ZERO WASTE ALLIANCE IRELAND

Towards Sustainable Resource Management

Response to the European Commission's Public Consultation on an Integrated Action Plan for the Management of Nutrients

26 August 2022

Zero Waste Alliance Ireland is a member of

EEB European Environmental Bureau and IEN Irish Environmental Network

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1. INTRODUCTION

When the European Commission announced a public consultation on an action plan for the better management of nutrients, with reference to complementing the existing **zero pollution action plan** for air, water and soil, and to the revision of other relevant European Union legislation, we saw this an excellent opportunity to provide feedback on a topic in which Zero Waste Alliance Ireland has a long and continuing interest. It has always been our policy that the wasting or discarding of plant nutrients (nitrogen and phosphorus) essential for agriculture and food production cannot be seen in isolation, but must be addressed as part of a larger issue, including the way in which we consider wastewater as no more than an effluent to be treated to make it acceptable for discharge to surface waters or groundwater, but unfortunately not yet regarded as a valuable resource from which essential raw materials can be extracted or recovered.

The most important of these "raw materials" include the water itself, which is commonly purified and recovered for other uses, and also the essential plant nutrients of dissolved nitrogen and phosphorus, the production and supply of which have become increasingly critical. Widespread failure to recover these nutrients from wastewater is a symptom of our European-wide ineffective management of nutrients, with resulting serious damage to aquatic ecosystems by water pollution, loss of aquatic biodiversity, and threatening the security of food supplies in Europe. Poor management of nutrients in agriculture is also leading to soil damage through over-fertilisation, resulting in the loss of healthy soils capable of growing the quantities of food which Europe needs. The in-combination effects of nutrient mismanagement are therefore likely to lead to further problems of adverse and damaging political and social changes.

It is our submission that to halt ecosystem breakdown and to limit costs of further damage, the EU needs an integrated nutrient management directive, supported by a management and action plan, which will not only regulate the agricultural use of nitrogen and phosphorus, but will also bring to an

end, or will severely reduce, the loss of these essential nutrients, and will incorporate them into the circular economy.

A new directive on the better management of nutrients, together with an action plan, must go beyond the current, inadequate regulations by taking into account nutrient balances, regional differences, diverse cultures and lifestyles across Europe, different agricultural practices; and must be integrated with other key legislation and policies including the European Green Deal, the Circular Economy Action Plan, the Biodiversity Strategy, the Common Agricultural Policy (CAP), the Farm To Fork Strategy, the Waste Framework Directive, the Directive on Urban Waste Water Treatment, and other relevant regulations.

For example, to ensure the success of the Farm to Fork Strategy, a new EU policy and a supporting directive on the better management of nutrients, together with an action plan, are urgently needed to promote the sustainable application, re-use and cycling of nutrients. The "*nutrient directive*" must also address the way in which the production, marketing and distribution of artificial fertilisers have developed as a component of the global economy, resulting in Member States' dependency on critical resources of phosphate rock in a few countries, and in the long-distance transportation of raw materials for fertiliser manufacture, and the fertilisers themselves; thus shifting fertiliser production away from locally available organic sources, and from local needs and services.

The large-scale production of artificial fertilisers has also become increasingly dependent on fossil fuels, causing significant release of greenhouse gases, and further damaging changes to the Earth's climate. The planetary boundaries for climate change, biodiversity loss and the nitrogen/phosphorous cycle have already been breached,[1] while climate modelling has predicted that continued greenhouse gas emissions are very likely to cause average global temperature increases of around 3°C [2], and some models predict extreme increases of 5°C by 2100.[3] To avoid this catastrophic impact on society and on biodiversity, global warming must be kept below 1.5 °C.[4]

The "nutrient directive" must therefore address these globally important issues; further emphasising a vital need for comprehensive integration.

[1] Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J. and Nykvist, B., 2009. A safe operating space for humanity. nature, 461(7263), pp.472-475.

[2] Solomon, S., Manning, M., Marquis, M. and Qin, D., 2007. Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge university press.

[3] Zhang, G., Zeng, G., Yang, X. and Jiang, Z., 2021. Future changes in extreme high temperature over China at 1.5 C–5 C global warming based on CMIP6 simulations. Advances in Atmospheric Sciences, 38(2), pp.253-267.

[4] Allen, M.R., Dube, O.P., Solecki, W., Aragón-Durand, F., Cramer, W., Humphreys, S., Kainuma, M., Kala, J., Mahowald, N., Mulugetta, Y. and Perez, R., 2018. Framing and context. Global warming of, 1(5).

2. ZERO WASTE ALLIANCE IRELAND (ZWAI)

Zero Waste Alliance Ireland is therefore pleased to have the opportunity to make this submission in response to the European Commission's public consultation on an integrated action plan for the management of nutrients; and at this point we consider that it is appropriate to mention the background to our submission, especially the history, policy, strategy and activities of ZWAI.

2.1 Origin and Early Activities of ZWAI

Zero Waste Alliance Ireland, established in May 1999, and registered as a company limited by guarantee in 2004, is a Non-Government Environmental Organisation (eNGO) and a registered charity. During the past two decades ZWAI has submitted to the Government and to State Agencies many policy documents on waste management, on using resources sustainably, on promoting re-use, repair and recycling, and on development and implementation of the Circular Economy. During more recent years (2021 and 2022), ZWAI has responded to the European Commission's call for submissions on a variety of topics on wastewater and solid wastes.

One of our basic guiding principles is that human societies must behave like natural ecosystems, living within the sustainable flow of energy from the sun and plants, producing no materials or objects which cannot be recycled back into the earth's systems, or reused or recycled into our technical systems, and should be guided by economic systems and practices which are in harmony with personal and ecological values.

Our principal objectives are:

i) sharing information, ideas and contacts,

ii) finding and recommending environmentally sustainable and practical solutions for domestic, municipal, industrial and agricultural waste management; and for more efficient and ecologically appropriate uses of natural resources such as water and soil;

iii) lobbying Government and local authorities to implement environmentally sustainable waste management practices, including clean production, elimination of toxic substances from products, re-use, recycling, segregation of discarded materials at source, and other beneficial practices;

iv) lobbying Government to follow the best international practice and EU recommendations by introducing fiscal and economic measures designed to penalise the manufacturers of products which cannot be re-used, recycled or composted at the end of their useful lives, and to financially support companies making products which can be re-used, recycled or are made from recycled materials;

v) raising public awareness about the long-term damaging human and animal health and economic consequences of landfilling and of the destruction by mass burning of potentially recyclable or re-usable materials by incineration;

vi) investigating, raising public awareness and lobbying Irish Government departments and agencies about our country's failure to take adequate care of vulnerable and essential natural resources, including clean water and air, biodiversity, and soil;

vii) advocating changes in domestic and EU legislation to provide for more ecologically appropriate, environmentally sustainable and efficient uses of natural resources; and,

viii) maintaining contact and exchanging information with similar national networks in other countries, and with international zero waste organisations.

2.2 Our Basic Principles

In nature, the waste products of every living organism serve as raw materials to be transformed by other living creatures, or benefit the planet in other ways. Instead of organising systems that efficiently dispose of or recycle our waste, we need to design systems of production that have little or no waste to begin with.

There are no technical barriers to achieving a "*zero waste society"*, only our habits, our greed as a society, and the current economic structures and policies which have led to the present environmental, social and economic difficulties.

"Zero Waste" is a realistic whole-system approach to addressing the problem of society's unsustainable resource flows – it encompasses waste elimination at source through product design and producer responsibility, together with waste reduction strategies further down the supply chain, such as cleaner production, product repairing, dismantling, recycling, re-use and composting.

ZWAI strongly believes that Ireland and other Member States, and the EU as a whole, should have a policy of not sending to other countries our discarded materials for further treatment or recycling, particularly to developing countries where local populations are being exposed to dioxins and other very toxic POPs. Relying on other countries' infrastructure to achieve our "recycling" targets is not acceptable from a global ecological and societal perspective.

ZWAI also strongly believes that naturally occurring water bodies (streams, rivers, lakes and seas) and their biodiversity are vitally important components of the Earth's global ecosystem, and that the destruction or unnecessary wasting of these natural resources must not be allowed to continue. We also believe that how human societies utilise water reflects the fashion of each age.

One of the consequences of our industrial society is that we have transformed water "*from a spiritual substance that could baptize the newborn and purify the dead and the living, into a scarce resource in need of technological management, a kind of cleaning fluid that has lost the ability to excite our imagination, especially in the urban spaces where most of us live*".[5]

We need to ask what we are doing with water – from where do we obtain it, how are the natural reservoirs of water maintained and safeguarded, what happens when we use water, and how we, as a society and as individuals, choose to deal with our liquid wastes, i.e., human excreta, wash waters and the products of our domestic and social cleansing activities. While we have learned to treat the resulting wastewater to make it acceptable for return to the natural environment, we do not yet see wastewater as a valuable resource from which the essential nutrients of dissolved nitrogen and phosphorus can be extracted, recovered and utilised. ZWAI strongly believes that this situation must change.

By ensuring that nutrients in wastewater are returned to the soil as a natural fertiliser, we would be engaging in a recycling process common to all sustainable ecosystems.

2.3 What We are Doing

One of our principal objectives is to encourage the European Union (including Commission and Parliament), Irish government agencies, Irish local authorities and other organisations to develop and implement environmentally sustainable resources and waste management policies, especially resource efficiency, waste reduction and elimination, the promotion of re-use, repair and recycling, and the development and implementation of the Circular Economy.

