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Status of nutrient bookkeeping in the Baltic Sea countries

For our Environment

Landwirtschaftskammer Niedersachsen

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Status of nutrient bookkeeping in the Baltic Sea countries

by

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On behalf of the German Environment Agency

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Federal Ministry for the
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Building and Nuclear Safety

Vorwort

Die Ostsee bildet einen wertvollen und zentralen Teil unseres Naturerbes, den Deutschland mit acht weiteren Staaten teilt. Zur Bewahrung der Ostsee wurde 1974 die Helsinki-Konvention unterzeichnet. Damit wurde die Grundlage gelegt für die regional koordinierenden Arbeiten der Helsinki Kommission (HELCOM) zwischen den neun Ostsee-Anrainerstaaten und der Europäischen Union. Im Jahr 2007 wurde der Ostsee-Aktionsplan verabschiedet, ein weiteres grundlegendes HELCOM-Dokument mit dem Ziel, bis 2021 eine gesunde Ostsee zu erreichen.

Ein erheblicher Anteil an der ökologischen Belastung der Ostsee stammt aus diffusen Quellen an Land. Eine der Hauptursachen für Nährstoffeinträge in die Ostsee sind Nährstoffverluste der Landwirtschaft, insbesondere seit alle Anrainerstaaten beträchtliche Anstrengungen beim Neu- und Ausbau von Kläranlagen unternommen und die Einführung phosphatfreier Waschmittel in den nächsten Jahren verbindlich zugesagt haben.

Nährstoffeinträge verursachen Überdüngung, die so genannte Eutrophierung. Diese sorgt für Algenblüten, darunter auch giftige, für sauerstoffarme und sogar sauerstofffreie Zonen auf dem Meeresgrund. Das wiederum gefährdet die wirtschaftliche Grundlage für die Fischerei und den Tourismus.

Umweltbelastungen durch Nährstoffe werden dann minimiert, wenn Nährstoffe in der Landwirtschaft effizient eingesetzt werden. Düngemittel sollen die Erträge von Nutzpflanzen optimieren und nicht im Gewässer landen. Voraussetzung für einen effizienten Nährstoffeinsatz im landwirtschaftlichen Betrieb ist es, die Höhe und den Zeitpunkt notwendiger Düngung präzise zu ermitteln. Hierfür sind unter anderem Nährstoffgehalte und Nährstoffverfügbarkeiten der Böden zu ermitteln und Erträge vorherzusagen. Eine aussagekräftige Nährstoffbuchführung verschafft dem Landwirt einen Überblick und ist unverzichtbares Hilfsmittel sowohl für eine optimale Düngeplanung als auch für eine exakte Nährstoffbilanz.

Die Umweltministerinnen und -minister der HELCOM-Mitglieder beschlossen daher im Rahmen ihrer Konferenz vom Oktober 2013 in Kopenhagen, eine Nährstoffbuchführung in allen Vertragsstaaten bis Ende 2018 einzuführen. Plattform für diese Aktivität sollte die HELCOM Agri Group sein, eine Untergruppe der Helsinki-Kommission. Deutschland führt derzeit den Vorsitz in dieser Gruppe.

Nährstoffbuchführung in landwirtschaftlichen Betrieben setzt wissenschaftliche Grundlagen voraus, aber auch methodische Werkzeuge, die sich regional unterschiedlich herausgebildet haben und praktiziert werden. Es ist wichtig, dass die zuständigen Akteure aus den jeweiligen HELCOM-Vertragsstaaten einen methodischen Austausch pflegen und eine rege, offene und (selbst-)kritische Diskussion über ihr jeweiliges Vorgehen führen.

Um diesen Prozess voran zu bringen förderte das Umweltbundesamt ein Projekt der Landwirtschaftskammer Niedersachsens. In diesem Projekt wurde der Status der Nährstoffbuchführung in den HELCOM-Vertragsstaaten vorgestellt und diskutiert. Die Landwirtschaftskammer hat dazu Ende April 2015 in Oldenburg einen Workshop mit Fachleuten aus allen Ostsee-Anrainerstaaten vorbereitet und durchgeführt.

Dies ist die Dokumentation der Veranstaltung. Sie enthält alle Vorträge und versucht darüber hinaus, wesentliche Schritte für die kommenden zwei Jahre in den Mitgliedstaaten aufzuzeigen.

Die einzelnen HELCOM-Ebenen werden sich eingehend mit dem Bericht befassen. Die Agri Group steht darüber hinaus als Informationsplattform und auch als Netzwerk und Begleiter für den Umsetzungsprozess zur Verfügung. Allen Akteuren, die zu diesem Projekt beigetragen haben, den Referentinnen und Referenten, insbesondere aber den zuständigen Mitarbeiterinnen und Mitarbeitern der Landwirtschaftskammer Niedersachsen sei für ihren engagierten und kompetenten Einsatz ganz nachdrücklich

und herzlich gedankt! Mögen wir den Zielen des Ostsee-Aktionsplans ein Stück näher kommen, nämlich einer Ostsee ohne Eutrophierung, mit klarem Wasser, natürlichem Algenbewuchs, einer natürlichen Verteilung und Vorkommen von Pflanzen und Tieren sowie natürlichem Sauerstoff-Gehalt.

Wir wünschen Ihnen viel Freude bei der Lektüre.

Maria Krautzberger

Präsidentin des Umweltbundesamtes

Monika Stankiewicz

HELCOM-Generalsekretärin

Gerhard Schwetje

Präsident der Landwirtschaftskammer Niedersachsen

Preface

The Baltic Sea represents a valuable and central part of our natural heritage, which Germany shares with eight other countries. To safeguard the Baltic Sea environment, the Helsinki Convention was signed in 1974, providing the basis for the regional work of the Helsinki Commission (HELCOM) between the nine coastal countries and the European Union. In 2007 the Baltic Sea Action Plan, to achieve a healthy sea by 2021, was passed, another crucial HELCOM document.

The Baltic Sea is under considerable ecological pressure from nutrient input originating from land-based diffuse sources and nutrient losses caused by agricultural land use. Significance of the latter source is increasing especially as within the framework of HELCOM, all Contracting Parties have made considerable efforts to build and extend municipal wastewater treatment plants and have declared in a binding manner to introduce phosphate free laundry detergents during upcoming years. Nutrient inputs are responsible for causing eutrophication, toxic algae blooms, hypoxic and anoxic zones at the sea bottom and thus jeopardize the economic basis of both fishery and tourism.

The environmental burden from nutrient loads is reduced if nutrients in agriculture are applied in a more efficient manner. Fertilizers are meant to optimize crop yields and not to end up in ground and surface waters. Comprehensive nutrient bookkeeping provides a basic prerequisite (tool) for efficient nutrient use in agricultural holdings; this applies as well for fertilizer planning ex ante as for nutrient balancing ex post. Therefore in October 2013 the environment ministers of the HELCOM countries decided during their conference in Copenhagen to introduce nutrient bookkeeping on farm level in all Contracting Parties by the end of 2018. A platform for these activities should be provided by the HELCOM Group on Sustainable Agricultural Practices, a subsidiary body of HELCOM. Germany is currently holding the chairmanship of this group.

Nutrient bookkeeping in agricultural holdings is based on both scientific knowledge and methodological tools which in different regions have been developed and are applied in various ways. In the sense of a continuous improvement it should be useful to bring competent bodies from the HELCOM Contracting Parties together for an exchange of methodological views and an open and (self-)critical discussion about their procedures respectively. To assist this process the Federal Environment Agency sponsored a project performed by the Chamber for Agriculture of Lower Saxony during which the status of nutrient bookkeeping in the HELCOM countries was communicated and discussed. For this purpose the Chamber organized a workshop in Oldenburg, Germany in April 2015 with speakers and experts from all Baltic Sea countries. This report is a record of the event, produced by the Chamber. It contains all presentations and identifies relevant steps for upcoming years to be taken by and in the HELCOM countries.

Relevant HELCOM groups will take into account the findings of this report. Furthermore the HELCOM Agri Group is available as an information exchange platform and a network and partner during implementation. We wish to express our gratitude to all stakeholders contributing to this process, the speakers and above all the colleagues in charge of the project in the Chamber for Agriculture of Lower Saxony for their competent and profound effort. We hope we have come some steps closer to meet the objectives of the Baltic Sea Action Plan, i. e. a Baltic Sea unaffected by eutrophication, with clear water, natural algal growth, natural distribution of plants and animals as well as natural oxygen level.

In this sense, we hope for a good use of the report.

Maria Krautzberger

President of Federal Environment Agency

Monika Stankiewicz

HELCOM executive secretary

Gerhard Schwetje

President of the Chamber for Agriculture of Lower Saxony

Abstract

Nutrient emissions causing eutrophication are among the most urgent environmental problems of the Baltic Sea. According to the latest HELCOM report in 2014 the entire open Baltic Sea is affected by eutrophication. This leads to the conclusion that further measures are needed urgently to recover the good ecological status of the Baltic Sea. Since parts of diffuse nitrogen and phosphorus loads originate from agricultural areas, the HELCOM ministerial conference designed agri-environmental measures aiming at a reduction of nutrient losses from agriculture by improved nutrient management in 2013. For this purpose nutrient bookkeeping is a suitable approach to improve nutrient management on farms in terms of environmental impacts as well as in terms of efficiency. Therefore the HELCOM Agri-group aims to implement nutrient bookkeeping on farm level until 2018. A workshop was considered the most suitable way to create a common working basis, since various bookkeeping methods have been introduced already by the individual HELCOM member states. A further contribution of the workshop was the identification and evaluation of main issues for implementation of nutrient bookkeeping all over the Baltic Sea countries. All participants agreed that often the missing legal background is one of the main obstacles. The calculation methods for nutrient balances need to be harmonized to achieve comparable results. These are not only required, to enable the identification of hotspots with urgent need for improved nutrient management, but also to observe long term development of nutrient surpluses or shortages. Furthermore the availability of representative background data and standard values, especially concerning fodder production and nutrient contents of manure, has to be improved for this purpose. Additionally the intensification of rural extension services is considered necessary. The degree of required support to calculate nutrient balances depends on the actual experience level of the concerned parties.

Kurzbeschreibung

Eutrophierung als Folge von Nährstoffemissionen gehört zu den drängendsten Umweltproblemen der Ostsee. Der letzte HELCOM-Bericht aus 2014 zeigte, dass bereits die gesamte Hochsee eutrophiert ist. Daher sind weitere Maßnahmen dringend notwendig, um den guten ökologischen Status der Ostsee wiederherzustellen. Da große Teile der diffusen Stickstoff- und Phosphoreinträge aus der Landwirtschaft kommen, versucht die HELCOM-Ministerkonferenz bereits 2013 diese durch Agrarumweltmaßnahmen zur Verbesserung des Nährstoffmanagements zu reduzieren. Nährstoffbuchhaltung kann hierzu, sowohl im Sinne des Umweltschutzes, als auch im Zuge einer Erhöhung der Nährstoffeffizienz einen wichtigen Beitrag leisten. Das Ziel ist es deshalb bis 2018 Nährstoffbuchhaltung auf Betriebsebene flächendeckend in allen HELCOM-Mitgliedsstaaten einzuführen. In den einzelnen Ländern werden bereits verschiedene Methoden zur Nährstoffbuchhaltung eingesetzt. Deshalb wurden in Rahmen eines Workshops zunächst eine gemeinsame Basis geschaffen und gleichzeitig Lösungsansätze für noch vorhandene Schwierigkeiten bei der Umsetzung flächendeckender Nährstoffbuchhaltung diskutiert. Alle Teilnehmer waren sich einig, dass oft der fehlende gesetzliche Rahmen eine der Hauptschwierigkeiten darstellt. Darüber hinaus ist eine einheitliche Methode zur Berechnung von Nährstoffbilanzen notwendig um vergleichbare Ergebnisse zu erhalten. Diese sind nicht nur die Voraussetzung um auf regionaler Ebene dringenden Handlungsbedarf feststellen zu können, sondern auch um die längerfristige Entwicklung von Nährstoffüberschüssen beobachten zu können. Die Verfügbarkeit einheitlicher und repräsentativer Standardwerte, insbesondere bei innerbetrieblicher Futterproduktion muss hierfür ebenfalls verbessert werden. Zusätzlich muss sicherlich in vielen Fällen die landwirtschaftliche Beratung intensiviert werden, um die notwendige Unterstützung bei der

Berechnung von Nährstoffbilanzen bieten zu können. In welchem Ausmaß hier zusätzliche Hilfe notwendig ist, hängt jedoch sicherlich auch davon ab, inwieweit bereits Erfahrungen bei der Berechnung von Nährstoffbilanzen vorhanden sind.

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AES	Agri-Environmental-Scheme (Finland)
CBA	Cost-benefit analysis
EGS	Ecosystem Goods and Services
EU	European Union
ha	Hectare
HELCOM	Convention on the Protection of the Marine Environment of the Baltic Sea Area.
IAEP	Institute of Agroengineering and Environmental Problems of Agriculture, St. Peters-burg, Russia
JKI	Julius Kühn Institute (Germany)
K	Potassium
kg	Kilogram
MTK	Central union of agricultural producers and forest owners (Finland)
N	Nitrogen
NGO	Non-government organization
NVZ	Nitrate Vulnerable Zone
P	Phosphorus
TI	Thünen Institute
UBA	Federal environmental agency (Germany)
WFD	Water Framework directive

Summary

Nutrient emissions causing eutrophication are among the most urgent environmental problems of the Baltic Sea. The latest report of the Baltic Marine Environment Protection Commission (HELCOM) on the eutrophication status assessment of the Baltic Sea in 2014 yielded alarming results. According to this report the entire open Baltic Sea is affected by eutrophication, which leads to the conclusion that the measures that have been implemented so far have not been sufficient to promote the recovery of good ecological status of the Baltic Sea. Since 70-90 % of diffuse loads of nitrogen and 60-80 % of diffuse phosphorus loads are considered to originate from agricultural areas the HELCOM ministerial conference designed agri-environmental measures aiming at a reduction of nutrient losses from agriculture by improved nutrient management in 2013. Nutrient bookkeeping, accounting or balancing is a suitable approach to improve nutrient management strategies in terms of environmental impacts as well as in terms of increasing production levels of agriculture ensuring food security. Therefore various bookkeeping methods are already implemented in the individual Baltic Sea countries or regions. The workshop on the status of nutrient bookkeeping in the Baltic Sea countries intended to provide a common working basis all over the participating countries, especially in preparation of the future task of the HELCOM Agri-group, namely the scheduled implementation of nutrient bookkeeping on farm level in all HELCOM member nations. Besides, the workshop offered an excellent opportunity to exchange experiences and notions regarding water protection all over the various backgrounds of the participants. During the workshop progression different nutrient bookkeeping systems were illustrated by representatives of the respective countries.

Denmark has the most advanced system for nutrient bookkeeping in the Baltic Sea region as it combines fertilization planning and annual accounting of nutrients at the farm level. National regulations are in place. It is a state run system with farm registration, reporting, inspection, as well as standard values for nutrients in manure, crop demands and soil types. Fines are charged to farm operations exceeding nutrient application limits. Additionally, other economic tools such as tax free trade of fertilizers considering the application limits, are in use.

In **Estonia** there is no legal obligation for calculating nutrient balances. Registration of input of fertilizers as well as of yields is mandatory on field level. Holdings over 300 livestock units with liquid manure are obliged to prepare three year fertilization plans. Such plans are approved by the Environmental Board. The registration of fertilizer input is legally regulated, but there is no centralized database. Estonia has a negative phosphorus balance on the national level. Grassland yields are not monitored, which is one of the obstacles for nutrient balance calculations. Rural extension service needs to be enhanced to offer nutrient balance calculation support to farmers.

In the course of the implementation of the Nitrates Directive in **Finland** nutrient input and yield level must be documented in field books. The maximum, crop specific nitrogen application levels are also regulated. If the farmer participates in the agri-environmental scheme, more detailed documentation is needed and the allowed nitrogen levels are lower than in the Nitrates Directive. Besides nitrogen, also phosphorus levels are regulated. Farmers can use results of nutrient analysis or the standard values (new tables are available) for example for manure. According to the agri-environmental scheme farmers have to make also a cultivation plan every year. Nutrient balances are not mandatory. The advisory service has a key role to enhance nutrient balances

A national legal framework regulating mandatory calculation of surface balances on farm level in **Germany** is already in place. Planning is mandatory but there is no standardized documentation. Changes in the legal framework, which are expected in 2016, will introduce a mandatory farm gate balance by 2018, registration of manure exports from farms and lower nutrient surplus target values. For exceeding surplus targets a financial punishment will be introduced. Additionally a delineation of fertilizer

planning will be mandatory in the future. Furthermore the federal states of Germany will be empowered to introduce more restrictive legislation in endangered regions.

In **Latvia** there are neither strict requirements for farmers to calculate nutrient balances systematically nor for reporting, but elements of nutrient balancing are included in different regulatory systems. Farms over ten animal units (five in the nitrate vulnerable zone) are to record all livestock wastes and to keep the records for three years. The farmer can choose to use normative values or values based on laboratory tests on manure samples for manure composition calculations. Fertilization plans are obligatory for farms inside nitrate vulnerable zone if they operate on agricultural land lager than 20 hectares (field crops) or larger than 3 hectares (potatoes, vegetables, orchards) and they should also maintain the records of field history (for every field of farm) and keep them for at least three years. These farms should also keep the records about obtained mineral fertilizers and its chemical composition (at least NPK content).

Even though the whole Lithuanian territory is designated as a nitrate vulnerable zone, nutrient balance calculations are not obligatory in **Lithuania**. Some farmers have participated in projects but the interest towards voluntary nutrient calculation balances is low due to the many assumptions which need to be made. Fertilization plans are obligatory for farms applying organic fertilizers over 50 hectares of agricultural land while it is voluntary for other farms. New regulation from 2016 onwards is expected for farmers participating in the Rural Development Program for organic farming to calculate nutrient balance on farm level. New methodology is under preparation.

