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MEDITERRANEAN ACTION PLAN

MED POL

GUIDELINES FOR THE APPLICATION OF BEST ENVIRONMENTAL PRACTICES (BEPs) FOR THE RATIONAL USE OF FERTILISERS AND THE REDUCTION OF NUTRIENT LOSS FROM AGRICULTURE FOR THE MEDITERRANEAN REGION

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- Curbing Pollution
- Safeguarding Natural and Cultural Resources
- Managing Coastal Areas
- Integrating the Environment and Development

FOREWORD

The riparian States of the Mediterranean Sea, aware of their responsibility to preserve and develop the region in a sustainable way, and recognizing the threat posed by pollution to the marine environment, agreed in 1975 to launch an Action Plan for the Protection and Development of the Mediterranean Basin (MAP) under the auspices of the United Nations Environment Programme (UNEP) and, in 1976, to sign a Convention for the Protection of the Mediterranean Sea against Pollution (the Barcelona Convention). The Convention entered into force in 1978 and was amended in 1995.

Recognizing that pollution from land-based activities and sources has the highest impact on the marine environment, the Contracting Parties to the Barcelona Convention signed in 1980 a Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (LBS Protocol). The Protocol entered into force in 1983 and was revised in 1996 to better cover industrial pollution sources and activities and to enlarge the coverage to include the hydrologic basin.

A Strategic Action Programme (SAP MED) to address pollution from land-based activities, which represents the regional adaptation of the principles of the UNEP Global Programme of Action (GPA) to address land-based pollution activities, was adopted by the Contracting Parties to the Barcelona Convention in 1997 as a follow up to the provisions of the revised LBS Protocol. The SAP MED identifies the major pollution problems of the region, indicates the possible control measures, shows the cost of such measures and establishes a work plan and timetable for their implementation.

In order to assist the Mediterranean countries in the long-term implementation of the SAP MED, particularly in the formulation, adoption and implementation of National Actions Plans (NAPs), a three-year GEF Project “Determination of priority actions for the further elaboration and implementation of the Strategic Action Programme for the Mediterranean Sea” was implemented by MAP, and in particular by the MED POL Programme, the MAP Regional Activity Centres and WHO/EURO. The project consists of numerous activities which include, among others, the preparation of regional guidelines and regional plans, whose main aim is to guide and assist countries to achieve the pollution reduction targets specified in SAP MED.

The present document is part of a series of publications of the MAP Technical Reports that include all the regional plans and guidelines prepared as part of the GEF Project for the implementation of the SAP MED.

TABLE OF CONTENTS

1. INTRODUCTION AND SCOPE OF THE GUIDELINES

1.1 Setting the Problem

Agriculture in the Mediterranean Action Plan (MAP) countries[(1)] encompasses a very wide range of situations from the production point of view, but also from the environmental point of view. From the Mediterranean word it could be understood that a common features of these countries is a Mediterranean type climate[(2)]; however this is not true because, for instance, large parts of France have an Atlantic type of climate and the southern fringe of most MAP countries have a desert climate. For simplicity we will focus on the areas of these countries with a Mediterranean climate or similar although most of the Best Environmental Practices (BEPs) retained could be applied in other areas.

In broad terms in all of these countries agricultural production is limited by water scarcity (Annex 2) even though some places have temperature limitations like the Pyrenees and some other are high mountains. Being very few places with optimum moisture and temperature conditions, highly productive agriculture relays in irrigation (Annex 1 and 3) in most cases.

The massive use of water for irrigation in MAP countries gives to the water issue a different dimension than to northern European countries, where irrigation[(3)] is marginal. Water balance presents a higher deficit in the MAP countries where less water resources are available; this makes more difficult to achieve certain environmental goals (wetlands, nitrates in groundwater, etc) and make even more critical the nutrient losses from agricultural activities.

Land degradation processes are also specific for MAP countries. Although desertification –a poorly defined and understood processes– deserves a top position in the media and political arena, individual processes like erosion, soil organic matter depletion, salinization, compaction and land use changes are the real driving forces of land degradation and they should be considered in the first place when a set of Best Environmental Practices (BEPs) for fertilizers is tried on.

Spatial concentration of fertility is one of the prerequisites for the development of productive agriculture. The replenishment of nutrients has been a challenge for all agricultural systems; a wide variety of techniques has been used, always adapted to the local conditions, and in fact ancient civilizations have evolved near the large rivers where a natural system of replenishing the soil fertility existed (i.e. the floods of Nile river). Only late in the XIX century and beginning of XX, but mostly after 1950, the problem of soil nutrient shortage was solved, making possible a dramatic increase in yields.

The agricultural systems are very much different among countries. In the most economically developed of those (Italy, Spain, France, Israel, Greece) the most industrialized systems exists, with high inputs of fertilizers and pesticides and areas with high animal density; in some others (Syria, Albania, Algeria, Morocco, etc.) the extensive agriculture is prevalent, with minor inputs of fertilizers and also concentrated animal husbandry has a minor extent (Annex 4 and 5). However extensive systems with very little fertilizers inputs are quite common in large areas of almost all MAP countries and also large horticultural and/or glasshouse developments occur in the less developed countries.

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(1) MAP countries include Albania, Argelia, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Lybia, Malta, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey.

(2) Mediterranean type climate may be defined as a rainfall limited climate with enough temperature for growing crops in most parts of the year. The most typical feature is a dry period in summer and a rainy period in winter.

(3) Irrigation has a different meaning in northern Europe and Mediterranean countries. In the first cases only supplementary irrigation is applied; in the last large amounts of water are needed.

Agricultural systems[4] are dynamic in nature and in fact are the result of the continuous adaptation to socio-economical changes. Land stewardship is only possible in well established agricultural system, where land managers are conscientious of their role of maintaining a high quality of land; quick evolving, poorly productive agricultural systems, where soil is used as the ultimate resource to survive or to face high productivity standards to cope with raising standards of living in other activity sectors, draining human resources from agriculture, lead very often to the degradation of the land.

Losses of nutrients from fertilizers used in agriculture to the environment have produced impacts in several parts of the ecosystems (See 2. Main environmental…). There is clearly need for a better use of agricultural fertilizers. We use “fertilizers” in a wide sense, encompassing all the materials containing plant nutrients used in agriculture: mineral fertilizers and organic manures. We focus in N and P because are the anthropogenic nutrients with more impact in ecosystem (natural and managed).

A set of Best Environmental Practices (BEPs) should be based in a rational use of fertilizers and should aim:

A- Maintain/increase agricultural production

Several of the MAP countries are not self-sufficient in basic agricultural products (Annex 7); in such situation marginal land prone to degradation is cultivated.

Maintaining high productivity in the best soils will save land for environmental enhancement and other functions of agriculture. For most agricultural species final production is related directly to the amount of water (evo) transpired by the crop; such relation was first depicted by de Wit (1992). Proper crop management (weed control, timing of agricultural operations…) but especially nutrient management improves such relationship.

So from many point of views (economic, social, environmental.) achieving and maintaining good soil productivity, which only is possible with the use of fertilizers which return to the soil the nutrients exported by the crops, is the best situation.

B- Minimize losses to the environment (soil, water and air) helping to improve environmental quality

Nutrients from different materials containing fertilizers used in agriculture can be lost to the environment. Some of these losses are unavoidable because the system is intrinsically inefficient, being called inevitable losses; under current technology it is not possible to decrease them under a certain threshold.

The risk of losses is even larger under agricultural systems with erratic rainfall or poor agricultural management.

Also they will improve environment through:

- Use of agricultural by products as a fertilizer.
- Use of urban and industrial wastes as a sources of nutrients for plants and organic matter to restrain soil fertility.
- Carbon sequestration: through the increase of soil organic matter content.
- Soil quality.

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(4) Agricultural systems are defined as a complex of relationships among land (soil, climate, hydrology, vegetation, …), work and capital under a certain economic and socio-politic environment controlled by a manager (farmer) o group of them in order to obtain certain products.

C- Reduce the energy inputs and use of the natural resources for fertilizer production

Chemical fertilizers use energy and mineral resources to be manufactured. From an environmental point of view minimizing their use is the best option. This is only possible with an efficient use of all the available nutrients.

D- Avoid nuisances

Nuisances associated with the use of fertilizers, specially the organic ones, should be minimized.

E- Do not threat human health

Improper use of fertilizers may pose a risk for human health under certain situations. A must in fertilizer management should be to avoid the presence of such situations.

Such rational approach for chemical fertilizer and organic manure use implies to look at the productivity side, but also to the non-wanted outputs of the agricultural practice. Also the concentration factor, which in terms of scale usually means increases in productivity, should be counterbalanced by the other soil and agricultural functions. This means, in many cases, to have to accept a certain ceiling for productivity, according to a carrying capacity defined in terms of ecosystem, natural or managed, characteristics and derived environmental standards.

1.2 Aims and Scope of the Guidelines

The Guidelines will cover a full set of BEPs related to agricultural fertilizers used in the different agricultural systems existing in MAP countries. As it has been said before, we are not restricting ourselves to mineral fertilizers in the Guidelines; we pay attention to all the nutrients used in agriculture[(5)] because such overall approach is the only way to achieve high nutrient use efficiency, reducing in this way emissions to the environment.

The aim of the Guidelines is, starting from the characteristics of the MAP agricultural systems and the environmental problems related to the use of fertilizers in agriculture, to identify and review a full set of BEPs.

The approach taken when BEPs are reviewed is to move to sustainable agricultural systems, accommodating them to the needs of existing and future agricultural systems of the area. In that sense the approach taken is clearly the fine-tuning of current agricultural systems.

Best environmental practices mean here (Annex 11) to take some overall approach. In practical terms when applied to agricultural systems means to take in account productivity but also conservation of natural resources (soil, air, water, energy, biodiversity) and ecosystems.

The overall aim of the BEPs is an efficient use of nutrients meaning:

a. Reduce/minimize the emissions to the environment (water, air and soil) of nutrients used in agriculture.

b. Minimize the impacts of such emissions to the ecosystems (both, natural and managed).

c. Maintain levels of production to keep agriculture as a profitable economic activity.

d. Keep/restore soil fertility avoiding soil (nutrient) mining.

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(5) Crop and animal production; it includes also grazed lands artificially fertilized

The BEPs employs the cleanest, least polluting available technology. They are focused in N and P because, up to now, are the most conflicting ones. Others, heavy metals, are not covered in these Guidelines because they are very much restricted to certain situations.

Some types of agriculture LISA (Low Input Sustainable Agriculture) but especially organic type could be considered by some as a BEP in itself. Also the same may be said about Integrated Agriculture.

However these Guidelines will not form in itself a full package of agricultural practices or a particular orientation of agriculture. The emphasis will be in a particular BEP; for each situation a specific combination of BEPs will be the best solution and this should be selected by the stakeholders and decision makers operating in such area.

Because some of the above mentioned aims are conflicting among them for each situation (agricultural system) a decision should be taken; in some cases to keep good environmental standards it will be necessary to decrease slightly the production.

2. MAIN ENVIRONMENTAL IMPACTS OF FERTILIZERS USED IN AGRICULTURE

These Guidelines encompass both mineral fertilizers and organic manures (solid manures, slurry, compost, sewage sludge and so one). We will concentrate in nitrogen and phosphorous because both are the key anthropogenic nutrients for their impact in the environment, especially in air and water. Until know attention, from an environmental point of view, has been focused in water (Nitrate Directive, 91/676/CEE) but increasingly more attention is paid to air (Directive 2001/81/CE about emission of certain atmospheric contaminants) and soil (Towards a Thematic Strategy for Soil Protection, COM 2002, 179 final).

Annexes 8 to 10 gives information about the impacts in the environment of MAP countries from nutrient fertilizers. It should be noticed the Mediterranean see itself, being a nutrient poor water body, does not seems to be very sensitive to such environmental impacts; however certain areas (Adriatic, some coastal areas etc.) are more affected.

It is out of the scope of these Guidelines a full review of such effects; the reader is referred to the many textbooks and reports on the topic.

The main different chemical species from fertilizers used in agriculture that may endanger the environment are:

- Nitrate. Mostly pollution of groundwater. The water becomes unusable for drinking. In coastal areas it may contribute to eutrophication and hypoxia.
- Ammonia. Redistribution of ammonia in the landscape and large range transport Acid rain.
- NO_x and NO_2: Greenhouse gases and it is assumed they have a detrimental effect on the ozone layer.
- Phosphorus. Eutrophication of inland water.

3. MAP AGRICULTURAL SYSTEMS AND CHEMICAL FERTILIZERS AND ORGANIC MANURE USE

Agricultural systems existing in MAP countries are very diverse because climates (Annex 2), soils[7] and socio-economical and political situations are also very diverse. However almost all of them have water limited yield, being this fact –water availability– the main yield limiting factor.

In a first attempt the following agricultural systems may be identified:

- Dry land agricultural systems
  - Cereal, low input
  - Vineyard
  - Olive
  - Almond
  - Mixed crops
  - All above + intensive animal husbandry
- Irrigated agricultural systems
  - Mixed crops
  - Fruit trees
  - Citrus
  - Cereal monoculture
  - Some above + intensive animal husbandry
  - Horticulture (Vegetable) → intensive / → extensive
  - Soil less horticulture
- Animal grazing systems
- Concentrated animal operations.

<u>Chemical fertilizers</u>

The water yield-limiting factor of many areas of MAP countries prevents the use of high amounts of chemical fertilizers per hectare (Annex 4); this is especially true if we compare with some northern countries (for instance Netherlands and Belgium). However for irrigated land, and especially in vegetable production, large amount of nutrients per hectare are used.

Large differences exist between countries (Annex 4) and inside a same country in some cases. The technical, social and economic situations are very much different; so the driving forces for fertilizer use are also different. In some cases environmental forces (Nitrate Directive) may play a role; in other cases the fall off the economic system is determinant.

In Northern African and Eastern Mediterranean MAP countries rates of chemical fertilizers application are very low and surely nutrient mining as well as soil organic matter depletion occurs in many places. In such situations chemical fertilizer use is a wise solution with beneficial effects, both productive and environmentally.

<u>Organic manures</u>

The availability of organic manures is linked mostly to the existence of large number of animals (Annex 5) and to a minor extent to urban areas where large wastewater treatment plants produce significant quantities of sewage sludge and compost.

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[7] As Mancini (1967) told it is not very appropriate to speak about "Mediterranean soils". Even though such soils may share a set of common characteristics similar soils may be found in other areas in the globe. Mashali (2000), Roquero (1979) and others stresses as common characteristics: high $CaCO_3$ contents, salt affected soils, larger proportion of shallow, stony soils, very often dry conditions of such soils.

Inside countries there are several areas where large concentrations of animals occurs, especially pigs (ITP, 2001) but also dairy and poultry. These areas with high animal stocking rate and large concentrate animal feeding operations are the ones where the risk of nutrients to the environment is higher. Specialization of agriculture with animal husbandry and crop production in separated (spatial or not) enterprises increases such risks.

Under this situations nutrient inputs exceeds to outputs and internal recycling is poor.

4. CHEMICAL FERTILIZERS AND ORGANIC MANURES USED IN AGRICULTURE: SOURCES, CHARACTERISTICS AND BEHAVIOUR

In this section main fertilizers used or that can be used in Mediterranean areas are described instead of presenting an extensive list of all products available in these countries. According to their origin they will be classified as mineral or organic. There are some special fertilizers known as slow-release nitrogen fertilizers, which will be mentioned as one of the specific BEPs for selected agricultural systems.

4.1 Chemical Nitrogen Fertilizers

Mineral nitrogen fertilizers will be classified according to the nitrogen form in them: nitrate fertilizers, ammonium fertilizers, ammonium-nitrate fertilizers and ammonia fertilizers.

Nitrate fertilizers: Nitrate salts are quite soluble. Nitrate nitrogen is readily available to plants and it is the preferred form of N by most of them. Nitrates can be leached with percolating water although alternating dry periods can led to a net upward nitrate capillary movement. They are recommended in order to satisfy quick demand of crops, mostly in spring, but also in periods of sparse rains in dry regions and to split N applications.

Ammonium fertilizers: Ammonium cation from ammonium salts is not very mobile in soils, when dissolved, is mostly adsorbed by cation exchange in soils, other ammonium ions stays in soil solution and others can be also fixed. The ammonium ion can be utilized directly by plants mostly in early growth stages. Ammonium ion in soil oxidizes into nitrate. The process can take days or weeks. They are recommended in autumn or winter or for long cycle crops.

Ammonium-nitrate fertilizers: They link in one product the characteristics of ammonium fertilizers and nitrate fertilizers.

Ammonia fertilizers: Ammonia is obtained from natural gas hydrogen and nitrogen from the air. Thus it has an energy important cost. It is the first product of any nitrogen fertilizer manufacture. Ammonia is water-soluble and because of its polarization it is adsorbed by clay or organic matter.

4.2 Organic Manures

Organic nitrogen fertilizers consist of animal excreta alone or with bedding material, usually straw, in varying quantities and at varying stages of decomposition. Other organic products are considered organic nitrogen fertilizers as sewage sludge, compost from different raw materials as dried blood, urban residues and other by-products. Differences between them can be associated to the different rate of nitrogen mineralization. The relationship between the carbon and nitrogen content in the organic fertilizer is considered an indicator of the potential mineralization rate.

Organic nitrogen fertilizers with low C/N ratio (lower than 8), as pig slurry, have a quick nitrogen evolution (mineralization in three or five weeks period). Organic nitrogen fertilizers with high C/N ratio as farmyard manure with straw (higher than 8), have a lower mineralization rate depending upon the distribution of different carbon products.

Nevertheless, there are some associations: excreta-carbon products with carbon difficult to degrade that can be considered as quick nitrogen evolution organic fertilizers.

Table 4.1
Mineral nitrogen fertilizers

Type of mineral N fertilizer	N content %	Salinity index	Salinity index per unit of N	Action on soil pH	Observations
I. Nitrate fertilizers					
Sodium nitrate $NaNO_3$	15	100	6.06	Basic	25 % Na content. Additional Na ions are not recommended in arid and semiarid environments
Calcium nitrate $Ca(NO_3)_2$	15			Basic	19 % Ca. Mostly recommended in acid soils, which are not often found in Mediterranean countries. High hygroscopicity, an advantage for plant absorption in dry periods
Potassium nitrate KNO_3	13	74	5.34		36 – 38 % K. High cost. The use of K by plants does not contribute to salinity load. Low ratio N/K respect to plant needs
II. Ammonium fertilizers					
Ammonium sulphate $(NH_4)_2SO_4$	20	69	3.25	Acid	23 – 24 % S. Ammonia losses (up to 30 %) can be recorded on calcareous soils from surface application on moist soils
III. Ammonium – nitrate fertilizers					
Ammonium nitrate NH_4NO_3	35	105	2.99	Acid	In surface applications on calcareous soils loses of ammonia are smaller than ammonium sulphate
Nitro chalk (Ammonium nitrate with limestone)	20 - 33			Acid	It's a stabilized ammonium nitrate fertilizer
Ammonium nitro sulphate	26				15 % S
IV. Ammonia fertilizers					
Urea. $CO(NH_2)_2$	44	75	1.62	Acid	High solubility. In soils it hydrolyses into ammonia
Aqua ammonia	20			Acid	Liquid fertilizer, injected into soils

Table 4.2

N content of some organic manure

Type of organic N fertilizer	Total N %, dry-weight basis	Total N	Organic N	Ammonium N	Remarks
		(kg/m^3 or kg/Mt)			
I. C/N < 8					
Heifer slurry		2.7	0.6	2.1	
Pig slurry		5.9	2.5	3.4	
Swine slurry		3.4	0.9	2.5	
Hen		12.9	2.2	10.7	
Sewage sludge	4.3	-	-	-	
II. C/N > 8					
Farmyard cow manure		5.0	4.5	0.5	
Farmyard pig manure		4.7	4.2	0.5	
Municipal waste compost	1.3	-	-	-	
Poultry manure		30.7	20.8	9.9	

Table 4.2 gives some indication of the N content of several organic types of manure. Being these very bulky products their composition is very much related to dry matter content, but other factor plays a role: type of animal, system of rearing, diet, treatments, etc.

As a rule testing the composition of organic manure is a prerequisite for good management when they are used in large quantities.

5. BEST ENVIRONMENTAL PRACTICES

5.1 Nutrient management

BEP name: Farm nutrient management plans

Description: A nutrient management plan is established for the entire farm. It includes a prevision of the nutrients available in the farm (animals, legume), the needs in a field basis as well as possible surplus. It should be made prior to any major investment. Usually the plan is made in a N basis but in some cases it should be made in a P basis; the last occurs in high quality environmental areas or soils with very high P content.

General remarks: This BEP is a fundamental one in areas where large amounts of nutrients (N and P) per unit area are managed. Although farmers may be reluctant to its adoption, it should be promoted and enforced .