As an environmental NGO, and a not-for-profit company with charitable status since 2005, ZWAI also campaigns for the implementation of the UN Sustainable Development Goals, including (but not limited to) Goal 12, Responsible Consumption and Production; Goal 6, Clean Water and Sanitation (having particular regard to the need to avoid wasting water); and Goal 15, to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, to halt and reverse land degradation and halt biodiversity loss.

In responding to many Irish and European public consultations, ZWAI in its role as an environmental NGO has given presentations and made submissions on:

1. How the European Union has addressed the problem of plastic waste (March 2019);
2. On Single-Use Plastic Packaging by the food industry (November 2019);

[5] "*The Re-Imagination Of Water – Dealing with the Threats to Groundwater, Drinking Water, Rivers and Lakes*", Jack O'Sullivan, paper presented at a Seminar on Public Participation and Water Quality, Environmental Change Institute, NUI Galway, 23 June 2007.

3. Feedback to the European Commission in response to a public consultation on the proposed revision of the EU Regulation on Shipments of Waste (January 2022);
4. Feedback to the European Commission in response to a public consultation on protecting, sustainably managing and restoring EU soils, including comments on the proposed updating of the 2006 EU Thematic Strategy on Soil (February 2022);
5. Feedback to the European Commission in response to a public consultation on revision of the EU plant and forest reproductive material legislation (March 2022);
6. Providing feedback to the European Commission on the waste-related environmental performance of Ireland and certain other EU Member States, and the probability of their achieving the 2025 recycling targets and the 2035 landfill target, with observations on the Early Warning Report System (August 2022);
7. Providing feedback to the European Commission on the urgent need to reduce the waste of unwanted or discarded food, at every stage of the food production process (August 2022);
8. On transforming the construction industry so that it could become climate neutral (instead of its present position as a major emitter of greenhouse gases and toxicants); and,
9. Several submissions on the separation, recovery and reuse of the phosphorus and nitrogen content of wastewater (2019 to 2022).

ZWAI is primarily concerned with the very serious issue of the misuse of key and critical natural resources, and the problems of discarded substances, materials and goods, whether from domestic, commercial or industrial sources, how these become "waste", and how such "waste" may be prevented by re-design along ecological principles. These same ecological principles can be applied to the many ways in which we abstract and use water as a resource, and also to the equivalent volumes of wastewater produced as a consequence of these uses.

We believe that at a time of increasing scarcity of certain resources, including, for example contaminant-free phosphate rock as a raw material for fertiliser production, and the shortage of other resources, for example natural gas for the production of synthetic nitrogenous fertilisers, it is more essential than ever to ensure that raw materials are not wasted, but are used wisely and efficiently

ZWAI is represented on the Irish Government's Waste Forum and Water Forum (An Fóram Uisce) by one of our Directors, ZWAI is a member of the Irish Environmental Network and the Environmental Pillar, and is funded by the Department of Communications, Climate Action and the Environment through the **Irish Environmental Network**.

In 2019 ZWAI became a full member of the **European Environment Bureau** (EEB); and we participate in the **Waste Working Group** of the EEB. Through the EEB, we contribute to the development of European Union policy on waste and the Circular Economy. In November 2021, the EEB established a **Task Force on the Built Environment**; and ZWAI was accepted as a member of this new group, and we continue to contribute to discussions on the sustainability of construction materials, on buildings and on the built environment.

Zero Waste Alliance Ireland (ZWAI) is very pleased to have the opportunity to provide feedback to the European Commission on this important matter, and we have undertaken some research to provide the Commission with reasonably detailed and evidence-based comments. We trust that the observations in this submission will be considered as a relevant and a positive contribution to EU strategies and measures which would aim to achieve a "zero waste society".

3. Background to the Consultation – the Nutrient Waste Problem, and the Current Initiative by the European Commission

3.1 Nutrient Losses and their Consequences

Nutrients (nitrogen & phosphorus) are essential for life and important natural resources. Human activities have significantly altered natural nitrogen and phosphorous cycles, causing nitrate pollution in drinking water, airborne particulate matter, eutrophication, the loss of biodiversity in lakes, rivers and seas throughout the EU, and impacts on soil biodiversity, productivity and a wide range of climate-change impacts, including higher greenhouse gas emissions.

In Europe, surplus nitrogen and phosphorus in the environment are already exceeding safe planetary boundaries (for nitrogen by a factor of 3.3 and for phosphorus by a factor of 2).[6] This represents a severe threat to nature and to the Earth's climate; and this nutrient loss is causing air, soil and water pollution, loss of biodiversity and climate-change impacts.

Two thirds of the excessive nitrogen and phosphorus levels in waters originate from fertilisers in agriculture and a third comes from industrial and domestic wastewaters. According to the latest Nitrates Directive report, 36% of rivers and 32% of lakes, 31% of coastal waters, 32% of transitional waters and 81% of marine waters have been reported as eutrophic for the period 2016-2019.[7]

Cost-benefit analysis has revealed that the overall environmental costs of all reactive nitrogen losses in Europe (estimated at €70–€320 billion per year at current rates) far outweigh the direct economic benefits of using nitrogenous fertilisers in agriculture. The highest societal costs are associated with loss of air quality and water quality, linked to adverse impacts on ecosystems and especially on human health.[8]

It Is also a matter of extremely serious concern that atmospheric emissions of nitrogen pollutants (half of which come from agriculture and half from the burning of fossil fuels) from traffic, energy and industry are estimated to be responsible for 374,000 premature deaths in the EU every year. Estimates of the health impacts attributable to exposure to air pollution indicate that $PM_{2.5}$ concentrations in 2016 were responsible for about 412,000 premature deaths originating from

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[6] Is Europe living within the limits of our planet? An assessment of Europe's environmental footprints in relation to planetary boundaries. A joint report by the European Environment Agency (EEA) and the Swiss Federal Office for the Environment (FOEN); published as EEA Report No. 01/2020; Luxembourg: Publications Office of the European Union, 2020.

[7] Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2016–2019; COM(2021) 1000 final; Brussels, 11 October 2021.

[8] The European Nitrogen Assessment – Sources, Effects and Policy Perspectives; Cambridge University Press, 2011; pp. xxiv – xxxiv.

long-term exposure in Europe (over 41 countries) of which around 374,000 were in the EU-28. The estimated impacts of exposure to NO_2 and O_3 concentrations on the population in these 41 European countries in 2016 were around 71,000 and 15,100 premature deaths per year, respectively, and in the EU-28 around 68,000 and 14,000 premature deaths per year, respectively.[9]

Deposits of atmospheric emissions are continuing to cause soil acidification and eutrophication, adversely affecting biodiversity. Nitrous oxide (70% of which is released by agriculture[10]) is an important greenhouse gas, 300 times more powerful than CO_2 in terms of its global warming potential, and it is also a powerful ozone-depleting substance. The industrial production of chemical fertilisers consumes 1-2% of all energy produced in the EU, generating CO_2 emissions and increasing Europe's dependency on fossil gas, and issue of considerable concern to the European Commission, the Parliament and all Member States.

Phosphorus is included on the list of critical raw materials, raising serious concerns about future supplies and market prices (see section 4.2 below). The principal global producers of phosphorus are China (74%), Kazakhstan (9%) and Vietnam (9%); and the EU gets its supplies of phosphorus from these countries in the following proportions: Kazakhstan, 71%; Vietnam, 18%; and China, 9%. Import reliance on supplies from these countries is considered to be 100%.

The principal global producers of phosphate rock as a raw material for phosphate fertiliser production are China (48%), Morocco (11%) and the United States (10%); and the EU obtains its supplies of phosphate rock from these countries in the following proportions: Morocco, 24%; Russia, 20%; and Finland, 16%. Import reliance on supplies from non-EU countries is calculated at 84%,[11] primarily because of the availability of supplies from Finland.

3.2 Need for New and Strengthened Legislation at EU Level

Long-standing EU legislation has sought to tackle the continuing loss of valuable nutrients via wastewater discharges to surface waters and groundwater, and via agricultural and industrial emissions to water and air. While existing legislation has helped address this problem in recent decades, adverse effects on human health and the environment (including those described briefly above) are still

[9] Air quality in Europe, 2019 report; EEA and the European Topic Centre on Air Pollution, Noise, Transport and Industrial Pollution (ETC/ATNI); EEA Report No. 10/2019; Executive Summary, page 8. See also https://www.eea.europa.eu//publications/air-quality-in-europe-2021 and https://www.eea.europa.eu/publications/air-quality-in-europe-2021/air-quality-status-briefing-2021.

[10] https://data.worldbank.org/indicator/EN.ATM.NOXE.AG.ZS?locations=EU.

[11] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability; COM(2020) 474 final; Brussels, 03 September 2020.

continuing, notably as a consequence of shortcomings in specific legislation and to significant issues in implementing the legislation.

Another important reason for the continuation of these problems may also be due to the lack of an integrated approach on nutrient pollution encompassing air, water, soil and climate, and we address this issue in section 6 below).

Given the cross-border nature of nutrient losses causing pollution of water and air, action at EU level is more beneficial compared to national, regional or local action alone, as it indispensable to ensure the same level of standards of protection of human health and the environment, as well as legal certainty and a level playing field in the single market. EU action is already helping Member States address nutrient pollution, and implementing the legislation has brought significant improvements over the past decades. However, without additional EU action, progress is expected to be insufficient. There are implementation and enforcement gaps and these need to be addressed, and the current system lacks a holistic approach to the nutrient cycles. There is a need to close the nutrient cycles to prevent nutrients leaching into the environment.