In **Poland** fertilization plans are obligatory for entities breeding poultry in the range over 40 000 places. Fertilization plans are also mandatory for farms breeding pigs in the range over 2 000 places for pigs weighing over 30 kg or 750 places of sows. Furthermore fertilization planning is compulsory for the buyers of natural fertilizers sold from the entities mentioned above as well as for farms in nitrogen vulnerable zones bigger than 100 hectares and for farmers in the agri-environmental schemes via cross-compliance. Changes to the Polish total area of nitrate vulnerable zones are considered. The implementation of the plan is the matter of environmental inspection agents. There have been good results through recent public promotion campaigns on nutrient management coordinated by the Polish Ministry of Agriculture and Rural Development. Moreover, economic drivers are important for the farmers as they try to reduce expenses for mineral fertilization which is quite costly in Poland (55 % of the total number of Polish farms are small farms – between 1-5 hectares). Poland has launched several new agri-environmental measures under the second pillar, which contributes directly to the reduction of nitrogen and phosphorus.

Nutrient accounting is mainly used by the state authorities for the purposes of soil protection in **Russia**. Field balances are used by the regional authorities for assessment of nutrient application and to evaluate the correlation of agricultural land and manure produced by animal farms. Within a project, gate balances were calculated for model animal farms based on statistical data and nutrient surpluses were estimated between 40-60 kg nitrogen and 10-20 kg phosphorus. Application of manure by the large industrial farms is a subject of state environmental surveillance.

Nutrient accounting based on farm gate nutrient balance is voluntary for farmers in **Sweden** but can be made mandatory if it is part of environmental permits. In the nitrate vulnerable zones the development of fertilization plans is obligatory for nitrogen fertilization. The major obstacle for nutrient accounting is uncertainty of standard values used as input parameters. National ordinance regulates the annual rate of manure application, its storage, application period etc. In the whole country mandatory phosphorus balance between amount of animals and agricultural land area should be calculated for farms with more than ten animal units. The limit is 22 kg phosphorus per hectare and per year in average for the whole available spreading area.

Based on the presented status of nutrient bookkeeping systems in the individual countries and the following discussions several circumstances could be identified as main obstacles for the implementation of nutrient bookkeeping in the Baltic Sea region.

One of the main issues implementing a comprehensive nutrient bookkeeping system in the Baltic Sea region is the insufficient legal background, if voluntary bookkeeping is restricted because of different reasons or circumstances. Nevertheless, changes of the legal background have to be considered as a long term approach. Thus the urgent need to reduce nutrient imissions into the Baltic Sea as soon as possible and distinctly has to be coped with implementing additional measures. Promotion and support of voluntary nutrient accounting can increase the implementation in agricultural practice, if lack of knowledge and unawareness of the benefits are the reasons why nutrient accounting has been renounced so far. This could be achieved with help of intensified rural extension services and stronger focus on nutrient accounting in advisory services.

Another problem the representatives of the Baltic Sea countries highlighted was the availability of reliable data to calculate nutrient balances, even though it was generally confirmed that a sound database plays a major role in the implementation of nutrient bookkeeping in agricultural practice. Nonetheless missing or inaccurate data is often hindering successful evaluation of nutrient surpluses. Apart from affecting the applicability of the results, implausible results due to an inaccurate data background decrease the readiness of farmers to use nutrient balances to improve their nutrient management. Especially estimating nutrient fluxes in fodder production, such as grasslands or pastures, provides difficulties whereas precise nutrient contents and yields of cash crops are generally known by the farmers if standard values do not correspond with farm specific conditions. In livestock production there are still uncertainties regarding the manure excretion and nutrient contents of organic fertilizer. For once the high diversity of livestock production in terms of animal housing and feeding strategies implies enormous efforts to develop applicable standard values. This issue is aggravated by the difficult assessment of representative samples in order to use farm specific data instead of standard values. Nevertheless the task to harmonize standard values could be accomplished within the next few years by focused research even though a high level of preliminary work to elaborate precise research questions is required in advance.

In view of nutrient balances as agri-environmental indicators, the great variation within the applied methodologies assessing nutrient surpluses reduces the applicability of results obtained by these methods. First of all the results of different countries, regions, or even institutions can hardly be compared. Also, even in single cases, the identification of urgent needs for reduction of nutrient surpluses is made difficult through lacking reliability of collected data. Methodological changes in order to improve applied calculations moreover make it complicated to judge on long term developments or to specify target values.

The issue of varying methods of nutrient balancing, applied by different institutions is exemplary for another issue that was identified in the course of the workshop: An urgent need to improve the cooperation between the involved authorities, institutions or professional associations. This might partly be caused by a lack of awareness, concerning the connections between farming practices and environmental problems, especially with respect to marine eutrophication as a consequence of inefficient or excessive nutrient fertilization. In spite of different methods to calculate nutrient balances, monitoring concepts to detect high nutrient surpluses on regional level or on farm level could be implemented in the short term without the claim to assess comparable results for entire countries or to show long term trends.

Zusammenfassung

Eutrophierung als Folge von Nährstoffemissionen gehört zu den drängendsten Umweltproblemen der Ostsee. Der jüngste Bericht der „Baltic Marine Envirionment Protection Commission“ (HELCOM), über die Untersuchungen zum ökologischen Status der Ostsee, bezüglich der Eutrophierung veröffentlicht aktuelle und alarmierende Ergebnisse, die zeigen, dass bereits die gesamte Hochsee eutrophiert ist. Es wird deutlich, dass die bereits eingesetzten Maßnahmen bisher nicht ausreichten einen guten ökologischen Status der Ostsee wiederherzustellen. 2013 wurde von der HELCOM Minister-Konferenz die Einführung von Agrar-Umweltmaßnahmen beschlossen, um Nährstoffeinträge aus der Landwirtschaft durch verbessertes Nährstoffmanagement zu reduzieren. Vor allem große Teile der diffusen Stickstoff- und Phosphoreiträge stammen aus der Landwirtschaft. Der Anteil des Stickstoffs aus der Landwirtschaft an den diffusen N-Einträgen wird auf 70-90 % geschätzt, während der Anteil des Phosphors aus der Landwirtschaft an den diffusen Phosphoreinträgen bei ca. 60-80 % liegt. Nährstoffbuchhaltung und –bilanzierung bieten die Möglichkeit das Nährstoffmanagement sowohl in Bezug auf die Reduzierung der Umweltbelastung durch Nährstoffausträge zu verbessern, als auch den hohen quantitativen und qualitativen Anforderungen an die Lebensmittelproduktion im Zuge der Ernährungssicherung Rechnung zu tragen. Deshalb werden in mehreren Ostseeanrainerstaaten oder einzelnen Regionen bereits verschiedene Methoden der Nährstoffbuchhaltung oder –bilanzierung eingesetzt.

Ziel des Workshops zur Erfassung des Status quo der Nährstoffbuchhaltung war es, einen gemeinsamen Kenntnisstand als Ausgangsbasis für die teilnehmenden Länder zu schaffen. Dieser Schritt war im Hinblick auf das Ziel der HELCOM Agri-Group, Nährstoffbuchhaltung auf Betriebsebene flächendeckend einzuführen, von entscheidender Bedeutung. Darüber hinaus bot der Workshop eine ausgezeichnete Gelegenheit zum Erfahrungsaustausch in verschiedenen Bereichen des Wasserschutzes. Im Verlauf des Workshops stellten Vertreter beteiligter Behörden und Organisationen den Stand der Nährstoffbuchhaltung in den einzelnen HELCOM-Mitgliedsstaaten vor.

In **Dänemark** kommen derzeit die weitreichendsten Regulierungen zur Nährstoffbuchhaltung in den baltischen Staaten zum Einsatz. Die geltenden gesetzlichen Regelungen schreiben sowohl Düngeplanung als auch Buchführung zum Düngereinsatz auf Betriebsebene vor. Für die meisten Landwirte ist eine Registrierung vorgeschrieben, um ein sogenanntes Nährstoffkonto zu erhalten. An- und Verkäufe von Wirtschaftsdüngern müssen gemeldet werden. Für die Berechnung der Nährstoffbilanzen stehen Standardwerte zur Verfügung, die eine Kontrolle der gemeldeten Daten durch Plausibilitätsabgleich ermöglichen. Die detaillierten Standardwerte erlauben es dennoch weitestgehend betriebsspezifische Gegebenheiten, wie beispielsweise Bodeneigenschaften, den kulturspezifischen Nährstoffbedarf oder Nährstoffgehalte der anfallenden Wirtschaftsdünger zu berücksichtigen. Bei Überschreiten der zulässigen Düngungsobergrenzen müssen Bußgelder bezahlt werden. Zusätzlich werden für kleinere Betriebe weitere Anreize für die freiwillige Führung eines Nährstoffkontos, wie beispielsweise Steuervergünstigungen beim Mineraldüngerzukauf, geschaffen.

In **Estland** gibt es keine gesetzliche Verpflichtung zur Berechnung von Nährstoffbilanzen. Die feldspezifische Nährstoffzufuhr (Dünger) und der Nährstoffentzug durch Erträge müssen jedoch erfasst werden. Betriebe mit mehr als 300 Großvieheinheiten müssen einen Düngeplan für einen Zeitraum von drei Jahren erstellen. Die Düngepläne sind mit der Umweltbehörde abgestimmt. Die Registrierung von Nährstoffzufuhr durch Dünger ist zwar gesetzlich vorgeschrieben, es gibt jedoch keine zentrale Datenbank für die erhobenen Daten. Auf Landesebene hat Estland eine negative Phosphorbilanz. Grünlanderträge werden jedoch nicht erfasst. Dies ist zugleich eines der Hauptprobleme bei der Berechnung von Nährstoffbilanzen. In Bezug auf die Datengrundlage müsste die landwirtschaftliche Beratung verbessert werden, um die Landwirte bei der Berechnung von Nährstoffbilanzen stärker zu unterstützen.

In **Finnland** werden, im Zuge der Umsetzung der Wasserrahmenrichtlinie, Nährstoffzufuhr und das Ertragsniveau flächenspezifisch dokumentiert. Die kulturspezifische Höchstmenge für die Nährstoffzufuhr ist gesetzlich vorgegeben. Landwirte, die am Agrar-Umweltprogramm teilnehmen, müssen Nährstoffzufuhr und –abfuhr genauer dokumentieren und die zulässigen Höchstmengen für Düngung sind geringer. Es steht den Landwirten frei, ob Richtwerte oder eigene Analyseergebnisse verwendet werden. Aktuelle Standardwerte liegen jedoch vor. Die Richtwerte für Nährstoffgehalte von Wirtschaftsdüngern wurden beispielsweise kürzlich aktualisiert. Im Rahmen des Agrar-Umweltprogramms müssen die Landwirte zwar einen Anbauplan erstellen, die Berechnung von Nährstoffbilanzen ist jedoch nicht vorgeschrieben. Der Beratung kommt hier eine besondere Bedeutung zu, um Nährstoffbilanzierung besser in der Praxis zu etablieren.

Auch in **Deutschland** gibt es bereits gesetzliche Vorgaben, die die Erstellung von Nährstoffbilanzen auf Betriebsebene vorschreiben. Düngeplanung ist zwar gefordert, es gibt jedoch keine Vorgaben, in welcher Form die Düngeplanung durchgeführt oder dokumentiert werden muss. Im Rahmen der neuen Düngeverordnung, die voraussichtlich 2016 in Kraft treten wird, könnte eine Verpflichtung zur Berechnung von Hoftorbilanzen ab 2018 eingeführt werden. Hinzu kommt eine Meldepflicht für die Abgabe von Wirtschaftsdüngern und eine Reduzierung der Obergrenzen für Überschüsse bei Nährstoffbilanzen. Eine Überschreitung der Nährstoffbilanzen könnte dann zukünftig ein Bußgeld zur Folge haben. Zusätzlich wird eine verpflichtende Düngebedarfsermittlung eingeführt und die einzelnen Bundesländer werden bevollmächtigt die gesetzlichen Regelungen in bestimmten Gebietskulissen zu verschärfen.

In **Lettland** ist derzeit weder die Berechnung von Nährstoffbilanzen vorgeschrieben, noch gibt es eine Meldepflicht für Nährstoffzufuhr. Einzelne Elemente der Nährstoffbilanzierung werden aber bereits im Rahmen bestimmter Regulierungen verwendet. Landwirtschaftliche Betriebe mit mehr als zehn Großvieheinheiten (bzw. fünf Großvieheinheiten in auswaschungsgefährdeten Gebieten) müssen den Nährstoffanfall aus der Tierhaltung dokumentieren und Nachweise drei Jahre aufbewahren. Die Landwirte können hierfür Standardwerte oder Ergebnisse eigener Wirtschaftsdüngeranalysen verwenden. In auswaschungsgefährdeten Gebieten ist Düngeplanung für den Landwirt verpflichtend, wenn die bewirtschaftete Fläche größer als 20 ha ist. Für Obstbau, Kartoffel- oder Gemüseanbau gilt dies bereits bei einer Fläche größer als drei Hektar. Schlagspezifische Aufzeichnungen zur Bewirtschaftung sollten ebenfalls für mindestens drei Jahre aufbewahrt werden. In auswaschungsgefährdeten Gebieten müssen außerdem Nachweise zum Nährstoffgehalt von Mineraldünger aufbewahrt werden.

Die gesamte Fläche **Litauens** wurde zwar als auswaschungsgefährdetes Gebiet einegstuft, die Berechnung von Nährstoffbilanzen ist jedoch nicht vorgeschrieben. Einige Landwirte haben zwar bereits im Rahmen von Projekten Nährstoffbilanzen berechnet, das Interesse daran ist jedoch relativ gering, da die Berechnungen aufgrund der Datengrundlage häufig ungenau sind. Die mangelhafte Datengrundlage hatte zur Folge, dass sich die Ergebnisse nur schwer beurteilen ließen. Für Landwirte, die Wirtschaftsdünger auf über 50 ha ausbringen ist eine Düngeplanung vorgeschrieben, während alle anderen Landwirte Düngeplanung auf freiwilliger Basis durchführen können. Als Folge von Gesetzesänderungen werden Landwirte die am Entwicklungsprogramm für ländliche Räume und Bio-Landwirte ab 2016 verpflichtet auf Betriebsebene Nährstoffbilanzen zu berechnen. Neue Berechnungsmethoden werden derzeit erarbeitet.

In **Polen** ist Düngeplanung für bestimmte Betriebe vorgeschrieben. Dazu gehören landwirtschaftliche Betriebe mit mehr als 40000 Tieren Zuchtgeflügel, Betriebe mit mehr als 2000 Schweinen über 30 kg und Betriebe mit mehr als 750 Sauen. Düngeplanung ist außerdem für alle Betriebe, die Wirtschaftsdünger von den oben genannten Betrieben kaufen oder aufnehmen, vorgeschrieben. In auswaschungsgefährdeten Gebieten muss auf landwirtschaftlichen Betrieben über 100 ha ebenfalls ein Düngeplan erstellt werden. Im Rahmen des Agrar-Umweltprogramms und von Cross-Compliance ist Düngeplanung ebenfalls vorgeschrieben. Die Klassifizierung der auswaschungsgefährdeten Gebiete wird

gerade überarbeitet. Prüfer der Umweltbehörden kontrollieren, ob die Vorgaben eingehalten werden. Die bisherigen Ergebnisse waren sehr zufriedenstellend, vor allem da die Beteiligung durch mehrere Kampagnen des polnischen Ministeriums für Landwirtschaft und ländliche Räume gefördert wurde. Die meisten Landwirte versuchen allein schon aus Kostengründen Wirtschaftsdünger effizienter einzusetzen, da sie so die Kosten für Mineraldüngerzukauf reduzieren können. Dieser ist in Polen relativ teuer. Hinzu kommt, dass viele der Landwirte lediglich eine Fläche zwischen einem und fünf Hektar bewirtschaften. Polen hat mehrere neue Agrar-Umweltmaßnahmen unter der zweiten Säule gestartet, die direkt zur Minderung von Stickstoff und Phosphor beitragen.

In **Russland** wird Nährstoffbilanzierung bisher hauptsächlich von den staatlichen Behörden, mit dem Ziel die Bodenfruchtbarkeit zu erhöhen, eingesetzt. Flächenbezogene Bilanzen werden von den jeweiligen Behörden berechnet um flächenspezifischen Nährstoffeinsatz, verfügbare Fläche und Nährstoffanfall aus der Tierhaltung zu erfassen. Basierend auf der statistischen Auswertung dieser Daten wurden, im Rahmen eines Projektes, Hoftorbilanzen für tierhaltende Modellbetriebe erstellt. Die Ergebnisse zeigten Stickstoffüberschüsse zwischen 40 und 60 kg N/ha und Phosphorüberschüsse zwischen 10 und 20 kg P/ha. Die Ausbringung von Wirtschaftsdüngern großer Betriebe wird durch die staatliche Umweltüberwachung überprüft.

Nährstoffbuchhaltung, basierend auf Hoftorbilanzen ist in **Schweden** nicht verpflichtend für Landwirte**,** kann jedoch Teil bestimmter Umweltauflagen sein. In auswaschungsgefährdeten Gebieten muss darüber hinaus zur N-Düngung ein Düngeplan erstellt werden. Die größten Schwierigkeiten korrekte Nährstoffbilanzen zu erstellen, liegen in diesen Fällen in der Ungenauigkeit der Standardwerte und somit in der Erfassung der Input-Parameter. Eine Verordnung regelt die jährliche Wirtschaftsdüngerausbringung, den verfügbaren Lagerraum, Ausbringungszeiten und weitere Rahmenbedingungen. Landesweit müssen auf Betrieben mit mehr als zehn Großvieheinheiten P-Bilanzen erstellt werden, die sowohl Tierzahlen, als auch verfügbare Fläche berücksichtigen. Die Obergrenze für Phosphordüngung liegt bei 22 kg P/ha und wird für die zur Verfügung stehende Fläche gemittelt.

Anhand der Vorträge und der sich anschließenden Diskussionen, konnten einige Faktoren, als Hauptschwierigkeiten bei der flächendeckenden Einführung von Nährstoffbuchhaltung bestimmt werden.

Eine der Hauptschwierigkeiten Nährstoffbilanzierung flächendeckend einzuführen, liegt in den unzureichenden gesetzlichen Rahmenbedingungen. Dies wirkt sich besonders gravierend aus, wenn freiwillige Nährstoffbilanzierung aus verschiedenen Gründen nicht umgesetzt werden kann. Änderungen der gesetzlichen Rahmenbedingung müssen jedoch langfristig vorbereitet und geplant werden und können somit dem dringenden Handlungsbedarf bezüglich der Nährstoffeinträge in die Ostsee nur unzureichend gerecht werden. Daher sind weitere Maßnahmen zur Verminderung der Nährstoffemissionen aus der Landwirtschaft dringend erforderlich. Förderung der freiwilligen Berechnung von Nährstoffbilanzen und Unterstützung bei der Anwendung können die Umsetzung ebenfalls deutlich verbessern. Dies trifft vor allem bei mangelndem Bewusstsein für die Problematik zu, aber auch, wenn mangelnde Kenntnis der Berechnungsmethode der Grund dafür ist, dass bisher keine Nährstoffbilanzen erstellt wurden. Verstärkte Beratung bei der Auswertung der Ergebnisse, auch bezüglich wirtschaftlicher Vorteile, beispielswese durch effizientere Wirtschaftsdüngernutzung, kann die Bereitschaft zur Berechnung von Nährstoffbilanzen erhöhen. Die verstärkte Umsetzung und Schulung in der landwirtschaftlichen Beratung ist somit von entscheidender Bedeutung.