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Basic tool for proper nutrient management • Avoids unplanned surplus of nutrients in certain areas • Helps to adopt management (tactic) measures	• Need of technical advice or special skill	• Compulsory, especially for large confined animal operations or large vegetable farms • Education and training • Availability of integrated software • Constant service	• Large farms • Availability of technical personal	• Marginal/low nutrient input farms	• Forcing enterprises to adopt it may attack viability of environmental friendly small farms

BEP name: Enough capacity and impermeability of the animal waste storers

Description: Storers of animals' dejection and other farm wastewater should have enough capacity to allow field application according to the crop needs. These storers should be impervious and, obviously, covered.

General remarks: Under sizing of animal waste storers is one of the main reasons of water pollution problems; also very often the land spreading programme is determined by the size of the storers.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Help to match crop nutrient needs to soil supply • Avoids discharge to the soil • Avoids groundwater pollution and ammonia volatilization	• Cost	• Regulatory with the permits of operation • Integrate the manure management costs	• Intensive animal operation	• Extensive grazing system	• The same applies for wastewater treatment plants and other organic byproducts • Separation of runoff water from the building is needed in order to avoid the oversize of the storers

BEP name: Apply nutrients uniformly and at the required rates

Description: Mechanical equipment for the application of organic manures and chemical fertilizers should be able to apply uniformly the nutrients throughout the field. Also such equipment has to allow application at the required rates. Fertigation equipment has to be included.

General remarks: Non-uniform land application leads as a result overfertilization in many cases. To achieve this maintenance a regular checking is needed.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Better use of nutrients • Avoids overfertilization and decreases risk of nitrate leaching • Less fertilizers are used (cost)	• Cost • Availability of equipment • Availability of land to spread organic manure at low rates • Labour	• Make the checking of equipment compulsory • Field demonstrations • Education • Make available the equipment (subsidy)	• Highly technified ones • Sprinkler and drip irrigated	• Marginal ones • Systems where land is not available to spread organic manure • Surface irrigation	

BEP name: Treatment and processing of organic wastes

Description: Modifications of the organic wastes characteristics in order to improve their capabilities to be used as fertilizers.

Treatment	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Solid-liquid separation	• Better residue management and further treatment	• Machinery investment • Time consuming • Energy consuming	• Subsidy	• Any • Those where reduction of mass and volume of the residue may be necessary		• Further treatment is needed
• Composting	• Hygienization of the residue • Stabilization of organic matter • Volume and density reduction	• Aprox. >15% d.m. in the residue • Knowledge on appropriate mixtures of residues	• Promote compost market			• C/N ratio is critical • Nutrients concentrate • Gaseous emissions if the used system is not closed

BEP name: Treatment and processing of organic wastes (*continuation)*

Treatment	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Anaerobic digestion	• Reduces VOCs emission • Recovers energy • Stabilizes (transforms into CH4) the most labile organic matter • Overall, reduces CO2 emissions (if no electrical co-generation is applied)	• Cost of construction of the digestor • Technical control is needed • Resulting gases from combustion	• Centralized management • Technical advice	• Large farmers or associations where energy be limiting		• Be aware of co-generation implications • Only recovers energy • Economic feasibility is subject to co-digestion of certain mixtures of residues • Further treatment is necessary before soil application of the residues
• Lagooning	• Cheap where land availability is not limiting • Nutrient reduction in the waste	• No control on gaseous emissions • Only limited amounts of waste can be treated, depending on surface availability • The lagooned area becomes inadequate for many other uses • Sludges are generated	• Make knowledge available	• Where land surface is not limiting • Liquid wastes		• It does not work or slows down on cold weather (<5ºC)

BEP name: Treatment and processing of organic wastes (*continuation)*

Treatment	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Nitrification-denitrification	• Reduces the amount of nutrients (N) in areas with large amount (excess) of nutrients	• Cost (energy) • Sludges are generated • Satisfactorily applicable only to liquid wastes	• Where nitrogen and phosphorous be in excess, this treatment directly tackles the core of the problem	• Animal farming (concentrated)	• In extensive systems is meaningless	
Other non-biological treatments exist. In general terms they are not optimized for the treatment of heavy-load organic wastes, its operation is relatively expensive (energy and consumables) and they involve the generation of difficult to handle by-products.						

5.2 Nutrient air emissions reductions

5.2.1 Ammonia emission reduction

BEP name: Dietary manipulation measures

Description: Matching the animal nitrogen intake more precisely with the nitrogen requirement. Efficiency of N utilisation is frequently still low because of undesirably high crude protein contents in feed, due to the use of protein of insufficient quality for rumen degradability and content of limiting metabolizable amino acids or by the omission of appropriate complementary feeding in summer grazing of intensively fertilised pastures. Reducing dietary protein, without reducing performance, increases N utilisation and simultaneously reduces ammonia volatilisation from manure due to a decline in the absolute, as well as relative amount of urea, in total N excretion. This kind of measures is very important to implement because they are minimisation measures at the source.

General remarks: Its adoption will be very much area dependent; these is: importance of air emissions, existence of valuable natural reserves.

Dietary manipulation measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Keep an optimal protein (nitrogen) content and amino acid composition in fodder	• Minimise ammonia loss from urine	• External fodder supply • It may imply AA supplementatio n (cost)	• Directly reflect the protein content of fodder on its price • The effect of reducing dietary N on N volatilisation might be sufficiently high for farmers to accept clearly elevated feed costs, provided the demands to reduce N emissions are high enough	• Any farm with enough animals to manage different animal lots	• Extensive grazing systems		Kirchmann *et al.*, 1998. Kröber *et al.*, 2000
• Balance N fertilisation of grazing land to achieve optimal grass protein content	• Optimise grass protein content	• Know-how	• Technical advice • Tax residual nitrogen (on the soil)		• Non-grazing animal rearing systems		Kirchmann *et al.*, 1998

BEP name: Animal housing measures

Description: Removing waste from emitting surfaces (floors) as quickly as possible or concentrating it in confined areas, and minimising emissions by construction measures relative to ventilation.

General remarks: Large new concentrated animal feeding operations are the most likely ones to adopt some of such measures. Enforcement through the permits is one of the ways. Adoption is linked always to local conditions.

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Scraping and flushing systems	• Decrease emitting surface by removing waste as quickly as possible	• Investment cost	• Subsidy	• Intensive livestock farming	• Extensive livestock farming		
• Bio-filtration of the air for housings with mechanical ventilation	• Trap (avoid air dilution) of the ammonia emitted in the animal house	• Housing with mechanical ventilation • Investment cost • Bio-filter maintenance	• Subsidy • Training for bio-filter understanding and maintenance	• Intensive livestock farming with mechanical ventilation	• Extensive livestock farming	• Be aware of animal welfare • Do not use to justify increases of animal density	
• Temperature control to encourage excretion over a minimal area	• Concentrate emission • Minimize the emitting area • Increase control on the generation of emissions	• Investment cost	• Subsidy	• Intensive livestock farming	• Extensive livestock farming		

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Application of wood shavings/sawdust on the floor (and replacement several times during fattening)	• The temperature increase of the litter together with the droppings is reduced	• Cost	• Subsidy	• Broilers • Turkey	• Extensive livestock farming	• Be aware of the potential persistence of pathogens in wood residues	IPPC, 2001
• Nipple- or under-floor-drinking systems for poultry housing (broilers)	• Minimizing drinking water losses to obtain an as much solid as possible residue to avoid it flowing	• Investment cost	• Subsidy	• Broilers • Intensive livestock farming			Lekkerkerk, 1998
• Cooling of manure culverts to keep the temperature of animal wastes and the air flow around the wastes as low as possible	• It reduces the ammonia available for emission (by affecting ammonia/ammonium equilibrium)	• Energy consuming • Investment	• Subsidy	• Intensive livestock farming	• Extensive livestock farming		Kirchmann *et al.*, 1998
• Reduce air ventilation above the manure. Ventilate the air breathed by animals but not the air being in contact with the animal wastes	• It reduces volatilization	• Investment cost	• Subsidy	• Intensive livestock farming	• Extensive livestock farming	• Be aware of animal welfare • Do not use to justify increases of animal density	Kirchmann *et al.*, 1998

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Use (precast) concrete floors with grooves and perforations and a dung scraper	• Allows urine draining and therefore ammonia volatilization reduction • Avoids sloping concrete floors which are considerably slippery	• Cost (investment and maintenance) • Perforations can clog, specially those behind the fed rack, where least urination takes place	• Subsidy • Permits	• Cow farms		• The type of floor finishing can influence the health of the animals hooves, the behaviour of the animals, and their locomotion • Slurry pits covered with slotted floors can contain gases toxic to humans and cattle. When using grooved floors with a total floor opening less than 1% of the total floor area, the toxicity of the air in the pit increases. Do not enter into the slurry pit before it has been adequately ventilated	• Swierstra *et al.*, 2001

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Double-sloped solid floors with under floor slurry storage but without under floor airflow	• Reduction of ammonia volatilization (about 50% when compared to slatted floor)	• Investment	• Subsidy • Taxation on ammonia emission	• Cow farms • Farms with scraping combined with spraying of water (further volatilization reduction can be achieved)	• Extensive livestock farming	• Under floor airflow must be prevented. Air exchange between pit and house during the storage period must be reduced. Flexible vertical flaps, connected to the floor at the floor openings and dipping into the slurry might be a solution • Reliable and justified indicators for taxation may be difficult to determine	Braam *et al.*, 1997

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Fully slatted floor (FSF) either with a vacuum system for the withdrawal of the slurry, with flushing of a permanent slurry layer in channels underneath, or with flush gutters or flush tubes	• Reduction of NH_3-emission because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storers • Less water is needed in FSF than with partially slatted or solid concrete floors	• Energy requirement • It may imply more volume generation (flushing with water) • More time consuming (more often removal of slurry)	• Taxing emissions • Make it compulsory	• New installations for mating and gestating sows on FSF	• Extensive livestock farming	• Due to changes in EU-legislation on pig welfare, the FSF may be banned	IPPC, 2001
• Partly slatted floor (PSF) either with a reduced manure pit, with manure cooling fins, with a vacuum system, with flushing of a permanent slurry layer in channels underneath, with flush gutters or flush tubes, with scraper under the slats, with fast removal of slurry and littered external alley	• Reduction of NH_3-emission (relative to FSF) because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storers	• Extra investment • Energy requirement for operation • More time consuming (more often removal of slurry)	• Taxing emissions • Make it compulsory	• New installations for mating and gestating sows	• Already existing farms • Extensive farming system		IPPC, 2001

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Solid concrete floor with littered external alley	• Reduction of NH_3-emission (relative to FSF) because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storer		• Taxing emissions • Make it compulsory	• New installations for mating and gestating sows			IPPC, 2001
• System-integrated housing techniques for farrowing sow such as: crates with FSF and either a board on a slope, a combination of a water and a manure channel, a flushing system with manure gutters, a manure pan or manure surface cooling fins; crates with PSF or crates with PSF and a manure scraper	• Reduction of NH_3-emission (relative to crates with FSF) because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storers.	• Extra investment • Energy requirement for operation • More time consuming (more often removal of slurry)	• Taxing emissions • Make it compulsory with the permits	• New installations for farrowing sows. Some systems are also easily applicable in the reconstruction of already existing buildings	• Extensive farming system		IPPC, 2001

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• System-integrated housing techniques for weaned piglets such as pens or flat decks with either: FSF and concrete sloped floor to separate faeces and urine, FSF and manure pit with scraper, or with FSF and flush gutters of flush tubes; and such as pens with PSF, and either a sloped or convex solid floor, a shallow manure pit and a channel for spoiled drinking water, triangular iron slats and manure channel with gutters, a manure scraper, triangular iron slats and manure channel with sloped side wall(s) or manure surface cooling fins	• Reduction of NH_3-emission (relative to pens or flat decks with FSF) because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storers	• Extra investment • Energy requirement for operation • More time consuming (more often removal of slurry) • Some systems are vulnerable to the wear of the top coating of the floor • Extra solid-liquid separation is needed in some systems	• Taxing emissions • Make it compulsory with the permits	• New installations for weaned piglets. Some systems are also easily applicable in the reconstruction of already existing buildings	• Extensive farming systems		IPPC, 2001

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• System integrated housed techniques for finishers with either: FSF with flush channels and aeration, FSF with flush gutters/tubes with aeration, PSF with manure surface cooling fins with concrete or iron slats PSF with flush canals (with or without aeration), PSF with flush gutters/tubes (with or without aeration), PSF channel with slanted side walls with concrete or metal slats or PSF with scraper with metal slats	• Reduction of NH_3-emission (relative to group-housed pigs on FSF) because the contact time of the slurry with the air (before transfer to the storers) is decreased by facilitating often and/or rapid transfer to the storers	• Extra investment • Energy requirement for operation • More time consuming (more often removal of slurry)	• Taxing emissions • Make it compulsory	• New installations for finishers. Some systems are also easily applicable in the reconstruction of already existing buildings	• Extensive livestock farming		IPPC, 2001

BEP name: Animal housing measures (*continuation)*

Animal housing measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• End-of-pipe measures for the reduction of ammonia emissions from housing of pigs: bio-scrubbers or chemical wetscubber	• Relatively easy to implement	• Extra investment • Energy requirement for operation • Extra water consumption (about 1 m^3 per pig place per year) • Requirements to a discharge may limit its applicability • Need channelling the airflow in the building • The chemical wetscubber consumes and disposes acids					IPPC, 2001

BEP name: Animal residues handling

Description: Measure to reduce ammonia emissions by appropriate handling of animal residues.

Animal residues handling	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Rapid transfer of the residues to the storage area	• Decrease the duration of emission and the emitting surface by removing waste as quickly as possible • Improve animal welfare • Improve farmer working conditions	• Investment cost of machinery • Time consuming	• Development of adequate machinery • Subsidy for the installation of automatic cleaning systems (craping and flushing systems)	• Intensive livestock farming • Cows, pigs, sheep and rabbit rearing	• Marginal livestock farming • Grazing animals		
• Quick separation of faeces and urine from cowsheds	• Avoids the contact of the urease enzyme with urea, decreasing urea hydrolysis and the subsequent ammonia volatilisation	• Investment cost • Time consuming	• Technical advice • Subsidise the investment	• Intensive livestock farming	• Marginal livestock farming • Grazing animals	• Urinary urea has been reported to be linearly related to NH_3 emissions because it is more rapidly converted into NH_3 than faecal N	Lekkerkerk, 1998 Kröber *et al.*, 2000

BEP name: Animal residues handling *(continuation)*

Animal residues handling	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• Use urease inhibitors	• Urea hydrolysis is limited and therefore less ammonia volatilises • Urease inhibitors can be used to control ammonia emissions from animal wastes, prevent environmental damage, and produce a more balanced (N:P) fertilizer from manure	• Cost • Chemical products are freed on to the environment	• Make knowledge available			• There exist alternative and/or complementary management options such as multiple combinations of nutritional management, housing systems, treatment options, storage and application of animal residues	Varel *et al.*, 1999

BEP name: Animal residues handling *(continuation)*

Animal residues handling	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems/ situations to adopt the proposed BEP	Remarks	References
• The following techniques are applicable to battery housing of laying hens: manure removal by belts to closed storage, vertical tired cages with manure belts to closed storage, and enriched cages (*)	• Decrease the duration of emission and the emitting surface by removing waste as quickly as possible • Improve animal welfare • Improve farmer working condition	• Investment cost • (*) Energy input depending on belt system. It implies the full replacement of the cage system	• Subsidise the investment	• Battery housing of laying hens	• Any other	• (*) Compulsory system as from 1-1-2012 on in Europe (this or the non-cage housing system)	IPPC, 2001

BEP name: Slurry storage measures

Description: Minimise contact of the surface with the air and disturbance except during filling or emptying operations.

General remarks: Attention to local conditions.

Slurry storage measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Covering the storers (with either a tight fitting lid, a roof, light expanded clay aggregates, plastic foil or other effective methods)	• Minimise contact of the surface with the air and disturbance except during filling or emptying operations	• Investment cost • Dangerous	• Subsidy	• Any animal farm		.	Gustavsson, 1998.
• Correct storers sizing	• Avoid waste overflow • Minimise investment	• Knowledge	• Training (extension) • Clear definition of the acceptable possibilities	• Any animal farm			
• Control the shape of the storers in order to minimise its surface	• Minimise the contact surface	• Investment cost	• Subsidy	• Any animal farm			

BEP name: Slurry storage measures *(continuation)*

Slurry storage measures	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Acidify the residue during storage	• Decrease the fraction of nitrogen present in the volatile ammonia form	• Expensive • It may hinder further application of the residue	• Training • Available technology	• Any animal farm	• Those with acid soils		
• Homogenise the slurry in the storers before transporting it to the field	• Homogeneous fertilising value of the applied residue	• Investment cost	• Subsidy	• Any animal farm			

BEP name: Measures for the land application of slurry

Description: Minimise the amount and/or time of exposure of applied waste on the ground surface by getting it below the ground surface or vegetation canopy.

General remarks: The soil condition will determine the feasibility of most of the measures; some of them very difficult in dry soils.

Measures for the land application of slurry	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Slurry injection	• Minimise the time of exposure of applied waste on the ground • Diminishes odour nuisances	• Investment on machinery • Steep slopes • Stony soils • Dry soils • Compacted soils • Heavy equipment is needed	• Subsidy • Benefit on higher N use efficiency • Ecological agriculture • By diminishing odour nuisances, it increases the compatibility of farming with other activities	• Those which handle liquid residues	• Those handling solid residues on steep slopes, stony or compacted soils • Dry soils		
• Prompt (within 4 h after application) plug-in or plug-in at the time of application with a slurry incorporator	• Minimise the time of exposure of applied waste on the ground	• Time consuming • Applicability depends on the crop • Grassland • Cover fertilisation • Work organization	• Using the proven available machinery and manpower on a farm as a criterion to provide it with operation permit (as a function of the number of heads) •		• Grasslands • Dry soils • Conservation tillage areas		Gustavsson, 1998

BEP name: Measures for the land application of slurry *(continuation*

Measures for the land application of slurry	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems / situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Increasing infiltration by blending the residue with aspersion irrigation water	• Minimise the time of exposure of applied waste on the ground	• Matching with water availability	• Training (extension)	• Irrigated ones	• Dry land		
• If broadcasting is the only application possibility, dilution (a decrease of 4,5% in dry matter content) is advisable	• Decrease in ammonia volatilisation	• It increases the volume to be applied	• Valorising the nitrogen contained in the residue	• Those where broadcasting is the only option	• Those with water limitations		Morken and Sakshaug, 1998

BEP name: Chemical form of fertiliser

Description: Measures to achieve emission abatements through the control of the form of chemical fertiliser applied

Chemical form of fertiliser	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Replacement of high-emitting products by low-emission ones in the following order (worse to best fertiliser for NH_3 emission reduction): urea > ammonium sulphate > nitrogen solution (mixed urea and ammonium nitrate) > di-ammonium phosphate > anhydrous ammonia > ammonium nitrate (AN) = calcium AN = mono-ammonium phosphate = other complex NK, NPK fertilisers	• Decrease ammonia generation	• Price	• Training (extension) • Modify the prices		• Marginal ones		EEA, 2001
• Decrease commercial fertiliser applied to the field by the corresponding amount of animal residue nutrients applied	• Economic • Environmental	• Internalisation of environmental costs	• Technical advice and extension (education) supporting nutrient accounting	• Any			CAST, 1996

BEP name: Chemical form of fertiliser *(continuation)*

Chemical form of fertiliser	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Add urease regulators/inhibitors	• Slow down ammonia generation	• Cost	• Extension and training	• Systems with single large doses	• Low N input systems	• Fertiliser substitution may be a more interesting option • In tropical and temperate regions with flooded rice, and irrigated cotton, wheat and maize the use of newly developed urease inhibitors may increase the yield of crops • More interesting in irrigated systems	EEA, 2001. Ferney, 1996
• Place the fertiliser granule into the soil at the same depth as the seed (*c.* 7-8 cm)	• Decrease ammonia loss			• Spring crops and grass reseeds in autumn		• When using urea be ware of not placing it so close to the seed that germination be inhibited	EEA, 2001
• Incorporate fertiliser-N prior to rice planting or delay application until panicle initiation	• Reduce ammonia emissions from rice fields			• Paddy soils		• This measure may not reduce total N losses in soils with large nitrification or denitrification rates	EEA, 2001

5.2.2 Nitrogen oxides emission reduction

BEP name: Nitrogen management for the reduction of NO_x emission (limiting nitrogen oxides emissions)

Description: Fertiliser, crop residues and water management possibilities in order to limit nitrogen oxides emissions through nitrification and/or denitrification without reducing crop yields.