Nutrient losses and inefficiencies in the nutrient cycle require significant additional action at EU level to improve food security, protect human health and preserve the ecosystem.

3.3 The European Commission's Proposals for Action

The European Commission's proposed integrated nutrient management action plan will hopefully examine the entire nitrogen and phosphorus cycles. It is intended to cover all environmental media (air, water, marine and soil), and all relevant sources of pollution (e.g. agriculture, industry, urban, waste, energy, and transport). It will identify policy gaps for a more coherent and integrated approach to reducing pollution throughout the nutrient cycles. The initiative will develop a framework for action needed at all levels (EU, national, regional) in order to achieve the objectives set in EU law and the climate and environmental commitments under the Green Deal.

The integrated nutrient management action plan will contribute to the achievement of the European Climate Law objectives, the 2030 biodiversity target, and the "***farm to fork***" strategies to reduce nutrient losses by at least 50%, which will entail reducing the use of fertilisers by at least 20%. This will include looking at how to ensure a more sustainable application of nutrients (identifying nutrient load reductions with Member States, applying balanced fertilisation and sustainable nutrient management), tackling nutrient pollution at source, increasing the sustainability of agriculture and other sectors, and stimulating the markets for recovered or recycled nutrients.

It will also contribute to the objectives of the **zero pollution action plan** by tackling in a holistic manner other industrial and urban sources of nutrient losses. The action will include looking at the indicators and tools for monitoring to improve assessment and comparability, and at best practice sharing to increase effectiveness. This will feed into an integrated assessment of nutrient pollution and progress tracking, e.g. through the **Zero Pollution Monitoring and Outlook** reports.

The action plan will aim to focus the efforts of Member States on nutrient pollution hotspots in order to reduce pollution effectively and minimise the gaps to targets. It will also look at creating tools to improve application of environmental and climate legislation in full. It will aim to maximise synergies with the common agriculture policy, making best use of the new green architecture. The holistic approach proposed will also contribute to achieving targets for non-CO_2 emissions from the agriculture sector, as proposed in the '*Fit for 55'* package.

Action may range from regulatory initiatives, including evaluating and revising legislation (if necessary) and complementing legislation to achieve a more holistic approach to nutrient pollution, to non-regulatory initiatives facilitating cross-sectoral approaches and drawing on technological developments.

The integrated nutrient management action plan (INMAP) is expected to have an impact on bringing nutrient loads to within safe operating levels (i.e., not exceeding safe planetary boundaries).

Reducing nutrient losses will help improve public health, mainly by having a positive impact on air and water quality. It will also have a significant positive impact on the restoration and the preservation of lifecycles and ecosystems in soil and water. Lower levels of acidification and eutrophication of soil and waters will benefit agricultural land fertility and the biodiversity of Natura 2000 areas. Restoring aquatic ecosystems will help replenish fish stocks and have a positive impact on tourism sectors. Reducing nutrient losses is necessary to achieve good status for surface water and groundwater in the EU under the Water Framework Directive.

The action plan will have a direct impact on achieving the following sustainable development goals (SDGs):

- SDG 2 Zero hunger (sustainable food production systems);
- SDG 6 Universal access to safe and affordable drinking water and to improve water quality;
- SDG 14 Life below water;
- SDG 12 Sustainable consumption and production; and
- SDG 13 Climate action.

Concerted actions taken under the action plan should help Member States and stakeholders in their efforts to reduce nutrient pollution and compliance with EU legislation, to adapt their agricultural practices, food production processes, waste management practices, wastewater treatment, air quality protection and nutrient recycling. Tackling nutrient pollution hotspots will require Member States to take resolute action, as reducing nutrient loss will have to be more substantial in these areas.

Future monitoring of nutrient flows, losses and their impacts on human health and the environment will draw on the existing monitoring networks and indicators set up under EU environmental and climate legislation, but these may need to be complemented by new indicators drawn up under the action plan.

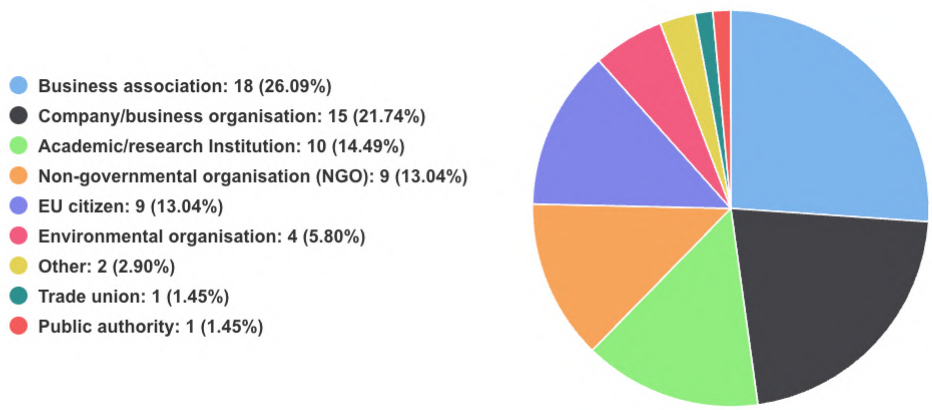
Zero Waste Alliance Ireland fully supports the Commission's proposals for action as described above; however, we have some concerns (expressed in the following sections of this submission) that the proposals may not go far enough, and may not be sufficiently comprehensive and enforceable.

3.4 Consultation strategy

As part of the work to prepare the action plan, the Commission is carrying out:

- an online public consultation, launched in the second quarter of 2022;
- sectoral consultations with specific stakeholder groups; and,
- consultation with Member State's authorities via the relevant expert groups.

The Commission has also invited members of the public and the wider community of stakeholders affected by nutrient pollution to share their views on this initiative. A preliminary "Call for Evidence", was open from 29 March to 26 April 2022, and it resulted in 69 submissions. Zero Waste Alliance Ireland did not respond to that "Call for Evidence".



The current **Public Consultation** on the Commission's action plan for better management of nutrients opened on 23 May 2022, and closes on **26 August 2022**. It is this public consultation to which Zero Waste Alliance Ireland is now responding.

4. Our Observations on the Nutrient Waste Problem, and Suggestions for Addressing the Problem

4.1 The Long-term Effects of the Green Revolution

Following the introduction of genetically improved crops in the Green Revolution beginning in the 1960s, larger crop yields in agriculture were initially possible.[12] The improved crop varieties responded well to increased fertiliser applications. Accelerations in fertiliser use including synthetic nitrogenous and phosphate fertilisers have occurred over the past century, allowing for increased food availability and subsequent population growth worldwide.

However, the planetary boundaries for the biogeochemical flows of nitrogen and phosphorus have now been severely breached, resulting in environmental damage and food insecurity (see section 3.1 above).

Agricultural production is the leading cause of planetary boundary transgression, especially for the phosphorus cycle.[13] Regarding the depletion of phosphate rock reserves, estimates range from 20 to 300 years (see Figure 4.3 below). While there is some uncertainty, the general consensus is that the quality and accessibility of remaining phosphate rock reserves are decreasing, and costs of fertiliser will increase.[14] This will result in damaging consequences for agriculture and food production, as well as social and economic burdens. In Figure 4.1 below we show a visual representation of the current status of the nine planetary boundaries.[15] Note that the biogeochemical flows for phosphorus and nitrogen are beyond the zone of uncertainty.

4.2 The Key Role of Phosphorus

Phosphorus is essential to plant growth and cannot be substituted. Phosphorus is a chemical element, therefore it cannot be created or destroyed. Humans and animals eventually excrete 100% of the phosphorus they obtain from food, and in a natural phosphorus cycle this is returned to the soil and is re-absorbed by plants. Contemporary industrial society had led to the disruption of this cycle. Agricultural intensification results in increased removal of phosphorus from soil by crop plants, which must be replaced by industrial phosphate fertilisers. Phosphorus is generally concentrated in wastewater and is lost to the

[12] Evenson, R.E. and Gollin, D., 2003. Assessing the impact of the Green Revolution, 1960 to 2000. science, 300(5620), pp.758-762.

[13] Tilman, D. and Clark, M., 2014. Global diets link environmental sustainability and human health. Nature, 515(7528), pp.518-522.

[14] Cordell, D. and White, S., 2011. Peak phosphorus: clarifying the key issues of a vigorous debate about long-term phosphorus security. Sustainability, 3(10), pp.2027-2049.

[15] Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A. and Folke, C., 2015. Planetary boundaries: Guiding human development on a changing planet. science, 347(6223), p.1259855.

environment, ending up in rivers, lakes and oceans. This lost phosphorus is currently uneconomical or impossible to recover. Furthermore, soil erosion and run-off deplete phosphorus from soils.