Ein weiteres Problem ist die häufig schlechte Verfügbarkeit, der als Berechnungsgrundlage von Nährstoffbilanzen benötigten Daten. Dies ist häufig der Fall, obwohl bereits allgemein anerkannt wurde, dass repräsentative Daten für aussagekräftige Nährstoffbilanzierung und die Umsetzung von entscheidender Bedeutung sind. Dennoch wird die Ermittlung, insbesondere von Nährstoffüberschüssen, häufig durch fehlende oder ungenaue Ausgangsdaten erschwert. Eine unzureichende Datengrundlage bei der Berechnung erschwert aber nicht nur die Bewertung der Ergebnisse im Sinne des Umweltschutzes,

sie wirkt sich zusätzlich negativ auf die Bereitschaft der Landwirte aus Nährstoffbilanzen auf freiwilliger Basis zu berechnen, da die Ergebnisse kaum zur Verbesserung des betriebsspezifischen Nährstoffmanagement verwendet werden können. Besonders problematisch ist die Ertragsermittlung bei innerbetrieblicher Verwertung, zur Futterproduktion, wie beispielsweise Grünlandaufwuchs oder Weideflächen. Bei Marktfrüchten hingegen sind Ertrag und auch Nährstoffgehalte in der Regel den Landwirten bekannt, so dass auf betriebsspezifische Werte zurückgegriffen werden kann, sollten keine Standardwerte vorliegen. In der Tierhaltung erschwert die hohe Bandbreite verschiedener Tierhaltungs- und auch Fütterungssysteme die Ermittlung des genauen Nährstoffanfalls aus der Tierhaltung, der Nährstoffgehalte von Wirtschaftsdüngern und die Verwendung von Standardwerten. Abgestimmte Forschungsvorhaben könnten jedoch einen wertvollen Beitrag leisten in den nächsten Jahren repräsentative Standardwerte zur Verfügung zu stellen. Dies setzt jedoch im Vorfeld eine detaillierte Absprache und intensive Zusammenarbeit aller Beteiligten voraus, um präzise Versuchsfragen formulieren zu können.

Bei der Verwendung von Nährstoffsalden als Umweltindikator stößt man, insbesondere bei großflächiger Auswertung der Ergebnisse auf unterschiedliche Berechnungsmethoden. Unterschiede zwischen den angewendeten Berechnungsverfahren verringern jedoch den Nutzen von Nährstoffbilanzen als Umweltindikator für nachhaltige Landwirtschaft, da hierdurch die Vergleichbarkeit der Ergebnisse in verschiedenen Regionen oder von verschiedene Institutionen stark eingeschränkt wird. Durch beständige Weiterentwicklung der Berechnungsgrundlagen wird die Methodik zwar verbessert, es ist jedoch deutlich schwerer, beispielsweise die Entwicklung des Nährstoffmanagements auf regionaler oder auch auf Betriebsebene zu verfolgen. Da bei Änderungen des Berechnungsverfahrens häufig auch Zielwerte angepasste werden müssen, wird die Vergleichbarkeit oder die Erfassung von Langzeiteffekten zusätzlich verkompliziert.

Das Problem, dass häufig sogar in der gleichen Region verschiedene Institutionen unterschiedliche Berechnungsmethoden verwenden, steht beispielhaft für eine weitere große Herausforderung bei der flächendeckenden Einführung der Nährstoffbilanzierung, die im Laufe des Workshops erarbeitet wurde: Die Zusammenarbeit der beteiligten Institutionen, Organisationen und Behörden kann noch deutlich intensiviert werden, vor allem, wenn die unzureichende Zusammenarbeit bisher eine Folge mangelnder Kenntnis der Zusammenhänge, wie in diesem Fall zwischen effizienter Nährstoffnutzung in der Landwirtschaft und mariner Eutrophierung war.

Trotz der beschriebenen Schwierigkeiten, wie ungenaue Standardwerte, oder unterschiedlichen Berechnungsmethoden, könnten die jeweiligen Formen der Nährstoffbilanzierung kurzfristig bereits verwendet werden, um ohne Anspruch auf vergleichbare Ergebnisse oder die Evaluierung von Langzeittrends, dringenden Handlungsbedarf zu erkennen und bei der Weiterentwicklung von Maßnahmen besser berücksichtigen zu können.

1 Introduction

Why is nutrient bookkeeping of importance to protect the marine environment of the Baltic Sea from pollution?

Increasing nutrient efficiency plays a key role in the reduction of nutrient emissions from agriculture and for an enhancement of agricultural systems sustainability.

The HELCOM (further information about the organization is provided in the following chapter) report of 2014 on the Eutrophication status of the Baltic Sea (2007 to 2011) came to the conclusion, that the entire open Baltic Sea was affected by eutrophication within the assessed period. These results show clearly that the countermeasures which had been conducted previously and during this period were not sufficient to reduce nitrogen and phosphorus imissions as much as it would have been necessary. The HELCOM report thus deduces that further measures need to be implemented urgently. Even more so, because many interacting processes such as phosphorus release from anoxic sediments or prevalence of blooms of nitrogen-fixing cyanobacteria will slow down the recovery of the ecosystems from their eutrophic state. The results clearly show the serious demand for efficient interdisciplinary and international cooperation to develop and implement such measures and achieve the goal of a good ecological status all over the Baltic Sea.

Sustainable agricultural production with minimized nutrient losses is one of the main keys to reduce eutrophication and thus towards a healthier Baltic Sea. Improving efficiency in nutrient management on farms enables a reduction of the agricultural impact on other ecosystems on the one side and implicates economic benefits for the farmer at the same time. At the HELCOM Ministerial meeting in 2013 the Baltic Sea countries agreed to promote and advance annual nutrient accounting on farm level at the latest in 2018.

1.1 HELCOM

HELCOM is the Baltic Marine Environment Protection Commission and an intergovernmental organization consisting of the nine Baltic Sea coastal countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland Russia and Sweden) and the European Union. The organization is working to protect the marine environment of the Baltic Sea from all sources of pollution and to ensure safety of navigation in the region. Figure 1 shows the area covered by the Baltic Marine Environment Protection Commission. The marine area covers 415 000 km². The catchment area of 1.72 million km² is approximately four times the size of the marine area. Since 1974, HELCOM has been the governing body of the “Convention on the Protection of the Marine Environment of the Baltic Sea Area”, more commonly known as the Helsinki Convention. Helcom was founded in 1974.

Figure 1: Map of the HElCOM area; by HELCOM 2009

1.1.1 HELCOM Agri-group

HELCOM is arranged in several groups that focus on different threats for the marine envi-ronment of the Baltic Sea. The Agri-Group works on reducing nutrient imissions from agriculture into the Baltic Sea. The main nutrient imissions from agriculture into the Baltic Sea originate from diffuse sources, and therefore are complicated to assess and even more difficult to reduce. Germany has taken the lead together with Denmark to coordinate work towards fulfilling the ministerial commitment and the HEL-COM Agri group welcomed the offer by Germany to organize a workshop as a first step for stocktaking of the on-going activities related to the nutrient accounting at farm level in the Baltic Sea countries.

Figure 2 and Figure 3 show the nutrient load to the Baltic Sea. 70-90 % of diffuse load of nitrogen are considered to come from agriculture and 60-80 % of diffuse phosphorus loads come from agricultural sources.

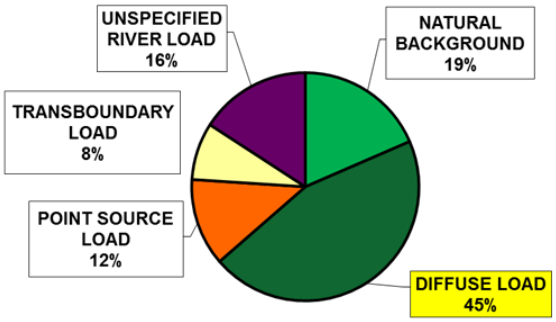


Figure 2: Nutrient load to the Baltic Sea; total nitrogen by HELCOM

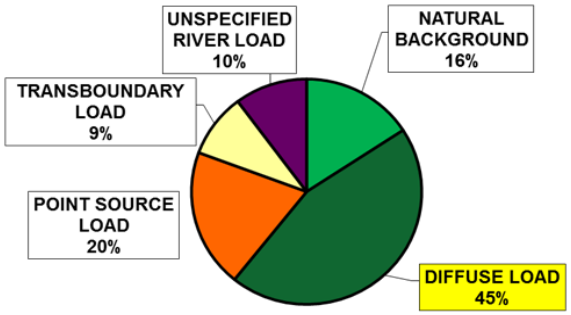


Figure 3. Nutrient load to the Baltic Sea; total phosphorus by HEL-COM

Implementation of annual nutrient bookkeeping on farm level in the Baltic Sea countries can contrib-ute considerably to reduce nutrient losses from agricultural areas and identify needs for action improv-ing nutrient management. Comparable results can only be achieved using a consistent method all over the Baltic Sea region.

In 2013 agri-environmental measures were drawn up by the HELCOM Ministerial to reduce nutrient losses from agriculture by improved nutrient management. National measures are to reduce nutrient surpluses and fertilization practices are to be enhanced to reach nutrient balanced fertilization. Im-proved fertilization practices are to be established to increase nutrient efficiency of manure. Further-more nutrient bookkeeping on farm level should be established in the Baltic Sea countries until 2018.

1.2 Nutrient bookkeeping

Sustainable nutrient management is an urgent task for agriculture in general. It is of vital importance to avoid environmental impact of agriculture to other ecosystems such as eutrophication due to nutri-ent losses. On the other hand efficient nutrient use in agriculture is essential to secure food security, in terms of quality as well as in terms of quantity.

Nutrient balancing can be one of the best suited measures, not only to assess the efficiency of nutrient application in agriculture, but also to produce comparable results and to identify needs for further environment protection measures.

Nutrient bookkeeping can also include fertilization planning, calculation of nutrient balances and thus forward regional or even farm specific approaches to avoid nutrient losses. Especially the efficient ap-plication of manure contributes considerably to reduce nutrient emissions from agriculture. Efficient methods of nutrient bookkeeping on farm level should also consider farm and site specific conditions,

such as nutrient content in the soil or climatic conditions as these for example have a considerable influence on the nutrient availability from manure.

1.3 Why did we need a workshop?

The workshop on the status of nutrient bookkeeping in the Baltic Sea countries took place 28th and 29th April 2015 in Oldenburg (Germany). The intention of the workshop was to improve nutrient bookkeeping methods and first of all to find a common working-basis all over the Baltic Sea region. Furthermore the workshop provided an excellent opportunity to exchange experiences and notions of water protection across the various backgrounds of the participants. Therefore the workshop aimed to assess the current status of nutrient bookkeeping in the Baltic Sea countries. Since methods and incentives in nutrient bookkeeping in the Baltic Sea countries hitherto have differed greatly, the assessment of the status of nutrient bookkeeping is a vital step towards the implementation of efficient nutrient bookkeeping on farm level in the Baltic Sea countries.

In preparation of the second Agri-group meeting which took place 27-29 May 2015 the workshop ensured a common knowledge base of all participants. Furthermore positive examples of already existing regulations for nutrient bookkeeping were provided for all members.

Regarding the aims of the workshop, the following key questions had been specified beforehand:

1. What is the status of nutrient bookkeeping in the HELCOM-member-countries?
2. Which are the main obstacles for promotion of nutrient bookkeeping?
3. What are country specific requirements to introduce nutrient bookkeeping on farm level?
4. Which steps will the countries be able to take within the next two years?

2 Status of nutrient bookkeeping in the Baltic Sea countries

The main part of this report aims to give an impression of the status of nutrient bookkeeping in the individual Baltic Sea countries and to show which further measures are taken to prevent nutrient losses from agriculture and thus nutrient imissions into the Baltic Sea. Thus the following chapters give an overview on the current status of nutrient bookkeeping in the respective countries.

A common legal background for the Baltic Sea countries joined in the European Union for environmentally friendly nutrient management in agriculture is provided by several directives, such as the “Water Framework Directive or the “Nitrates directive”. However, strict compliance to all requirements is not always sufficient to achieve the demands for the condition of the Baltic Sea defined by HELCOM.

Still the current status of nutrient bookkeeping and the methods of implementation differs greatly within the Baltic Sea countries. For this reason the structure of the single chapters varies, to provide for the individual circumstances, yielding descriptions of country specific regulations and methods.

2.1 Denmark

The status of nutrient bookkeeping in Denmark was presented by Mr. Anders Nemming and Mr. Rune Ventzel Hansen from the Ministry of Food, Agriculture and Fisheries of Denmark.

2.1.1 Background information

In Denmark 2.6 million hectares off the national territory are agricultural land. 6 % of the agricultural area is used as permanent grassland. The Danish national territory in total includes 4.6 million hectares. Altogether there are 43 000 agricultural holdings, including 24 000 livestock holdings.

2.1.2 Legal background

Fertilizer accounts and fertilization plans were initially implemented by the “Act on agriculture use of fertilizers and plant cover” in 1992. It still regulates the agricultural use of fertilizers and defines the legal requirements for plant cover and other crop related measures to reduce nitrogen leaching. Besides it determines if farmers have to register and keep a nutrient account. Framers have to register if they their farm has an annual turnover of more than 50,000 Danish kroner, which corresponds with 6,600 € relating to agricultural activity. Farmers also have to keep a nutrient account if they hold more than ten livestock units or more than one livestock unit per hectare. Another condition that obliges the farmer to keep a nutrient account is the reception of more than 25 tons of livestock manure.

Furthermore all registered farmers have to prepare a fertilizer plan. This plan has to be stored for five years at least. In addition all registered farmers are required to calculate the nitrogen-quota for their farm and to submit a fertilizer account. Farmers, who are recorded in the register for fertilizer accounts, can buy mineral fertilizer tax-free. Otherwise the tax on mineral fertilizer comes to 0.66 € per kilo of nitrogen. This is the reason why farmers who are not obliged to register for a fertilizer account, enter the register voluntarily. To keep a fertilizer account voluntarily is possible for farmers with an annual turnover between 20,000 Danish kroner and 50,000 Danish kroner.

2.1.3 Fertilizer plans and Fertilizer accounts

Fertilizer-plans have to be prepared before the start of the growing season. They contain a farm-specific field map and detailed information such as the size of the single fields, soil type, previous crops and planned crops. The area size of the farm size consists of cultivated and uncultivated areas as well as set-aside areas.

They also show the general nitrogen standard for the planned crop as well as for the crops cultivated last year and the farm specific nitrogen quota. The specific standard additionally considers site specific factors, as for example previous catch crops. The whole area of the farm is considered, even though for

uncultivated land the nitrogen standard may be zero. The farm specific nitrogen quota is the sum of the specific nitrogen quotas of each field. The field specific nitrogen quota is calculated considering the field size and the nitrogen standard of the planned cop. The nitrogen standard takes into account the soil type, irrigation and the previous crop. Thus the farm specific amount of fertilizer (mineral fertilizer as well as manure) that can be applied is given by the nitrogen quota.

After the growing season a fertilizer account has to be submitted at the Ministry of Food, Agriculture and Fisheries of Denmark.

Furthermore the fertilizer account gives information about the number of livestock units, the type of livestock and the amount of nitrogen that originates from livestock production. Since the amount of manure, and therefore also nitrogen, are calculated for the fertilizer account the type of housing for the animals, feedstuff and details concerning livestock production methods have to be indicated in the fertilizer account. The following table shows the prescribed nitrogen efficiency of manure for some examples.

Table 1: Efficiency of nitrogen in manure in Denmark by Mr. Anders Nemming and Mr. Rune Ventzel Hansen

Type of manure	Efficiency
Pig slurry	75 %
Cattle slurry	70 %
Mink and poultry slurry	70 %
Liquid manure	65 %
Deep litter	45 %

Furthermore the exchange manure and the manure stock have to be specified to complete the fertilizer account. To exchange fertilizers between farms the supplying farmer as well as the accepting farmer needs to be included in the “Register for Fertilizer Accounts“. Signed documents are mandatory to record the exchange of fertilizers. To give a complete impression of nutrient fluxes in agriculture fertilizer accounts also consider the purchase and delivery of mineral fertilizer. For this reason farmers have to report purchased fertilizers and all suppliers are obliged to report amount and type of sold fertilizer to the so called “register of suppliers”. Beyond all this opening and closing stock of fertilizer are assessed every growing period.

The control of the regulations on limitation of the land use of fertilizers is executed by the Danish AgriFish Agency. Within these controls the responsible authority executes on site checks on 1 % of the farms.

The control departments are located in five districts. Moreover an administrative control is executed on about 4 % of all farmers who keep a fertilizer account. The criteria according to which farmers are chosen for the controls are risk based. They are evaluated and enhanced every year. In the Control Database of the Danish AgriFish Agency data of several institutions is combined and checked for plausibility. This database includes the individual fertilizer accounts, records of farm sales of mineral fertilizer. Additionally biogas plants and processing plants deliver data concerning input and output of manure and substrate (biomass). For the purpose of plausibility checks, the central Food and Agricultural Database provides field data from single payment application. The amount and quality of organic waste production for agricultural use is available from the municipalities. Furthermore Mineral fertilizer companies record the amount of nitrogen delivered to the farms.

According to Cross Compliance regulations farmers have to prepare and submit their fertilizer account after every growth period. They have to submit their fertilizer account at the latest the 31st of March. If

nitrogen in manure, from livestock is transferred either to another registered farmer or to biogas facilities, processing plants or abroad it can be deducted. It is forbidden to exceed the farm specific nitrogen quota.