NO_x emission reduction through	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Better matching of N-fertiliser to crop requirement • Avoid N application in excess of the economic optimum	• N_2O emission reduction • NO emission reduction • NH_3 emission reduction	• Risk of yield reduction	• Technical advice • Education • N accounting • Make full allowance for N available in the soil from previous crop residues, organic residues application and mineralization of soil organic matter	• Short season growing crops • High value crops			EEA, 2001
• Timing of fertiliser-N application to coincide with crop demand	• N_2O emission reduction • NO emission reduction	• Time consuming • Technological knowledge	• Technical advice • Education	• Winter cereal		• It is also effective in reducing nitrate leaching	EEA, 2001
• Timing the incorporation of crop residues to avoid incorporating when soils are poorly aerated	• N_2O emission reduction • NO emission reduction	• Weather constraints. • Farm work organization	• Technical advice • Education				EEA, 2001

BEP name: Nitrogen management for the reduction of NO_x emission (limiting nitrogen oxides emissions) *(continuation)*

NO_x emission reduction through	Advantages (benefits)	Constraints and limitations for farmer's adoption	Measures to support farmer's adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems / situations to adopt the proposed BEP	Remarks	References
• Urea substitution by AN	• NO emission reduction • Also reduces NH_3 emission	• Habit • Price, at certain periods of time	• Technical advice • Education • Prices policy	• Any		• Since, in temperate climates, nitric oxide emissions (NO) are considered to be predominantly a consequence of nitrification, the use of urea fertiliser will produce larger NO emissions than equivalent amounts of nitrogen applied as ammonium nitrate (AN) • At present, there is insufficient data to discriminate between the effect of fertiliser-N sources on NO emissions	EEA, 2001
• Improve soil drainage	• N_2O emission reduction • NO emission reduction	• May increase nitrate leaching					
• Improve irrigation	• N_2O emission reduction • NO emission reduction • Also reduces nitrate leaching	• Existing old irrigation schemes	• Technical advice • Investment in irrigation infrastructures	• Irrigated ones • Those provided with modern irrigation systems	• Non irrigated ones		

5.3 Fertilizer applications

BEP name: Record keeping of organic and chemical fertilizers applications for each field

Description: Records are kept for each field. This includes: type, time and amount of fertilizers applied to each field.

Advantages (Benefits)	Constraints and limitations for farmers' adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks.
• Allows a clear view of how nutrient management is done • Use less mineral fertilizers • Helps to farmers' sensibilisation • Allows a rational use of fertilizers	• Time consuming • Difficult to estimate the nutrient composition of manure	• Access to new technologies • Access to special and integrated software packages • Education and sensibilisation • Linkage to the technical management of the farm	• Availability of technical advice • Education of the farmers • Farming systems with large nutrient inputs • Large farms with small number of fields	• Marginal agricultural systems	• In areas with low nutrient inputs has little interest • It helps to adjust fertilization plans using actual information and soil/plant analysis

BEP name: Spread manure in all available land

Description: Use all the available land to spread manure, giving preference to fields with crops with high demand in nutrients and consider soil and site limitations.

General remarks: Over-fertilization of fields near the animal houses occurs very often; such fields act as a polluting source.

Advantages (Benefits)	Constraints and limitations for farmers' adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoids excessive soil P buildup • N use efficiency increases • Limits nitrate leaching	• Costs of transport	• Favour transportation of manure • Reallotment of land. • Alloation of intensive animal feeding operation • Transfer of rights to spread	• Moderately intensive animal rearing farming systems	• Agricultural enterprise that is not in the vicinity of animal rearing enterprises	• Rotate fields • Preference to high demanding crops • Considerations to specific soil qualities

BEP name: Test organic manure (bulk organic fertilizers) for nutrient and dry matter content

Description: Test manure in order to ascertain the amounts of manure applied. Test should include N, P, K and dry matter.

Quick field methods are advisable. Also indirect estimations of nutrient amounts of applied manure are very much helpful.

General remarks: Large uncertainty exists about manure composition. Some specific information is needed in order to revent manure from flowing.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Nutrients applied are known • Better assessment of future nutrient application during crop growth	• Cost • Time and labour consuming • Heterogeneity of manure • Availability of reliable quick field methods	• Promote lab and consultant services • Promote homogenization facilities • Technical advice • Tax residual soil N	• Animal based systems • Confined animal operations	• Grazing systems • Mineral fertilizer based systems	• Heterogeneity of manure makes difficult sampling • Enough land should be order to spread the manure at appropriate rates

BEP name: Routine soil testing

Description: Testing soil basic fertility parameters: N, P, K … for each field

General remarks: When large amounts of nutrients are used per unit area, the only way to adjust fertilizer management is through soil analysis.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• It allows to refine fertilization practices, adjusting them to actual soil values • Avoids nutrient (P) build up • Saves money (less mineral fertilizers are used)	• Cost • Labour	• Promote establishment of lab services and consultancy	• High value crops • Large amount of nutrients managed	• Marginal agricultural systems	• Periodically, samples and analysis should be made for each situation

BEP name: Available nitrogen balance

Description: The availability of N is estimated for each field taking into account inputs and outputs from the system. The system allows predicting with reasonable accuracy the needs of fertilizer. It allows taking in account the contribution of organic fertilizer, yields, etc.

General remarks: The use of a farm-gate balance needed in order to plan other measures than land application.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• As a first approximation it helps very much to adjust fertilizer applications • Saving mineral fertilizers and (in many cases) increases production	• Time consuming • Available skills and technical advice	• Availability of: - Technical advice - Software or other packages • Adaptation to local conditions	• Large use of fertilizers • Organic fertilizers • Vegetable farms	• Low input and marginal systems	• Use realistic yield objectives, considering actual weather conditions • Complement with some method of measure of N availability • Give accurate credit to organic fertilizers and crop residues • Integration with other farm software is advisable

BEP name: Match nitrogen supply and demand through some control of nitrogen availability

Description: The aim is to provide different tools in order to control nitrogen status in the agricultural systems at real time. In order to match nitrogen supply and demand in crops with a rather poor root system, splitting nitrogen fertilizer dressings will be required.

General remarks: For the nitrogen, it is necessary the use of technologies allowing fine-tuning.

Method of control	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Mineral soil nitrogen (N min)	• Easy and cheap test. • Quick test that allows a quick changes in fertilization according to nitrate content in the soil	• Need to technical advice close to the farm	• To develop a technical net service. It can be just a soil nitrate test vehicle	• Intensive agricultural systems	• Low value crops. • Low input N	• There is a quick soil test • Need to adjust the method for each region and farming system • $N\text{-}NH_4$ may be important in some situations	Wetselaar *et al.*, 1998
• Quick plant sap nitrate or chlorophyll concentration	• Easy and cheap test	• It is difficult to establish a relationship with final yields	• Idem as above	• Cereals. • Horticultural crops	• Idem as above		Coulombe *et al.*, 1999

BEP name: Match nitrogen supply and demand through some control of nitrogen availability *(continuation)*

Method of control	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Systems of N recommendations or models of nitrogen dynamics	• They predict uptake, mobility and leaching of mineral N in soil profiles thus irrigation and fertilization can be easily adapted in time • Also there are some systems developed for the recommendation of split application of N fertilizer • Some of them are free or run for free on internet	• Lack of knowledge about how to use these tools	• Training availability of the system	• Horticultural crops. • Cereals	• Idem as above		Greenwood et al.,1989. Lorentz *et al.*, 1989 Rahn *et al.*, 1996.
• Light reflection by the crop	• Indirect and quick test	• Must be done with experts because the relationships will depend upon the crop	• As previous				Booij *et al.*,(1996)

BEP name: Shift from N to P based applications of organic manure in P sensitive areas or when soil P levels are too high

Description and discussion: N based application with organic fertilizer produces, in most cases, a build-up of soil P. This in turn may increase the content of P in surface waters. For P sensitive areas and in order to prevent excessive soil P contents in a certain moment is advised to shift to P based organic fertilizer applications instead of N based ones.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoids excessive soil P content buildup	• Amount of manure to be applied per hectare is reduced; so more land is needed to spread the same amount of manure	• Facilities to transport manure to other areas • Availability of lab and consultant facilities • Education	• Intensive animal rearing farming systems	• Agricultural areas where only mineral fertilizers are used	• Few areas have adopted such criteria

BEP name: Crop residues management

Description: Take into account in management strategies the nitrogen present in crop residues especially in rich ones.

Method of Management	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Leave soil residues rich on N on the surface and plough them before sowing or remove them later	• It can also help to soil erosion control. • It avoids a quick N mineralization • They can be removed later and composted with other N deficient residues	• Some problems related to the survival of diseases or traffic ability can appear • Residues removal can increase labour costs • Ammonia volatilization also will increase	• To promote crop rotations	• Horticultural systems, which maintain bare soil during a rain period			Everaarts *et al.*, 1996
• Plough soil residues after harvest	• N in the crop residues and residual soil mineral N can supply the N needed by the crop. In these cases nitrogen fertilisation can be avoided thus reducing costs	• Survival of diseases. • Release of N dynamics depends on the C: N ratio of the residue. High C: N ratio can lead to an initial N immobilization and additional N fertilisation must be required for initial stages of the next crop • Difficulties in the elaboration of a N fertilisation schedule	• To promote crop rotations				Rahn *et al.*, 1992 Neeteson *et al.*, 1994

BEP name: Split fertilizer applications, avoiding large doses

Description: In order to match crop nitrogen requirements it is advisable to split fertilizer applications, especially in the crops demanding large amounts of N, with long growing seasons or both and when large amounts of manure are used. This allows, if necessary, late applications, near the peak demand period or application of small amounts. Although it is advisable in a routine basis it is best suited when used in combination with some soil/plant analysis system.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Increase N use efficiency • Adjust N applications to crop demand • Adjust N applications for a correct balance between vegetative growth and fruiting	• More labour is needed • Small applications should be possible	• Make lab and consultancy services available • Establish premiums for low residual mineral nitrogen	• High N demanding crops • Long growing seasons	• Marginal systems • Low amount of nutrients used. • Short growing crops • Difficult with organic manures	• Better results are achieved when used in combination with soil/plant analysis • Combination of organic manures with chemical fertilizer is usually advisable in order to match nutrient crop demands	Dobermann *et al.*, 2000 Toselli *et al.*, 2000

BEP name: Localized fertilizer placement application.

Description: Application of fertilizer close to root system in only a part of the soil.
The objective of these methods of nitrogen fertilizer application is to increase fertiliser utilization efficiency.

Method of placement	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Injection of a starter fertiliser solution	• Easy mechanical handling • Facilitates availability of nutrients in: • Young crops with restricted root systems • Plants grown on soils with physical constraints to root growth • Compatibility with some liquid insecticides	• The use of a selected fertiliser • High local salt concentrations in drying soils can reduce germination or damage plants • On high-fertility soils no differences in final yields could be observed	• Access to appropriate farm machinery	• Horticultural systems with wide-spaced row crops • Extensive irrigated agricultural systems with row crops as corn	• Extensive dry land or irrigated agricultural systems • Grazing areas		Bednarz *et al.*, 2000 Brewster *et al.*,1991 Costigan, 1988 Greenwood, 1990 Stone, 2000 Thompson *et al.*,1990
• Fertigation under drip irrigation	• Nutrients can be applied according to plant demand	• Expensive system • Need of a more accurate irrigation technology		• Horticultural and orchard systems	• Large scale field crops		
• Band application of P	• Increases P efficiency		• Extension services	• Row crops. • High P fixing soils			

BEP name: Timing of N application

Description: Adjust the temporal needs of the crop with the type of fertilizer and the time of application.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Improves N use efficiency reducing losses	• Availability of labour • Cost of extra applications	• Premium for quality products • Limitations to total N used • Tax residual N	• Vegetable • Cereals	• Marginal systems • Intensive animal systems	• Take in account soil behaviour according to the type of fertilizer

BEP name: Inject or incorporate manure whenever possible

Description: Injection of manure or incorporation of manure shortly after application.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoid surface runoff contamination • Also P inputs to surface waters are reduced • Increase N use efficiency decreasing NH3 volatilization	• More labour is needed • Usually heavier equipment is required	• Make collective equipment available • Regulations to enforce short time for incorporation or injection	• Medium textured soils in temperate climates	• No tillage • Dry or compacted soils • Sloping areas	• Incorporation should be done, soon, at least at the end of the working day. If possible it would be better to inject. • Heavier equipment is needed; compaction may occur

BEP name: Slow release nitrogen fertilizers

Description: The aim of the use of these fertilizers is to retard or control the mineral nitrogen availability in order to improve nitrogen fertilizer efficiency.

Slow release nitrogen fertilizer	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Urea-aldehydes	• Reduce ammonia volatilisation and leaching losses • Can improve availability of nutrients throughout the season • Labour savings due to less frequent fertiliser applications	• The ratio of polymers in mixture and environmental conditions influence the rate of N transformation, and may not be synchronized with plant demand.	• Extension services	• Crops grown in the wintertime with high water soil content • High value crops	• Crops with a short growing period • Horticultural crops		Bharati *et al.*, 2000 Belligno *et al.*, 1995 Chaiwanakupt *et al.*,1996 Guertal, 2000 McCarty, 1999 Owens *et al.*, 1999 Puttanna et al ,1999 Rajendra *et al.*,1995 Salas *et al.*, 1995 Sutton 1990 Wang *et al.* 1996
• Coated urea		• Yield advantages can be only found in special agricultural situations depending of soil type, the duration of leaching and other aspects • Its price is higher than conventional fertilizers per unit of nitrogen	• Extension services	• Saline soils • Sandy soils • Crops grown in a period of high rainfall • Irrigated rice as a basal incorporation • Urban landscapes (parks and gardens) • High value crops			

BEP name: Use calibrated equipment able to apply uniformly the nutrients

Description: Chemical fertilizers and organic manure should be applied in a uniform manner. Also the applications should be done with calibrated equipment, able to apply the amounts required.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Uniformity prevents (avoid) over fertilization • Calibrated equipment allows to apply the amount required, including low quantities	• Time and labour consuming • Cost of equipment	• Encourage routine checking • Encourage the use of calibrated equipment • Machinery shows • Technical advice	• Highly and maintenance mechanized systems		• For highly inhomogeneous materials, such some organic manure it could be difficult to achieve uniformity • Fertigation equipment may be viewed in the same sense

BEP name: Site-specific management

Description: Take into account the characteristics of the site, mainly soil, to fertilizer.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• It allows theoretically, to match precisely the nutrient needs, minimizing nutrient losses to the environment and maximizing productivity	• Cost • High-tech environment is needed	• Availability of standard equipment • Lab services and consultancy	• Highly technified ones	• Marginal • Scattered, small fields	• In some sense is synonymous of precision agriculture • More research is needed (i.e. modelling contribution of soil organic matter) in order to be operative

BEP name: Do not apply liquid manure on steep land unless it be injected or incorporated before the end of the same day.

Description: Avoid the application of liquid manure on steep land in order to avoid formation of runoff, which may reach watercourses.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoid runoff generation • Avoid direct pollution • By diminishing odour nuisances, it increases the compatibility of farming with other activities	• Labour demanding (extra cost) • Availability of non-steep land • Extra cost of injection systems • Stony soils • Dry soils • Compacted soils	• Education • Subsidy of the machinery investment • Benefit on higher N use efficiency • Ecological agriculture	• Animal based	• Marginal, mineral ones	• Injection or prompt incorporation (within 4 h of application) also limits ammonia volatilisation

BEP name: Do not apply organic manure near watercourses or water wells

Description: Avoid the application of manure near watercourses or water wells in order to avoid direct pollution.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoid direct pollution • Preserve the good social image of the primary sector	• Availability of land not subject to this limitation • Transportation time due to the higher distance existing to more suitable land	• Education • Technical advice • Exchange the land with this limitations with other without them • Direct payment for a differential management of such areas	• Any close to water courses or water wells	• Those where it does not apply	• Be aware of seasonal water courses

BEP name: Do not apply slurry or manure on waterlogged soils

Description: Avoid application of manure on waterlogged soils or in floodplain soils during high water periods.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Prevent nitrate leaching • Avoid denitrification • Preserve the good social image of the primary sector	• Availability of land not subject to this limitation • Transportation time due to the higher distance existing to more suitable land	• Education • Technical advice • Exchange the land with this limitation with other without them • Direct payment for a differential management of such areas	• Those where soils become waterlogged or in floodplains during high water periods	• Those where it does not apply	• Gravity irrigated soils may present equivalent risks during the irrigation season

BEP name: Do not apply manure on frozen or snow-covered soil

Description: Avoid uncontrolled nutrient loss from sites where soil is frozen or covered with snow.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Value of advantages in front of constraints and limitations	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Avoid direct runoff pollution formation • Prevent nitrate leaching • Avoid denitrification • Preserve the good social image of the primary sector	• Availability of land not subject to this limitation • Enough storage capacity for the manure • Transportation time due to the higher distance existing to more suitable land	• Education • Technical advice • Direct payment for a differential management of such areas	• Subsidize the investment on sufficient storage capacity • Education on the minimization of manure volume generation	• Those where snow falls and soil freezes	• Those where the restrictions don't exist	

5.4 Related Side BEPs

In general all the practices promoting good crop development and productivity should be considered BEPs.

We will not review all these practices but it should be retained that only productive agricultural systems are able to use efficiently plant nutrients.

BEP name: Efficient use of water

Description: Use water efficiently is possible. This includes the combined use of rainfall and irrigation water. More efficient field application methods should be used whenever possible. Uniform field application is a must for any system. Some irrigation water scheduling should be applied, including field water meters. For some situations deficit irrigation could be advisable.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks
• Reduces N leaching Saves water • Better yields. • Less costs (water and fertilizers)	• Cost	• Incentives to water shaving (water management changes etc.) Available facilities			• It is always important

BEP name: Erosion control measures

Description: Set of practices aimed to control soil and water erosion. They include a wide number of technologies being currently the so-called conservation tillage or minimum tillage. Other measures are contour cropping, terracing, etc. Very often under this concept also water conservation measures are included.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Soil and water conservation • In some situations better yields are achieved with lower cost • Avoid surface runoff	• Cost • Limitations to ploughing the land	• Education and training	• Extensive agricultural systems		• If properly designed minimize surface runoff and, consequently P input to surface water

BEP name: Water reuse

Description: Waste water or partly treated contains very often some amount of nitrogen and other nutrients. Also well water from highly intensive used agricultural land.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Availability of water	• Quality of waste water (sanitary, salinity)	• Promote wastewater use through available facilities	• Extensive crops	• Vegetables for direct consumption	• Be aware of the sanitary implications.
• Less nutrients are needed	• Availability of water • Uncertainty of water composition	• Lab and consultant facilities			

BEP name: Weed, pest and disease control

Description: Healthy crops are more productive and uptake more nutrients.

General remarks : So a prerequisite to avoid nitrate leaching is to leave productive crops.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks
• Less leaching of nitrates occurs	• Cost	• Training • Extension	• Any	• Marginal	• All systems are suited

BEP name: Crop rotations

Description: Crops grown on a given field one after the other that can be repeated in the same order or not. Crop rotations can be designed in order to maintain soil quality.

Type of crop rotation	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Crops that belong to different families (p.e. Sudangrass – onions) • Combine high and low residue crops (p.e. cotton – tomato – garlic • Deep-rooted crop after shallow rooted crop (p.e. wheat – onions) • To enhance the maintenance of soil organic levels • To enhance biologically integrated pest management	• Minimizes the build up of soil pathogens by breaking their cycles • Recycles crop residue biomass, which is related to the maintenance of soil organic levels • Scavenger soil nitrate crops that can take profit of remaining soil nitrate, thus reducing fertilizer N requirements of the deep-rooted crop	• Crops grown on a given field can vary annually because they are based primarily on anticipated revenue	• To facilitate information about fertilization planning	• Irrigated agricultural systems		• In cereal dry land farming some leguminous crops, with low water demand can be introduced during the cold season • A very large range of organic matter recycling results from different cropping rotations	• Mitchell *et al.*, 1999

BEP name: Intercropping

Description: The aim is to grow different crops in order to increase N use efficiency.

Method of intercropping	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• With a legume crop. (p.e. mixed grass-clover, maize -soy beans, spring barley –peas…) • Without a legume crop	• N fertilization can be reduced for similar yields or, if not, it can lead to higher protein contents in the cereals	• In some systems labour costs increase • Other conflicting factors can appear related to the compatibility between species, the lifetime and others as the market		• Orchards or • pastures with full water availability • Cereals			• Loiseau *et al.*, 2001

5.5 Specific BEPs for Selected Agricultural Systems

5.5.1 Intensive vegetable production

Outdoors vegetable production is done with several levels of intensity. Sometimes in rotation with field crops in others with other vegetables.