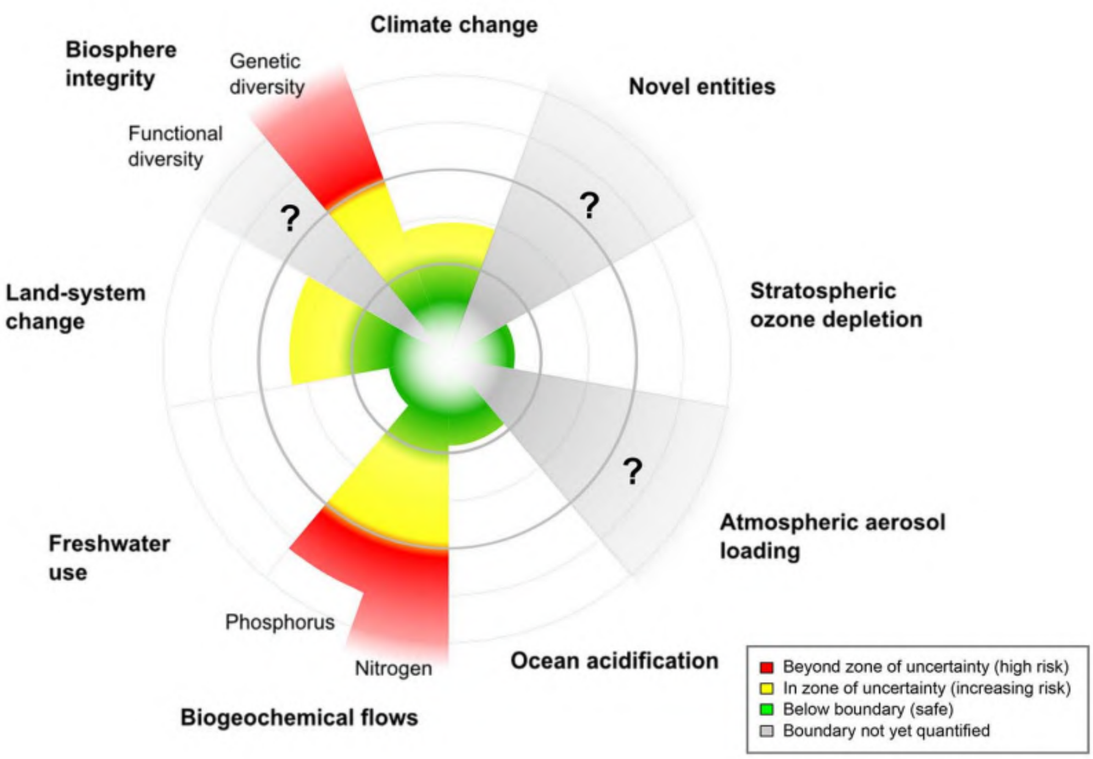


Figure 4.1 **Representation of the current status of the nine planetary boundaries; note that the biogeochemical flows for P and N are beyond the zone of uncertainty**

Though it is the eleventh most common element on earth, phosphorus scarcity is of increasing concern, as there is no atmospheric source of phosphorus. Some 90% of phosphorus is obtained from non-renewable phosphate rock, and the main sources of phosphate rock are in Morocco (including reserves located in Western Sahara), China, Egypt, Algeria and Syria.[16] See our observations in section 3.1 above on the availability of phosphate rock, and Figure 4.2 below.

Significant deposits exist also in Russia, but serious disruptions in the supply of phosphorus from Russia can be expected as a consequence of the Russian invasion of Ukraine and the continuing war and destruction imposed by Russia on Ukraine, together with the effects of other countries' sanctions on Russia, and political decisions to cease the importation of raw materials from Russia.

Phosphate fertiliser production in Morocco is associated with heavy metal pollution,[17] which suggests that the phosphate rock is contaminated with heavy

[16] https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-phosphate.pdf

[17] Gaudry, A., Zeroual, S., Gaie-Levrel, F., Moskura, M., Boujrhal, F.Z., El Moursli, R.C., Guessous, A., Mouradi, A., Givernaud, T. and Delmas, R., 2007. Heavy metals pollution of the Atlantic marine environment by the Moroccan phosphate industry, as observed through their bioaccumulation in Ulva lactuca. Water, air, and soil pollution, 178(1), pp.267-285.

metals. As phosphorus resources become more scarce, lower grade phosphate rock with comparatively high levels of heavy metals may have to be exploited, with the consequence that heavy metals may accumulate in soils, leading to adverse health and environmental effects. To achieve phosphorus sustainability in agriculture, it will be necessary to reduce phosphorus loss through erosion and leaching and to improve phosphorus availability in soils.

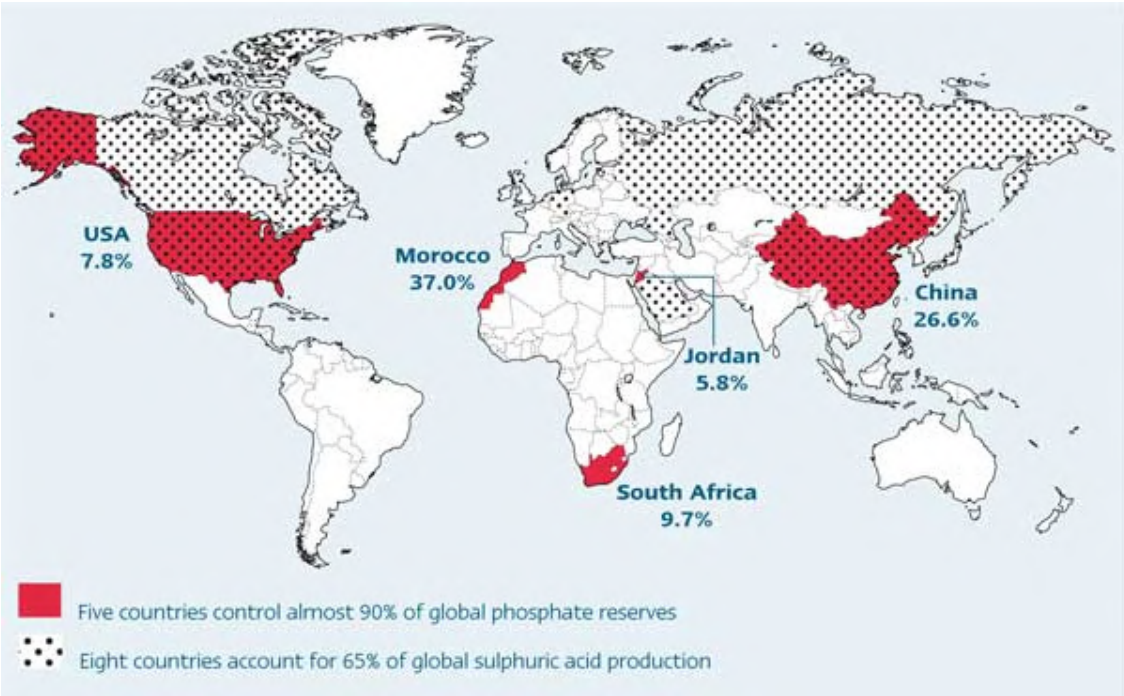


Figure 4.2 Countries with remaining phosphorus rock reserves and countries that supply sulphuric acid necessary for the processing of phosphate rock into phosphatic fertiliser.

The depletion of phosphorus resources is often referred to as "*peak phosphorus*", a term used similarly to peak oil. As briefly noted in section 4.1 above, estimates of the future availability of phosphorus range from 20 to 300 years (see Figure 4.3 below). The key differences between peak oil and peak phosphorus are:

1. Oil can be replaced by other forms of energy as it becomes scarce;
2. There is no substitute for phosphorus in fertiliser production, as phosphorus cannot be produced or synthesized commercially; and,
3. Phosphorus can be captured after use and recycled for further use within economic and technical limits.

It is therefore of strategic importance that phosphorus should not be wasted, but that existing and well-tried methods should be implemented to conserve and recycle it. The wastage of phosphorus can be avoided, and phosphorus can be easily recycled.

Given the present need to phase out dependency on mined phosphorus rock from Russia and the issue with toxic metals present in imported phosphorous from North Africa, it is now critical that Europe finds a way to increase the supply of phosphorus in order to avoid future shortages in our food supplies.

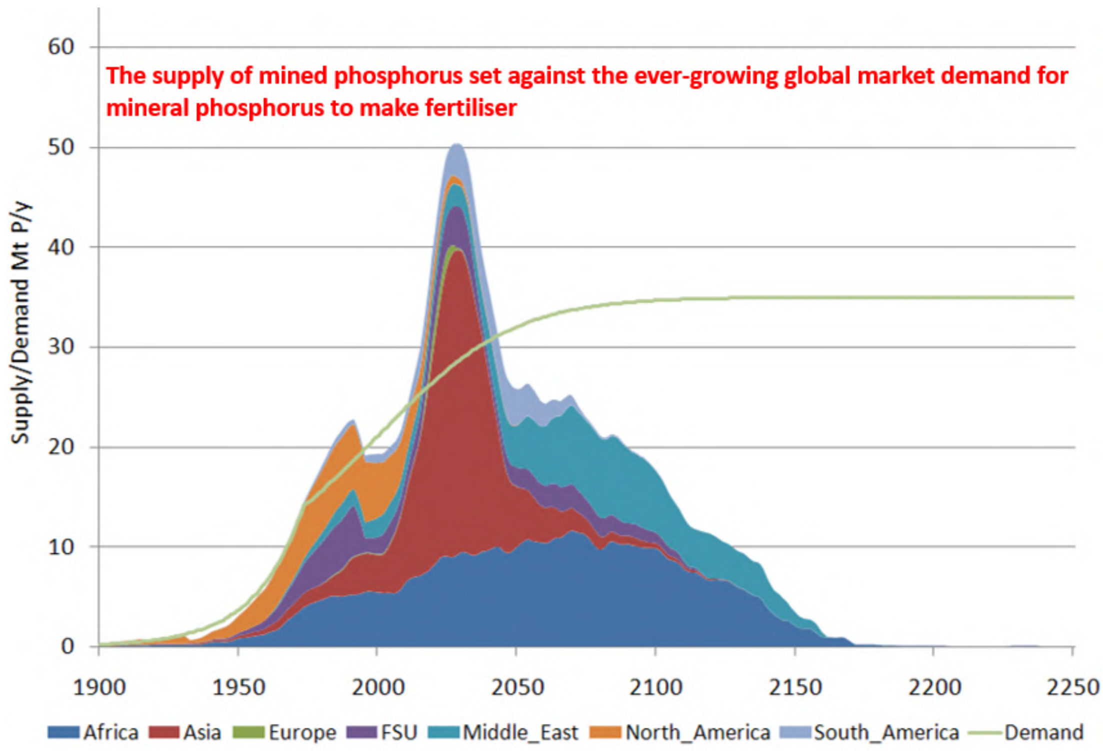


Figure 4.3 **Estimate of the future supply and availability of mined phosphate rock (FSU = Former Soviet Union).**