2.1.4 Guidelines on fertilization and harmony rules

Limits on allocation of manure (Guidelines on fertilization and harmony rules) have to be respected. The “Guidelines on fertilization and harmony rules” are published every year the 1st of August by the Danish Plant Directorate. They include among other requirements the already mentioned nitrogen standards. The nitrogen standards are used to calculate the amount of manure and mineral fertilizer which are permitted to be applied on the farm in the following growing period. In early spring the nitrogen standards are adapted according to the nitrogen forecast. The nitrogen forecast is based on the precipitation and nitrogen content of the soil in early winter. It is also categorized according to soil types and geographical regions. The prescribed standards are set below the economical optimum. Thus for example the standards were 16 % below the economical optimum in the growing season 2010/2011. Moreover catch crops have to be established according to normal operating principles to prevent nitrate leaching in autumn or winter. This shows that, additional to compulsory nutrient bookkeeping further measures are taken to prevent nutrient imissions from agricultural systems.

2.1.5 Action Plan on the Aquatic Environment III and Green Growth agreement

Currently the “Action Plan on the Aquatic Environment III” from 2004 to 2015 is running. The action plan III aims to reduce nitrogen leaching in 2015 about 13 % compared to 2003 and to reduce the phosphorus surplus about 50 %. This is to be achieved by several measures. The amount of mandatory catch crops increased from 10 % up to 14 %. Henceforward 25,000 hectares of nine meter wide buffer stripes along streams and lakes are to be established. The reduction of phosphorus surplus is to be promoted by a tax on fodder additives with mineral phosphorus. Besides organic farming is strengthened and increased and other ways of environmentally sensitive farming are to be established.

In addition to the Action plan III there is the “Green Growth Agreement” running from 2009 until 2015. The current Green Growth Agreement deals with the problems that occur, achieving the goals of the “Action Plan on Aquatic Environment III”. The “Action Plan on Aquatic Environment” aims to reduce nitrogen leaching from the root zone and about 21,000 tons of Nitrogen. The Green Growth Agreement on the other hand intents to reduce nitrogen discharge to the aquatic environments from 2010 to 2015 about 19,000 tons. Considering the goals of “Action Plan on Aquatic Environment”, the targets of the Green Growth Agreement were revised. Now, according to the revised Green Growth Agreement, nitrogen discharge has to be reduced about 9,000 tons. This is to be achieved by various measures. Buffer stripes (width: nine meters) are to be provided along all surface waters such as rivers and lakes. These buffer stripes are not to be cultivated and are thus necessarily fertilizer free and pesticide free. They cover an area of approximately 25,000 hectares. To prevent nitrogen leaching in autumn and winter the area covers with catch crops is to be increased about 140,000 hectares. Furthermore certain forms of soil cultivation are prohibited in autumn to avoid increasing mineralization in the soil. Beyond these measures, ploughing grass fields is forbidden in certain periods of the year. Besides, 10,000 hectares of wetlands are established and forestation and organic farming are promoted.

All these measures contribute to meet the demands of the nitrates directive in Denmark. In accordance to the upper limit of 170 kg nitrogen per hectare from manure given by the nitrates directive, the Danish Guidelines on fertilization and harmony rules prescribe 140 kg nitrogen per hectare from pigs and other livestock, 170 kg nitrogen per hectare from cattle and 230 kg N/ha according to derogation arrangements for cattle.

Summary: status of nutrient bookkeeping in Denmark

In Denmark fertilizer application is restricted according to the farm specific nitrogen quota. The nitrogen quota for each farm is determined anew every year. Since all data is forwarded to the responsible authority, controls are mainly conducted cross-checking the provided data for plausibility. The individual calculations are conducted, using standard values.

Furthermore there are other legal requirements to prevent nutrient losses from agricultural areas, such as a certain amount of catch crops or buffer stripes along the borders of surface water.

2.2 Estonia

Mrs. Livi Rooma from the Agricultural research center presented the status of nutrient bookkeeping in Estonia.

2.2.1 Legal background

In Estonia the Water Act provides the main legal background for the implementation of the Nitrates Directive the Water Framework Directive and the HELCOM objectives. The Water Act defines the legal requirements to fertilizer application. Additionally to the upper limit of 170 kg N/ha originating from manure, which is given by the Nitrates Directive the Water Act sets the maximum of allowed fertilization for phosphorus at 25 kilogram per hectare.

2.2.2 Current implementation of nutrient bookkeeping on farm

Even though nutrient balancing is not yet compulsory in Estonia, nutrient bookkeeping is already implemented by the mandatory “field record book” that has to be kept by the farmers. It must be stored for at least ten years and is transferred to new owners in case that the field is sold. The field book contains among other data: date, work type, worker and size of the area. In terms of fertilization the field book informs about the amount and type of applied fertilizer and its nutrient content in terms of nitrogen, phosphorus and potassium.

Another inducement for farmers promoting the implementation of nutrient bookkeeping is the demand of a fertilization plan to apply for subsidies according to the environmentally friendly management scheme. The environmentally friendly management scheme is part of the rural development plan. Figure 4 shows the Estonian area covered by the environmentally friendly management scheme in 2013, marked in green, whereas the Nitrate Vulnerable Zone is outlined pink.

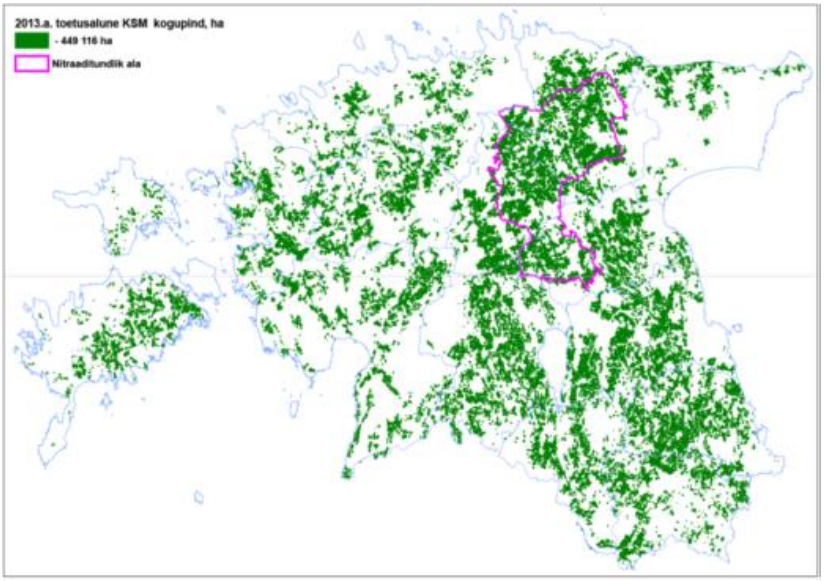


Figure 4: Estonian area, covered by the environmentally friendly management scheme

The environmentally friendly management scheme covers about 46 % of single payment area. The field book and the fertilization plan are controlled by inspectors of the “Estonian Environment Inspectorate” and the “Agricultural Registers and Information Centre”.

Even though calculation of farm specific nutrient balances is not mandatory for the farmers, some use it with the intention to improve their nutrient management. As one result of the “Baltic Deal Project” a MS Excel tool to calculate nutrient balances has been developed in 2013. However this tool is not widely spread as it was not promoted by advisory services.

2.2.3 Nutrient balances at national level

The main part of nutrient balances in Estonia is calculated at national level by “Statistics Estonia”. Statistics Estonia started nutrient balancing in 2011 and calculated nutrient balances retroactively from 2004 on. The method is described in the “Eurostat (2013). Nutrient Budgets - Methodology and Handbook; Version 1.02; Eurostat and OECD, Luxembourg” The whole agricultural area of Estonia was taken into account as reference area. Thus the area which was considered included arable land and permanent grassland as well as permanent crops. Farmers who cultivate areas larger than 500 hectares are obliged to forward information, regarding plant production as well as livestock input and output to the responsible authority. Data of smaller farms is assessed selectively. This is the database to calculate the nitrogen and phosphorus balance for Estonia (more detailed information is also given online “Nitrogen and phosphorus balance in agricultural land”). The results of the calculation of the gross nutrient budget from 2004 until 2013 are shown in Figure 5

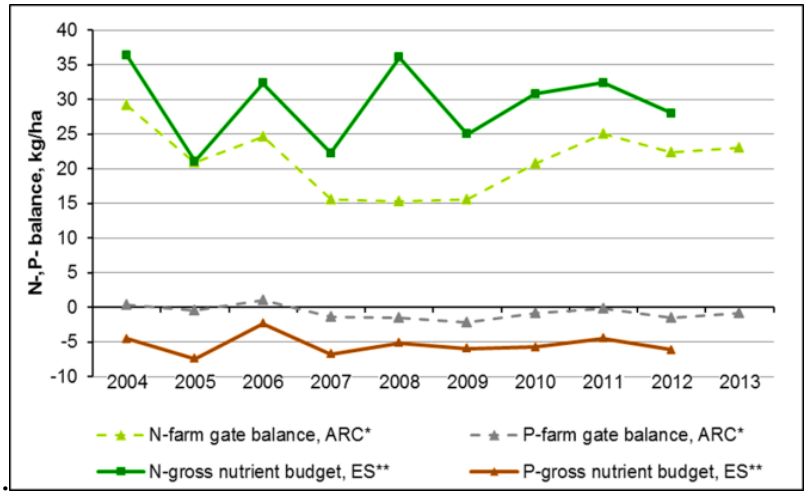


Figure 5: Nitrogen and phosphorus farm gate balance and gross nutrient budget according to the *agricultural research center and **Statistics Estonia by Mrs. Livi Rooma

For the gross nutrient balance total input and total output are considered for nitrogen just as for phosphorus. The total input includes mineral fertilizer, manure from livestock production, biological nitrogen fixation, atmospheric deposition and other input factors such as seeds or planting material. To calculate the total output harvested crops, fodder crops and crop residues removed from the field are summed up. Fodder crops include for example grazing consumption or harvested grassland. Further implications from the results depend on the specific model used for the calculation. Nevertheless the calculation enables to observe the development in a certain period, even though the quality of the administrative data may vary.

2.2.4 Farm gate balances

In addition to the calculation of the gross nutrient budget, the Estonian Agricultural Research Center calculated annual farm gate balances for monitoring and evaluation of the impact of the “Rural Development Plan” and agri-environmental measures since 2004. The results are shown in figure 6.

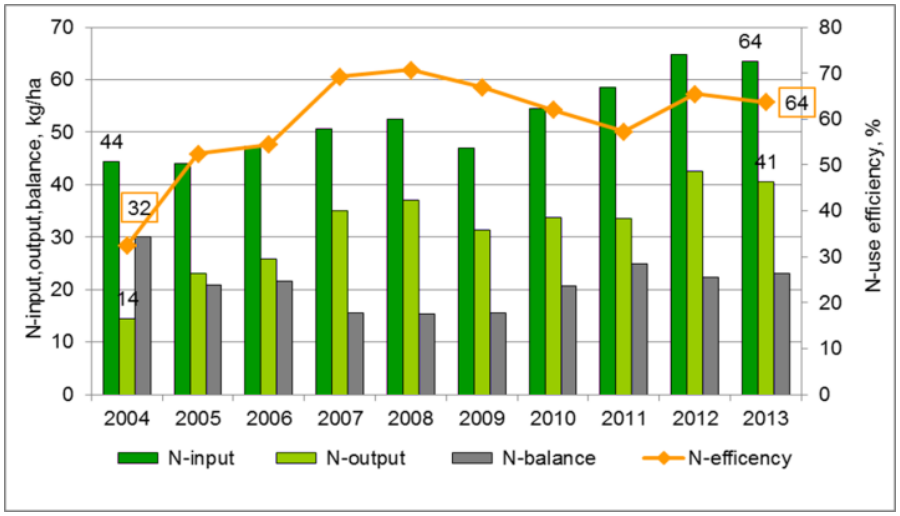


Figure 6: Farm gate nitrogen balance, nitrogen input and output as well as nitrogen efficiency from 2004 until 2013 according to the agricultural research center by Mrs. Livi Rooma

Even though the Estonian agricultural research center and Estonian statistics used different methods to calculate nutrient balances the same developments can be observed. The balance of nutrients (nitrogen, phosphorus and potassium in kg/ha per year) and efficiency (% nitrogen, phosphorus and potassium) is calculated for the period from January 1 to December 31 (corresponding to the economy reporting period). During the period 2004-2013 survey data was collected every year from about 120 farms. As far as possible the same farms were selected for the study.

Data was collected from farmers’ field record books and bookkeeping records by trained interviewers. As input were considered: animal fodder, straw, mineral and organic fertilizer, seeds, livestock, biological nitrogen fixation (by leguminous plants) and atmospheric deposition. Crop production, livestock production, organic fertilizer, animal fodder and straw are taken into account to sum up the output.

2.2.5 Further tasks

Although nutrient balances can support farmers improving their nutrient management there are still difficulties in the implementation of nutrient balancing and in the calculation. One of the main obstacles is insufficient data concerning quantity and quality of production and consumption. The assessment of data about nutrient flows concerning fodder from grassland is also a challenge, because the data is hardly specified, regarding different uses such as hay, silage, green fodder. But there are also more specific problems, as for example the assessment of the proportion of leguminous crops in grassland and thus their contribution to nitrogen input by fixation of atmospheric nitrogen. The great variation of nutrient contents in organic manure complicates the calculation of farm specific nutrient balance additionally.

To advance nutrient management the Estonian Ministry of the Agriculture is planning in the framework of the program “Applied Agricultural Research and Development in the years 2015-2021” to order the advanced version of the Humus Calculator and web-based Plant Nutrient Balance Calculator.

Summary: Status of nutrient bookkeeping in Estonia

Even though it is not mandatory to calculate nutrient balances in Estonia, records concerning the nutrient management are kept by field books. Many farmers provide fertilizer plans voluntarily as these are required to apply for subsidies according to the environmentally friendly management scheme.

Nutrient balances are mainly calculated on national level by Statistics Estonia. The results show improvements in nutrient management but there is still need to reduce nitrogen and phosphorus losses further on.

An important step to promote the implementation of nutrient balances in agricultural practice would be increasing the accuracy of the results, providing more precise standard values.

2.3 Finland

Mrs. Aino Lauto-Tiuttu from the Central union of agricultural producers and forest owners (MTK) presented the current status of nutrient bookkeeping in Finland.

2.3.1 Legal background

The legal background for nutrient bookkeeping in Finland is given by the “Nitrate degree”, which implements the Nitrates directive in Finland. The whole of Finland is classified as nitrate sensitive area. According to the Nitrate degree farmers have to record how much total nitrogen and soluble nitrogen is applied on plot-level. Time of application and harvested yield are also assessed. The compliance of the Nitrate degree is compulsory for all farmers.

Additionally there is the Agri-Environmental-Scheme, which is part of the Finnish Rural Development Program. It is voluntary for the farmers to participate; nonetheless more than 90 % of the agricultural area is covered by the Agri-Environmental-Scheme. According to the lately revised rules for the Agri-Environmental-Scheme, farmers need to keep record of the amount of applied soluble nitrogen and total phosphorus, the type of fertilizer (organic and inorganic), spreading time and method, soil organic matter content and phosphorus-level, as well as harvested yield level. Thus nutrient bookkeeping is compulsory for all farmers, nutrient balancing on the other hand is done voluntarily.

2.3.2 Who is involved in nutrient bookkeeping?

There are several parties involved in nutrient bookkeeping in Finland. The ministry of the Environment is responsible for the implementation of the Nitrates directive. The Ministry of Agriculture on the other hand is accountable for the legislation concerning the Agri-Environmental-Scheme. The Agency for Rural affairs and regional centers for Economic Development, Transport and the Environment are in charge to put the Agri-Environmental-Scheme into practice and execute controls. Municipalities are the nearest level of administration for the farmers. They deal with farmers’ applications and take care of the payments of compensations and subsidies. They also control the compliance to the rules of the Nitrate degree. Rural extension services play a key role increasing the distribution of nutrient balancing on farm level and to produce comparable results that can be used for further development and improvement of environment protection measures. Besides rural extension services contribute considerably to the economic benefit of the farmers because evaluating the results of nutrient balances the nutrient efficiency can be improved.

The Natural Resources Institute Finland, Finnish Environment Institute, and University of Helsinki are also involved, by means of research, monitoring and knowledge transfer.

2.3.3 Methodology and intention of nutrient balancing

In Finland the method of nutrient bookkeeping is not standardized. IT-programs for cultivation planning are available, but handwritten records are accepted as well to fulfill the requirements of the Agri-Environmental-Scheme. The calculation of nutrient balances is done voluntarily. Usually balances are calculated for nitrogen, phosphorus and in some cases potassium at farm level. The Natural Resources Institute generates nutrient balances for specific regions or countrywide. The calculation of nutrient balances is part of cultivation planning programs, but generally not nutrient balances are calculated. There are also special nutrient balancing programs freely available online, such as Ymparisto or Agri-market. Rural extension services differentiate between soil-surface balances and farm-gate balances, according to the used program.

The natural resources institute calculates nutrient balances for specific regions and countrywide. The soil-surface balance shows the difference between nutrient inputs to the field and nutrient uptake by plants. Nutrient input to the field consists of the amount of fertilizer, sown seeds and crop-specific

nitrogen-fixation. Harvested products represent the nutrient uptake by plants. These factors are specified either by nitrogen, phosphorus and potassium per kg or percent of elemental nitrogen, phosphorus and potassium.

Soluble nitrogen is used to calculate nitrogen-balances. Nutrient amount in organic fertilizers (for example manure) can be determined by laboratory analysis but standard values can be used instead. The nutrient content of commercial fertilizers is provided by the manufacturer.

Total phosphorus is used to calculate phosphorus-balances. According to the Finnish Agri-Environmental-Scheme (2007-2014) 75 % of autumn spread nitrogen in manure and 85 % of phosphorus in manure had to be taken into account for nutrient balancing. From now on 100 % of nitrogen and phosphorus will be taken into account. Even though this implies that the comparison of old and new balances will be difficult.

Data on nutrient content of the crop can be obtained from laboratory analysis or from standard values. Usually atmospheric deposition or even nitrogen fixation is excluded from calculations because of a lack of data. However, if possible leguminous nitrogen fixation should be taken into account because the amount of fixed nitrogen can be remarkable, and is sometimes the only nitrogen-source. If crop residues such as straw are harvested, their nutrient content is also considered. The yield level is measured or estimated by the farmer, which is sometimes complicated as for example the moisture level of grass varies a lot. To estimate the yield level of pasture land is also difficult. Experience from daily life also shows that the precise determination of the amount of organic fertilizers applied, such as manure or slurry is not always possible. Nevertheless soil-surface balances are still a good indicator for the efficiency of applied nutrients. Besides harmful environmental effects, such as nitrate leaching, a significant surplus in balances is often unprofitable from the economic point of view.