Nutrient use intensity is high or very high sometimes when using farmyard manure. In special cases, a fertilization approach is used, which in some ways resembles the soil-less culture (i.e. use of nutrient solutions but with natural soil); this approach, even optimised, uses large amounts of nutrients and large losses for the environment are likely to occur. In such cases a shift to soil-less culture techniques should be encouraged.

In other cases most of the BEPs described under 5.3 (Fertilizer application) or 5.6 are well suited to cope with the problems resulting from such intensive vegetable production system.

BEP name: Recycle nutrient solutions in soilless culture

Description: Soilless culture uses nutrient solutions. If reused (recirculated) in the some crop strong reduction of nutrient losses takes place.

General remarks: In very intensive vegetable production areas, especially in those with glasshouses.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Reduce dramatically nutrient emissions to the soil	• Cost • Facilities almost unavailable • Diseases in the nutrient solution, including various pests	• Restrictions to nutrient use • Sanitation facilities • Charges to discharge	• Only soil less culture		• Destination of the remanent solution should be considered	Schwarz, 1995 Winsor and Schwarz, 1990

5.5.2 Intensive animal farming rearing systems

Emphasis is in these cases is on animal diet (reduction of N, P and volume of excreta) and also in a residual volume reduction. Other parts are covered under several headings.

BEP name: Diet

Description: The aim for animal diet modification is to keep or put up the efficiency/conversion index from food to animal products, thus reducing the amount of nitrogen and phosphorus per unity of meat, milk, eggs. This measure can reach reductions in the amount of P and N up to 60%.

N reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Increase protein digestibility. Use food with high contents of protein	• Put up the efficiency in the nitrogen use by the animal. Kg N in the farmer production by kg ingested • Reduce the amount of N excreted in manure • Suitable C/N relation • Possibility in having a bigger livestock charge by unity of agricultural surface • Reduce the lost of N ammonium (gaseous)	• Bigger cost of the raw material with high food digestibility • External dependence to get food, which has protein with high digestibility (soybean) • Many farmers are not self-sufficient in the subject of animal food. They usually get the food from a manufacturer, or through vertically integrated companies	• Choose the proteical food more suitable to the conditions of the zone • Subsidize the food with the biggest protein content • Increase the cost of the food	• Industrial livestock production systems • Mixed crop-livestock systems	• Grazing land production systems		Succi and Grovetto, 1999

BEP name: Diet *(continuation)*

N reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Increase the digestibility of the protein: Thermal treatment of food • Steam flaking, or steam rolling	• As previous • Makes starch more digestible	• Higher energetic costs • Need for an equipment which will produce more expensive, although more modern, food • Lost of the phytasic activity	• Integrate the cost of the food (feed) and the cost of the nitrogen excrement management	• Industrial livestock production systems • Mixed crop-livestock systems	• Grazing land production systems		Owens *et al.*, 1997 Bradford *et al.*, 1999 Latimier and Pointillart, 1993
• Increase the digestibility of the protein: Use of enzymes	• Improve digestibility of the food, especially fibre • Allow using lower quality cereals with (barley) in the chicken diet • Put up the efficiency in the nitrogen used by the animal. (Kg N in the farmer production by kg ingested) • Reduce the amount of N excreted in manure • Suitable C/N relation. • Possibility of having larger livestock charge per unit of agricultural land • Reduce N ammonia (losses)	• Enzymes cost. • Difficulties in case of granulation (thermal treatment could damage it) • Farmers do not always accept enzymes • Availability of enzymes	• Integrate the cost of the food (feed) and the cost of the excreted nitrogen management • Social programs to promote their use .The purpose are to increase the aptitude of the local raw material and also reduce the external dependence	• Industrial livestock production systems • Non-ruminant, especially poultry	• Grazing lands production systems • Ruminants		Campbell, 1993 Bradford *et al.*, 1999

BEP name: Diet *(continuation)*

N reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Adjust protein content of the fodder to the animal needs	• Increase the nitrogen use efficiency of the animal. (Kg N in the farmer production by kg N ingested by the animal) • Reduce the amount of N excreted in manure • Suitable C/N relationship • Possibility of bigger livestock charge per unity of agricultural surface • Reduce lose of N ammonia (gassy) • Improve the well being of animals	• Availability of the raw material, which permit the adjustment • Difficulties during the management in of the manufacturation process, stock, and during the distribution of a wide range of food • High cost of this measure • Need of a better technological level to design the diets	• Integrate the cost of the food (feed) and the cost of the management of the nitrogen in the excreta • Develop the required technical information that permit the adjustment of the protein necessities to the animals adapted to local conditions (own raw material, productive skills, type of animal, etc.)	• Industrial livestock production systems • Mixed crop-livestock systems	• Grazing lands production systems		Succi and Grovetto, 1999

BEP name: Diet *(continuation)*

N reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Lower protein/nitrogen input through supplementation with synthetic aminoacids	• Increase the efficiency in the use of nitrogen by the animal. (Kg N in the farmer production by kg N ingested by the animal) • Reduce the amount of N excreted in manure • Suitable C/N relationship • Possibility of having a larger livestock charge by unity of agricultural land • Reduce the loss of N ammonia • Reduce the need of food that has got high protein content (soy) • Reduce the external dependence	• Need to buy synthetic aminoacids. • Possible social rejection of productive ways, which pretend to use synthetic substances in the diet	• Integrate the cost of the food (feed) and the cost of the management of the nitrogen in the excreta • Reduce the cost of aminoacids	• Industrial livestock production systems. Pig and poultry			Liebert, 1999 Shutte and Jong, 1999 Torrallardona, 1999

BEP name: Diet

P reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Use of enzymes: Phytasas of synthesis	• Reduce the amount of phosphorus excreted in manure • Improve mineralization • Decrease land needed for manure disposal and lower manure application cost (P criteria) • It increases the amount of N and K recovered but the crop, in case of choosing the P criteria	• Phytasas cost • Many farmers purchase their animal food from a manufacturer.	• Integrate the cost of the food (feed) and the cost of the management of the phosphorous in the manure	• Industrial livestock production systems • Pigs	• Grazing lands production systems • Ruminants		Bradford et al, 1999 Bosch *et al.*, 1998 Jongbloed and Lenis, 1999

BEP name: Diet *(continuation)*

P reduction	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems /situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Use plant ingredients contain high phytase activities	• Reduce the amount of phosphorus excreted in manure	• Technical difficulties to determine exactly the phytase content • Cereal phytase content varies markedly from one lot to another	• Same as above	• Industrial livestock production systems • Mixed crop-livestock systems	• Grazing land production systems		Jongloeb *et al.*, 1991
• Adjust phosphorous content in the food to the animal needs	• Reduce the amount of phosphorus excreted in manure	• Availability of row materials to be able to adjust the phosphorous level • Technical constraints	• Integrate the cost of the food (feed) and the cost of the management of the phosphorous in the manure • Technical consultancy	• Industrial livestock production systems • Mixed crop-livestock systems	• Grazing land production systems		

BEP name: Volume reduction - Water management

Description: One of the biggest costs in the management of solid organic manures and (slurries), is derived from their transport and application. The high livestock density forces to carry out the manures quite far; it means the cost of the transportation is larger than the value of the nutrients contained in the manure. For purpose to make easy the management mentioned, all the actions that allow reducing the volume and increasing the concentration involve a reduction in the management cost.

Water management	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/ situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Cleaning: system of high pressure and low volume	• Reduces the consumption of water • Reduces the volume of manure. • Reduces the time of the action	• Cost of the equipments	• Subsidize the acquisition of these kinds of equipments • Estimate the reduction in the cost of management in the manure. • Install water meter	• Indoors housing systems	• Grazing lands productions systems • Outdoor systems.		Callejo and Diaz, 1998
• Keep apart from the manure stores the rainfall water	• Reduction the consumption of water • Reduce the volume of manure • Put up the value of the manure as fertilizer	• Cost	• Install water meter • Reutilization of rainwater, washing etc, for cleaning the dirtiest areas				

BEP name: Volume reduction - Water management (*continuation)*

Water management	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/ situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Design systems that can easily be cleaned	• Improve hygienic-health of the farmer • Reduce the volume of manure	• Need to cover the stores • Need to build storage areas and evacuation of rainwater including own pipe systems					
• Food: limit diets with high contents in raw protein or very salty	• Reduce the ingestion of water by the animal • Reduce the volume of the manure	• Availability of raw material					
• Solid food	• Reduce the ingestion of water by the animal • Reduce the volume of the manure						
• Limit the environmental conditions (temperature, humidity, ventilation) that increase the animals' thirst	• Reduce the ingestion of water by the animal • Reduce the volume of the manure • Improve the well being of the animals • Improve animal production	• Energy cost for the farmer to operate the installation	• Legal limits in new equipments	• Indoors housing systems			

BEP name: Volume reduction - Water management (*continuation)*

Water management	Advantages (benefits)	Constraints and limitations for farmers adoption	Measures to help farmers adoption	Best suited agricultural systems/ situations to adopt the proposed BEP	Less suited agricultural systems /situations to adopt the proposed BEP	Remarks	References
• Solid manure with bedding	• Reduce the volume of manure compared with the slurry • Better manure quality and more suitable C/N relationship • Make easier the management and storage • Animal well-being	• Cost of the bed • Availability or raw materials for bedding • Cost and problems during the time the farm spends moving from a slurry system o a solid manure one • Difficulties in the mechanical and automatic handling of the manures	• Subsidize the project design of such farmers • Promote the technique among farmers and consumers				

5.5.3 Extensive dryland systems

Nutrient mining occurs mainly in such extensive systems but may occur as well in others.

BEP name: Return (replace) the nutrients exported by the harvested crops

Description: Crops uptake nutrients from the soil and when harvested they may be exported from the field. A prerequisite for sustainable agriculture is to avoid soil nutrient mining that is to return to the soil at least the nutrients exported in order to avoid in the long-term soil degradation and yield decline.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Maintain and increases yield, making agriculture profitable	• Cost of mineral fertilizers • Availability of organic fertilizers	• Make fertilizers available to farmers • Extension services • Subsidize up to a certain amount of fertilizer per hectare	• In all agricultural systems		• Soil nutrient mining occurs now in some areas with erratic yields or in some former central plan economies	Ayanaba *et al.*, 1976 Jiménez and Lamo de Espinosa, 1998

5.6 BEPs for Areas with Excess of Nutrients or with High Environmental Quality

BEP name: Vegetated buffer strips

Description: Natural vegetation prevents surface runoff to reach directly water bodies or watercourses, trapping sediments and nutrients. Also shallow groundwater may be intercepted by deep rooted plants (trees), nutrient absorbed or nitrate denitrified near the water courses where zones with some anoxia exists.

General remarks: Measure with high value for the multifunctionality of agricultural landscapes has also an important value to prevent water pollution.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Avoids nutrient flow to watercourses and bodies • It is also potentially good to trap particulate wastes and sediment-attached microbes and pesticides • Perennial vegetation supplies diversity of cover and food for wildlife; also add visual diversity to a cultivated cropland landscape	• Competition for land, light and water • It requires additional cost to install	• Regulatory • Payments or agricultural multifunctionality	• Cropland, grazing land, livestock enclosures and pastures close to small streams and lakes • Areas where land erosion is also important and sediments can also damage aquatic habitat and fill reservoirs		• It is a proved BEP.	Dosskey *et al.*, 1997a. Dosskey *et al.*, 1997b. Dosskey *et al.*, 1997c. Fajardo et al,. 2001 Nichols *et al.*, 1998

BEP name: Avoid soil sterilization

Description: Soil sterilization is a method for controlling pathogenic fungi, weeds, nematodes, phanerogamic parasite, bacteria and other biotic and abiotic agents. Nitrifying bacteria (Nitrosomonas and Nitrobacter spp.) are very sensitive to fumigants and their population may be greatly reduced. As recovery of nitrifying bacteria can be very slow, nitrification may be inhibited for a considerable period of time, thus increasing ammonium in fumigated soils. Also fumigation could be detrimental to vesicular-arbuscular mycorrhizal fungi needed for normal growth of some crops and nitrogen-fixing bacteria.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• It avoids negative impacts on beneficial microorganisms • It avoids disturbing biological balance in the soil.	• The need to control soil borne pathogens and pests in intensively cropped soils	• To promote alternative measures of control as crop rotations or at least other mild treatments as soil solarisation	• Less intensive vegetable systems.			Katan and Devay, 1991

BEP name: Nitrification inhibitors

Description: Addition of nitrification inhibitor to liquid manure or use a chemical fertilizer with a nitrification inhibitor in order to delay nitrification, prevent leaching and match crop N requirements.

Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Better matching with crop N requirements if there is a significant control of the nitrification inhibition achieved. It ends shortly before the crops require a significant amount of N • It may be added to mineral and organic fertilizers (pig manure, sewage sludge)	• Mixing of nitrification inhibitor with slurry is not easy • Cost • Inhibitory effect may depend on temperature, soil pH and moisture • Broad classes of inhibitors; the mode of action of some of them are still unknown • If not buried after application they can increase ammonia volatilization loses • The effectiveness of nitrification inhibition is still under debate in the scientific community	• Field demonstrations • Limitations of total N application • Payments for environmental goals	• Animal systems • High value crops • Sensitive areas • Winter crops autumn fertilized	• Low applications	• Avoid over dosage • More knowledge about the behaviour of nitrification inhibitors is needed	Barth *et al.*, 2001 Blaise *et al.*, 1997 Prakasa and Puttanna, 1987 Prasad and Power, 1995. Quemada *et al.*, 1998 Slangen and Kerkhoff, 1984

BEP name: Foliar N application

Description: Foliar N application is a measure used under some soil nitrogen limitations (p.e. saline, dry conditions or other stress) or for minimizing leaching of nitrates although soil-applied N is necessary. Also used for late applications when high amounts of N are needed. Under normal situations yield responses are not consistent.

General remarks: Its role is in supplying N to the crop in some critical moments.

Fertilizer product	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Urea, low in biuret	• It can increase protein content in wheat and grasses • It can be an additional measure to control excessive vegetative growth	• High additional costs linked to the number of sprays • Non-consistent responses to the foliar application	• Quality goals	• Extensive agricultural systems • Others such as citrus or peach. • High value crops	• Low input system	• Other products may be used as well	Clapp, 1993. Embelton *et al.*, 1974 Gooding et al,. 1992 Heitholt, 1994. Johnson *et al.*, 2001 Romero-Aranda *et al.*, 1996

BEP name: Cover crop/catch crop

Description: Cover crops and catch crops can be effective in reducing nitrate leaching potential by absorbing residual soil mineral nitrogen from earlier crops and available water, thus reducing losses outside the growing season. As the catch crop is buried some of the absorbed N is returned to the soil and it is available to the following crop. They are also an aid in reducing precipitation runoff and soil erosion.

Cover/catch crop	Advantages (Benefits)	Constraints and limitations for farmers adoption	Measures to promote farmers adoption	Best suited agricultural systems/situations to adopt the proposed BEP	Less suited agricultural systems/situations to adopt the proposed BEP	Remarks	References
• Legumes (e.g. vetches)	• They provide an additional N source to the following crop by biological fixation	• Delayed cover crop incorporation can reduce N availability to the crop by microbial immobilization • It increases labour costs • Water consumption	• Subsidise • Remove structural constraints (irrigated areas)	• Irrigated agricultural systems • Rain fed agricultural systems with enough water availability during winter	• Dry land agricultural systems because they compete for water against the crop	• Soil water availability is a crucial point to farmers' adoption of this BEP.	Francis *et al.*, 1998 Martin *et al.*, 1983 Monks *et al.*, 1997 Rasse *et al.*, 2000 Wagger *et al.*,1998 Wyland *et al.*, 1995
• Non-legumes (e.g. small grains)	• They can scavenge residual soil inorganic N						

6. GENERAL DISCUSSION

6.1 Introduction

Best environmental practices (BEP), used in the sense of a wider approach than similar terms (good agricultural practices, best management practices) may play a significant role in reducing nutrient (N, P) emissions to the environment, preventing land degradation and enhancing soil quality in particular and of the environment in general.

However, it is clear that an integral approach should be adopted to deal with this kind of problems; policies tend to be sectorial and to forget side effects in related areas.

BEPs represent a fine-tuning of nutrient (N, P) use, but in environmental terms other considerations should be taken into account if they have to be effective. The integral approach should result in a specific set of measures for each region and each agricultural sector.

6.2 Framework for Successful BEPs Implementation

6.2.1 Land use planning

Land is heterogeneous at various scales. Sometimes changes are abrupt, other times such changes occur over long distances. Such variations are in terms of soils, climate, hydrology, land use, biological communities, etc. Also human values are different from place to place. Very often land use tends to assume land is homogenous over large areas and under this assumption the variations in land characteristics are not taken into account which would allow fine tuning in management; as a result this has dramatic effects on environmental quality.

At this very moment, strong tendencies exist to give pre-eminence to the market globalisation competitive forces in front of regulatory uses, even though the last are increasing in number, and perhaps less, in their effectiveness. Although concepts as carrying capacity of the land or critical load have been introduced and are gaining wider acceptance it is very difficult to implement them in a case-by-case basis as it is done with the environmental impact assessment.

In terms of nutrient (N, P) environmental problems related to agriculture, the most complicated situations occur in areas with intensive (concentrated) animal rearing and intensive vegetable production. In both cases surplus of nutrients occurs over large areas (tenths or hundreds of thousands of hectares), which make some problems (i.e. N emission to air and water) very difficult to handle, through for instance, dilution of the pollution, which is especially difficult in the dry inland Mediterranean areas. But such spatial concentration of economic activities is promoted by natural conditions (climate, irrigation water...), infrastructures and other facilities. Such concentrations are highly effective in economic terms because of the induced effects and tend to increase -if left alone to the market forces- such concentration and intensification.

Land use planning, at a proper scale, is a powerful tool to make possible both economic growth and environmental quality. It may prevent the undesirable environmental side effects, making possible high development standards through in many cases diversification and making compatible in a same tract of land different economic activities.

Land use planning, a participatory process, should be done at various scales based on sound land information and with clearly established economic and environmental goals. Understanding the basic processes going on in a region is a prerequisite for such successful land use planning exercise.

BEPs are unable, by themselves, of reversing the trends in both, very intensive and marginal areas. In both cases, problems and conflicts may be expected (in certain areas) for certain environmental parameters related to nutrient (N, P) use: groundwater quality, surface water eutrophication, nutrient mining, ... As said before, BEPs may significantly reduce nutrient emissions, but in some cases a technical economical ceiling exists for such reductions to be effective in terms of the environmental standards set up somewhere for a certain land use system. So, land use planning is a prerequisite to the adoption of an effective set of BEPs.

Contamination dilution (Fereres)

6.2.2 Environmental standards

Quality standards for different resources or environmental components are set up with different aims (sanitary, ecosystem functions, engineering, etc.).

Water is a key issue worldwide, but especially in the Mediterranean area. It has been suggested somewhere that some standards are unachievable in such dry areas because:

- Less water exists in natural conditions.
- Large amounts of water are withdrawn from the natural system.
- The standards are in terms of concentration (mass/volume).

The final result is that the remaining water is more concentrated for several components brought to it by anthropogenic activities, for instance nitrates.

This discussion is out of the scope of these Guidelines but it should be kept in mind when BEPs or related policies are to be implemented and evaluated.

6.2.3 Education, training and technical advice

A good standard education is needed for land managers to achieve a proper level of BEP adoption. However, such standard education could not be sufficient in many cases; the so-called traditional knowledge is needed.

Such traditional knowledge includes in many instances a better understanding of the natural part of the agro ecosystems as well as a different set of values associated to such components. In that sense, this type of education should be maintained and promoted.

Many BEPs require special training that should be provided specifically. In addition to that, technical advice should exist. More and more land managers are concerned with economical and management aspects and less with technical aspects. Farmer extension services - nowadays generally declining worldwide- should be revisited adding the environmental aims to the former dominant productivity approach.

Demonstration form.

6.2.4 Awareness of the environmental problems and the socio-economic role of agriculture

Agricultural activities tend to be socially low ranked in industrialised societies and some sort of marginalisation occurs. Adoption of BEPs has to lead to a good land stewardship and this is possible only if well-educated and motivated people are in charge.

Although land managers may have a right perception of environmental degradation in most cases, often fail in recognising the effects of their own activity. Prior to BEPs implementation comes a sensibilisation of the people involved in the agricultural business.

Even though productivity and total gross income increases in most of the agricultural systems, their relative contribution to the national gross products shrinks more and more with time. This leads to the situation of marginalisation of agriculture. Urban people do not recognize the importance of agriculture; such recognition will help BEPs implementation.

Highly productive agriculture, as it is practised nowadays everywhere, may generate negative environmental impacts in MAP countries and elsewhere. From a sustainability point of view, local food sources are very important; despite of this little attention has been paid to this matter in recent times.