Therefore, it is ZWAI's assertion that wastewater treatment and disposal systems can and should play their part to help prevent future food security threats. At present, none of the municipal sewage treatment plants in Ireland or the EU are recovering and recycling phosphorus to agriculture "*without toxic metals or organic pollutants*". Though Regulation (EU) 2019/1009 has laid down criteria on agronomic efficiency and safety for the use of phosphorus by-products in EU fertilizing products, it has not been made mandatory to recover phosphorus in EU member states. Additionally, the presence of pharmaceutical residues and heavy metal contamination in wastewater cannot be ignored and may hinder the recovery and re-use of nitrogen and phosphorus in agriculture.

It Is therefore our submission that Regulation 2019/1009 must be expanded and strengthened to provide for mandatory recovery of phosphorus from wastewater in all EU Member States; and the revised regulation must take into account the wider issues to which we have referred in our introduction, section 1 above.

4.3 The Key Role of Nitrogen

Nitrogen is abundant in the atmosphere but in a non-reactive form which cannot be used by plants, and it must therefore be "fixed" by transforming it biologically or chemically. Biological fixing of nitrogen by micro-organisms in root nodules of certain plants, e.g., clover species, has been known for centuries; while the conversion of nitrogen to ammonia and urea is a relatively recent process, no more than a century old.

Nitrogen fertiliser has become easily obtainable through the Haber-Bosch process, which converts atmospheric nitrogen to a form useable by plants. Unfortunately, this process requires very large amounts of energy, which has until now been provided by gas or oil, resulting in massive CO_2 emissions from the burning of these fossil fuels. As we urgently need to conserve energy and leave remaining fossil fuels "in the ground" in order to mitigate climate change, the future synthesis of nitrogenous fertilisers is in doubt; and therefore nitrogenous fertilisers must be considered as a resource critical for the continuation of agriculture in the EU.

The environmental impacts of increased pollution by dissolved and biologically available nitrogen, including eutrophication and ocean acidification, are now becoming widely observed. The interactions between the N-cycle and carbon-cycle are not yet fully understood, leading to uncertainty as to how the disruption of the N-cycle will impact climate change. Furthermore, research is needed to develop efficient methods to recover N from wastewater.

Recovering dissolved nitrogen from wastewater would therefore save energy, would also have the benefit of reducing eutrophication of rivers, lakes and coastal waters, and reduce the level of uncertainty noted above. It is therefore our submission that recovery of nitrogen from wastewater must become a prime task of the Commission's integrated nutrient management action plan (INMAP).

4.4 Integration of Soil Health, Water Management and Nutrient Management Frameworks

The problem of loss of nutrients into the environment may provide an excellent opportunity for the application of the Nature-based Solutions (NbS) concept. The International Union for Conservation of Nature (IUCN) defines NbS as: "*Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"* [18].

Because nutrient loss is intricately linked with many other natural systems, strategies to reduce nutrient loss must complement and synergise with other EU strategies, for example the Biodiversity Strategy for 2030, Farm to Fork Strategy, Water Framework Directive, Circular Economy Action Plan and the 2030 Climate Target Plan (see section 1 above). The adoption of nature-based solutions to

[18] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S., 2016. Nature-based solutions to address global societal challenges. IUCN: Gland, Switzerland, 97, pp.2016-2036.

nutrient loss will result in a more holistic approach that generates economic, social, and environmental benefits.

In March 2022 ZWAI submitted a detailed feedback to the EU Commission on the Proposed Directive on Soil Health; and we suggested that, because aspects of soil and water are closely linked, it stands to reason that an integrated soil and water management framework would be an effective and efficient policy. Strategies to improve soil health will contribute to better water and nutrient management through reduced fertiliser use, reduced erosion and reduced run off/ leaching. Furthermore, the addition of a nutrient management action plan to this integrated soil and water management framework would allow for a more holistic approach. Since these natural systems do not operate in isolation, the management policies we devise should be likewise unified.

This holistic approach is already gaining traction in the EU; and, in Ireland, with the establishment of River Basin Districts in order to comply with the requirements of the Water Framework Directive. However, the level of integration is quite poor,[19] though there are indications of new thinking to encompass water and nutrient management and land uses (see section 6 below).

4.5 Water Pollution by Nutrients

Nutrient pollution includes mainly nitrogenous compounds such as organic nitrogen, ammonia, ammonium, nitrate and nitrite, and phosphorus in both organic and inorganic forms. Phosphorus is a major limiting factor in aquatic ecosystems and is usually scarce. When phosphorus is introduced to water bodies, extreme algal blooms can occur.

Excess nutrient loading in aquatic ecosystems leads to over-abundance of algae, known as eutrophication. As the algae die off and begin to decompose, bacteria and other microorganisms in the water consume the available dissolved oxygen to decompose the algal biomass. This results in anoxia (lack of oxygen), which in turn causes the death of fish and other aquatic organisms. Observations have revealed that excess nutrient loading also negatively affects aquatic ecosystem functioning. The breakdown and nutrient cycling of natural organic matter such as leaf litter is reduced in nutrient enriched streams.[20]

Impacts on aquatic ecosystem functioning may go beyond the effects on litter breakdown, because changing litter dynamics can have strong effects on nutrient retention, invertebrate activity and other functional ecosystem attributes. The disruption of aquatic ecosystems by nutrient loading will therefore have far-

[19] In March 2022, Zero Waste Alliance Ireland made a lengthy submission to the Department of Housing, Local Government and Heritage in response to a Public Consultation on the draft River Basin Management Plan for Ireland 2022 to 2027; and we raised in that submission many issues about the lack of integration in the management of water resources.

[20] Woodward, G., Gessner, M.O., Giller, P.S., Gulis, V., Hladyz, S., Lecerf, A., Malmqvist, B., McKie, B.G., Tiegs, S.D., Cariss, H. and Dobson, M., 2012. Continental-scale effects of nutrient pollution on stream ecosystem functioning. Science, 336(6087), pp.1438-1440.

reaching consequences on the systems we rely on for food production, climate change mitigation and water security.

4.6 Strategies to Reduce Nutrient Losses in Agriculture

It is a key component of our submission that appropriate soil and water conservation strategies can significantly reduce nutrient losses.[21] In 2016, farms covered 173 million hectares of land in the EU, amounting to 39 % of the total land area. Therefore, managing nutrient losses from agriculture is crucial. In addition to reduced nutrient losses, improvement in soil health is associated with:

- Reduced erosion;
- Higher biodiversity;
- Increased crop yield;
- Reduced fertiliser demand;
- Reduced agrochemical demand; and,
- Increased water infiltration and capacity.

Phosphorus loss from land can impair water quality. Minimising phosphorus loss from agricultural soils can be achieved by reducing run-off. Identifying those areas which lose the most phosphorus, and focusing mitigation strategies on such areas, is more effective than farm-wide strategies [22].

4.6.1 No Till Cultivation

By avoiding ploughing of agricultural land, in combination with cover crops to reduce weed infestation, a healthy soil structure can be maintained, while organic matter from crop residues builds up on the surface. Soil health markers improve, including water infiltration, water capacity, plant available nutrients and total nitrogen.[23] Erosion and run-off are reduced, with the result that less nitrogen and phosphorus are lost.

4.6.2 Buffer Strips & Field Margins

Decreased nitrogen pollution was observed from a conventional agricultural field when a 5m wide margin was established around the periphery,[24] thereby

[21] Han, Y., Feng, G. and Ouyang, Y., 2018. Effects of soil and water conservation practices on runoff, sediment and nutrient losses. Water, 10(10), p.1333.

[22] McDowell, R.W., 2012. Minimising phosphorus losses from the soil matrix. Current Opinion in Biotechnology, 23(6), pp.860-865.

[23] Nunes, M.R., van Es, H.M., Schindelbeck, R., Ristow, A.J. and Ryan, M., 2018. No-till and cropping system diversification improve soil health and crop yield. Geoderma, 328, pp.30-43.

[24] De Cauwer, B., Reheul, D., Nijs, I. and Milbau, A., 2006. Effect of margin strips on soil mineral nitrogen and plant biodiversity. Agronomy for sustainable development, 26(2), pp.117-126.

providing a semi-natural habitat which supports biodiversity while preventing the run-off of soil nutrients into waterways.