The aim of soil-surface balances is to identify farm-specific needs for improvement of nutrient management. Therefore the purpose of soil-surface balances is to gain field-specific information about the level of nutrient efficiency and to prevent nitrate leaching or phosphorus run-off adjusting management activities. The farm balance (or farm-gate-balance) on the other hand considers nutrient flow to the farm and from the farm. Nutrients that come to the farm are seeds, seedlings, feed, new animals and fertilizers. Nutrients leave the farm mainly in form of milk, meat, eggs, grain, manure (if given to another farm) and sold animals. The nutrients from harvested yields and fertilizers can be accounted for the same way as in the case of field balances. Standard values are provided, in case no specific data concerning the nutrient contents is available. However, the utility of farm-balances is improved with increasing accuracy and availability of farm-specific data. The farm-balance considers one calendar-year. Thus fertilizers that were stored and not bought in the respective calendar-year are not considered in the account. The farm balance indicates the efficiency of nutrient management on farm level. It shows how much nutrients have been utilized in production on the farm and the amounts that have been leached, evaporated, retained in the soil, or used by animals.

Within a national Finish project field balances were calculated for participating farmers. Advisors, as well as farmers considered field balances a satisfying tool to evaluate nutrient management on the farm. The results of the project point out, that even though farm balances were usually at equilibrium, it is essential to identify needs for action and fields where the risk of nutrient losses is highest. Two Finnish grain companies have also calculated nutrient balances for the farmers. They use the results as advisory material. Additionally to the improvement of nutrient management, nutrient balances can indicate further factors that restrict plant growth besides fertilization. It should be kept in mind that the effects of unalterable, influencing factors, as for example specific climatic conditions can be remarkable. However, balance-calculation is continually becoming more widely spread.

2.3.4 Further tasks

Still the benefit for environment protection and farmer could be increased by better comparability of the results. To enable, and later on to facilitate the classification of farm- or field-specific results, is an important task for future research. Regarding the current obstacles, presently it is advisable to calculate nutrient balances continuously for several years, to get an impression of the respective nutrient flows. Besides there is still a lack of knowledge concerning site- and crop-specific target values. Furthermore the calculation methods need to be standardized to obtain representative results. Currently nutrient balances are tested in many levels and in different fields, yet routine is still missing. Advisory services should pay more attention how the results of nutrient-balancing can be implemented in cultivation planning, fertilization or other management activities.

Status of nutrient bookkeeping in Finland

According to the Nitrate degree all farmers in Finland have to record how much total nitrogen and soluble nitrogen is applied on plot-level. Time of application and harvested yield are also assessed.

According to the Agri-Environmental-Scheme, farmers need to keep record of the amount of applied soluble nitrogen and total phosphorus, the type of fertilizer (organic and inorganic), spreading time and method, soil organic matter content and phosphorus-level, as well as harvested yield level. Thus nutrient bookkeeping is compulsory for all farmers, nutrient balancing on the other hand is done voluntarily.

There is no common method how to calculate nutrient balances, even though they are often used in rural extension services. Therefore a standardized method would be a great progress and enhance the comparability of the results. Further knowledge is needed to evaluate crop- and site specific results.

2.4 Germany

The status of nutrient bookkeeping in Germany on farm and national level was presented by Mr. Maximilian Hofmeier in cooperation with Mrs. Dr. Kerstin Panten, from the Julius Kühn-Institute (Federal Research Centre for Cultivated Plants).

2.4.1 Legal background and involved institutions

The legal requirements given by the Nitrates Directive and the Water Framework Directive are implemented by several laws, ordinances and specific decrees, such as for example the fertilization ordinance (ordinance on fertilizer application) and the fertilizer ordinance (ordinance on fertilizer quality). Additionally there is an ordinance on marketing and transport of manure. Nutrient management, especially fertilization also has to regard the federal soil conservation act and the federal nature conservation act.

Due to the federal structure of Germany many parties take part in data assessment and calculation of nutrient balances as well as in the analyzing process. Some organizations or institutions are involved on federal level and some on country level. The most important institutions and organizations are shown in Table 2.

Table 2: Selection of institutions and organizations involved in nutrient management in Germany

Institution/organization	
Federal Ministry of Food and Agriculture Federal Environment Ministry	
Federal Research Institutions (i.e. JKI, TI) Federal Environment Agency (UBA)	
Ministries of Agriculture and Environment of the Federal States	
Regional Authorities for Agriculture & State Research Centers for Agriculture	
Chambers of Agriculture	
Agricultural and Environmental Associations, NGOs, Societies, etc.	

The last revision of the ordinance of fertilizer application was in 2007. An amendment of the ordinance is in progress since 2012 and will probably be completed in 2016. The current ordinance includes site specific regulations for fertilizer application such as periods in which spreading of animal manure is prohibited and restrictions for fertilizer application after harvest of the main crop.

Requirements in regard of storage capacity and an upper limit for manure application are given as well. Regulations concerning application techniques and fertilizer incorporation are described. The fertilization ordinance prescribes the preparation of a nutrient management plan including nitrogen (N) and phosphorus (P) balances and the assessment of crop specific nutrient demand.

Basic principles for fertilizer application are also specified. Thus the assessment of fertilizer demand, aiming to maintain site-specific soil fertility and to respect a balance between nutrient demand of the crop and nutrient supply, is mandatory before fertilizer application. To achieve a balance between nutrient demand and nutrient supply several field or site specific parameters

have to be considered, such as the nutrient content of the soil and site specific nutrient availability. The specific nutrient availability is influenced for example by the soil pH or organic matter content. Additionally, cultivation measures such as previous crops, tillage measures or irrigation need to be taken into account to estimate the actual fertilizer demand. For N, the annual calculation for each field or management unit considering mineral nitrogen in the soil (N_{min}), either with help of regional standard values or site specific soil samples, is mandatory. The results of a soil analysis for P have to be provided at least every sixth year. Furthermore, timing and amount of nutrient application have to be as close as possible to plant uptake. The revised ordinance for fertilizer application intends to prescribe compulsory field or management unit specific assessment of fertilizer demand. The current valid version of the fertilization ordinance requires the calculation of N and P balances according to the nutrient management plan. The nutrient management plan has to be compiled until the 31.03. for the previous fertilizer year and has to be shown in case of control. The nutrient management plan contains field balances or nutrient balances for management units. The results are taken into account for a multi-year management plan. For the calculation of the nutrient management plan minimum N-indices for organic fertilizer considering deduction of shed as well as storage and application losses, have to be taken into account. Standards for unavoidable N losses are also given. There are upper limits for surpluses in the nutrient balances generated by the nutrient management plan. The thresholds for acceptable N surpluses decreased since 2006. Table 3 shows the development of legal requirements reducing N surpluses according to the nutrient management plan. The revision of the ordinance aims to continue reducing the nutrient surpluses.

Table 3: Development of acceptable N and P balance surpluses in the nutrient management plan in Germany

Period	Acceptable N and P balance surplus	Considered period
2006 - 2008	≤ 90 kg N ha/year	3 years
2007 - 2009	≤ 80 kg N ha/year	
2008 - 2010	≤70 kg N ha/year	
Since 2009	≤ 60 kg N ha/year	
Since 2006	≤ 20 kg P ha/year	6 years

The federal states are responsible for the control. This task is mostly assigned to specialized authorities of lower administration level. Approximately 1 % of the farmers are controlled every year to ensure that the requirements of Cross Compliance are fulfilled. Disregard of the Cross Compliance demands leads to deduction of direct payments. If the nutrient management plan is not correct or not available in case of control this is considered as an administrative offence and leads to financial penalties.

2.4.2 Nutrient balances on different scales

Nutrient balances are calculated on several scales, taking different data sources into account. The kind of data chosen depends on the purpose of the nutrient balance. Table 4 shows the different scales of nutrient balances, the respective purpose and the corresponding data sources. Nutrient balances on national scale are calculated according to the farm gate balance methodology. Inputs from mineral and organic fertilizers, atmospheric nitrogen deposition, biological nitrogen fixation, seeds and planting material as well as from fodder and animal imports are summed up, and the difference to the calculated output with crop and livestock market products .is the nitrogen surplus or deficit. Using the field and livestock balance it is possible to differentiate between input from crop production and from livestock production. Gaseous ammonia losses from manure can also be considered.

Table 4: Data sources and purposes of different nutrient balances on various scales in Germany

Scale	Balance‡	Data source	Purpose
National level 	FB_{gross}	Statistical data (Destatis) and estimations	Eurostat/OECD → Reporting duty Nitrate report → Monitoring
	FGB (FB_{net} +LB)		Agri-Environmental Indicator → Strategy of Sustainability/Biodiversity
Regional level 	FB_{net} (top-down)	FSS data and estimations	Implementation of EU-WFD → Emission monitoring
	FB_{net} (bottom-up)	FADN data, bookkeeping	
Farm level 	FB_{net}	Estimations and bookkeeping	Fertiliser Ordinance → Monitoring of CAP Fertilizer planning
	FGB	Bookkeeping	Advisory service, Fertilizer planning
Field level 	SSB	Field record system	Advisory service, Fertilizer planning

‡ FGB = Farm gate balance; FB = Field balance; LB = Livestock balance; SSB = Soil surface balance; gross = including gaseous N-losses (NH_3); net = without gaseous N-losses

Using the field and livestock balance it is possible to differentiate between input from crop production and from livestock production. Gaseous ammonia losses from manure can also be considered.

2.4.3 Different calculation methods

The respective N surplus can vary depending on the methodology. Figure 7 shows the differences in national N balance surpluses calculated according to three different methods. Differences up to 35 kg N/ha occurred between calculated surpluses, as for example nitrogen balancing according to the fertilization ordinance does not take into account atmospheric nitrogen deposition or gaseous ammonia losses.

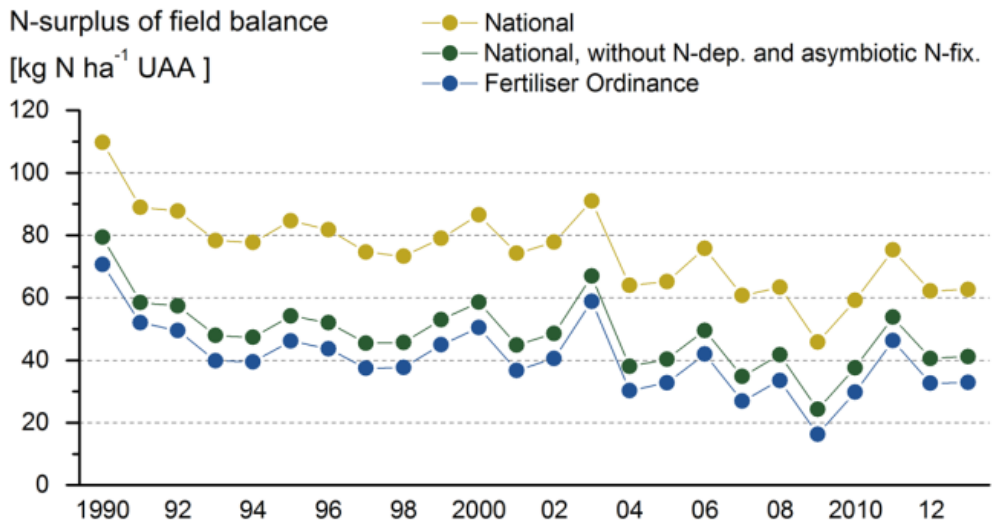


Figure 7: Nitrogen surplus from 1990 to 2013 of different calculation method

Another uncertainty is in some cases the estimation of yield or N and P content of harvested crops, especially in fodder production. Further difficulties calculating nutrient balances or comparing results are caused by variations in the availability of reliable data. For example there is only selling data available for mineral fertilizer but no data regarding the actual use of mineral fertilizer. Moreover there is no reliable data about import and export of manure from and to the Netherlands on hand.

2.4.4 Nutrient balances as agri-environmental indicator

The national N balance surplus can be used as an agri-environmental indicator in order to track the integration of environmental concerns into the Common Agricultural Policy (CAP) at EU, national and regional levels. Figure 8 shows the development of the national N balance surplus of crop and livestock production from 1990 to 2013. It shows a continuous decline since 1990 of 52 kg N/ha.

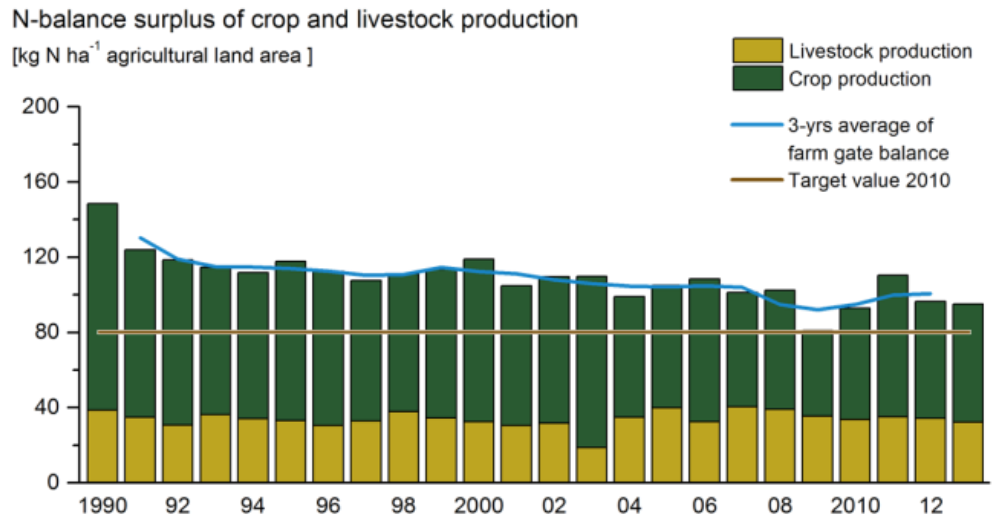


Figure 8: Development of nitrogen balance surplus of crop and livestock production from 1990 to 2013

However, the last Nitrates Report from 2012 showed that 49 % of the groundwater monitoring stations have a poor chemical status, because of a nitrate concentration higher than 50 mg NO_3-/l and that there are even rising trends in some areas. High nitrate concentrations mainly occur in areas with high livestock density, intensive cultivation of vegetables or a high concentration of biogas plants. The problem

of high nitrate concentrations is additionally intensified in some regions by a low groundwater recharge rate.

Summary: Status of nutrient bookkeeping in Germany

The main legal background for fertilizer application in Germany is provided by the Fertilizer Application Ordinance. This ordinance is currently under revision. In the course of drawing up a nutrient management plan nutrient balances are calculated. The nutrient management plan has to be stored and shown in case of control.
Nutrient balances are calculated for various purposes on several scales, taking different data sources into account. Methodology has to be considered when N surpluses are compared. Nutrient balances on regional or national level are used as agri-environmental indicators to show areas where an improvement of nutrient management is necessary.

2.5 Latvia

Professor Aldis Karklins from the Latvia University of Agriculture presented the status of nutrient bookkeeping in Latvia and showed the development of legislative, methodological and organizing framework for nutrient balance calculations on farm level.

Nutrient (usually nitrogen, phosphorous and potassium) balance calculation is used in research as well as for fertilizer application planning in Latvia already for a long time. However different approaches regarding methodology and data interpretation as well as data use are a common phenomenon. Recently the main focus was pointed out on application of methodology recommended internationally because plant nutrient balances are considered as important agro-environmental indicator characterizing the sustainability of farming activities. Therefore for assessment of agricultural activities especially from the environmental point of view Soil Surface and Farm gate balances are more popular.

2.5.1 Legal regulations

There is no strict requirement for farmers in Latvia to calculate plant nutrient balances annually or to report these data, but many elements of balance calculation are included in legislative acts, recommendation systems and for fertilization planning, or else, requirements of these acts give possibility to make such balance calculations because farmers are obligated to record and forward the respective information.

The main legislative act regulating the use of nitrogen containing fertilizers in Latvia is the Cabinet Rule No. 834 “Regulations on water and soil protection from agricultural activities due to pollution by nitrates”, issued in accordance with the Law on Pollution on December 23, 2014. The first requirement is to account all organic wastes (manure, digestate, composts etc.) produced, obtained or sold in (from) the farm and to keep these records for three years. Manure composition is specified using standard values which are included in the same legislative act. As an alternative, farmers can send manure samples to certified laboratories and use these results for more precise fertilizing planning. Therefore at least one component of nutrient input should be recorded for all farms of Latvia.

For farms located in “Nitrate Vulnerable Zone” of Latvia more strict regulations were established. The location of Nitrate Vulnerable Zones in Latvia is shown in Figure 9. Currently only a part of the territory of Latvia is defined as Nitrate Vulnerable Zone and includes approximately of 15 % of agricultural land.

Figure 9: Nitrate vulnerable zones in Latvia; Liga Drozdovska; Latvian Ministry of Agriculture

If farmers manage agricultural land lager than 20 hectares (field crops) or larger than three hectares (potatoes, vegetables, orchards) they are obliged to keep records of field history (for every field of their farm) and store them for at least three years.

These farmers should also keep the records about obtained mineral fertilizers and its chemical composition (at least nitrogen, phosphorus and potassium content). The preparation of a field specific fertilization plan is mandatory in these areas, too.

A summary of the fertilization plans has to be sent to the authorities of State Plant Protection Service. Its layout is standardized and the information is maintained using an electronic data base. These requirements are mandatory only for farms located in vulnerable zone. For the rest of farmers similar requirements are suggested but not compulsory. Additionally the Code of Good Agricultural Practice (published in 1999 and revised in 2008) encourages farmers to use these possibilities to improve their nutrient management in every farm, but hitherto these are only recommendations.

2.5.2 Implementation and projects

Until now there were manifold activities to implement the calculation of nutrient balances in agricultural practice. Among other measures there was an international, EU-funded project to improve methods to calculate nutrient balances on farm level from 1991 until 2001. Figure 10 shows the project partners of the “MAINTAINE” (Managing Inputs of Nutrients to Avoid Insufficient or Excess) project.