All this facts lead to a picture of agriculture as a marginal activity; in this situation little hope exists for spontaneous BEPs adoption by the farmers if proactive action is not taken by public authorities.

6.2.5 Integral nutrient management

The use of all the (bio)nutrients existing in a certain area is a prerequisite to obtain overall nutrient use efficiency. This is not very often the case and although some parts of it may use nutrients very efficiently, the overall result is very poor. This approach will mean each source of nutrients (compost, sewage treatment sludge, waste water, manure, mineral fertilizers, ...) has a certain role in covering the needs of the agricultural systems.

The end result will be that the base fertilisation is done with organic products and mineral fertilizers are used in smaller quantity. This envisaged scenario is developing in practice, especially in the most urbanised and industrialised areas; chemical fertilizers are less and less used as bulk fertilizers and are replaced by highly specialised products (i.e. coated fertilizers, slow release fertilizers, highly soluble fertilizers, etc.).

For large areas it will imply moving large amounts of wastes (low concentration fertilizers) from one place to another; it will also imply the proper treatment of such wastes according to their agricultural destination (Boixadera et al, 2001) in order to adapt them to be used as a fertilizer for a specific agricultural system. Much more is needed to proceed in that direction, because, nowadays, most treatments are developed only for industry or urban waste treatment biased.

Such approach at regional level will means for the farm a major effort. At a farm scale also a sustainable approach should be taken, being it termed sometimes integrated nutrient management.

6.2.6 Nutrient (N, P) related environmental problems and other land degradation processes in MAP countries

Nutrient (N, P) excess problems are less extensive in MAP countries than in other areas, i.e. Northern Europe. However, nutrient mining may be important in several parts of MAP countries, specially in former central planning ones, or in marginal farming systems.

However, in MAP countries there occur other forms of land degradation related to agricultural land uses. They are: soil erosion, salinisation and desertification.

6.3 Retained BEPs

The BEPs presented under Section 5 have been retained among the many existing possibilities.

6.3.1 General aims of the retained BEPs

The BEPs retained have several aims, all with the overall one to reduce nutrient emission to the environment, nutrient mining is an exception, but this may be achieved in different ways:

A. Reduce (decrease) the external inputs of nutrients to the agricultural system (i.e.: less chemical fertilizer, lower stocking ratio, ...).

B. Use (take in account) all the nutrients existing in a certain area, increasing their overall use efficiency.

C. Make a more efficient use of nutrients in a certain compartment of the agricultural system (i.e.: animal feeds, fertilizers, ammonia volatilisation).

D. Increase the usefulness (value) of wastes as fertilizers.

E. Reduce/avoid the transfer of nutrients to other environmental compartments or critical parts of the environment.

In addition to that, another general consideration should be made about the BEPs. Some BEPs tend to the extensification of land use and others will allow even a more intensive use of land; although the last will improve the situation from the point of view of nutrient management, other side effects are less known and special attention should be paid to this point prior to generalised adoption.

As a general recommendation, mixed farming systems with different compatible land uses should be encouraged in general as a better way to achieve environmental goals.

6.3.2 Measures to help BEPs adoption by the farmers

As it has been discussed before, sensibilisation (increasing awareness) about the environmental results of their own economic activity is a prerequisite to voluntary adoption of BEPs by land managers, a wider concept than that of farmers.

Consciousness of their role in land stewardship is fundamental but this cannot be achieved under the prevalent marginalisation process that agriculture is suffering.

Other available tools are:

- Including the adoption of certain BEPs in the achievement of some environmental production permits.
- Taxation for the use of certain products.
- Taxation for certain (nutrient) discharges to the environment above a critical level.
- Financial support for the adoption of certain BEPs (i.e. as for instance is currently done for the agro environmental measures of the CAP).
- Regulations enforcing the use of certain BEPs in some areas (zoning).
- Making available facilities.
- Making available technological tools or integrated packages.

Traditional knowledge and non-formal education are important also but their role becomes quickly degraded and economically useless in the most intensive systems with the environmental costs externalised. Mixed agricultural systems can benefit substantially if such knowledge is used in their management.

As already stated, many BEPs are technically very complex. Therefore, only well educated, specially trained people with technical services at their reach, will be able to adopt them.

6.3.3 Status of the retained BEPs

Some of the BEPs retained are currently used in several parts of the world, others have been proposed on the basis of some relevant experience but implementation is pending, and the efficiency of others has been demonstrated but constraints (technical, economic, legal) for their application still exists.

6.3.4 A set of BEPs for each situation and the need for integration

Each agricultural system has its own specificities in terms of physical, biological, human and management characteristics. So, no single set of BEPs may be defined for all the existing agricultural systems; specific sets may be recommended for specific agricultural systems but even so they will have to be refined at local level in order to match the requirements of an individual farming system.

Another important remark is the need of integration into the farming system, otherwise BEPs may be regarded as extraneous to it becoming useless. It will never be said enough about the need of BEPs integration in such a way that they become part of the farming system.

6.3.5 Technical ceilings and economic paradoxes

Thousands of field experiments have been carried out in the world aiming at knowing the crop response to increasing doses of fertilizer. From these experiments certain "laws" have been derived and knowledge gained about nutrient behaviour, although most of these experiments are incomplete and they have not been performed for many years in the same site (long term experiments).

In general terms it may be stated that:

- Agricultural nutrients -specially nitrogen- are used with large losses to the environment (soil, air and water) occur and in many cases, the process is not well known ("unaccounted for" in the scientific literature).
- Large room for improvement exists for nutrient use efficiency, but there is agreement on that there is a ceiling for such improvement (inevitable losses).
- Nitrogen use efficiency is higher in temperate agricultural systems than in drier (Mediterranean) or irrigated ones. The efficiency is linked to water availability.
- There are large differences among the different crops with regard to their ability to use nitrogen; vegetable crops are in general, less efficient than, for instance, cereals.
- Increasing doses of fertilizer are used less efficiently (that is, the response curve flattens to the top) probably because other factors become limitant; de Wit (1992) proved that in terms of agricultural system, nutrient (N) use efficiency increases through time despite doses increase too. However, it should be kept in mind that the total amount of nutrients emitted to the environment per unit area increases in many cases and dilution of pollution plays a role in such a situation.

In addition to that, the uncertainty of rainfall, the cost of fertilizers and the price of the products makes that the most rational (economically) behaviour be that of over fertilising, using fertilizer as a kind of insurance. Other similar paradoxes may be described for vegetable growers and the uncertainty of nitrogen availability for the plant.

As a result of all the above combined with the scarcity of water, it may make it very difficult to reach certain environmental goals (i.e.: nitrate concentration in the groundwater) under the current technical and economical conditions, especially in areas with a la large number of intensive farm units (spatial concentration, limited "dilution"). However BEPs adoption may solve many situations and alleviate many others.

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Cyprus
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Croatia
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Egypt
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Malta
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Canadian Institute of Fertilizers:
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ANNEXES

Annex 1

Land Use (ha) and Agricultural production (Mt=Metric tons) (Dryland and Irrigated) of MAP Countries+B3

		1995	1996	1997	1998	1999	2000	2001
Albania	Total Area	2875000	2875000	2875000	2875000	2875000		
	Non Arable and no permanent crop	2038000	2038000	2040000	2041000	2041000		
	UAS (Ha)	1127000	1131000	1129000	1128000	1128000		
	Arable Land	577000	577000	578000	577000	577000		
	Permanent crops	125000	125000	122000	122000	122000		
	Permanent pasture	425000	429000	429000	429000	429000		
	Vegetable cultivated Surface (Ha)	34,200	38,600	35,100	35,200	34,300	34,400	34,400
	Vegetable Production (Mt)	580,000	730,000	600,000	626,000	630,000	652,000	652,000
	Total cereal cultivated surface (Ha)	245,137	220,526	227,488	226,906	193,400	222,200	222,200
	Total cereal production (Mt)	662,400	518,714	616,043	620,746	512,000	580,000	580,000
	Wheat Cultivated Surface (Ha)	141,219	124,721	136,200	140,910	109,000	132,000	132,000
	Wheat Production (Mt)	405,342	271,150	388,391	395,067	272,000	330,000	330,000
	Barley Cultivated Surface (Ha)	3,229	2,388	2,565	1,700	1,600	1,900	1,900
	Barley Production (Mt)	7,274	3,195	3,738	3,248	2,900	3,500	3,500
	Corn Cultivated Surface (Ha)	68,870	65,654	61,145	56,599	55,000	60,000	60,000
	Corn Production (Mt)	215,566	214,059	194,818	189,130	206,000	215,000	215,000
	Citrus Cultivated Surface (Ha)	500	450	470	480	480	480	480
	Citrus Production (Mt)	3,782	3,001	3,017	2,216	2,200	2,200	2,200
Argelia	Total Area	238,174,000	238,174,000	238,174,000	238,174,000	238,174,000		
	No Arable land and no permanent cr	230,145,000	230,134,000	230,015,000	230,000,000	229,959,000		
	UAS (Ha)	39,649,000	39,636,000	39,690,000	42,641,000	42,715,000		
	Arable Land	7,519,000	7,521,000	7,650,000	7,661,000	7,700,000		
	Permanent crops	510,000	519,000	509,000	513,000	515,000		
	Permanent pasture	31,620,000	61,596,000	31,531,000	34,467,000	34,500,000		
	Total cereal cultivated surface (Ha)	2,579,490	3,663,900	1,115,640	3,575,400	1,888,810	1,083,720	1,848,630
	Total cereal production (Mt)	2,139,957	4,902,005	869,898	3,025,659	2,020,891	934,508	1,942,000
	Wheat Cultivated Surface (Ha)	1,680,720	2,278,500	825,240	2,577,150	1,372,400	827,000	2,400,000
	Wheat Production (Mt)	1,499,920	2,982,604	661,514	2,280,000	1,470,000	760,361	1,980,000
	Barley Cultivated Surface (Ha)	824,170	1,282,500	264,840	939,210	468,960	216,000	482,000
	Barley Production (Mt)	584,980	1,800,222	190,892	700,000	510,000	163,287	500,000
	Corn Cultivated Surface (Ha)	260	260	120	180	240	400	400
	Corn Production (Mt)	419	446	257	310	537	1,556	1,500
	Citrus Cultivated Surface (Ha)	40,280	38,810	40,240	41,110	40,780	41,380	41,340
	Citrus Production (Mt)	323,078	334,094	350,724	418,356	453,925	433,015	440,780
	Vegetable cultivated Surface (Ha)	237,480	231,630	227,920	235,880	254,080	252,400	253,400
	Vegetable Production (Mt)	2,561,626	2,434,032	2,421,177	2,621,637	2,961,637	2,559,219	2,560,200

Bosnia and Herzegovina	Total Area	5,113,000	5,113,000	5,113,000	5,113,000	5,113,000		
	No Arable land and no permanent cr	4,450,000	4,450,000	4,450,000	4,450,000	4,450,000		
	UAS (Ha)	1,850,000	1,850,000	1,850,000	1,850,000	1,850,000		
	Arable Land	500,000	500,000	500,000	500,000	500,000		
	Permanent crops	150,000	150,000	150,000	150,000	150,000		
	Permanent pasture	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000		
	Total cereal cultivated surface (Ha)	187,200	237,900	352,483	381,091	364,509	473,100	473,100
	Total cereal production (Mt)	671,360	841,400	1,242,059	1,326,635	1,273,585	1,311,100	1,311,100
	Wheat Cultivated Surface (Ha)	70,000	55,000	95,178	106,165	82,250	114,000	114,000
	Wheat Production (Mt)	238,750	165,700	287,372	340,931	257,764	275,000	275,000
	Barley Cultivated Surface (Ha)	16,200	18,000	21,571	24,065	22,046	27,000	27,000
	Barley Production (Mt)	42,000	47,000	58,032	63,402	56,295	64,000	64,000
	Corn Cultivated Surface (Ha)	93,000	147,000	206,906	219,104	228,705	300,000	300,000
	Corn Production (Mt)	372,000	588,000	830,445	846,638	888,845	900,000	900,000
	Citrus Cultivated Surface (Ha)	No Data	No Data	No Data	No Data	No Data	No Data	No Data
	Citrus Production (Mt)	65	50	50	70	70	70	70
	Vegetable cultivated Surface (Ha)	122,900	123,150	124,900	129,650	131,050	182,250	182,250
	Vegetable Production (Mt)	595,405	575,500	652,000	703,500	698,100	689,300	689,300
Croatia	Total Area	5,654,000	5,654,000	5,654,000	5,654,000	5,654,000		
	No Arable land and no permanent cr	4,359,000	4,162,000	4,150,000	4,005,000	4,002,000		
	UAS (Ha)	2,332,000	2,980,000	2,992,000	3,151,000	3,151,000		
	Arable Land	1,117,000	1,305,000	1,317,000	1,458,000	1,461,000		
	Permanent crops	116,000	125,000	125,000	129,000	129,000		
	Permanent pasture	1,099,000	1,550,000	1,550,000	1,564,000	1,561,000		
	Total cereal cultivated surface (Ha)	631,755	612,087	634,028	686,629	625,096	496,345	675,295
	Total cereal production (Mt)	2,759,724	2,761,924	3,178,744	3,209,900	2,883,483	2,724,022	2,976,355
	Wheat Cultivated Surface (Ha)	227,044	200,852	208,377	241,734	169,280	235,939	224,000
	Wheat Production (Mt)	876,507	741,235	833,508	1,020,450	558,217	1,032,085	800,000
	ORDI Cultivated Surface (Ha)	32,518	31,034	33,759	42,737	44,517	46,363	40,000
	ORDI Production (Mt)	103,281	88,091	108,496	143,510	124,890	151,439	151,439
	Corn Cultivated Surface (Ha)	354,059	361,268	371,273	377,818	384,184	388,639	385,750
	Corn Production (Mt)	1,735,060	1,885,515	2,183,144	1,982,545	2,135,452	1,526,167	2,005,900
	Citrus Cultivated Surface (Ha)	2,650	3,750	3,750	3,850	3,750	3,600	3,600
	Citrus Production (Mt)	10,134	20,921	16,722	22,806	19,445	20,303	20,303
	Vegetable cultivated Surface (Ha)	40,629	41,807	43,305	49,986	53,636	53,636	53,636
	Vegetable Production (Mt)	344,863	357,516	373,738	466,522	504,365	504,365	504,365

Cyprus	Total Area	925000	925000	925000	925000	925000		
	No Arable land and no permanent cr	781,000	781,000	783,000	780,000	781,000		
	UAS (Ha)	147,000	147,000	145,000	148,000	147,000		
	Arable Land	100,000	99,000	98,000	101,000	101,000		
	Permanent crops	43,000	44,000	43,000	42,000	42,000		
	Permanent pasture	4,000	4,000	4,000	4,000	4,000		
	Total cereal cultivated surface (Ha)	60,870	58,940	43,020	59,090	58,940	51,480	51,340
	Total cereal production (Mt)	145,170	141,190	47,780	65,850	127,100	47,850	125,400
	Wheat Cultivated Surface (Ha)	3,650	3,700	5,250	5,800	6,600	6,150	6,000
	Wheat Production (Mt)	11,000	13,000	11,500	11,500	14,000	10,000	10,000
	Barley Cultivated Surface (Ha)	57,000	55,000	37,500	53,000	52,000	45,000	45,000
	Barley Production (Mt)	134,000	128,000	36,000	54,000	112,700	37,600	11,500
	Corn Cultivated Surface (Ha)	No data	No data	No data	No data	No data	No data	No data
	Corn Production (Mt)	No data	No data	No data	No data	No data	No data	No data
	Citrus Cultivated Surface (Ha)	7,150	7,150	6,900	6,210	6,210	6,190	6,190
	Citrus Production (Mt)	176,900	151,900	143,400	123,350	143,750	116,050	125,850
	Vegetable cultivated Surface (Ha)	4,130	4,078	4,084	3,965	4,125	4,142	4,217
	Vegetable Production (Mt)	141,695	136,559	135,640	148,885	157,375	145,320	147,370
Egypt	Total Area	100,145,000	100,145,000	100,145,000	100,145,000	100,145,000		
	No Arable land and no permanent cr	96,262,000	96,245,000	96,245,000	96,245,000	96,245,000		
	UAS (Ha)	3,283,000	3,300,000	3,300,000	3,300,000	3,300,000		
	Arable Land	2,817,000	2,820,000	2,834,000	2,834,000	2,834,000		
	Permanent crops	466,000	466,000	466,000	466,000	466,000		
	Permanent pasture	No Data	No Data	No Data	No Data	No Data		
	Total cereal cultivated surface (Ha)	2,726,636	2,545,317	2,735,816	2,646,833	2,707,099	2,761,724	2,761,724
	Total cereal production (Mt)	16,097,252	16,542,173	18,071,326	17,964,394	19,400,571	20,105,078	20,105,078
	Wheat Cultivated Surface (Ha)	1,055,384	1,017,192	1,044,593	1,017,282	999,998	1,034,985	983,947
	Wheat Production (Mt)	5,722,441	5,735,367	5,849,134	6,093,151	6,346,642	6,564,053	6,254,580
	Barley Cultivated Surface (Ha)	188,143	44,254	57,705	60,000	56,764	48,896	30,905
	Barley Production (Mt)	638,297	119,522	125,575	148,021	114,359	99,392	93,305
	Corn Cultivated Surface (Ha)	735,874	742,966	814,336	876,987	817,224	843,029	843,029
	Corn Production (Mt)	4,535,175	5,165,338	5,806,070	6,336,802	6,143,360	6,474,450	6,474,450
	Citrus Cultivated Surface (Ha)	129,692	127,417	130,152	131,378	141,152	136,388	139,897
	Citrus Production (Mt)	2,278,458	2,379,173	2,226,292	2,121,218	2,433,085	2,372,284	2,441,218
	Vegetable cultivated Surface (Ha)	422,502	456,387	481,257	504,818	545,937	546,294	546,294
	Vegetable Production (Mt)	10,247,979	11,701,082	12,295,926	12,261,386	13,588,449	13,661,558	13,661,558

France	Total Area	55,150,000	55,150,000	55,150,000	55,150,000	55,150,000		
	No Arable land and no permanent cr	35,517,000	35,549,000	35,527,000	35,493,000	35,495,000		
	UAS (Ha)	30,059,000	29,998,000	29,960,000	29,944,000	29,900,000		
	Arable Land	18,310,000	18,288,000	18,320,000	18,362,000	18,361,000		
	Permanent crops	1,183,000	1,173,000	1,163,000	1,155,000	1,154,000		
	Permanent pasture	10,566,000	10,537,000	10,477,000	10,427,000	10,385,000		
	Total cereal cultivated surface (Ha)	8,291,655	8,840,425	9,206,544	9,289,795	9,289,795	8,931,584	9,200,135
	Total cereal production (Mt)	53,545,493	62,599,234	63,431,583	68,660,514	64,803,912	66,574,971	60,881,000
	Wheat Cultivated Surface (Ha)	4,745,000	5,040,300	5,110,000	5,234,000	5,115,195	5,269,000	4,825,000
	Wheat Production (Mt)	30,880,000	35,948,900	33,847,000	39,809,000	37,050,000	37,559,000	32,065,000
	Barley Cultivated Surface (Ha)	13,869,000	1,535,000	1,690,000	1,631,000	1,534,000	1,572,700	1,698,000
	Barley Production (Mt)	7,683,000	9,519,000	10,124,000	10,591,000	9,539,000	9,927,000	9,851,000
	Corn Cultivated Surface (Ha)	1,650,800	1,733,500	1,858,000	1,799,000	1,759,000	1,834,000	1,902,000
	Corn Production (Mt)	12,739,600	14,529,700	16,832,000	15,206,000	15,643,000	16,469,000	16,478,000
	Citrus Cultivated Surface (Ha)	2,671	2,736	2,786	2,888	2,974	3,030	3,072
	Citrus Production (Mt)	32,261	26,616	27,718	29,605	32,565	33,565	33,500
	Vegetable cultivated Surface (Ha)	458,079	454,665	446,419	447,724	440,637	434,829	429,900
	Vegetable Production (Mt)	7,858,469	7,895,007	7,778,371	7,983,752	8,008,689	8,009,520	7,805,300
Greece	Total Area	13,196,000	13,196,000	13,196,000	13,196,000	13,196,000		
	No Arable land and no permanent cr	8,986,000	8,991,000	9,005,000	9,008,000	9,020,000		
	UAS (Ha)	9,054,000	9,049,000	9,035,000	9,032,000	9,020,000		
	Arable Land	2,821,000	2,810,000	2,789,000	2,784,000	2,762,000		
	Permanent crops	1,083,000	1,089,000	1,096,000	1,098,000	1,108,000		
	Permanent pasture	5,150,000	5,150,000	5,150,000	5,150,000	5,150,000		
	Total cereal cultivated surface (Ha)	1,307,144	1,323,598	1,307,329	1,295,874	1,258,700	1,278,931	8,961,000
	Total cereal production (Mt)	4,902,743	4,683,250	4,705,177	4,358,614	4,620,218	4,792,820	3,907,200
	Wheat Cultivated Surface (Ha)	878,800	864,854	859,813	855,422	837,900	859,780	855,000
	Wheat Production (Mt)	2,314,838	1,882,488	1,990,803	1,880,000	2,063,990	2,183,360	1,500,000
	Barley Cultivated Surface (Ha)	156,300	154,447	146,256	139,198	128,600	122,131	120,000
	Barley Production (Mt)	411,500	356,000	348,000	326,000	320,000	302,924	280,000
	Corn Cultivated Surface (Ha)	182,487	213,000	210,645	213,938	209,800	215,000	215,000
	Corn Production (Mt)	1,838,779	2,110,000	2,025,281	1,816,441	1,949,920	2,037,500	1,850,000
	Citrus Cultivated Surface (Ha)	60,160	60,420	60,020	59,920	58,070	59,700	60,550
	Citrus Production (Mt)	1,213,242	1,259,110	1,291,457	1,101,904	1,402,994	1,336,244	1,196,000
	Vegetable cultivated Surface (Ha)	134,750	137,439	135,429	137,626	142,400	139,300	139,300
	Vegetable Production (Mt)	4,186,078	4,256,476	4,145,479	4,239,622	4,276,136	4,228,474	4,208,500