4.6.3 Crop Rotation

Plants make better use of the available nutrients in soil when grown in rotation. Higher uptake of nutrients by crops will minimise loss through leaching and run-off. An experimental crop rotation system reported 25.6% higher barley grain yield compared with conventional monoculture.[25]

4.6.4 Perennial Crops

Perennial crops differ from annual crops such as wheat or rice, in that they persist in the soil year after year and can develop more extensive root networks. This allows the plants to access nutrients and minerals from deeper soil layers. Phosphorus can build up in deeper soils layers through leaching after decades of fertilisation. The root structures of perennials help to stabilise the soil and reduce soil erosion and leaching of nitrogen and phosphorus.

Perennial grain crops have great potential as sustainable food sources of the future, and it has been shown that perennialisation of existing grain crops through breeding and crossing may prove successful. Domestication of wild perennials for grain production is another interesting possibility.[26]

4.6.5 Intercropping

Planting cover crops with fibrous roots in between rows of conventional crops such as maize or wheat can help to stabilise the soil, thereby preventing nutrient loss through erosion and leaching, and also reducing run-off to a lesser extent.[27] Legumes as cover crops can even contribute nitrogen to the soil as they grow.

4.6.6 Agroforestry

Reforestation is an effective way to minimise erosion of soil. Incorporating trees into conventional agriculture can reduce erosion, especially on sloped ground.[28]

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[25] Woźniak A., Soroka M. Structure of weed communities occurring in crop rotation and monoculture of cereals. International Journal of Plant Production, 9 (3), 487, 2015.

[26] Østerberg, J.T., Xiang, W., Olsen, L.I., Edenbrandt, A.K., Vedel, S.E., Christiansen, A., Landes, X., Andersen, M.M., Pagh, P., Sandøe, P. and Nielsen, J., 2017. Accelerating the domestication of new crops: feasibility and approaches. Trends in Plant Science, 22(5), pp.373-384.

[27] Blanco-Canqui, H., 2018. Cover crops and water quality. Agronomy Journal, 110(5), pp.1633-1647.

[28] García de Jalón, S., Graves, A., Palma, J.H., Williams, A., Upson, M. and Burgess, P.J., 2018. Modelling and valuing the environmental impacts of arable, forestry and agroforestry systems: a case study. Agroforestry systems, 92(4), pp.1059-1073.

4.6.7 Biochar

Biochar is charcoal produced from the pyrolysis of biomass at high temperatures, and it has gained widespread attention since 2018 as a potential soil amendment to improve soil health, water capacity, soil biodiversity and carbon sequestration. The carbon contained in biochar may remain in soil for hundreds or thousands of years.

Additionally, biochar has potential as a method for delivering slow-release fertiliser to soils while reducing the risk of run-off, and thereby minimising loss of nutrients either to the atmosphere or to adjacent waterways. The phosphorus content of biochar is increased by adsorption because of its porous structure.

In an experiment, biochar was soaked in a saturated KH_2PO_4 solution, and applied to soil.[29] The experiment demonstrated that biochar can be used to deliver slow release phosphorus to soil, and less phosphorus may be required for soil fertilisation compared to conventional phosphate fertiliser, leading to cost reductions.

4.7 Wastewater Treatment Methods which Include Nutrient Recovery and Utilisation

Wastewater and wastewater sludge are gaining attention as sources of useful nutrients; and, as stated earlier; the recovery of dissolved phosphorus and nitrogen from waste water is one of our principal points of this submission, and should be a key aim of an EU integrated nutrient management action plan.

4.7.1 Activated Sludge Process

Traditional wastewater treatment requires high energy input and is associated with high costs and maintenance. The activated sludge process is widely used for sewage and wastewater treatment; it was first developed in 1914, and even though it has been much improved in the last 100 years, the process remains essentially unchanged. In this process, the wastewater is pumped into large tanks, aerated to introduce oxygen, to allow bacteria and protozoa to oxidise and remove organic matter and nutrients, including nitrogen and phosphorus.

The microorganisms then flocculate or cling together to produce a sludge which is allowed to settle, by pumping the mixed liquid to a settling tank where solid organic matter is removed by settlement. The settled sludge consists of a mixed blend of microorganisms, 95% of which are a variety of mostly aerobic species of bacteria, but the sludge also contains populations of fungi, protozoa and some species of small invertebrates.

The intention of the process is to remove organic matter and sewage-derived microorganisms, producing a clarified liquid which contains a significant quantity

[29] Li, H., Li, Y., Xu, Y. and Lu, X., 2020. Biochar phosphorus fertilizer effects on soil phosphorus availability. Chemosphere, 244, p.125471.

of nutrients released from by breakdown of the organic matter. Little attention has been given to how these nutrients may be recovered or utilised.

4.7.2 Microalgae Water Treatment

As energy resources become scarce and low-carbon technologies become favoured, the use of microalgae to treat wastewater is gaining attention as an alternative to activated sludge. In addition to nutrient removal from wastewater, a useful biomass is produced, and this is an additional benefit, as biomass resources are being now considered as sources of renewable energy, given the necessity to reduce our reliance of fossil fuels.

Aquatic biomass may have advantages over land-based biomass, as it does not compete with food production on land, and the following examples show how microalgae may be used for the recovery of nutrients dissolved in wastewater.

Lemna minor, a floating macrophyte belonging to the family Lemnaceae, has great potential for wastewater treatment. Also known as common duckweed, these aquatic plants are the smallest flowering plant in the world and can multiply rapidly.[30] *Lemna minor* is used in the polishing stage of domestic wastewater treatment, for the removal of nitrogen and toxic pollutants. It can be removed from the treated water by simple separation.

Chlorella sorokiniana is a unicellular pollution-tolerant microalga, also used in the treatment of wastewater. An experiment in wastewater treatment with *Chlorella sorokiniana* determined that nitrogen and phosphorus removal was 5%–10% and 10%–55%, respectively, <u>higher</u> than in the activated sludge process.[31]

A recent experiment used both *Chlorella sorokiniana* and *Lemna minor* in a bioreactor to treat raw sewage[32] on a small scale. Results indicated a 99% removal of chemical oxygen demand (COD), 88% removal of total nitrogen and 91% removal of total phosphorus, without CO_2 enrichment or pH adjustment.

Following water treatment, *Lemna minor* biomass can be harvested and composted. Alternatively, the biomass can be used for the production of pyrolysis products – syngas, bio-oil and biochar.[33] Some obstacles remain however, for

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[30] Ekperusi, A.O., Sikoki, F.D. and Nwachukwu, E.O., 2019. Application of common duckweed (Lemna minor) in phytoremediation of chemicals in the environment: State and future perspective. Chemosphere, 223, pp.285-309.

[31] Fan, J., Cao, L., Gao, C., Chen, Y. and Zhang, T.C., 2019. Characteristics of wastewater treatment by Chlorella sorokiniana and comparison with activated sludge. Water Science and Technology, 80(5), pp.892-901.

[32] Kotoula, D., Iliopoulou, A., Irakleous-Palaiologou, E., Gatidou, G., Aloupi, M., Antonopoulou, P., Fountoulakis, M.S. and Stasinakis, A.S., 2020. Municipal wastewater treatment by combining in series microalgae Chlorella sorokiniana and macrophyte Lemna minor: Preliminary results. Journal of Cleaner Production, 271, p.122704.

[33] Muradov, N., Fidalgo, B., Gujar, A.C. and Ali, T., 2010. Pyrolysis of fast-growing aquatic biomass–Lemna minor (duckweed): Characterization of pyrolysis products. Bioresource technology, 101(21), pp.8424-8428.

example. the accumulation of heavy metals in the biomass which can prevent continued application on farmland. More research is needed in this area to allow for true circular treatment of wastewater with useful biomass and fertiliser produced, including the recovery of nutrients..

4.7.3 Struvite Production and Utilisation

Struvite crystallization from wastewater is a promising recovery technique to mitigate nutrient loss problems, as the recovered precipitate (which is rich in phosphorus) can be re-used as a slow-release fertilizer.[34] Struvite is a phosphate compound: magnesium ammonium phosphate ($MgNH_4PO_4{\cdot}6H_2O$). Struvite is most easily recovered from human urine, which can be easily separated at source and collected for use.

ZWAI proposes the following nutrient recovery measures, based on practical and well-known technology:[35]

i) The European Commission should issue a Directive or Regulation to all Member States to "*allow, permit and encourage*" EU citizens and communities to use composting toilets, and to undertake the separate treatment of urine to make struvite;

ii) This proposed Directive or Regulation should require Member States' governments to allow and encourage EU citizens to use dilute urine to grow non-food plants, as a way to partially or significantly utilise the nutrient content of urine. These plants can be harvested after 3 to 5 years, and then composted to break down bio-absorbed pharmaceuticals and antibiotics in order to make a fertile rich soil, particularly in those areas and regions of the EU that are suffering from topsoil erosion;

iii) This proposed Directive or Regulation should require Member States' governments to allow and encourage EU citizens to utilise urine by other nature-based solutions such as algal turf scrubbing; and,

iv) This proposed Directive or Regulation should encourage and permit Member States to allow their local or national water authorities (which are responsible for wastewater treatment) to collect urine from households, to make both struvite as well as ammonium sulphate as non-toxic recycled fertilisers.[36]

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34 Li, B., Boiarkina, I., Yu, W., Huang, H.M., Munir, T., Wang, G.Q. and Young, B.R., 2019. Phosphorous recovery through struvite crystallization: challenges for future design. Science of the total Environment, 648, pp.1244-1256.