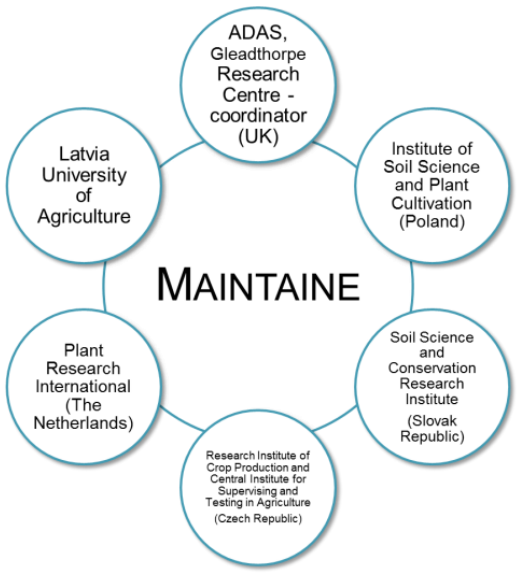


Figure 10: Project partners of the MAINTAINE project on nutrient balances

In the framework of this project, reference values for plant nutrient uptake were developed for the crops grown in countries of participation. Mutual comparison and validation of these standard values was performed as well. Thereupon a computer program to calculate nutrient balances was evolved and tested in the respective countries. The straightforward program is based on MS Excel and includes corresponding data sheets containing algorithms as well as necessary reference values. By entering the input data all calculations are conducted automatically and the final result is displayed on the sheet of results. Displaying all instructions, the program enables the user to replace standard values in favor of analysis’ results and thus, for example to consider the specific nutrient content of manure. The program can be used to calculate Soil surface balances just as well as Farm gate balances

2.5.3 Calculation of soil surface balances and farm gate balances

To calculate Soil surface balances it is possible to consider either all agricultural land within the farm or fertilized area only. Which database is to choose depends on intention and aims of calculating a nutrient balance.

To calculate a soil surface balance several factors are taken into account:

- Manure produced within the farm during the period of concern; Calculations of NPK content is based on number and type of animals as well as on type of housing and manure storage technology. By default reference values from Cabinet Rules No. 834 are used (see above).

- Manure purchased; NPK content is derived from reference values or by entering the real data from the result of analysis. A Catalog of manure types is presented.
- Commercial fertilizers; a catalog of fertilizer types is given with standard NPK contents.
- Biological nitrogen fixation; nitrogen content is calculated, based on the area of crops and obtained yield.
- Plant nutrients in seeds and planting materials; there is a catalog with possible materials and reference values of chemical composition.

The output of nitrogen, phosphorous and potassium is obtained, considering the yield (main product) and information about the use of by-products. Regarding the use of by-products the area where it is left on the field, where it is removed and in case of removal the way they are used, are of importance. A yield-ratio (main product versus by product) is calculated using reference values, but it is possible to change them easily if more appropriate information is available owing to specific analysis.

Nitrogen losses from manure during application are also taken into account. Calculations are done using coefficients. They base on type of manure, period of application, technology of application and incorporation into the soil. Nitrogen losses from manure during application could be ignored if all nitrogen within the balance were considered, regardless of possible losses during application, emissions, leaching etc. If these amounts should be taken into account depends on the intention of nutrient balance calculation.

The program displays the final results as single table, showing the total value of each variable as well as sum of input, output, the total NPK balance in farm and balance on the area of agricultural land (fertilised land). The balance intensity (input divided by output and expressed as percentage) is also calculated. Table 5 shows the way the results are presented.

Table 5: presentation of the results after calculation of soil-surface balances in Latvia

Variables	N	P_2O_5	K_2O
Input, kg			
1.1. Manure produced in farm (A)			
1.2. Manure purchased (B)			
1.3. Commercial fertilisers (C)			
1.4. Biological nitrogen fixation (D)			
1.5. Seeds and planting material (E)			
Output, kg			
2.1. Removal by yield (G)			
Results			
Balance per farm, kg: (A+B+C+D+E)-G = S			
Balance per ha, kg: S/area			
Balance intensity, %			

As already mentioned there is the possibility to calculate farm gate balances as well. The assessment unit is the whole farm including both sectors of production – crops and animals. Factors that are considered calculating the input can be gathered from Table 6, which shows the presentation of results after the calculation of a farm-gate balance in Latvia.

Table 6: presentation of results after calculation of a farm-gate balance in Latvia

Variables	N	P_2O_5	K_2O
Input, kg			
1.1. Commercial fertilisers (A)			
1.2. Purchased seeds and planting material (B)			
1.3. Purchased animals (C)			
1.4. Purchased feed (D)			
1.5. Purchased organic manures (E)			
1.6. Biological nitrogen fixation (F)			
Output, kg			
2.1. Crop products sold (G)			
2.2. Animal products sold (H)			
2.3. Losses from animal operations			
Results			
Balance per farm, kg: (A+B+C+D+E+F)-(G+H+I) = S			
Balance per ha, kg: S/area			

It was shown by several studies that there are no any difficulties to draw up such calculations based on primary in-farm data.

2.5.4 Current implementation

To improve the implementation the developed program was presented in seminars organized for advisers and farmers. Copies of program were distributed. Information about manure should be available to develop nutrient balances and to deduce fertiliser recommendations. Contribution of manure in plant nutrient fluxes could be very important, especially in farms managing high numbers of livestock units.

Extensive research was done in Latvia in 2006 – 2007 and before to evaluate the appropriate methods for manure output calculation as well as nutrient content assessment. The leader of these studies was Agrochemical Research Centre[1] in cooperation with other institutions. Reference values of manure output and chemical composition were developed which are used now in legislative acts, fertilizer planning and related issues.

For reporting of plant nutrient balances on the country level, it was the intention to harmonize the calculation methods in accordance to the requirements of the OECD and EUROSTAT, based on OECD/Eurostat Gross Nitrogen Balances Handbook (Gross Nitrogen …, 2003) and arrange the data base of standard values (coefficients) for calculations relevant for the Latvian situation. Therefore a pilot study on “Improving the quality of agro-environmental indicators – Gross Nutrient Balances” was started. In the framework of this study the methodology of balance calculation was adapted and a catalog of reference values was developed. Additionally nutrient balances were calculated for the year 2008 considering all utilised agricultural land of Latvia in average as well as for the six regions of country separately. The methodology of calculation was similar as described above. Except nitrogen deposition from atmosphere was added to the input factors. The average of atmospheric nitrogen deposition is six kilogram per hectare per year. On the other hand nitrogen losses from manure during application were not taken into account. The aim of this study was to enhance methodology and reference values for balance calculations at the country scale and its regions. Even though many algorithms

[1] The Agricultural Research Center is, as a separate institution no more in operation.

and reference values are similar – for balance calculation on the country level or on farm level. Therefore the additional knowledge raised in the framework of these pilot studies can be to improve nutrient balance calculation on farm level as well.

The major flaw of nutrient balance calculations on country level just as on regional level is information accuracy about the crops consumed inside the farm, such as non-marketed fodder crops). Looking closely for example on, grasslands, pastures etc. nutrient cycling in different areas varies considerably. In this case nutrients are not leaving farm by crop products, but partly by animal products. At the same time turnover of nutrients from soil to plants and from plants partly to other compartments or ecosystem could happen. Furthermore there are some problems related to the crop residues. Are they removed from the field, e.g. as energy sources or sold out from the farm? Besides, straw incorporation in the soil slows down the nitrogen turnover which has some effect on nitrogen balance, compared with other nitrogen input components. Doing balance calculation on farm level it is possible to evaluate these factors more precisely compared with national or regional balances. Table 7 shows the nutrient balances for the regions “Zemgale” and “Latgale” in 2008 as an example. It becomes evident that relatively “good” balance does not necessarily mean good agricultural performance. In this example the relationship between low input and low output is shown. Zemgale with highest nutrient input and output is a leader for agricultural production in Latvia.

Table 7: Nutrient balance of Zemgale and Latgale region of Latvia in 2008 [kg/ha] by Mr. Aldis Karklins

Parameters	Zemgale			Latgale		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Input						
Mineral fertilizers	49.83	16.51	21.72	9.55	3.02	3.41
Organic fertilizers	5.50	4.01	5.56	5.13	3.62	4.72
Symbiotic N fixation	3.48	×	×	4.32	×	×
Non-symbiotic N fixation	3.62	×	×	4.48	×	×
N deposition	6.00	×	×	6.00	×	×
Seeds and planting material	2.29	0.97	1.39	1.16	0.51	0.77
Total input	**70.72**	**21.49**	**28.67**	**30.65**	**7.15**	**8.91**
Output						
Output	71.51	28.72	69.27	33.33	12.09	36.52
Balance						
Balance	-0.79	-7.22	-40.60	-2.68	-4.94	-27.61
Balance intensity, %	99	75	41	92	59	24

2.5.5 Gross nutrient balances

More recently (after 2008) gross nutrient balances for Latvia, using developed methodology and reference values are calculated by EUROSTAT. For calculations of any type and different scales of nutrient balances as well as for studies of nutrient fluxes in agro-ecosystems the chemical composition of crops is of particular importance. Further, corresponding research by EUROSTAT was ordered in 2012 with the intention to specify nutrient contents of harvested crops and to work out coefficients, which are necessary for nutrient budget calculation. The pilot study focused on the development of scientific methodology and technical solutions for determination of nitrogen and phosphorous content in the harvested crops. Specific factors, such as climatic conditions, production system and management measures have to be considered to ensure the comparability of the results on an international level. The same research was conducted in terms of harvested by-products and crops and their by-products

of national significance. Another important point was the calculation of missing nitrogen and phosphorus content coefficients and re-calculation of existing coefficients, based on the latest scientific research results, as well as conduction of additional researches, if necessary. Besides a comparison of the obtained results with the outcomes of similar experiments, described in studies of other international experts and evaluation of possibilities for their use under Latvian conditions was conducted. As a result reference values of nitrogen and phosphorous content for 81 different crops were developed. For the main crops grown in Latvia a great number of recent experimental data was analyzed. Nitrogen and phosphorous budgets for 2012 and 2014 were calculated using obtained data. The total removal of nitrogen and phosphorous by the main products of crops grown in open field conditions accounted 91274.506 and 86514.331 tons of nitrogen and 32859.718 and 31305.992 tons of P_2O_5 respectively. Some kind of sensitivity analysis was performed showing the share of each crop in the total nitrogen and phosphorus removal Table 8. This means that crops contributing the biggest share in the NP budget are more sensitive to the reference values used in calculations and therefore these values should be updated more frequently. For a number of crops their share in national Gross NP balance is very small. Inclusion of these crops in calculations is only marginal significance. Therefore practical activities about keeping reference values updated and trying to differentiate them according to influencing factors (crop variety, farming intensity, yield level etc.) might be under consideration only for the crops having national importance (the limits or criteria should be defined, e.g. no less than 1% from the possible Gross NP Budget). The list of these crops is clearly restricted and currently for these crops already good data is available. The situation on farm level could be different. Crops with small national level impact might be very important on farm level due to the specialization of the farm. This is the case for example for vegetable growers and horticultural farms.

Table 8: Current share of individual crops in nitrogen and phosphorous budgets in Latvia, [%]; by Mr. Aldis Karklins

Crops, products	Share, % from the total NP budget			
	N		P_2O_5	
	2012	2014	2012	2014
Cereals	44.75	49,70	47.53	53,80
Winter wheat, grain	25.28	11,48	25.24	11,40
Winter rye, grain	2.04	1,98	2.79	2,69
Spring wheat, grain	7.62	23,77	8.06	25,00
Spring barley, grain	4.69	8,55	5.93	10,77
Spring oats, grain	2.35	2,80	2.16	2,57
Buckwheat, grain	1.52	0,17	1.67	0,19
Pulses	0.48	1,52	0.42	1,25
Potatoes	1.68	1,66	1.69	1,66
Industrial crops	9.86	6,61	14.97	9,79
Winter oilseed rape, seeds	6.01	3,17	9.66	5,07
Spring oilseed rape, seeds	3.80	3,38	5.27	4,67
Fodder crops	32.82	31,68	27.12	26,40
Perennial grasses, hay	14.72	11,87	11.51	9,23
Perennial grasses, green forage	15.08	16,62	11.76	12,90
Maize, green forage	2.11	2,61	3.05	3,76
Pastures and meadows	10.18	8,55	7.91	6,61
For hay	5.87	5,25	4.52	4,02
For green forage	4.31	3,31	3.39	2,59
Vegetables	0.35	0,42	0.35	0,42
Orchards	0.01	0,01	0.01	0,01

The quality of reference values depends on number of observations obtained using unified and professionally sound methodology. The development of representative and homogenous data set for all crops grown in Latvia seems to be a challenge in terms of expenses required and possible impact on the final

result of nitrogen and phosphorus budget calculation. The main crops are priority, but question of differentiation of reference values depending on possible influencing factors, such as yield and management level, regional factor and others is under discussion.

The revised reference values were used for fertilizer recommendations published in 2013 and distributed to farmers as a handbook for drawing up their fertilizer plans. All together 26 crops or crop groups was included. Crop nutrient requirement was shown on 20 tables each of them was made by two parts: recommended nutrient supply and corresponding nutrient balance (supply minus removal). If it was possible, a nutrient balance was shown for the respective crop after removal of the main crop only and in comparison a balance was calculated for the case that by-products are harvested as well. Using such an approach potential consequences are pointed out already in the initial stage of fertilizer planning. Thus it can be demonstrated that either the chosen amount of fertilizer at the expected yield level will give the surplus or deficit.

Summary: Status of nutrient bookkeeping in Latvia

There is no strict requirement for farmers to do plant nutrient balances systematically in Latvia. Some of them are doing calculations on voluntary basis using different technical aids, e.g., IT-programs. Part of these programs is commercially developed for planning of different farming activities: crop rotations, fertilizer planning, field history, recourses accountancy etc. In such programs calculation of plant nutrient balances also might be included. Usually the shortage of these programs is a fact that they are developed internationally, are not adapted and validated to the Latvia situation and are not running using our local experimental data. The distribution of them is spontaneous, like other commercial products without professional evaluation.

Methodological framework for plant nutrient balance calculation is sufficiently developed and it is possible to realize it on the routine basis even using very simple (in terms of layout, operation, updating) computer programs. Political initiative, administrative measures and possible developments should be discussed.

2.6 Lithuania

The status of nutrient bookkeeping in Lithuania was presented by Mrs. Dijana Ruzgiene from the Lithuanian Agricultural Advisory Service.

2.6.1 Background information

In Lithuania live about 2 979 000 people on an area of 65 300 km². In 2014 there were 119 202 registered farms in Lithuania and 600 associated agricultural enterprises. The average size of an agricultural holding is about 15.1 ha. Table 9 shows the distribution of land use in Lithuania. Covering an area of 3465.3 thousand hectares (53.1 %) the biggest part is agricultural land followed by forest land (32.5 %).

Table 9: Land use in Lithuania; by Dijana Ruzgiene

Land use	Area [thou. ha]	Percent
Agricultural land	3465.3	**53.1**
Forest land	2123	**32.5**
Other wooded land (bushes)	79.3	1.2
Roads	132.1	2
Urban territory	180.1	2.8
Water	262.5	**4**
Swamps (bogs)	117.2	1.8
Other land	170.5	2.6
Total	***6530***	***100***

2.6.2 General legal requirements

So far there are certain legal requirements to farmers in Lithuania regarding fertilization in general and manure application. They are based on the Nitrates directive and the Water Framework directive.

Concerning the application periods the legislation forbids to apply organic fertilizer on frozen soil, snow covered soil or waterlogged soil. The application of organic fertilizers is allowed during the vegetation period from the 1st of April until the 15th of November. However from the 15th of June to the 1st of August fertilization is only allowed on fallow, meadows, pastures or areas for winter-crop cultivation. It is also compulsory to incorporate manure within 24 hours after spreading.

Furthermore there are compulsory requirements regarding storage capacities for manure and slurry since farmers have to ensure that slurry and manure are stored preventing groundwater pollution as well as surface pollution. The storage capacity has to cover six months at least.

If organic fertilizer (since 2016 and mineral fertilizer as well) is applied on an area larger than 50 hectares fertilization plans have to be drawn up. These plans have to take into account manure specific and site specific conditions as well. Soil specific conditions are for example: soil type and soil conditions but also nutrient storage in the soil, soil-pH and the climate. Crop rotation, aimed yield and additional requirements due to specific land use conditions are also referred to, in preparation of fertilization plans. The records of these fertilization plans have to be kept in a “farm record book”.

The amount of manure which is applied on agricultural land is also restricted. It must not exceed 170 kilogram nitrogen per hectare. Manure left on fields after grazing has to be considered too.

The animal density on agricultural land is limited to 1.7 livestock units per hectare. On farms with higher animal density the area has to be increased or manure surpluses have to be transported to other farms that not exceed this limit.

2.6.2.1 Site specific restrictions for fertilizer application

For certain areas there are additional regulations to prevent nutrient losses from agricultural systems.

There are for example additional restrictions concerning hilly areas. They differ with regard of the slope inclination. If the slope inclination is higher than 5° perennial grass has to cover at least 35-40 % of the total crop-rotation area. On slopes with an inclination from 5-7° the proportion of perennial grass has to be increased up to 50 % or more. Slopes with an inclination of 7-10° demand 65-80 % coverage with perennial grasses. If the slope inclines between 10° and 15° no crop production but the cultivation of perennial grasses is allowed.

Slope inclination is also regarded in additional regulations for protection of surface water. Water protection stripes in general are required along rivers longer than ten kilometers or water accumulations bigger that 0.5 hectares. If the river side slope inclines more than 5° a water protection stripe of five meters is required. The width of the water protection stripe has to be increased up to ten meters if the stream side slope inclines between 5 and 10°. Side slopes inclining more than 10° require a water protection stripe of 25 m.

Figure 11: Karst sinkhole in Lithuania by Dijana Ruzgiene

Besides it is forbidden to drain or plough natural (flooded and dry) meadows and pastures or change their condition and grassland composition by other means. With respect to characteristic features of some Lithuanian regions, protection zones, comparable with protection stripes around karst sinkholes are legally required. The width of these protection zones varies from 5 to 10 m and depends on the type of the karst sinkhole.

2.6.3 Nutrient balances

Nutrient balances are calculated on level of river-basin district. The nutrient balances and the agricultural influence on water bodies are calculated within the river basin district management plans.

The first time river basin district management plans were prepared the Danish mathematical model of water quality - MIKE BASIN was used. The second time another mathematical model - SWAT (US) was chosen.

