. & Garibaldi, L.A. 2017. A review of social and economic performance of agroecology. International Journal of Agricultural Sustainability, 15 6): 632–644.

79 Commission, 2024, 600 million to support research and innovation on agroecology and animal health and welfare - European Commission (europa.eu)

Godfrey Majengo, Photo: Mark Wahwa.

Agroforestry Network

FOUNDED BY VI AGROFORESTRY

Reviewed by:

Andreas Prevodnik (The Swedish Society for Nature Conservation)

Sara Elfstrand (Swedbio)

Kristina Mastroianni (NIRAS)

Alice Tunfjord (SIANI)

Linus Linse (Agroforestry Sweden and Swedish University of Agricultural Sciences)

Linnea Pasquier (Agroforestry Sweden and Vi Agroforestry)

Matilda Palm (Vi Agroforestry)

Authors:
Monica Nderitu (Vi Agroforestry)
Bo Lager (The Swedish Society for Nature Conservation)

www.agroforestrynetwork.org