Israel	Total Area	2,106,000	2,106,000	2,106,000	2,106,000	2,106,000		
	No Arable land and no permanent cr	1,625,000	1,624,000	1,623,000	1,622,000	1,622,000		
	UAS (Ha)	582,000	583,000	584,000	585,000	585,000		
	Arable Land	351,000	351,000	351,000	351,000	351,000		
	Permanent crops	86,000	87,000	88,000	89,000	89,000		
	Permanent pasture	145,000	145,000	145,000	145,000	145,000		
	Total cereal cultivated surface (Ha)	98,728	94,445	95,000	100,311	73,128	58,100	93,650
	Total cereal production (Mt)	309,380	264,280	187,110	234,920	122,030	197,150	282,850
	Wheat Cultivated Surface (Ha)	79,680	80,970	82,530	85,680	63,653	40,000	75,000
	Wheat Production (Mt)	242,000	185,000	116,000	155,000	29,000	94,000	170,000
	Barley Cultivated Surface (Ha)	11,428	6,390	6,640	7,611	2,153	10,000	10,000
	Barley Production (Mt)	2,300	2,400	1,200	2,500	1,000	2,400	10,000
	Corn Cultivated Surface (Ha)	6,950	6,450	4,960	5,940	5,837	6,000	6,500
	Corn Production (Mt)	63,730	74,910	68,110	73,520	82,160	85,000	87,000
	Citrus Cultivated Surface (Ha)	29,235	29,288	27,820	28,920	27,250	25,520	25,560
	Citrus Production (Mt)	906,430	873,850	960,990	898,775	734,400	788,300	794,600
	Vegetable cultivated Surface (Ha)	51,371	45,403	46,480	49,373	51,028	50,150	49,980
	Vegetable Production (Mt)	1,627,716	1,519,663	1,457,335	1,652,315	1,737,460	1,672,680	1,586,800
Italy	Total Area	30,134	30,134	30,134	30,134	30,134		
	No Arable land and no permanent cr	18,483,000	18,405,000	18,437,000	18,274,000	17,989,000		
	UAS (Ha)	15,333,000	15,349,000	15,345,000	15,484,000	16,268,000		
	Arable Land	8,283,000	8,332,000	8,253,000	8,329,000	8,545,000		
	Permanent crops	2,645,000	2,674,000	2,721,000	2,808,000	2,877,000		
	Permanent pasture	4,405,000	4,343,000	4,371,000	4,347,000	4,846,000		
	Total cereal cultivated surface (Ha)	4,217,742	4,223,335	4,187,250	4,072,031	4,178,908	4,157,344	4227090
	Total cereal production (Mt)	309,380	264,280	187,110	234,920	122,030	197,150	282,850
	Wheat Cultivated Surface (Ha)	2,482,120	2,407,992	2,366,121	2,327,950	2,387,266	2,330,000	2,269,600
	Wheat Production (Mt)	7,946,080	7,987,241	6,758,351	8,338,301	7,742,800	7,463,968	6,350,000
	Barley Cultivated Surface (Ha)	374,000	359,362	356,661	362,631	353,850	345,331	340,000
	Barley Production (Mt)	1,421,600	1,350,494	1,179,575	1,378,940	1,313,300	1,261,600	1,187,100
	Corn Cultivated Surface (Ha)	942,475	1,022,670	1,039,229	968,799	1,028,000	1,064,000	1,184,000
	Corn Production (Mt)	8,454,200	9,547,540	10,004,697	9,030,860	10,017,200	10,137,500	11,189,000
	Citrus Cultivated Surface (Ha)	179,495	183,088	178,695	179,543	177,717	177,591	177,771
	Citrus Production (Mt)	2,607,693	2,867,717	2,917,877	2,365,460	2,902,371	3,111,205	3,139,002
	Vegetable cultivated Surface (Ha)	589,562	595,183	591,147	595,514	592,099	583,591	583,591
	Vegetable Production (Mt)	13,810,004	15,185,143	14,331,219	14,683,646	15,299,667	15,345,358	15,345,358

Lebanon	Total Area	1,040,000	1,040,000	1,040,000	1,040,000	1,040,000		
	No Arable land and no permanent cr	716,000	715,000	715,000	715,000	715,000		
	UAS (Ha)	322,000	324,000	324,000	324,000	324,000		
	Arable Land	180,000	180,000	180,000	180,000	180,000		
	Permanent crops	127,000	128,000	128,000	128,000	128,000		
	Permanent pasture	15,000	16,000	16,000	16,000	16,000		
	Total cereal cultivated surface (Ha)	39,077	38,289	54,895	38,306	38,785	39,720	39720
	Total cereal production (Mt)	100,385	93,796	90,069	94,342	92,935	96,300	96,300
	Wheat Cultivated Surface (Ha)	24,230	23,595	35,906	23,564	23,800	24,000	24,000
	Wheat Production (Mt)	60,005	58,342	58,394	58,670	58,000	60,000	60,000
	Barley Cultivated Surface (Ha)	11,320	11,253	16,384	11,305	11,500	12,000	12,000
	Barley Production (Mt)	33,410	28,423	26,043	28,650	28,000	29,000	29,000
	Corn Cultivated Surface (Ha)	2,007	2,034	1,384	2,015	2,050	2,250	2,250
	Corn Production (Mt)	4,670	4,772	3,551	4,779	4,700	5,000	5,000
	Citrus Cultivated Surface (Ha)	10,650	11,778	16,299	12,062	12,120	12,550	12,550
	Citrus Production (Mt)	314,000	335,478	406,451	355,264	353,500	368,500	368,500
	Vegetable cultivated Surface (Ha)	48,730	52,455	51,130	55,896	56,320	58,765	58,765
	Vegetable Production (Mt)	1,129,410	1,228,899	1,295,840	1,293,851	1,258,700	1,323,850	1,323,850
Lybia	Total Area	175,954,000	175,954,000	175,954,000	175,954,000	175,954,000		
	No Arable land and no permanent cr	173,739,000	173,588,000	173,588,000	173,804,000	173,804,000		
	UAS (Ha)	15,515,000	15,666,000	15,666,000	15,450,000	15,450,000		
	Arable Land	1,870,000	2,028,000	2,028,000	1,815,000	1,815,000		
	Permanent crops	345,000	338,000	338,000	335,000	335,000		
	Permanent pasture	13,300,000	13,300,000	13,300,000	13,300,000	13,300,000		
	Total cereal cultivated surface (Ha)	215,400	235,680	246,800	301,910	326,965	327,020	327020
	Total cereal production (Mt)	145,900	159,800	206,330	237,950	251,055	237,950	237,950
	Wheat Cultivated Surface (Ha)	160,000	170,000	155,000	160,000	165,000	165,000	165,000
	Wheat Production (Mt)	117,000	124,000	156,400	140,000	130,000	125,000	130,000
	Barley Cultivated Surface (Ha)	50,000	59,000	85,000	135,000	155,000	170,000	170,000
	Barley Production (Mt)	23,000	28,200	42,100	65,000	75,000	80,000	80,000
	Corn Cultivated Surface (Ha)	400	380	400	410	415	420	420
	Corn Production (Mt)	400	400	430	450	455	450	450
	Citrus Cultivated Surface (Ha)	6,200	6,130	6,150	6,275	6,400	6,510	6,510
	Citrus Production (Mt)	64,000	62,900	61,700	63,150	65,300	66,400	66,400
	Vegetable cultivated Surface (Ha)	53,220	58,420	60,405	64,080	66,270	68,840	68,850
	Vegetable Production (Mt)	766,320	833,680	841,900	863,500	887,000	904,700	905,800

Malta	Total Area	32,000	32,000	32,000	32,000	32,000		
	No Arable land and no permanent cr	21,000	21,000	22,000	23,000	23,000		
	UAS (Ha)	11,000	11,000	10,000	9,000	9,000		
	Arable Land	10,000	10,000	9,000	8,000	8,000		
	Permanent crops	1,000	1,000	1,000	1,000	1,000		
	Permanent pasture	No Data	No Data	No Data	No Data	No Data		
	Total cereal cultivated surface (Ha)	2,950	2,000	2,700	2,700	2,700	2,923	2923
	Total cereal production (Mt)	7,400	7,000	10,543	10,500	10,700	11,714	11,714
	Wheat Cultivated Surface (Ha)	2,400	1,100	2,200	2,200	2,200	2,381	2,381
	Wheat Production (Mt)	6,300	4,200	9,036	9,000	9,000	9,556	9,556
	Barley Cultivated Surface (Ha)	550	900	500	500	500	542	542
	Barley Production (Mt)	1,100	2,800	1,507	1,500	1,700	2,158	2,158
	Corn Cultivated Surface (Ha)	No Data	No Data	No Data	No Data	No Data	No Data	No Data
	Corn Production (Mt)	No Data	No Data	No Data	No Data	No Data	No Data	No Data
	Citrus Cultivated Surface (Ha)	140	140	140	140	140	140	140
	Citrus Production (Mt)	1,600	1,000	1,000	1,000	1,000	1,000	1,000
	Vegetable cultivated Surface (Ha)	3,700	4,680	5,380	5,660	5,140	5,610	5,610
	Vegetable Production (Mt)	48,020	83,100	65,179	67,740	65,356	64,454	64,454
Morrocco	Total Area	44,655,000	44,655,000	44,655,000	44,655,000	44,655,000		
	No Arable land and no permanent cr	34,881,000	34,664,000	34,735,000	34,654,000	35,185,000		
	UAS (Ha)	30,749,000	30,966,000	30,895,000	30,976,000	30,445,000		
	Arable Land	8,921,000	9,096,000	8,980,000	9,033,000	8,500,000		
	Permanent crops	828,000	870,000	915,000	943,000	945,000		
	Permanent pasture	21,000,000	21,000,000	21,000,000	21,000,000	21,000,000		
	Total cereal cultivated surface (Ha)	3,993,400	5,988,600	4,910,400	5,904,700	5,176,712	5,444,400	5118900
	Total cereal production (Mt)	1,783,230	10,103,620	4,098,200	6,631,590	3,858,953	2,005,875	4,814,750
	Wheat Cultivated Surface (Ha)	1,967,900	3,212,400	2,492,900	3,087,000	2,690,600	2,901,600	2,700,600
	Wheat Production (Mt)	1,090,710	5,915,790	2,316,490	4,378,480	2,153,540	1,380,700	3,316,380
	Barley Cultivated Surface (Ha)	1,578,500	2,430,000	1,996,000	2,426,000	2,069,880	2,250,900	2,126,000
	Barley Production (Mt)	607,690	3,831,130	1,324,240	1,970,000	1,473,980	466,810	1,155,240
	Corn Cultivated Surface (Ha)	387,400	253,500	340,900	310,000	331,000	237,500	254,200
	Corn Production (Mt)	50,490	235,090	374,460	200,500	136,380	95,000	53,560
	Citrus Cultivated Surface (Ha)	75,500	75,344	75,300	75,700	76,350	76,950	77,550
	Citrus Production (Mt)	997,300	1,392,806	1,228,500	1,596,700	1,308,200	1,415,700	983,700
	Vegetable cultivated Surface (Ha)	129,002	175,854	181,325	181,382	179,836	181,232	181,460
	Vegetable Production (Mt)	2,303,375	3,296,200	3,230,220	3,714,075	3,388,925	3,231,490	3,231,760

Slovenia	Total Area	2,025,000	2,025,000	2,025,000	2,025,000	2,025,000		
	No Arable land and no permanent cr	1,783,000	1,788,000	1,807,000	1,809,000	1,810,000		
	UAS (Ha)	538,000	525,000	495,000	490,000	500,000		
	Arable Land	196,000	191,000	173,000	172,000	171,000		
	Permanent crops	33,000	33,000	32,000	31,000	31,000		
	Permanent pasture	309,000	301,000	290,000	287,000	298,000		
	Total cereal cultivated surface (Ha)	101,696	100,134	96,420	96,025	91,850	103,564	103564
	Total cereal production (Mt)	453,456	486,984	543,728	556,997	468,894	498,653	498,653
	Wheat Cultivated Surface (Ha)	36,779	35,159	33,431	35,025	31,615	38,489	38,489
	Wheat Production (Mt)	155,575	137,120	138,930	169,097	117,251	163,369	163,369
	Barley Cultivated Surface (Ha)	12,719	12,535	10,828	10,871	10,935	11,703	11,703
	Barley Production (Mt)	44,018	40,626	38,834	43,407	33,065	38,188	38,188
	Corn Cultivated Surface (Ha)	46,750	47,123	47,491	45,592	44,401	48,612	48,612
	Corn Production (Mt)	240,415	296,302	355,285	333,456	308,000	285,831	285,831
	Citrus Cultivated Surface (Ha)	No Data	No Data	No Data	No Data	No Data	No Data	No Data
	Citrus Production (Mt)	No Data	No Data	No Data	No Data	No Data	No Data	No Data
	Vegetable cultivated Surface (Ha)	4,034	3,930	3,538	3,941	3,870	3,810	3,810
	Vegetable Production (Mt)	114,673	107,984	110,214	106,296	104,400	106,000	106,000
Spain	Total Area	50,599,000	50,599,000	50,599,000	50,599,000	50,599,000		
	No Arable land and no permanent cr	31,191,000	30,800,000	30,885,000	31,428,000	31,414,000		
	UAS (Ha)	29,719,000	30,139,000	30,059,000	29,958,000	29,980,000		
	Arable Land	14,045,000	14,450,000	14,285,000	13,684,000	13,680,000		
	Permanent crops	4,708,000	4,694,000	4,774,000	4,832,000	4,850,000		
	Praderas&Pastos Permanentes	10,966,000	10,995,000	11,000,000	11,442,000	11,450,000		
	Total cereal cultivated surface (Ha)	6,688,055	6,762,316	6,481,972	6,632,544	6,645,935	6,833,135	6426535
	Total cereal production (Mt)	11,574,293	22,366,038	19,323,595	22,557,318	18,001,760	24,632,760	17,832,460
	Barley Cultivated Surface (Ha)	3,555,900	3,572,200	3,682,160	3,535,200	3,106,600	3,306,700	3,005,700
	Barley Production (Mt)	5,046,600	10,697,000	8,549,540	10,895,300	7,434,300	11,283,100	6,216,600
	Corn Cultivated Surface (Ha)	357,500	439,700	486,447	459,100	397,500	424,900	501,300
	Corn Production (Mt)	2,690,400	3,751,000	4,451,502	4,349,100	3,768,600	3,897,700	4,778,600
	Citrus Cultivated Surface (Ha)	246,725	249,786	283,748	283,586	283,550	285,550	285,550
	Citrus Production (Mt)	4,767,849	4,211,826	5,789,418	5,126,490	5,823,900	5,405,825	5,352,900
	Vegetable cultivated Surface (Ha)	393,899	392,690	391,395	387,916	396,200	384,500	386,700
	Vegetable Production (Mt)	10,329,713	11,168,046	11,494,392	11,902,846	12,221,500	11,794,600	1,998,514

Syria	Total Area	18,518,000	18,518,000	18,518,000	18,518,000	18,518,000		
	No Arable land and no permanent cr	12,876,000	12,908,000	12,857,000	12,894,000	12,876,000		
	UAS (Ha)	13,789,000	13,790,000	13,804,000	13,754,000	13,767,000		
	Arable Land	4,799,000	4,739,000	4,771,000	4,709,000	4,701,000		
	Permanent crops	703,000	731,000	750,000	775,000	801,000		
	Permanent pasture	8,287,000	8,320,000	8,283,000	8,270,000	8,265,000		
	Total cereal cultivated surface (Ha)	3,684,915	3,256,247	3,417,756	3,346,257	3,074,872	3,058,623	3,052,524
	Total cereal production (Mt)	6,097,812	5,994,934	4,324,551	5,274,130	3,302,574	3,512,621	5,350,299
	Wheat Cultivated Surface (Ha)	1,643,609	1,619,188	1,760,799	1,721,412	1,603,020	1,678,797	1,683,780
	Wheat Production (Mt)	4,184,144	4,080,357	3,031,090	4,111,625	2,691,504	3,105,489	4,934,690
	Barley Cultivated Surface (Ha)	1,963,252	1,549,811	1,572,193	1,542,619	1,414,227	1,316,893	1,302,760
	Barley Production (Mt)	1,705,142	1,653,018	982,654	868,848	425,536	211,905	195,556
	Corn Cultivated Surface (Ha)	68,800	73,438	74,448	72,634	49,831	55,316	58,000
	Corn Production (Mt)	199,000	250,000	303,260	285,009	181,000	190,234	215,000
	Citrus Cultivated Surface (Ha)	25,900	26,739	27,096	27,740	29,123	29,490	29,490
	Citrus Production (Mt)	578,786	709,500	563,800	753,909	733,401	785,035	785,035
	Vegetable cultivated Surface (Ha)	132,865	131,326	115,634	124,031	109,621	113,443	112,773
	Vegetable Production (Mt)	1,911,122	1,761,990	1,644,052	2,043,836	1,823,818	1,851,351	1,861,975
Tunisia	Total Area	16,361,000	16,361,000	16,361,000	16,361,000	16,361,000		
	No Arable land and no permanent cr	10,658,000	10,512,000	10,457,000	10,436,000	10,436,000		
	UAS (Ha)	8,915,000	8,987,000	8,979,000	9,000,000	9,000,000		
	Arable Land	2,842,000	2,900,000	2,845,000	2,850,000	2,850,000		
	Permanent crops	2,036,000	2,124,000	2,234,000	2,250,000	2,250,000		
	Permanent pasture	4,037,000	3,963,000	3,900,000	3,900,000	3,900,000		
	Total cereal cultivated surface (Ha)	554,850	1,971,200	1,129,000	1,226,000	1,462,000	1,254,000	1,454,000
	Total cereal production (Mt)	622,100	2,869,310	1,056,300	1,667,320	1,819,000	1,095,000	1,095,000
	Wheat Cultivated Surface (Ha)	415,350	1,249,240	800,000	950,000	980,000	980,000	990,000
	Wheat Production (Mt)	530,800	2,017,650	884,900	1,353,520	1,390,000	850,000	850,000
	Barley Cultivated Surface (Ha)	121,500	703,960	311,000	260,000	466,000	260,000	450,000
	Barley Production (Mt)	80,300	834,660	160,400	302,800	420,000	240,000	240,000
	Corn Cultivated Surface (Ha)	No data	No data	No data	No data	No data	No data	No data
	Corn Production (Mt)	No data	No data	No data	No data	No data	No data	No data
	Citrus Cultivated Surface (Ha)	17,500	17,500	17,600	17,600	17,600	17,600	17,600
	Citrus Production (Mt)	194,200	223,700	205,800	226,600	209,700	220,200	220,200
	Vegetable cultivated Surface (Ha)	111,970	124,440	120,720	125,160	127,960	127,960	127,960
	Vegetable Production (Mt)	1,604,830	1,819,830	1,664,830	1,833,830	2,145,830	2,193,830	2,196,830