35 See, for example, the submission made by Zero Waste Alliance Ireland in 2019 to the EPA entitled: "*Code of Practice for Wastewater Treatment & Disposal Systems Serving Single Houses"*: https://www.zwai.ie/submissions-2019

36 https://www.kemira.com/insights/new-eu-regulations-make-selling-precipitated-phosphorus-appealing-for-water-utilities/

4.7.4 Constructed Wetlands

Natural wetlands, including peatlands, play an important role in mitigating and delaying surface water run-off and in flood prevention.[37] Constructed wetlands can be used to treat sewage, grey water, urban run-off or industrial effluents.

A constructed wetland is a sustainable wastewater treatment system, designed to look and function as a natural wetland. Constructed wetlands are created for the purpose of treating wastewater from small, rural communities and from industries in an environmentally-friendly way before allowing the tertiary treated wastewater to return safely to the aquatic environment.

Constructed wetlands are usually made up of a primary settlement tank where wastewater from the community is collected; followed by several ponds which are planted with wetland plants including reeds, rushes and sedges. The ponds are usually gently sloped towards a river or stream to allow the overflow water to migrate very slowly through the wetland before being discharged. Any particles that have been carried in the water will settle out in the ponds, and the plants and natural microorganisms (e.g. bacteria, algae and fungi) in the wetlands will break down and/or remove certain pollutants, e.g. phosphorus in the water.

An additional benefit is that the flow of water to the receiving environment is significantly reduced in volume by natural transpiration from the growing plants in the wetland ponds, and by the capturing of rainfall by these plants, followed by its immediate evaporation to atmosphere as soon as the rain ceases. In this way, the volume of wastewater being treated is actually reduced by passing through the wetland.

Integrated constructed wetlands are carefully planned to integrate into the natural surrounding landscape, and are built with natural materials like native plants, trees, soil, sand and stones.

The basic structure consists of a sand and gravel bed with water-tolerant plants. Water passes over the surface, or more effectively, beneath the surface for treatment. Levels of pathogens, excess nutrients, organic matter and heavy metals can be reduced by constructed wetlands, while simultaneously providing flood protection and habitats for wildlife.

In addition to treating wastewater from communities and small industries, constructed wetlands can play a vital role in the green infrastructure of the urban environment.[38] They have the potential to be integrated into urban run-off systems and into wastewater treatment, as well as agricultural run-off systems.

[37] De Groot, R., Stuip, M., Finlayson, M. and Davidson, N., 2006. Valuing wetlands: guidance for valuing the benefits derived from wetland ecosystem services (No. H039735). International Water Management Institute.

[38] Stefanakis, A.I., 2019. The role of constructed wetlands as green infrastructure for sustainable urban water management. Sustainability, 11(24), p.6981.

The concept of the "sponge city" is gaining traction in recent years, especially in China. Rapid urbanisation of Chinese cities lead to a vulnerability to flooding, water pollution and water scarcity which in turn resulted in a desire by the citizens for safer and more sustainable cities. The "sponge city" concept is in its early stages, i.e., it is too soon to draw meaningful conclusions about its effectiveness.

An experimental constructed wetland in Sicily demonstrated that a polyculture of plant species was more effective than a monoculture for the removal of organic pollutants.[39] The wastewater was used for irrigation after passing through the constructed wetland, which resulted in savings by avoiding the use of freshwater and fertilisers compared to conventional agriculture. Additionally, the giant reed *Arundo donax* used in the experiment grew well; and the authors suggested it could be harvested for biomass or the production of bioenergy. Conversely, the ongoing monitoring of the system for pathogens was deemed necessary for health protection, while food crops irrigated with the treated wastewater should be cooked before eating.

4.7.5 Nutrient Loss Monitoring

It is a key point of our submission that, while targets to reduce nutrient losses by at least 50% are imperative, and must be included in the Commission's proposed integrated nutrient management action plan (INMAP), these targets must be accompanied by a monitoring framework to accurately track the progress towards the goal. Without "milestones" to measure annual progress, any such action plan would be likely to be only partially effective.

5. Lack of An Integrated Approach to Controlling Pollution by Excessive Fertiliser Application in One Member State (Ireland)

As an example of what should not happen in any Member State of the EU, we describe a particular situation in Ireland, in which Government agencies do not collaborate to control water pollution and nutrient loss caused by excessive application of agricultural fertilisers (including "organic fertiliser" or animal slurry).

In this particular case, a local planning authority decided to grant planning permission for a large-scale intensive pig farm, to be located in a region of the country where the Director General of the Environmental Protection Agency stated that nitrogen levels in soil and water are too high, "*and they are increasing primarily because of agricultural activities".*[40] Nevertheless, the planning

[39] Licata, M., Gennaro, M.C., Tuttolomondo, T., Leto, C. and La Bella, S., 2019. Research focusing on plant performance in constructed wetlands and agronomic application of treated wastewater–A set of experimental studies in Sicily (Italy). PloS one, 14(7), p.e0219445.

[40] '*We can't have this ongoing growth of the dairy sector'* – Laura Burke. EPA chief Laura Burke says agriculture can't keep '*talking the environmental talk'* while ramping up

authority decided to grant permission without requesting or receiving any information from the applicant about the locations of the lands where the very significant quantities of pig manure ("organic fertiliser) would be spread.

The planning application was appealed to An Bord Pleanála (the Irish planning appeals board). The proposed intensive pig farm was also required to have an industrial emissions license from the Environmental Protection Agency (EPA), before it could begin to operate, but the applicant for planning permission did not (at the time) apply for the necessary license.

In response to a written request made by An Bord Pleanála to the Environmental Protection Agency, in which the Board asked the EPA to submit observations on the planning application, including observations on the applicant's Environmental Impact Assessment Reports, the Agency replied that:

i) The activity at the pig farm will be regulated by an industrial emissions licence for intensive agriculture;

ii) If an application for an industrial emissions licence is received by the EPA, the application will define the boundary of the site;

iii) The site boundary includes only the site of the pig rearing activity and the directly associated activities which occur only within that defined site boundary;

iv) Activities such as the processing of animal feed, transportation of feed, transportation of pigs, or the use of organic fertiliser (pig slurry) beyond the site boundary cannot be controlled by conditions attached to an industrial emissions licence which may be granted for the pig rearing activity, because these other activities will not be carried out within the defined site boundary of the pig rearing unit;

v) The recipient of the organic fertiliser (pig slurry) is responsible for the management and use of the organic fertiliser.

From a reading of the Agency's reply to An Bord Pleanála, it is clear that the EPA considers that it cannot control what happens to pig slurry ("organic fertiliser") beyond the defined pig rearing unit site boundaries; as the Agency states that it cannot specify any conditions governing the use (or misuse) of the slurry as a result of actions taken by the farmers who receive the slurry.

An Bord Pleanála has no power over the spreading of pig slurry, and cannot draw up or enforce planning conditions on lands which are not owned by the applicant for planning permission, but which are owned by the farmers accepting the nutrient-rich slurry on their lands. The result is that these farmers are individually responsible for the management and use of the slurry, with very little control over its application or pollution caused by excessive fertiliser use (including the

production, and she warned that some targets don't go far enough. Farming Independent, 28 September 2021.

combination of synthetic fertilisers and farm slurry). The only "control" is that the farmers accepting the slurry must adhere to "Good Agricultural Practice".

It is also worth noting that in its reply to An Bord Pleanála, the EPA made no reference whatsoever to any concerns about the unacceptably high nitrogen levels in the area where the pig slurry would be spread, despite this issue being raised publicly by the Agency's Director General.

The above planning application, which was made in June 2020, and is still to be determined by An Bord Pleanála, is a prime example of the "*implementation bodies*" or "*competent authorities*" failure to act together, or even to communicate meaningfully; and illustrates the conflict between planning policy and practice and the objectives of the Water Framework Directive, while policies on agriculture are a third element of the conflict. It is therefore obvious that the inclusion of a requirement to properly recover and utilise nutrients, or to control their agricultural use so that their application does not result in water pollution, can be quite difficult without new legislation.

We have very little doubt that similar situations occur in other Member States, even though it is our understanding that the failure in Ireland by competent authorities to communicate and interact with each other in order to recover nutrients which would otherwise be wasted, is a significant issue.

6. A Requirement to Include Land Use Planning and "Landscape" in an Integrated Nutrient Management Action Plan

A further point we wish to make in this submission is that all nutrient management issues should be addressed in an integrated land and water management framework which takes into account the way in which land is used and managed, how those land uses affect water quality and aquatic ecosystems, and how water (in every form) dominates and affects actual and potential land uses.

According to the Food and Agriculture Organisation of the United Nations (FAO), the ecosystems which provide the vital foundation for sustainable agriculture in productive landscapes are being degraded, their integrity disrupted at unprecedented rates, and the natural resource base of soils, water, land, and ecosystems upon which food production depends is under stress, degraded, or already significantly depleted.[41]

A paper published two years ago provides the following comment on the need for an integrated land-use strategic framework which, we would argue, must also include protection, management and conservation of plant nutrients and water resources:

[41] Landscapes for Life – Approaches to Landscape Management for Sustainable Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome, 2017.