The model MIKE BASIN is more straightforward than SWAT. MIKE BASIN calculates nutrients in the soil, assimilation by plants, leaching and transport by rivers, whereas SWAT has a stronger focus on agricultural factors. SWAT is designed to simulate a variety of crops, take into account the different crop growing technology and is therefore more detailed.

In both cases the main problem is the same: In Lithuania there is no reliable data on the use of nitrogen and phosphorus fertilizers on farm level. For this reason, all of simulations are based on various assumptions and estimated figures on fertilizer consumption. The amount of applied fertilizers is estimated, regarding the growing plots of the particular crops and research based optimal quantities of nitrogen and phosphorus in crop production. The model assumed that farmers fertilize the recommended amounts. These calculations are the basis of the nutrient balances.

2.6.3.1 Fertilization plans

Second method for nutrient balancing in agriculture is the fertilization plan. It is produced on farm level. Fertilization-plans are based upon the results of soil tests and have to be prepared each year before the fertilization. The individual fertilization plan includes the results of soil tests for nitrogen,

phosphorus, potassium, and pH. Soil sampling has to be repeated every third year. It shows the planned amount of manure or slurry and the expected nutrient demand of the specific crops. In addition it includes a fertilization timetable (in months) and a map of fertilized fields. Fertilization plans have to be available on the farm and shown in case of control.

As already mentioned nutrient balances have been calculated in 2010 for the river basin district management plans. It was estimated for example, with the help of the SWAT model, that the rivers of the territory of Lithuania transported about 31 thousand tons of nitrate-nitrogen, 41 thousand tons of total nitrogen, 602 tons phosphate and 1445 tons of total phosphorus to the Curonian Lagoon. The greatest part of these nutrients originates from agricultural area and pollution of the neighboring Belarus. About 30 % of nitrates and total nitrogen and about 43 % of total phosphorus content of the rivers originated from Belarus. This is especially the case for the river Nemunas. In Lithuania 53 % of nitrogen load and 37 % of phosphorus load have their origin in agriculture. About 12 % of total nitrogen and 9 % of total phosphorus are of natural origin.

The Lithuanian Ministry of Agriculture signed up a new regulation which is to be implemented in 2016, for farmers, who participate in the Rural Development Program. This new regulation will oblige these farmers to calculate nutrient balances on farm level. A new methodology is just being prepared. It is based on the identification of input and output of nitrogen, phosphorus and potassium on the farm. The calculation-method takes specific grain production, mineral fertilizers, livestock feed and various fodder additives into account as input to the farm. A period of twelve months is recorded. Farm- and site-specific aspects such as precipitation, nutrient content of the soil (N, P, and K) and nitrogen fixating plants are considered as well. The farm-specific nutrient output is calculated, considering harvested crops and livestock production.

Nutrient balances can be positive or negative. Satisfying, countrywide nutrient-balances can only be achieved involving the farmers and thus implementation of efficient nutrient use in the daily life of the farmers.

2.6.4 Implementation

As part of training programs, approved by the ministry of agriculture, the Lithuanian Agricultural Advisory service organizes many seminars about nutrient management every year. About 15 000 farmers participate these seminars every year. Especially in drawing up the fertilization plans and introducing nutrient accounting on farm level there still is a high demand for advisory services. Thus the farmers can be involved in the process and use nutrient accounting to improve nutrient management on farm level. There is also need to improve the exchange of data and knowledge of the involved organizations. The economic effect depends on the current price of nutrients, but it is clear that more efficient use of nitrogen and other nutrients induces also economical benefits for the farmers. The Lithuanian Ministry of Agriculture in partnership with Lithuanian Agricultural Advisory Service has started the development of new methodology to establish nutrient balance calculation on farms.

Summary: Status of nutrient bookkeeping in Lithuania

The legal background for fertilizer application in Lithuania defines an application period from the 1st of April until the 15th of November to prevent nutrient losses from agricultural systems. In order to avoid nutrient emissions into surface water site specific buffer stripes are mandatory.
So far nutrient balances have been calculated only on the level of river basin districts. The calculation of nutrient balances is difficult, because there is no reliable database for all required data.
The Lithuanian Agricultural Advisory service promotes nutrient balancing on farm level with the support of the Ministry of Agriculture.

2.7 Poland

The status of nutrient bookkeeping in Poland was presented by Karina Makarewicz, Tamara Jadczyszyn and Łukasz Wojcieszak from the Ministry of Agriculture and Rural Development , The Institute of Soil Science and Plant Cultivation - the State Research Institute and the Institute of Technology and Life Science.

2.7.1 Background information

In Poland agricultural land covers 15.5 million hectares and thus 49.6 % of the country area. 88% of agricultural land is utilized by individual family farms. Nearly 40 % of the population lives in rural areas (14,9 million). Poland is characterized by the large share of soils of limited suitability for agriculture. The agricultural land composes of 30 % of very acidic soils and 60 % - are sandy soils. Additionally agriculture has to be adapted to limited precipitation with an average level of 550 millimeter per year and a relatively short vegetation season of 200 up to 230 days per year. The average farm area in Poland is shown in Figure 12.

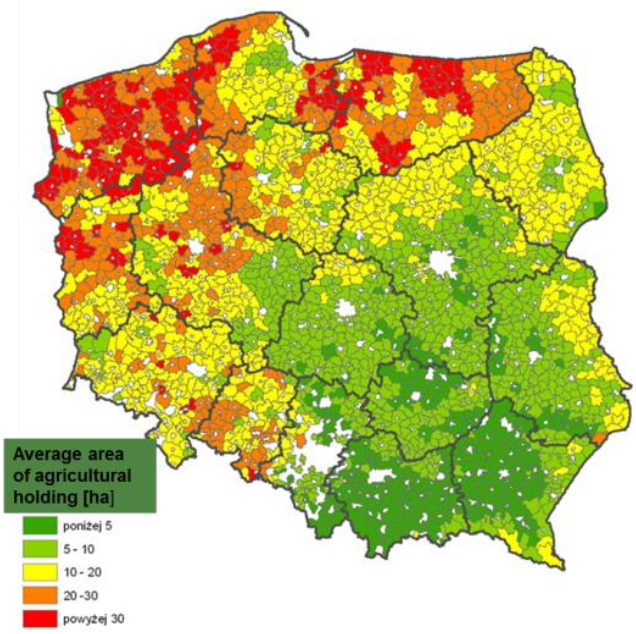


Figure 12: Average farm area in Poland, in hectare

Poland is a country with a strong agricultural heritage. Polish agriculture is based on family farms. They are regionally diverse, in particular in terms of their size, structure, economic, social and environmental functions. The average size of farm in the north of Poland is ca. 18 hectares, whereas in the south it is less than 4 hectares. Small farms (between 1 to 5 hectares) represent over 55% of the total number of farms and hold ca. 20% of the agricultural land. They played an important role in the economic transition, making the structural adjustment of the economy easier and reducing social costs of system transformation. Today, small farms perform also important public function, making rural areas viable.

2.7.2 Legal background

The relevant legislation concerning nutrient application is the “National Act on Fertilizers and Fertilization” to implement the Nitrates directive, and Cross Compliance regulations. Additionally the Act on Rural Development provides voluntary schemes to improve nutrient management. The new rural development plan includes measures to reduce nutrient load in waters. New agri-environmental measures and climate measures contribute to the reduction to nitrogen and phosphorus directly:

Package 2 Soil and water protection - appropriate agronomic practices (including intercrops , rational fertilization based on fertilizer plan), Package 1 Sustainable Agriculture, Packages 4 and 5 - Valuable habitats and endangered species of birds in Natura 2000 sites, valuable habitats outside Natura rational management of minerals and reduce their losses.

These agri-environmental measures demand fertilizer application with reduced emissions among other requirements. In Nitrate vulnerable zones investments to enlarge farm specific storage capacities for manure and to enhance fertilizer application techniques are required. The control of the Law on Environmental Inspection/Water Law, the Act on Fertilizing and Fertilizers and the Action program Nitrates Directive is conducted by the responsible authorities.

Limits for the concentration of total nitrogen (TN) and total phosphorus (TP) in rivers are already given by the Water Framework Directive environmental goals and are vital for the reduction of discharges of N and P. Therefore they should be the starting point for all planning work in water management and water protection within the Member States, including the Baltic Sea countries. Regarding the thresholds for nitrate and phosphorus given by the Water Framework directive, the Vistula river and the Oder river have already achieved so called good environmental status (GES).

2.7.3 Calculation methods

In terms of calculation methods as well as tools for nutrient balances, there have been several approaches to enhance the implementation of nutrient balancing in agricultural practice. There are several IT-tools to support farmers improving their nutrient management. Rural extension services use field balances to deduce recommendations for fertilizer application. Nutrient balances on farm scale are an essential advisory-tool to evaluate farm specific nutrient management. Therefore the IT program and decision support system “MACROBIL” has been developed to enhance the efficiency of nutrient management. Fertilizer dose is calculated on the basis of soil surface nutrient balance. Calculating soil surface balances, mineral fertilizer, manure, further purchased organic fertilizer, additional by-products incorporated into the soil, biological nitrogen fixation by leguminous crops and atmospheric deposition are summed up as input. The output includes all nutrients that are removed from the fields in form of plant products. Sub-models calculate specific parts of the nutrient balance, such as manure production, biological nitrogen fixation, and nutrient removal considering standard values. The sub-model calculating for example the amount of manure requires submission of the number of animals, the animal housing system and the grazing period. Nitrogen losses in the stable and in the storage are considered.

Farm gate balances are calculated considering a different model. Figure 13 visualizes input and output taken into account drawing up a farm gate balance. In general nutrients which are brought onto the farm are considered as input. These consist mainly of mineral fertilizer, purchased fodder, bought animals, nitrogen fixed by legumes, atmospheric deposition and biological fixation by non-symbiotic microorganisms. Plant products, animal products and animals leaving the farm are summed to calculate the output.

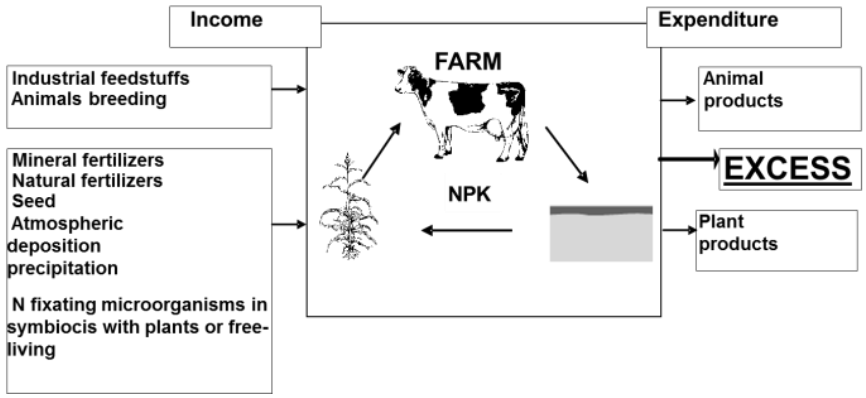


Figure 13: Overall concept of nutrient balancing on farm level

Table 10 shows the applied standard values for nutrient contents of some organic fertilizers.

Table 10: Examples for standard values of nitrogen (N), phosphorus (P) and potassium (K) contents in various types of organic fertilizers; in Poland

Fertilizer	N	P	K
	kg ·dt^{-1} (%)		
Manure from cattle - in general	0,47	0,122	0,537
Manure from pigs - in general	0,53	0,205	0,570
Manure from horses	0,54	0,127	0,785
Manure from sheep	0,76	0,175	1,033
Urine from cattle - in general	0,32	0,013	0,661
Urine from pigs - in general	0,28	0,017	0,339
Urine from horses	0,47	0,002	0,463
Slurry from cattle - in general	0,34	0,087	0,306
Slurry from pigs - in general	0,43	0,144	0,190

More detailed information on calculation methods and standard values are given online, for example in publications within the “balticsea2020” project. The guidelines for “Self-evaluation of farms for improved nutrient management and minimized environmental impact” have been published to support farmers improving their nutrient management.

The final version of this chapter has been amended by the Ministry of Agriculture and Rural Development.

Summary: Status of nutrient bookkeeping in Poland

The relevant legislation concerning nutrient management in general and fertilization especially is the “National Act on Fertilizers and Fertilization”. Furthermore there are several agri-environmental measures that promote environmentally friendly agriculture with participation on voluntary basis

Farmers have an elaborated IT program at their disposal which enables them to calculate nutrient balances considering specific conditions and circumstances.

2.8 Russia

The presentation on the status of nutrient bookkeeping in Russia was prepared by Mr. Minin. As Mr. Minin from the institute of agro-engineering and environmental problems of agricultural production himself could not attend the workshop Mr. Frank-Kamenetsky presented the nutrient bookkeeping in Russia at the workshop.

2.8.1 General introduction

Deduced from its original meaning in economic-sciences “balance” signifies an equilibrium, considering income and expenses. A nutrient balance on the other hand is a general indicator including various components. Three types of nutrient balances are differentiated. The first approach is to calculate a nutrient balance for an individual field or on a larger scale for an ecosystem. The second kind of nutrient balance, a farm-gate balance takes the whole farm into account and thus might also include nutrients from livestock production. Additionally nutrient balances can be calculated for larger areas, such as certain regions, districts or the whole country. Nutrient balances for larger areas usually include a combination of the two first previously described approaches. In Russia the first and the third approach are mainly conducted. The calculation is an indispensable tool to evaluate nutrient management and nutrient flows for all kinds of institutions concerned with monitoring of soil fertility, such as government centers, regional stations and agrochemical services. Balance calculation is recommended to farmers, but is not mandatory.

2.8.2 Previous implementation

In the year 2000 general methodological guidelines how to determine nutrient balances for nitrogen phosphorus, potassium, calcium and humus were published. They aimed to ensure the governmental control over formation of soil fertility and to provide the necessary background for the development of measures for its conservation and improvement. Figure 14 shows the most important factors, which are required to calculate a field balance, according to the guidelines.

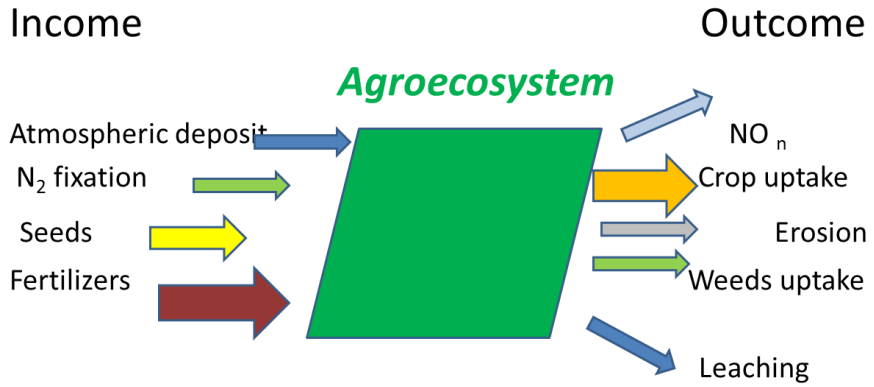


Figure 14: Essential factors assessing input and output of agroecosystems by Mr. W. B. Minin

It becomes evident, that mainly data which is already provided by farm specific accounting documents is needed to calculate a field balance, such as purchase of mineral fertilizer or seeds and sale of agricultural products. The assessment of further parameters, as for example weeds uptake or biological nitrogen fixation, on the other hand provides more difficulties. Nitrogen input due to non-symbiotic nitrogen fixation or precipitation for example, can contribute from ten or fifteen kilogram nitrogen per hectare to the nitrogen input. Leguminous nitrogen fixation can even amount up to 80-120 kilogram nitrogen per hectare.

Several tables are added to the guidelines, which offer standard values to estimate for example nitrogen input owing to nitrogen fixation, input of nitrogen and phosphorus via precipitation and extraction of nutrients from the field by erosion or other losses.

The first version of nitrogen and phosphorus balancing was developed between 2008 and 2009 by the institute of agro-engineering and environmental problems of agricultural production. This calculation method for nitrogen and phosphorus balances is based on information on the amount of slurry and manure in the respective area. The results confirmed that manure and slurry from livestock production could be used to fertilize the present area of agricultural land.

On request of the Committee on Agriculture and Fisheries of the Leningrad region the institute (IAEP) conducted a detailed study regarding the distribution of livestock and poultry farms, the amount of arising manure and agricultural area. The assessed data provided the necessary background to draw up a map, showing the distribution of nitrogen and phosphorus in the regional districts in correlation with the agricultural area. Figure 15 shows the results of the study. Further analysis of the results showed that in the Vyborgsij and Kirovskij regions nutrient surpluses, according to the upper limit of 170 kg nitrogen from manure, could be determined. The location of these areas is shown in figure 16.

Currently there has been a route network developed to transport manure and slurry into neighboring

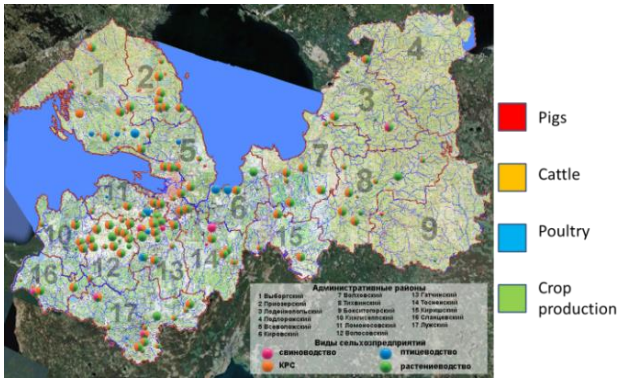


Figure 15: Farm distribution in the Leningrad region; according to results of IAEP research

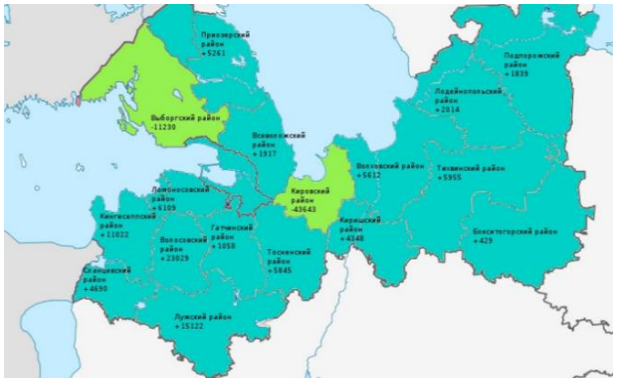


Figure 16: Areas with nutrient surplus according to the upper limit of 170 kg N/ha

regions. 2013 and 2014 additional costs for transport of manure into other regions were compensated by the government.