Turkey

Total Area	77,482,000	77,482,000	77,482,000	77,482,000	77,482,000		
No Arable land and no permanent cr	49,848,000	47,811,000	47,801,000	49,995,000	50,291,000		
UAS (Ha)	39,493,000	41,530,000	41,540,000	39,346,000	39,050,000		
Arable Land	24,654,000	26,680,000	26,579,000	24,438,000	24,138,000		
Permanent crops	2,461,000	2,472,000	2,583,000	2,530,000	2,534,000		
Permanent pasture	12,378,000	12,378,000	12,378,000	12,378,000	12,378,000		
Total cereal cultivated surface (Ha)	13,805,470	13,935,230	13,962,473	14,104,900	13,103,000	13,228,000	13,078,000
Total cereal production (Mt)	622,100	2,869,310	1,056,300	1,667,320	1,819,000	1,095,000	1,095,000
Wheat Cultivated Surface (Ha)	9,400,000	9,350,000	9,340,000	9,400,000	8,650,000	8,700,000	8,600,000
Wheat Production (Mt)	18,015,000	18,515,000	18,650,000	21,000,000	16,500,000	17,500,000	16,000,000
Barley Cultivated Surface (Ha)	3,525,000	3,650,000	3,700,000	3,770,000	3,550,000	3,600,000	3,550,000
Barley Production (Mt)	7,500,000	8,000,000	8,200,000	9,000,000	6,600,000	7,400,000	6,600,000
Corn Cultivated Surface (Ha)	515,000	550,000	545,000	550,000	525,000	550,000	550,000
Corn Production (Mt)	1,900,000	2,000,000	2,080,000	2,300,000	2,000,000	2,100,000	2,100,000
Citrus Cultivated Surface (Ha)	81,573	82,005	82,805	83,906	85,587	85,587	85,587
Citrus Production (Mt)	1,781,650	1,819,790	1,433,000	1,943,475	2,263,500	2,263,500	2,263,500
Vegetable cultivated Surface (Ha)	935,603	935,803	911,103	914,303	946,503	919,503	919,503
Vegetable Production (Mt)	1,604,830	1,819,830	1,664,830	1,833,830	2,145,830	2,193,830	2,196,830

Source: FAOstat Local sources: EUROSAT

Annex 2
Climatic data of selected meteorological stations of MAP Countries

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Albania, Tirana	**ºC**	6.7	7.7	9.9	13.5	17.7	21.6	24.2	23.9	20.6	15.9	11.7	8.3	15.2
	mm	143.7	133.7	116	92.5	94.6	66.8	34.4	39.2	69	99.3	170.6	148.2	1208
Dar-El-Beida, Algeria	**ºC**	10.4	11	12.4	14.5	17.3	20.8	23.7	24.4	22.3	18.6	14.6	11.6	16.8
	mm	102.8	82.9	76.4	58.5	38.8	15.1	2.4	5.4	32.5	85.5	109.3	129.3	738.9
Sarajevo, Bosnia & Herzego	**ºC**	-1.4	0.9	4.9	9.3	13.9	17	18.9	18.7	15.2	10.5	5	0.8	9.5
	mm	68.5	61.4	73.1	72	79.9	86.2	69.9	69.3	74.2	89.4	83	77.6	904
Sisak, Croatia	**ºC**	-1.3	1.1	5.6	11.2	15.2	19.1	20.6	19.8	16.1	10.9	6.3	1	10.5
	mm	55.2	51	51.8	74.4	87.9	102	79.5	91.1	77.5	64.8	89.4	78.9	903.5
Cairo, Egypt	**ºC**	13.8	15.2	17.4	21.4	24.7	27.3	27.9	27.9	26.3	23.7	19.1	15.1	21.7
	mm	5.1	3.8	3.7	1.5	1	0.2	0	0	0	1	2.5	5.7	24.8
Montpellier, France	**ºC**	6.8	7.4	10.1	12.7	16.3	20.3	23.8	22.9	20.3	16.3	10.8	8.2	14.8
	mm	69.8	55.8	71.2	58.8	61.3	39.5	23.6	43.8	85.1	109.2	81.9	71.8	772.3
Paris-Montsouris, France	**ºC**	3.5	4.9	6.9	10.4	13.6	17.3	18.7	18.1	16.2	12.3	7.2	3.5	11
	mm	182.3	120.6	158.1	204.9	323.1	300.5	236.8	192.9	66.3	63.3	83.2	154.7	2089.1
Athens,Greece	**ºC**	10.2	10.8	12.3	16.1	20.6	25.1	27.9	27.8	24.3	19.3	15.3	12	18.5
	mm	48	41	41.2	23.4	17.9	7.4	5	7.6	9.8	53	55.3	61.8	371.4
Jerusalem, Israel	**ºC**	8.1	9.1	11.9	15.7	19.9	22.3	23.5	23.9	22.4	20.3	15.2	10.4	16.9
	mm	139.7	110.5	116.2	17.2	5.6	0	0	0	0.4	10.6	68.2	129	616.3
Roma, Italy	**ºC**	7.2	8.3	10.5	13.7	17.8	21.7	24.4	24.1	20.9	16.6	11.7	8.4	15.4
	mm	80	70.9	68.6	66.8	51.5	34.1	16.3	24.4	69.2	1113.3	110.7	97.1	802.9
Beyrouth, Lebanon	**ºC**	13	13.3	15.3	17.9	20.4	23.2	25.2	26	25.3	22.9	19	15.7	19.7
	mm	187.1	151.2	96.4	50.6	18.8	2.3	0.3	0.3	6.3	47.5	119.1	175.9	872.9
Tripoli, Lybia	**ºC**	13.6	14.3	16	18.7	21.5	24.7	26.4	27.5	25.6	22.4	19	14.7	20.4
	mm	58.1	25.5	24.7	14.6	4.5	2.1	0	0	26.2	44.4	21	44.6	271.5
Rabat, Morrocco	**ºC**	12.2	13.2	14.7	15.7	17.3	20.1	22.3	22.6	22.1	19.4	16.8	13.8	17.6
	mm	80.4	67.5	64.9	56.8	24.2	8.1	0.3	0.9	7.5	45.8	83.2	101.3	538.4
Ljubljana, Slovenia	**ºC**	-1.5	0.2	4.6	9.2	14.4	17.1	20.1	19.3	16.2	10.9	3.4	0.6	9.4
	mm													
Almeria, Spain	**ºC**	12.2	12.7	14.4	15.8	18.7	21.8	24.9	25.6	23.3	19.5	15.6	13.2	18.1
	mm	31.6	19.7	21.9	26.9	16.9	6.8	0.6	3.3	11.7	25.5	24.7	33.2	224.7
Barcelona, Spain	**ºC**	9.1	10.3	11.8	14.1	17.4	21.2	24.2	24.1	21.6	17.5	13.1	9.9	16.2
	mm	38	37.5	47	47.2	43.8	37.7	27.5	43.8	76.3	96.2	51.2	43.7	590.1
Damascus, Syria	**ºC**	6.6	8.3	11.3	15.8	20.6	24.7	26.7	26.5	23.6	18.9	12.6	7.8	17
	mm	39.2	31.8	22.5	13.4	5.1	0.5	0	0	0	9.4	25.5	42.1	187.1
Tunis,Tunisia	**ºC**	10.4	10.8	12.8	15.2	18.3	22.6	25.5	26.3	23.9	19.5	14.8	11.7	17.7
	mm	61.6	52.4	45.6	38.4	22.2	10.4	3.3	7.2	32	54.9	53.5	62.9	446.1
Ankara, Turkey	**ºC**	0	1.2	5.3	11	15.9	19.8	23.1	23	18.4	12.7	7.3	2.2	11.6
	mm	40.8	35.2	35.7	38.4	51.6	31.8	13.3	8.9	17.5	23.7	30.1	46.2	374.6

Source: http://www.worldclimate.com

Annex 3
Irrigated Land in MAP Countries

	1995	1996	1997	1998	1999	% Irrigated area
Albania	340,000	340,000	340,000	340,000	340,000	48.64
Argelia	555,000	560,000	560,000	560,000	560,000	6.81
Bosnia and Herzegovina	2,000	2,000	2,000	2,000	3,000	0.46
Croatia	3,000	2,000	2,000	2,000	3,000	0.18
Cyprus	40,000	40,000	40,000	40,000	40,000	27.97
Egypt	3,283,000	3,300,000	3,300,000	3,300,000	3,300,000	53.80
France	1,630,000	1,750,000	1,907,000	2,000,000	2,100,000	10.76
Greece	1,383,000	1,414,000	1,482,000	1,422,000	1,441,000	37.23
Israel	199,000	199,000	199,000	199,000	199,000	45.23
Italy	2,698,000	2,698,000	2,698,000	2,698,000	2,698,000	23.62
Lebanon	105,000	110,000	117,000	120,000	120,000	38.96
Lybia	470,000	470,000	470,000	470,000	470,000	21.86
Malt	1,000	2,000	2,000	2,000	2,000	22.22
Morroccco	1,258,000	1,258,000	1,251,000	1,291,000	1,305,000	13.82
Slovenia	2,000	2,000	2,000	2,000	2,000	0.99
Spain	3,527,000	3,603,000	3,634,000	3,652,000	3,640,000	19.64
Syria	1,089,000	1,127,000	1,168,000	1,213,000	1,186,000	21.55
Tunisia	361,000	380,000	380,000	380,000	380,000	7.45
Turkey	4,186,000	4,200,000	4,200,000	4,380,000	4,500,000	16.87

% Irrigated area =Irrigated area/(Arable land+Permanent crops)

Source: FAO yearbook
Local source

Annex 4 Chemical Fertilizer Use (N,P,K) in MAP Countries

1999	Agricultural area (ha)	N usage (Mt)	P_2O_5 usage (Mt)	K_2O Usage (Mt)	$(N+P_2O_5+K_2O)$/ha
Albania	1,128,000	6,000	5,000	100	10
Argelia	42,715,000	63,900	30,900	51,000	3
Bosnia and Herzegovina	1,850,000	28,000	7,000	7,000	23
Croatia	3,151,000	10,943	43,706	51,000	34
Cyprus	147,000	10,911	7,347	1,938	137
Egypt	3,300,000	1,002,650	140,000	45,000	360
France	29,900,000	2,571,000	966,000	1,216,000	159
Greece	9,020,000	291,000	119,000	59,000	52
Israel	585,000	64,800	23,000	37,000	213
Italy	16,268,000	866,000	514,000	392,000	109
Lebanon	324,000	21,700	32,000	9,700	196
Lybia	15,450,000	21,100	34,700	6,700	4
Malt	9,000	451	131	131	79
Morrocco	30,445,000	168,900	102,000	56,900	11
Slovenia	500,000	34,392	19,751	24,451	157
Spain	29,980,000	1,063,114	643,000	491,000	73
Syria	13,767,000	251,202	111,861	8,256	27
Tunisia	9,000,000	63,325	43,000	4,200	12
Turkey	39,050,000	1,484,000	637,900	80,600	56

	1990 kg N/ha	1999 kg N/ha	% Changes (1999-1990)/1990
Albania	65.33	5.32	-91.86
Argelia	1.63	1.50	-8.16
Bosnia and Herzegovina*	31.57	15.14	-52.06
Croatia*	31.57	33.30	5.49
Cyprus	102.60	74.22	-27.66
Egypt	281.40	303.83	7.97
France	81.52	85.99	5.48
Greece	46.36	32.26	-30.41
Israel	84.93	110.77	30.42
Italy	52.19	53.23	1.99
Lebanon	34.70	66.98	93.01
Lybia	2.26	1.37	-39.69
Malt	53.85	50.11	-6.94
Morrocco	5.37	5.55	3.32
Slovenia*	31.57	68.78	117.88
Spain	34.89	39.36	12.82
Syria	13.69	18.25	33.24
Tunisia	4.59	7.04	53.25
Turkey	30.24	38.00	25.69

Year 1999	kg N/ha	kg P2O5/ha	kg K2O/ha
Albania	5.32	4.43	0.09
Argelia	1.50	0.72	1.19
Bosnia and Herzegovina*	15.14	3.78	3.78
Croatia*	33.30	13.87	16.19
Cyprus	74.22	49.98	13.18
Egypt	303.83	42.42	13.64
France	85.99	32.31	40.67
Greece	32.26	13.19	6.54
Israel	110.77	39.32	63.25
Italy	53.23	31.60	24.10
Lebanon	66.98	98.77	29.94
Lybia	1.37	2.25	0.43
Malt	50.11	14.56	14.56
Morrocco	5.55	3.35	1.87
Slovenia*	68.78	39.50	48.90
Spain	39.36	21.45	16.38
Syria	18.25	8.13	0.60
Tunisia	7.04	4.78	0.47
Turkey	38.00	16.34	2.06

***The datas for Bosnia and Herzegovina, Croatia And Slovenia for the year 1990 are the means of the former Yougoslavia**
The agricultural area is the UAS of each country.
Source: FAO Yearbook

Annex 5
Animal Husbandry and Concentrated Animal Operations in MAP Countries

Year 2001 Stocks (heads)	Cattle	Pig	Chickens	Sheep	Goats	Horses	Mules	Nº of pigs/Arable land (ha)
Albania	720,000	81,000	4,000,000	1,941,000	1,120,000	65,000	25,000	0.14
Argelia	1,700,000	5,700	110,000,000	19,300,000	3,500,000	48,000	50,000	0
Bosnia and Herzegovina	350,000	80,000	3,000,000	670,000	378,000	19,500	No Data	0.16
Croatia	440,000	1,362,000	10,356,000	246,000	80,000	11,000	No Data	0.93
Cyprus	54,000	418,000	3,200,000	528,000	378,000	650	1,500	4.14
Egypt	3,450,000	29,500	88,000,000	4,450,000	3,300,000	45,700	1,150	0.01
France	20,500,000	14,635,000	230,000,000	10,000,000	1,200,000	349,086	15,017	0.8
Greece	585,000	905,000	28,000,000	9,000,000	5,293,000	33,000	37,000	0.33
Israel	410,000	150,000	30,000,000	400,000	75,000	4,000	1,600	0.43
Italy	7,150,000	8,400,000	100,000,000	11,000,000	1,350,000	280,000	10,000	0.98
Lebanon	74,000	63,500	32,000,000	380,000	445,000	6,000	6,000	0.35
Lybia	220,000	No data	25,000,000	5,100,000	1,950,000	46,000	No Data	No Data
Malt	19,000	69,000	820,000	16,000	9,000	1,000	300	8.63
Morroccco	2,675,000	8,000	100,000,000	17,300,000	5,120,000	150,000	524,000	0.00
Slovenia	493,670	603,594	7,150,000	96,227	22,041	9,800	No Data	3.53
Spain	6,163,900	23,348,000	128,000,000	24,400,000	2,830,000	248,000	115000	1.71
Syria	993,000	770	22,000,000	13,800,000	1,060,000	30,000	20,000	0.00
Tunisia	795,000	6,000	43,000,000	6,600,000	1,450,000	56,200	81,000	0.00
Turkey	10,800,000	5,000	236,997,000	29,435,000	8,057,000	330,000	133,000	0.00

Number of live animals for 2001
Source: FAOstat

Annex 6

Good Agricultural practices adopted in MAP countries or in other areas with Mediterranean type climate

I. GOOD AGRICULTURAL PRACTICES ADOPTED IN MAP COUNTRIES

a. France, Greece, Italy and Spain are EU members and Nitrate Directive is in force in these countries. All of them have adopted Codes of Good Agricultural Practices.

   Most of them have adapted a regional approach, that is each region has its own Code, in order to deal with regional differences. These Codes are in line with the Nitrate Directive and they include as Good Agricultural Practice the following:

France:
National Code of Good Agricultural Practices: Arrêté du 22 novembre 1993 relatif au Code National des bonnes pratiques agricoles: http://aida.ineris.fr/textes/arretes/text0336.htm.

The National Code has been adapted for every department (i.e. Les bonnes pratiques agricoles constatées en Languedoc-Roussillon www.cte.agriculture.gouv.fr/03/11/actions-word/lr-bonpr).

Some programs and organism have been created to reduce and to prevent agriculture pollution by nitrogene like PMPOA, Fertimieux, Corpen or CTE.

Italy:
The National Code of Good Practice is: Decreto Ministeriale del 19 aprile 1999 recante "Approvazione del codice di buona pratica agricola" G.U. n°102 S.O. n°86 del 4 maggio 1999. http://www.politicheagricole.it/mipa/NormativaNew/mezzitec/19990419_DM.htm
This National Code has been adapted to every region considering their characteristics.

Greece:
There must be a national code, at least the transcription of the EU code, but it has not been found.

Spain:
The National code of the Ministry of agriculture: Código de buenas prácticas del MAPA:
http://www.sevsigloxxi.org/plataforma/legislac.htm
http://www.fertiberia.es/informacion_fertilizacion/medioambiente/buenas_practicas_mapa/index.html
Afterwards every community has adapted this code to the specific conditions of their region.
Catalunya: http://www.gencat.es/darp/c/camp/nitrogen/cnitro01.htm
Andalucia: http://platea.pntic.mec.es/~emoya/practicas.htm
Aragón: http://www.aragob.es/agri/pdf/it93.pdf
Madrid: http://www.comadrid.es/gema/revista/leyes/febmar99/boc041b.htm
Extremadura: http://www.juntaex.es/consejerias/aym/sgt/publica3.htm

All these codes are an adaptation of the EU code of good agricultural practices.

The codes include:
1. Periods when application of fertilizers is inappropriate.
2. Application of fertilizers in steep lands.
3. Applications of fertilizers in hydromorphic, waterlogged, frozen soils or covered with snow
4. The conditions to apply fertilizers to lands close to rivers or water surfaces.

5. The size and the design of the storage tanks for manure, the measures to avoid the pollution of water by runoff and infiltration in surface water or groundwater of liquid from manure or residues from vegetal stock products as ensilage.
6. Procedures to apply chemical fertilizers and manure to keep the lost of nutrients into waters at acceptable levels, considering periodicity and uniformity of applications.
7. Crop rotation management.
8. Keeping vegetation during rainy periods to absorb nitrogen, avoiding washing.
9. Establishment of fertilizing plans for every farm according to its situation.
10. Prevention of pollution of water by runoff and filtration of water under the root system.

Some agroenvironmental measures include the reduction of fertilizer use or the control of fertilizer inputs (integrated production).

b. We have been unable to find specific sets of Good Agricultural Practices for others countries, although in the literature there are some references.

Egypt:
National strategy and action plan for biodiversity conservation, January 1998, Nadia M. Ebeid Minister of Sate for the Environment.

Morocco: Code de l'environnement Ministère de l'aménagement du territoire, de l'environnement, de l'urbanisme et de l'habitat. Mars 1999.

These two references are not codes of good agricultural practices, but they are general codes to protect the environment from all kinds of pollution.

II. AREAS WITH MEDITERRANEAN TYPE CLIMATE

California:
The Fertilizer Research and Education Program and the Nitrogen Monitoring Program from the California Department of Food and Agriculture.
http://www.cdfa.ca.gov/is/frep/

The University of California has a department concerning sustainable agriculture.
http://www.ucdavis.edu

III. OTHER MEASURES SIMILAR TO GOOD AGRICULTURAL PRACTICES

Several organizations use strict regulations for fruit or vegetable production (i.e. EUREP) but they are no considered by themselves as Good Agricultural Practices.