> *"Sustainable land management is at the heart of some of the most intractable challenges facing humanity in the 21st century. It is critical for tackling biodiversity loss, land degradation, climate change and the decline of ecosystem services. It underpins food production, livelihoods, dietary health, social equity, climate change adaptation, and many other outcomes. However, interdependencies, trade-offs, time lags, and non-linear responses make it difficult to predict the combined effects of land management decisions. Policy decisions also have to be made in the context of conflicting interests, values and power dynamics of those living on the land and those affected by the consequences of land use decisions. This makes designing and coordinating effective land management policies and programmes highly challenging. The difficulty is exacerbated by the scarcity of reliable data on the impacts of land management on the environment …"* [42]

Landscape and territorial approaches that focus on people and their aspirations are among the most effective ways to address development needs while restoring and protecting natural resources. The rationale for applying integrated approaches at landscape scale is three-fold: landscapes offer a platform which is comprehensive in scope across sectors and domains, addressing issues at their appropriate scale, and thereby improving the likelihood of project success and sustainable outcomes.

The methodology used by the FAO is through watershed management, similar to river basin management, and is one of the more traditional and recognized approaches utilised throughout the world. This approach has a long history of addressing complex problems and providing solutions to support integration and collaboration across sectors, scales and actors, and to balance competing needs, so as to generate simultaneous benefits for people and environment. It follows the principles of common concern, multiple scales, multifunctionality and multi-stakeholders.

It is our submission that the Integrated Nutrient Management Action Plan should go further, and should include not only the management of nutrients and water resources, but should follow the principle of multifunctionality as described above.

The Plan should provide environmentally and socially sustainable management of a wide range of ecosystem services and goods, such as fresh water, timber, agricultural crops, other types of human and animal foods, fibres and useful plant species, together with protection and enhancement of terrestrial biodiversity,

[42] McGonigle D.F., Rota Nodari G., Phillips R.L., Aynekulu E., Estrada-Carmona N., Jones S.K., Koziell I., Luedeling E., Remans R., Shepherd K., Wiberg D., Whitney C., and Zhang W. (2020). A Knowledge Brokering Framework for Integrated Landscape Management. Front. Sustain. Food Syst. 4:13. doi: 10.3389/fsufs.2020.00013.

water storage, support for nutrient cycling, regulation of water flows, mitigation of climate change effects, and protection of air quality.

It is clear to us that such a multi-faceted approach will need far more integration of EU policies and actions; and also much improved inter-agency and inter-departmental cooperation than exists at present in many Member States including Ireland (and that is the reason why we provided the detailed example above). We suggest that there are no legal or administrative barriers to such integration, and many benefits – both environmental and socio-economic.

These benefits are derived from strengthening the interlinkages between biodiversity, ecosystem services, agriculture, fertiliser use, nutrient management, and water resource management through practices such as:

- forest restoration and sustainable forest management which will support air and water purification, carbon sequestration and storage;
- sustainably managed agricultural lands, forests and watercourses which will reduce risks and damage from floods, storms, bogslides (peat slides in Ireland) and increasingly serious droughts, particularly in southern European Member States;
- sustainable land management practices and properly managed permanent vegetation cover, which will promote nitrogen fixation processes and will strongly contribute to combating soil erosion and soil loss, maintaining soil health and fertility, and reducing the quantities of silt entering streams and rivers;
- sustainable livestock grazing, which will support balanced ecological mosaics, ecosystem diversity, nutrient cycling, and the dispersal of seeds, and will also support resilience, primary productivity, and protection from pests and diseases;
- integration of fisheries enhancement and maintenance, which will support good management of watercourses and water bodies, primary productivity in freshwater ecosystems, protection from waterborne pests and diseases, nutrient cycling and water purification; and,
- recovery and utilisation of dissolved phosphorus and nitrogen currently being discharged in wastewater.

An integrated land and water management framework would take into account the way in which land is used and managed, how those land uses affect water quality and aquatic ecosystems, and how water (in every form) dominates and affects actual and potential land uses:

> *"Sustainable land management is at the heart of some of the most intractable challenges facing humanity in the 21st century. It is critical*

for tackling biodiversity loss, land degradation, climate change and the decline of ecosystem services".[43]

The viewpoint which we are advocating is supported by the key messages from a relatively recent report by the European Environment Agency:[44]

- ✓ *Managing natural resources has historically focused on individual resources and value chain-based approaches. While these provide valuable insights, wider systems thinking is needed to address the complex interactions between different natural resources. For example, the links between food, energy and water resources point to the need for such a systems approach.*

- ✓ *The **resource nexus** concept fulfils this need, as it specifically looks at resource interlinkages. Applying it to policy interventions generates important information about synergies and trade-offs across several resource-related goals as a contribution to more effective management strategies.*

- ✓ *The findings of three case studies on organic farming, advanced biofuels and electric vehicles point to the usefulness of the approach for identifying knowledge gaps, imbalances in policy focus, potential "winners and losers", and as a basis for informed discussions.*

- ✓ *Resource nexus assessments add to the systemic understanding of sustainability challenges and responses. Combined with other tools and frameworks, e.g. foresight and governance approaches, they could effectively support the European Green Deal's ambitions of strengthening policy coherence and integration.*

The concept of the "resource nexus" was first introduced in resource management in 2011, to address key interdependencies among resources and their use, and it has since gained prominence in the international research community and among international organisations operating at the science-policy interface.

The Food and Agriculture Organization of the United Nations defines the resource nexus as a "*conceptual approach to better understand and systematically analyse the interactions between the natural environment and*

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[43] McGonigle D.F., Rota Nodari G., Phillips R.L., Aynekulu E., Estrada-Carmona N., Jones S.K., Koziell I., Luedeling E., Remans R., Shepherd K., Wiberg D., Whitney C., and Zhang W. (2020). A Knowledge Brokering Framework for Integrated Landscape Management. Front. Sustain. Food Syst. 4:13. doi: 10.3389/fsufs.2020.00013.

[44] Resource nexus and the European Green Deal, EEA Briefing Number 24-2021, published 17-Mar-2022.

human activities, and to work towards a more coordinated management and use of natural resources across sectors and scales".[45]

While early applications focused on exploring the interlinkages between water, energy and food, further developments embraced other natural resources, including land, materials, waste and ecosystems, and other dimensions such as climate and health. Collating these applications results in a complex web of direct and indirect interactions, which define the 'nexus' among the resources. Understanding this network of interactions provides important information, as a given intervention might have different effects across resources – positive or negative – depending on the way they interact. For example, demand for food can be met through various agricultural practices that may require different levels of land, energy, water, nutrients and other inputs, and the same is true for demands on other resources.

It is clear to see that in Ireland, the Member State with which we are most familiar, this concept has not been adopted or applied, despite what we would suggest is an urgent need for this type of systematic and integrative approach. However, in recent months there has been some indication of progressive thinking by An Fóram Uisce, an agency with no enforcement powers but with an innovative approach.[46]

7. CONCLUDING REMARKS

Past and present EU policies have proven to be inadequate for the management of the primary nutrients of nitrogen and phosphorus. Excessive fertiliser use is causing the accumulation of phosphorus in soils, in forms not directly available to crops and in ways that are harmful to the environment; while also causing nutrient run-off and eutrophication of water bodies.

The problems are well recognised, but control and management appear to be ineffective at the level of both the EU and Member States. In some regions, farmers continue to over-fertilise every year, even as phosphorus reserves are becoming more scarce and prices are rising.

[45] FAO, 2014, The water-energy-food nexus. A new approach in support of food security and sustainable agriculture, Food and Agriculture Organization of the United Nations, Rome, Italy.

[46] See, for example: "*A Framework for Integrated Land and Landscape Management, Protecting and Enhancing Our Environment",* An Fóram Uisce, March 2021; Submission the Department of Housing, Local Government and Heritage (DHLGH) in response to a Public Consultation on the River Basin Management Plan for Ireland, 2022-2027, An Fóram Uisce, 30 March 2022; and, "*An Assessment of Policy Coherence and Conflicts for Water and Environmental Management",* A Report to the Water Forum, April 2022. These reports are available on the website of An Fóram Uisce: https://thewaterforum.ie/publications/ Zero Waste Alliance is represented on An Fóram Uisce.

Addressing these multiple problems requires integrated solutions, supported by an effective and enforceable nutrient management action plan (INMAP). While this is envisaged in the Commission's documentation, it is our submission that the degree of integration is inadequate, and the issues addressed in the plan are too narrow, and do not sufficiently encompass the range of factors which determine the extent of the problems.

In our submission, we propose the adoption of an integrated land use and nutrient management policy and action plan, which must address environmentally and socially sustainable management of a wide range of ecosystem services and goods, such as fresh water; timber; agricultural crops; other types of human and animal foods; fibres and useful plant species; together with protection and enhancement of terrestrial biodiversity; water storage; support for the recovery, recycling, and re-use of nutrients; regulation of water flows, mitigation of climate change effects, and protection of air quality.

We suggest a "*landscape"* approach, and the adoption and application of the concept of the "*resource nexus",* as promoted by the Food and Agriculture Organization of the United Nations, and advocated by the European Environment Agency as part of the European Green Deal.

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This submission was researched and written by three members of Zero Waste Alliance Ireland: Jack Coffey (member and researcher, who contributed the major sections on the role of agriculture and nutrient recovery), Orla Coutin (researcher and membership secretary who contributed information on recovery of nutrients from urine), and Jack O'Sullivan (ZWAI founder member and Director), who added observations on the integration of resource management issues, policy analyses and edited the submission.

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