Table 11 shows exemplary the farm gate balances of an individual dairy farm and a meat cattle farm for nitrogen and phosphorus in 2011 and 2012.

Table 11: Farm-gate balances for individual milk farms and meat cattle farms in 2011 and 2012 in Russia, calculated by IAEP

Indicators	Dairy farm		Meat cattle farm	
	2011	2012	2011	2012
Nitrogen				
N_{ef} (output/input)	0.27	0.34	0.21	0.21
N surplus (N input-N output) kg/ha	29.5	41.9	48.3	57.6
Phosphorus				
P_{ef} (output/input)	0.2	0.26	0.2	0.25
P surplus (P input-P output) kg/ha	20.10	16.00	12.24	11.14

There are several measures which are considered necessary to reduce regional and field specific nutrient surpluses and avoid nutrient emissions from agriculture into the Baltic Sea. As one step it is proposed to develop common Baltic guidelines how to calculate nutrient balances in agriculture to obtain comparable results. Additional studies are needed to assess data which is not provided by the farms accounting documents, such as nitrogen fixation, denitrification or leaching under determined conditions. Consistent standard values for different kinds of manure or nutrient contents of agricultural products would be also helpful.

Summary status of nutrient bookkeeping in Russia

A standard method to calculate nutrient balances has been developed in Russia to obtain nationwide comparable results. An important future task will be the improvement of standard values. Even though farm specific nutrient balancing is recommended, it is not mandatory so far.

Nutrient balances have been calculated for single districts of Leningrad region and the results showed that there are two districts with nutrient surpluses according to the HELCOM requirements.

A standardized method to calculate nutrient balances, including results of additional studies of nitrogen fixation, denitrification and leaching coefficients under determined conditions, for applied in all Baltic Sea countries is needed to produce comparable results in the Baltic Sea regions.

2.9 Sweden

Mr. Rune Hallgren from the association of Swedish farmers presented the status of nutrient bookkeeping in Sweden.

2.9.1 Background information

In Sweden the losses from agricultural land due to cultivation of cash crops and livestock production are estimated to make up half of the nitrogen and phosphorus loads from land to water. Since Sweden joined the European Union in 1995 the Nitrates directive and the Water Framework directive changed the legal background for water protection. Nevertheless the Swedish government agreed a specific mitigation program to deal with nutrient losses from agricultural land already in 1988. Tightened legislation is one of the milestones in this program. Sweden started early to implement regulations for water protection and has still some of the strictest regulations in the European Union.

2.9.2 Legal requirements

One of the most important points is the countrywide limit of phosphorus application. It is recommended not to exceed the amount of phosphorus withdrawal by harvest, by phosphorus application. The upper limit for phosphorus application from manure is 22 kg of phosphorus per hectare and per year in average for the whole available spreading area.

There are additional regional regulations, which for example prohibit the application of manure from November until February. In southern Sweden at least half of the soil has to be covered by vegetation in winter to prevent nutrient leaching into ground water. Mandatory storage capacities for manure sufficient at least for six months are another important measure to ensure that demand driven nutrient supply of the crops is not exceeded by fertilizer application and thus to prevent nutrient losses from agricultural systems. The demanded storage capacity can be prolonged up to ten months depending on livestock density and livestock production system. Applied manure has to be incorporated at latest four hours after application in southern Sweden to reduce gaseous nitrogen emissions. Another measure to reduce ammonia losses is the mandatory cover of storage containers.

Buffer zones along surface water as well as compulsory training and documentation intend to prevent pesticides entering surface water. In 2000 the agri-environmental advisory program “Focus on nutrients” started. “Focus on nutrients” is a cooperative project, including the Swedish board of agriculture, the county administration boards, the federation of Swedish farmers and several agricultural companies.

2.9.3 Implementation

Nutrient balances are mainly calculated to evaluate the status quo of farm specific nutrient management in rural extension services and to show any progress improving the nutrient efficiency. Within the rural extension services in Sweden, there are approximately 5000 on farm advisory visits every year. About 46 % of all these advisory visits are made to calculate nutrient balances. On these occasions farm gate balances are calculated just as well as field balances.

The farm gate balance opposes nutrients coming to the farm and nutrients leaving the farm. The farm specific input is calculated summing up nutrient input from animals, fodder, seeds and other planting material, mineral fertilizer, manure or slurry, biogas digestates, other organic waste products, sewage, symbiotic nitrogen fixation and atmospheric deposition. The output considers animals, animal products, dead animals, sold manure and fodder and yield of cash crops. On farms without livestock production the farm balance equals the sum of the individual field balances. Figure 17 visualizes the calculation of a farm gate balance according to CHRISTER NILSSON (Baltic Deal Seminar 2013).

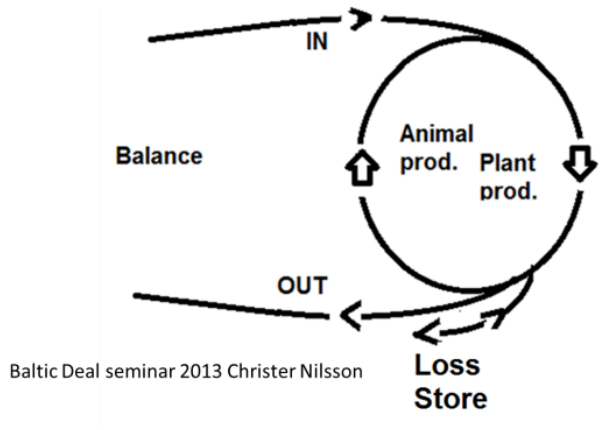
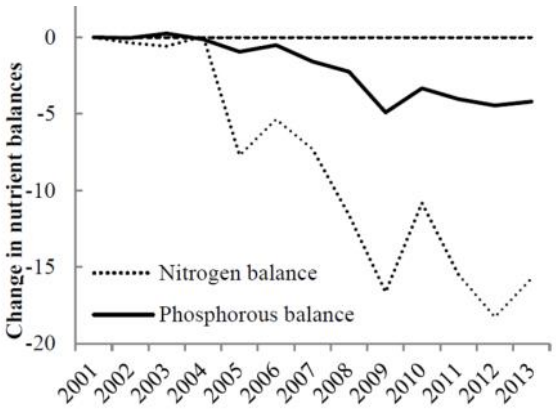


Figure 17: Calculation of a farm gate balance, according to Christer Nilsson; Baltic deal seminar; 2013

The farm gate balance gives an impression of the farm specific nutrient efficiency. It shows how much nutrients have been utilized in the respective production systems and the amount of nutrients that has been lost either due to leaching, gaseous emissions, evaporation or fixation in the soil. Farm gate balances as well as soil surface balances should be calculated for several years successively to be able to evaluate the results. Thus sufficient data is assessed to take into account long term nutrient fluxes on the farm and estimate the influence of year specific weather conditions.

If the balances show a high surplus for several years in a row, further inquiries concerning the farming practice is necessary not only to avoid excessive nutrient losses into other ecosystems, but also to reduce financial losses for the farmer due to superfluous fertilizer purchase. There are no legal consequences depending on the results of nutrient balances, as they are primarily a counseling tool. Reductions of surpluses in nutrient balances are not necessarily a direct indicator of reduced losses to the environment, but they show that agricultural production is becoming more efficient. Reduced surpluses are often a result of unchanged or increased harvests or increased livestock production, combined with reduced input of plant nutrients in the form of mineral fertilizer and feed.

The average surplus in the most recent balances was 41 kg nitrogen per hectare on crop farms, 130 kg nitrogen per hectare on dairy farms, 87 kg nitrogen per hectare on pig farms and 108 kg of nitrogen per hectare on farms with beef cattle. The risk of nitrate leaching, ammonia and nitrous oxide emissions, as well as phosphorus losses declines when the nutrient surplus is reduced. On the same type of soil, nitrogen leaching is generally relatively limited on a dairy farm while it can be more extensive on a crop farm or even greater on a pig farm with a high share of potato cultivation. All types of farm that handle manure have considerable nitrogen losses in the form of ammonia, whereas such losses are often negligible on crop farms. So far surpluses have declined because of reduced input of plant nutrients with mineral fertilizers (primarily on dairy farms) and fodder (mostly on pig farms). On crop farms and pig farms, removals of harvested products have increased significantly, which improved the efficiency. Purchases of mineral fertilizers could be reduced through better utilization of manure combined with improved fertilizing techniques and adaptation of fertilizer doses to the preceding crop. Reduced input of feed can be explained by better matching of feed rations to animal needs, improved utilization of the farm’s own grasslands and less feed waste.



Advisory services for nutrient utilisation. AgriFood Economics Centre Working Paper nr 2015:1.

Figure 18: Changes in nutrient balances in Sweden from 2001 until 2013

Figure 18 shows the changes in the nitrogen and phosphorus balances in Sweden from 2001 to 2013. The decreasing trend of nitrogen balances as well as phosphorus balances in the last ten years is remarkable. Nonetheless a closer look how to reduce phosphorus balances is necessary for further reduction.

All in all Nutrient balances according to the current system are comparatively easy to calculate. Nevertheless they are relatively accurate. The gained knowledge concerning nutrient fluxes enables the assessment of the efficiency of agri-environmental measures.

In addition to the utilization of nutrient balances in rural extension services it has been considered to extend the implementation and introduce mandatory “emission caps” for farms. The Federation of Swedish Farmers however considers the uncertainties in the determination of the input factors as too significant to use upper limits for nutrient balances for the development of control measures for legal requirements.

Summary. Status of nutrient bookkeeping in Sweden

Nutrient balances are considered a feasible and satisfactory tool to observe trends and efficiency in crop production and livestock farming. So far nutrient balances are calculated voluntarily within rural extension services, as the assessment of some factors is too inaccurate to use the results as a mandatory regulation or control measure. Evaluating the results it has to be considered, that surpluses do not necessarily lead to nutrient emissions into water, atmosphere or other ecosystems.

The project “Focus on nutrition” has led to considerably improved nutrient management on farms and better economic benefits as well as decreased nutrient emissions from agricultural land into the Baltic Sea.

3 Results of the workshop

The following table gives an overview of regulations for nutrient management in the Baltic Sea countries.

Table 12: Overview „Nutrient regulations in the Baltic Sea countries

Country	Nutrient accounting	Fertilization plan	Crop specific nitrogen application level	Field specific documents	Centralized database	Limits for nutrients from livestock	Regulatory for application of organic fertilizers
Denmark	x	x	x		x	x; 170 kg N ha^{-1}	x
Estonia		x >300 LU		x		x; 170 kg N ha^{-1}	
Finland		x in AES	x	x in AES		x; 170 kg N ha^{-1}	x
Germany	x	x from 2016	x from 2016			x; 170 kg N ha^{-1}	x
Latvia		x in NVZ	x	x	x in NVZ from 2016	x; 170 kg N ha^{-1}	x
Lithuania		x >50 ha				x; 170 kg N ha^{-1}	x
Poland		x*	x	x		x; 170 kg N ha^{-1}	x
Russia							
Sweden		x in NVZ				x; 22 kg P ha^{-1} 170 kg N ha^{-1}	x

*farms with intensive livestock production (40000 posts poultry, 2000 posts pigs, 750 posts cows) and in NVZ if >100 ha

**For livestock productions when manure has a high content of phosphorus (all animals but cows) the limit is 140 kg N ha $^{-1}$

AES → Agri-environmental scheme

3.1 Answers to the key questions

The key questions which have already been described in the introduction shall be picked up in this part of the report to lead through the results.

3.1.1 What is the status of nutrient bookkeeping in the HELCOM-member-countries?

In the EU-member countries the Water Framework Directive and the Nitrates Directive give a common legal background for regulations towards water protection. However the workshop highlighted once more the great variation between the agricultural conditions in the individual Baltic Sea countries and thus the differences in the necessity to regulate agricultural nutrient management. This is one of the reasons why methods and current implementation of nutrient bookkeeping diverge that much.

Furthermore the agricultural background influences the requirements to nutrient bookkeeping considerably. On the one hand nutrient bookkeeping is needed mainly as an advisory tool to improve the efficiency of applied fertilizer. This is the case if fertilizer is one of the limiting factors in crop production. On the other hand nutrient bookkeeping is needed to detect excessive or inefficient nutrient application, if the availability of cultivated land restricts agricultural production.

To complicate the production of comparable results after nutrient bookkeeping, the development of nutrient bookkeeping methods is always a balancing act between consideration of farm or even sites specific circumstances and comparable results by standardized methods and data.

3.1.2 Which are the main obstacles to promotion of nutrient bookkeeping?

As a result of the workshop several aspects could be identified as main challenges introducing nutrient bookkeeping on farm level. The following discussion shows that the identified issues often interact and which complicates the development of a holistic approach. An improved cooperation of the involved parties for example could promote the availability of reliable data or compensate deficiencies concerning the legal background.

3.1.2.1 Legal background

Getting an overview of nutrient bookkeeping all Baltic Sea countries, it became obvious that the present legal background does not succeed in satisfying introduction of nutrient bookkeeping in farming practice if implementation on a voluntary basis is hindered. Specific knowledge of motives for decline of nutrient accounting is essential to deal with these issues successfully.

For once reluctance of towards nutrient accounting can be based on a lack of awareness of the farmers of the advantages of nutrient accounting in terms of increasing farm specific nutrient efficiency and thus often creating economic benefit for the farmer. In this case intensification of rural extension services and improvement of accounting methods could be promising approaches.

High nutrient surpluses in farm gate balances or in field balances can also originate from economic demands. This situation occurs for example if crop specific quality demands require high nutrient input compared with the output or in case of high regional livestock densities leading to high abundance of organic fertilizer. These reasons for nutrient surpluses require other strategies than the issues described previously. In this case feasible regulations to restrict nutrient application might lead to reduced emissions and reduce economic disadvantages of more sustainable practices.

3.1.2.2 Available data

The lack of reliable data is a further issue towards the implementation of nutrient accounting. On the one hand there are uncertainties concerning the variation and thus the reliability of standard values or sampling methods, on the other hand there is often insufficient data specifying on farm used crops, for example in case of fodder production. Nevertheless these knowledge gaps could be closed by focused research after the main questions have been specified. Up-to-date standard values would also increase the trust of the appliers to the obtained results and thus support further distribution of nutrient accounting in practice.

More data is also required looking at site specific or regional target values for nutrient sur-pluses in sustainable agriculture. These enable the farmer or advisory services to evaluate the achieved results of farm specific nutrient balances. This is of great importance, as low balances and low nutrient emissions do not always correspond. Thus the balances of grazing cattle for example can be higher than the nutrient balance of intensive silage maize production, even though nitrate leaching into groundwater is lower from grasslands. In consequence specific target values are needed that enable the farmer to evaluate the results of his field balances according to their actual environmental impact.

To conduct further research as efficiently as possible, intensive cooperation to clarify responsibilities and to join already existing results is required.

3.1.2.3 Cooperation

The participants of the workshop also identified the necessity to improve the cooperation within the involved parties, especially since manifold, highly varying interests have to be considered. Nevertheless if interdisciplinary approaches are required, as it is the case in water protection, a high level of cooperation is essential to develop sustainable measures. The will to change the current situation implies the awareness of the problem. Increasing awareness of the problem and thus willingness to

change the current situation is therefore a vital step towards successful cooperation. Previous observation indicated that cooperation to promote environmentally friendly agriculture on small scales, dealing with specific regional matters is often easier than finding answers to fundamental questions.

3.1.2.4 Inconsistent methodology

A further obstacle to satisfying implementation of nutrient accounting in all the Baltic Sea countries, are differences in the used methodology to assess nutrient surpluses. These variations prohibit a comparison of the results and impede a common definition of target values or upper limits for nutrient surpluses.

The introduction of a common “Baltic method” of nutrient bookkeeping in contrast is complicated by already implemented nutrient accounting in some countries or regions and would therefore require an adaption of calculation methods or increase the required efforts towards environmentally friendly agriculture greatly.

Considering the need of comparable results to find the balance between consideration of regional conditions and common standard values as well as methodology will be a challenge in the process towards the implementation of nutrient accounting in all Baltic Sea countries.

3.1.3 Which steps will the countries be able to take within the next two years?

Some of the identified challenges can be tackled efficiently in the short term, because they can be adapted according to country specific requirements, or even consider already known regional needs for action.

An important step would be the **harmonization of standard values**. Additionally to providing a more reliable data base for nutrient accounting this measure would identify the need for further research. Standard values for manure excretion, nutrient contents in manure and nutrient uptake of crops are especially urgent do determine or to upgrade.

Even though a consistent method of nutrient accounting over all Baltic Sea countries will hardly be achieved in the next two years, the development of **concepts for monitoring** on farm level and the calculation of regional balances could help to identify hot spots of nutrient surplus and thus indicate urgent need for further actions.

Even though changes of the legal background and implementation of compulsory nutrient bookkeeping is regarded as a long term goal, **voluntary nutrient accounting can be promoted** further on. Stronger focus of rural extension services on efficient nutrient management could reduce surpluses especially if a lack of knowledge or awareness is the reason for nutrient emissions. These measures could be combined with varying kinds of other activities, depending on the specific conditions. Possibilities to increase the awareness are for example materials for teachers or information events.

3.2 Intended activities

To foster the increase of nutrient efficiency and reduction of nutrient fluxes into the Baltic Sea further measures and activities are required.

The intensified exchange of already gathered knowledge in the different Baltic Sea countries could forward the efforts towards the reduction of nutrient surpluses in agricultural systems considerably. The purpose of the enhanced dialogue between regions with similar conditions and challenges is mainly the reduction of the workload in the individual regions, but also helps with the creation of new ideas and the generation of possible solutions. Characteristics to classify the regions could be environmental conditions, economic background as well as agricultural production. With focus on solutions for regional challenges reducing nutrient surpluses a list of examples with successful measures or strategies could be made available for the involved parties.

Common definitions for the used terminology are needed to facilitate the exchange of knowledge. Especially a cleared definition of basic terms such as accounting, bookkeeping, balancing and planning is necessary to forward the cooperation between different institutions and countries.

It is planned to set up a list with examples for existing, successfully implemented nutrient bookkeeping, which is to be made available for everyone involved. Thus good regional practices can be shown and encourage others by useful suggestions. Furthermore results and reports of projects should be published additionally in English to enhance the international knowledge exchange between the HELCOM members.

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