Annex 7
Import-Export of Basic Agricultural Products in MAP Countries

Table 7.1 Import-Export for cereals in MAP countries. Year 1999 Source FAOSTAT

	Cereals (Mt)			Wheat (Mt)			Corn (Mt)			Rice (Mt)		
	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export
Albania	288,818	138	288,680	59,937	138	59,799	4,600	0	4,600	14,246	0	14,246
Argelia	5,765,668	0	5,765,668	4,099,000	0	4,099,000	1,100,000	0	1,100,000	46,000	0	46,000
Bosnia and Herzegov	406,805	10	406,795	165,300	0	165,300	128,000	0	128,000	2,200	0	2,200
Croatia	83,226	99,659	-16,433	6,927	13,159	-6,232	39,429	59,077	-19,648	8,962	340	8,622
Cyprus	584,071	870	583,201	87,342	9	87,333	200,116	0	200,116	4,013	29	3,984
Egypt	9,663,681	328,253	9,335,428	5,962,000	232	5,961,768	3,584,900	643	3,584,257	6,627	306,977	-300,350
France	1,329,387	34,859,040	-33,529,653	290,860	18,316,504	-18,025,644	241,044	8,352,274	-8,111,230	394,092	74,942	319,150
Greece	1,272,295	334,348	937,947	621,020	176,472	444,548	480,016	19,323	460,693	10,067	41,126	-31,059
Israel	2,935,013	778	2,934,235	1,567,386	60	1,567,326	551,000	150	550,850	86,324	40	86,284
Italy	8,082,216	2,030,646	6,051,570	5,952,776	123,594	5,829,182	1,233,361	50,773	1,182,588	66,212	667,367	-601,155
Lebanon	747,406	220	747,186	400,000	0	400,000	235,000	0	235,000	51,000	220	50,780
Lybia	1,689,846	0	1,689,846	298,000	0	298,000	200,000	0	200,000	110,000	0	110,000
Malt	187,205	18	187,187	52,060	0	52,060	62,497	0	62,497	2,058	4	2,054
Morroccco	4,379,395	64,751	4,314,644	2,814,760	3	2,814,757	718,514	0	718,514	1,395	3	1,392
Slovenia	865,489	14,998	850,491	210,000	71	209,929	382,000	1,173	380,827	15,286	3,100	12,186
Spain	6,885,362	1,556,842	5,328,520	3,233,639	146,578	3,087,061	2,934,986	88,413	2,846,573	85,836	314,633	-228,797
Syria	1,368,404	112,010	1,256,394	0	111,937	-111,937	632,826	10	632,816	134,279	0	134,279
Tunisia	2,015,353	114,769	1,900,584	1,086,451	15	1,086,436	681,432	0	681,432	21,055	0	21,055
Turkey	2,942,559	2,596,510	346,049	1,613,025	1,864,702	-251,677	839,096	6,205	832,891	246,935	1,468	245,467

Table 7.2 Import-Export for animal products in MAP countries. Year 1999 Source FAOSTAT

	Milk (Mt)			Beef (Mt)			Pork (Mt)			Lamb (Mt)			Chicken (Mt)		
	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export
Albania	2,641	0	2,641	3,787	0	3,787	8,522	0	8,522	250	0	250	142,218	0	142,218
Argelia	1,060	0	1,060	22,218	0	22,218	18	0	18	175	0	175	20	0	20
Bosnia and Herzegov	16,950	4,000	12,950	7,539	0	7,539	14,934	585	14,349	150	140	10	13,566	146	13,420
Croatia	53,900	18,220	35,680	6,947	6,071	876	17,871	2,656	15,215	422	1	421	3,016	5,288	-2,272
Cyprus	1,073	147	926	2,699	619	2,080	1,186	2,166	-980	926	41	885	778	300	478
Egypt	51	23	28	180,815	451	180,364	2	0	2	974	83	891	62	210	-148
France	912,109	947,961	-35,852	335,433	400,411	-64,978	452,471	570,493	-118,022	167,705	10,688	157,017	144,581	842,049	-697,468
Greece	87,458	822	86,636	191,208	3,084	188,124	203,715	2,810	200,905	17,991	472	17,519	46,518	5,253	41,265
Israel	0	670	-670	66,958	0	66,958	0	113	-113	860	0	860	22	5,974	-5,952
Italy	2,280,949	17,504	2,263,445	444,844	139,126	305,718	838,708	120,348	718,360	23,046	3,140	19,906	27,243	98,265	-71,022
Lebanon	1,100	0	1,100	12,550	0	12,550	3,278	0	3,278	370	0	370	2,000	0	2,000
Lybia	341	0	341	4,208	0	4,208	No Data	No Data	No Data	610	0	610	130	0	130
Malt	105	6	99	10,473	51	10,422	1,997	8	1,989	821	5	816	1,162	40	1,122
Morroccco	158	3	155	968	449	519	85	2	83	59	19	40	2,287	40	2,247
Slovenia	1,410	36,109	-34,699	1,566	6,582	-5,016	2	0	2	11	0	11	3,805	6,120	-2,315
Spain	329,956	175,098	154,858	88,468	148,201	-59,733	96,745	358,401	-261,656	11,384	14,191		95,663	54,134	
Syria	0	866	-866	3	29	-26	13	0	13	1	0	1	0	68	-68
Tunisia	0	159	-159	2,712	0	2,712	1	0	1	No Data	No Data	No Data	67	579	-512
Turkey	24	271	-247	11	186	-175	64	332	-268	0	1,357	-1,357	21	2,279	-2,258

Table 7.3 Import-Export for Horticultural products in MAP countries. Year 1999 Source FAOSTAT

	Fruits and Horatlizes (Mt)			Potatoes (Mt)			Tomatoes (Mt)		
	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export
Albania	70,558	2,745	67,813	6,500	0	6,500	6,100	74	6,026
Argelia	257,786	12,710	245,076	124,000	900	123,100	600	0	600
Bosnia and Herzegov	69,990	14,485	55,505	7,100	0	7,100	8,100	0	8,100
Croatia	234,646	21,765	212,881	8,733	1,181	7,552	9,563	28	9,535
Cyprus	34,978	212,000	-177,022	7,885	116,131	-108,246	49	126	-77
Egypt	503,508	539,252	-35,744	65,377	255,569	-190,192	20	5,344	-5,324
France	6,627,535	5,860,844	766,691	391,993	1,136,101	-744,108	394,261	99,056	295,205
Greece	535,236	1,522,967	-987,731	126,974	14,522	112,452	3,178	6,478	-3,300
Israel	153,907	694,985	-541,078	18,000	107,477	-89,477	170	9,405	-9,235
Italy	3,687,255	6,005,742	-2,318,487	412,211	291,992	120,219	47,357	114,832	-67,475
Lebanon	237,947	240,982	-3,035	50,000	57,419	-7,419	12,000	6,430	5,570
Lybia	94,357	13,656	80,701	14,000	1,000	13,000	123	0	123
Malt	54,164	7,327	46,837	4,815	7,079	-2,264	67	0	67
Morroccco	124,966	1,241,691	-1,116,725	35,341	91,775	-56,434	0	243,573	-243,573
Slovenia	271,454	24,453	247,001	11,000	702	10,298	41,000	80	40,920
Spain	3,845,375	9,243,596	-5,398,221	464,825	263,149	201,676	8,277	902,242	-893,965
Syria	96,123	532,411	-436,288	10,932	58,887	-47,955	0	143,396	-143,396
Tunisia	81,801	87,097	-5,296	20,445	3,383	17,062	5	1,072	-1,067
Turkey	No Data	No Data	No Data	24,298	64,607	-40,309	67	100,019	-99,952

Table 7.4 Import-Export for Others products in MAP countries. Year 1999 Source FAOSTAT

	Sugar (Mt)		
	Import	Export	Import-Export
Albania	69,783	30	69,753
Argelia	1,052,234	0	1,052,234
Bosnia and Herzegov	100,004	0	100,004
Croatia	10,924	290	10,634
Cyprus	31,444	828	30,616
Egypt	1,205,900	46	1,205,854
France	347,096	2,963,985	-2,616,889
Greece	54,921	4,727	50,194
Israel	488,700	1,423	487,277
Italy	338,847	406,296	-67,449
Lebanon	131,309	0	131,309
Lybia	220,674	0	220,674
Malta	24,007	7	24,000
Morroccco	467,445	0	467,445
Slovenia	18,599	254	18,345
Spain	396,280	205,248	191,032
Syria	648,856	0	648,856
Tunisia	296,159	276	295,883
Turkey	1,891	527,116	-525,225

Source: FAOSTAT

Annex 8

Effects of Water Nutrient Overloading

Anthropogenic nutrients, nitrogen and phosphorus, water loading have three main sources: agriculture, industry and household. Nutrients are incorporated by leaching, run-off, wastewater discharges and atmospheric deposition. The main diffuse sources of nitrogen to water are leaching of soils and run-off from agricultural land. Atmospheric deposition of nitrogen may also contribute to the nitrogen load; this nitrogen originates partly from ammonia evaporation from animal husbandry and partly from combustion of fossil fuel. Most of the phosphorus comes from households and industry discharging wastewater into freshwater or to the sea and from soil erosion.

The main problem that causes the excess of nutrients, in ground water occurs when this water becomes surface water. Ground water is extracted by wells and used as domestic water, watering water or industrial water, or it may infiltrate into freshwater, rivers or lakes, or marine water. The impacts of excessive nutrients are either manifested as a direct effect, or through an eutrophication effect.

In the European Union the Drinking Water Directive has regulated the concentration of nitrate in drinking waters since 1980. This establishes a guide level of nitrate of 25 mg/l and a maximum admissible concentration of 50 mg/l. Nitrate in drinking waters is considered to be a public health problem because nitrate rapidly reduces to nitrite in the body. The major effect of nitrite is the oxidation of blood hemoglobin to methemoglobin, which is unable to transport oxygen to the tissues. The reduced oxygen transport manifests itself particularly in young infants up to six months old, and causes the condition methemoglobinanemia or blue-baby syndrome. This phenomenon has only been observed at nitrate levels significantly above the 50 mg/l level; therefore this level delivers sufficient protection against this occurring. In addition, nitrite reacts with compounds in the stomach to form products, which have been found to be carcinogenic in many animal species, although the link to cancer in humans is at the moment not proved. Nevertheless, these two factors together totally justify a precautionary approach being taken in the establishment of this parameter.

In surface waters overloading with nitrogen and phosphorus can result in a series of undesirable effects. Excessive growth of plankton algae increases the amount of organic matter settling to the bottom. This may be enhanced by changes in the species composition and functioning of the pelagic food web by stimulating the growth of small flagellates rather than larger diatoms, which leads to lower grazing by copepods and increased sedimentation. The consequent increase in oxygen consumption can in areas with stratified water masses lead to oxygen depletion and changes in community structure or death of the benthic fauna. Bottom dwelling fish may either die or escape. Eutrophication can also promote the risk of harmful algal blooms that may cause discoloration of the water, foam formation, death of benthic fauna and wild or caged fish.

Increased growth and dominance of fast growing filamentous macro algae in shallow sheltered areas is yet another effect of nutrient overload which will change the coastal ecosystem, increase the risk of local oxygen depletion and reduce biodiversity and nurseries for fish. The major impacts of eutrophication are thus:

- Changes in the structure and functioning of the water ecosystems;
- Reductions in biodiversity;
- Reductions in the natural resources of dermersal fish and shellfish;
- Reduced income from aquacultures of fish and shellfish;
- Reduced recreational value and income from tourism;
- Increased risk of poisoning by algal toxins.

Sources:

EU Council (1997). The Implementation of Council Directive 91/676/EEC concerning the Protection of Waters against Pollution caused by Nitrates from Agricultural Sources. Report COM(97) 473.

EEA (1999). Nutrients in European ecosystems. Environmental assessment report Nº4.

EEA (2001). Eutrophication in Europe's coastal waters. Environmental topic report Nº7. 86 pp.

Annex 9

Main Situation of Water Pollution Related to Use of Agricultural Fertilizers and Other Ecosystem Disturbances

Albania:
The distribution of the chemical fertilizers according to the country districts has not been uniform. The highest levels of application, more than 100 kg/ha active elements (N+P2O5+K2O), are noticed in Lushnja and Mallakastër, generally in the lowland area. On the contrary, the lowest level of fertilizer use is noticed in the hill-mountainous area, where in 10 districts the use has been 11-25 kg/ha active elements. But also in the areas famous for the agriculture such as Gjirokastra, Korça, Lezha and Saranda, the level of fertilizer use is more than 25 kg/ha active elements. In general, we can say that the present level of application of chemical fertilizers does not constitute an environmental pollution problem.
Source: State of the environment in Albania 1997-1998.
http://www.grida.no/enrin/htmls/albania/soe1998/eng/index.htm

Algeria:
The main sources of water pollution in Algeria are urban and industrial wastewater.
Source: Direction générale de l'environnement.
http:/www.environnement-dz.org

Bosnia Herzegovina:
No data available

Cyprus:
Nicosia District: Groundwater nitrate pollution (% of 239 sampling sites and nitrate concentration in 1995): 60% under 10 mg/l, 22% between 10 mg/l and 25 mg/l, 14% between 25 and 50 mg/l, and 4% over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Limassol District: Groundwater nitrate pollution (% of 232 sampling sites and nitrate concentration in 1995): 64% under 10 mg/l, 17% between 10 mg/l and 25 mg/l, 13% between 25 and 50 mg/l, and 6% over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Larnaca District: Groundwater nitrate pollution (% of 78 sampling sites and nitrate concentration in 1995): 73% under 10 mg/l, 13% between 10 mg/l and 25 mg/l, 10% between 25 and 50 mg/l, and 4% over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Paphos District: Groundwater nitrate pollution (% of 182 sampling sites and nitrate concentration in 1995): 54% under 10 mg/l, 29% between 10 mg/l and 25 mg/l, 9% between 25 and 50 mg/l, and 7% over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Famagusta District: Groundwater nitrate pollution (% of 26 sampling sites and nitrate concentration in 1995): 65% under 10 mg/l, 23% between 10 mg/l and 25 mg/l, 8% between 25 and 50 mg/l, and 4% over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Croatia:
Information Only in Croatian.
http://www.mzopu.hr/

Egypt:
Most of agricultural pollution is considered as a non-point problem. Agricultural non point sources include: soil sediments, nutrients (particularly nitrates); pesticides, mineral salts, heavy metals; and disease pathogens water is polluted from agricultural activities in three major area: sedimentation, nutrients, and pesticides.

Three important aspects of agriculture's role in water pollution can be identified. First, the generation of residuals is unavoidable by-product of production. Second, economic decisions including changing crop mix, changing production practices, or developing technologies affect the composition and timing of agricultural waste flows. Third, the production process also affects the spatial and temporal dimensions of water out flows, which in turn affect the delivery and transport of the potential loading.

Nitrate content in water: 340 p.p.m. (Year 1993).
Source: Food, Rural and Agricultural Policies In Egypt. Ahmed Abu-Zeid.

France:
Nappe d'Alsace: Groundwater nitrate pollution (% of 117 sampling sites and nitrate concentration): 29% under 10 mg/l, 43% between 10 mg/l and 25 mg/l, 25% between 25 and 50 mg/l, and 3% over 50 mg/l; from 117 sampling sites in year 1995. . **Source:** Technical report No 22, EEA 1999.

Basse Normandie: Surface water quality concerning nitrates: excellent: 2%, good: 60%, poor: 38%. A rising of the contamination of the underground water has been detected. Some areas are over 50 mg N/l, even 100 mg N/l.

Bretagne: Very Important problems concerning water pollution.

Centre: 53 % of the control stations are classified as bad or very bad quality concerning Nitrogen pollution. Concerning phosphorous pollution 40,9 % of the control station in the Seine basin are classified as bad or very bad quality. In the Loire basin 15,5 % of the control station show bad to very bad quality. But the main origin of phosphor is urban wastewater.

Languedoc-Roussillon: Diffuse pollution from agriculture in the surface aquifer of Vistrenque and the deep plioquaternary aquifer of Roussillon. **Source:** Prefecture de la Region Languedoc Roussillon.

Midi-Pyrenées*:* few problems.

Nord et Picardie: Groundwater nitrate pollution (% of 793 sampling sites and nitrate concentration in 1995) 10 % under 10 mg/l, 39% between 10 and 25 mg/l, 47% between 25 and 50 mg/l, and 5% over 50 mg/l. **Source:** Technical report No 22, EEA 1999

Poitou-Charentes*:* Groundwater nitrate pollution (% of 24 sampling sites and nitrate concentration in 1995) 4% under 10 mg/l, 14% between 10 and 25 mg/l, 25% between 25 and 50mg/l, 67% over 50mg/l, from 24 sampling sites in the year 1995. . **Source:** Technical report No 22, EEA 1999.

Rhône-Alpes-Corse Bassin: Groundwater nitrate pollution (% of 299 sampling sites and nitrate concentration in 1995) 35% under 25 mg/l, 50% between 25 and 50mg/l, 12% between 50mg/l and 100 mg/l and 4% over 100 mg/l, from 299 sampling sites in the year 1997-1998. **Source:** Réexamen des zones vulnérables aux pollutions par les nitrates d'origine agricole dans le bassin Rhône-Méditerranée-Corse. Rapport définitif annexe à l'arrêté du préfet coordonnateur de bassin
http://www.environnement.gouv.fr/rhone-alpes/bassin_rmc/poll_agricoles/ZV_reexamen_99.htm

Greece:
The quantities of nitrogen and phosphorus loads that are transferred into the sea are estimated to be 5 000 - 15 000 t P/y and 30 000 - 130 000 t N/y. Intensive agriculture, farming, and municipal wastes are the main causes for the observation of red tides along Greek coasts and for eutrophication of Greek lakes.

The main rivers of the Balkan Peninsula discharge their load into the northern section of the Aegean Sea. The mean discharge is about 1 000 m3/sec, which carries into the sea about 170 000 t N/y, 23 000 t P/y, and 45 - 60 Mt of suspended sediments/y. Black Sea water, which enters the Aegean Sea through the Dardanelles, also contributes to the enrichment of the Aegean Sea's nutrients.
Source: Environmental Problems of Greece from a Chemical Point of View
Chemistry International Vol. 22, No. 1 **January 2000.**

Attica: Groundwater nitrate pollution (% of 13 sampling sites and nitrate concentration in 1996): 31 % under 10 mg/l, 15 % between 10 and 25 mg/l, 31 % between 25 and 50 mg/l and 23 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Central Macedonia: Groundwater nitrate pollution (% of 35 sampling sites and nitrate concentration in 1996): 51 % under 10 mg/l, 29 % between 10 and 25 mg/l, 17 % between 25 and 50 mg/l and 3 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Crete: Groundwater nitrate pollution (% of 21 sampling sites and nitrate concentration in 1996): 48 % under 10 mg/l, 14 % between 10 and 25 mg/l, 38 % between 25 and 50 mg/l and 0 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

East Macedonia: Groundwater nitrate pollution (% of 23 sampling sites and nitrate concentration in 1996): 35 % under 10 mg/l, 48 % between 10 and 25 mg/l, 13 % between 25 and 50 mg/l and 4 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

East Mainland: Groundwater nitrate pollution (% of 21 sampling sites and nitrate concentration in 1996): 24 % under 10 mg/l, 48 % between 10 and 25 mg/l, 24 % between 25 and 50 mg/l and 5 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

East Peloponessus: Groundwater nitrate pollution (% of 26 sampling sites and nitrate concentration in 1996): 31 % under 10 mg/l, 19 % between 10 and 25 mg/l, 27 % between 25 and 50 mg/l and 23 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Epirus: Groundwater nitrate pollution (% of 17 sampling sites and nitrate concentration in 1996): 65 % under 10 mg/l, 12 % between 10 and 25 mg/l, 18 % between 25 and 50 mg/l and 6 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

North Peloponessus: Groundwater nitrate pollution (% of 27 sampling sites and nitrate concentration in 1996): 48 % under 10 mg/l, 19 % between 10 and 25 mg/l, 26 % between 25 and 50 mg/l and 7 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Thessaly: Groundwater nitrate pollution (% of 25 sampling sites and nitrate concentration in 1996): 48 % under 10 mg/l, 52 % between 10 and 25 mg/l, 8 % between 25 and 50 mg/l and 0 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Thrace: Groundwater nitrate pollution (% of 38 sampling sites and nitrate concentration in 1996): 50 % under 10 mg/l, 37 % between 10 and 25 mg/l, 13 % between 25 and 50 mg/l and 0 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

West Macedonia: Groundwater nitrate pollution (% of 25 sampling sites and nitrate concentration in 1996): 56 % under 10 mg/l, 32 % between 10 and 25 mg/l, 8 % between 25 and 50 mg/l and 4 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

West Mainland: Groundwater nitrate pollution (% of 25 sampling sites and nitrate concentration in 1996): 68 % under 10 mg/l, 28 % between 10 and 25 mg/l, 0 % between 25 and 50 mg/l and 4 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

West Peloponessus: Groundwater nitrate pollution (% of 20 sampling sites and nitrate concentration in 1996): 40 % under 10 mg/l, 25 % between 10 and 25 mg/l, 20 % between 25 and 50 mg/l and 15 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Israel:

Lake Kinneret: During the past 50 years, several changes made in the catchment basin of the Lake Kinneret have modified the balance of the lake's ecosystem. Draining of the Hula wetlands in the 1950s caused sediments and nutrients to flow directly into the lake while increased population and agricultural activity in the lake's watershed area have led to contamination by several different pollutants, especially pesticides, fertilizers and cowshed wastes.

The coastal aquifer: Nitrate accumulation: Nitrate concentrations in the coastal aquifer have increased considerably due to intensive use of fertilizers in agriculture and the use of treated effluents for irrigation. Since 1950, average nitrate concentrations in wells have increased from 30 mg/l to 40-50 mg/l today, with an annual rate of increase of close to 1 mg/litre. Some

17% of current groundwater production exceeds levels of 70 mg/l, and nearly 60% exceed recommended levels of 45 mg/l. A study of nitrate trends in the aquifer through 1981 has shown that nitrate levels in wells appeared to be levelling off in the 1970's in which the average rate of increase declined to 0.13 mg/l per year. However, a more recent trend study showed that the average rate of increase rose to 0.67 mg/l per year during the 1980's, an increase of five fold over the previous decade.
Nitrate contamination of the aquifer is considered to be caused primarily by intensive use of fertilizers in agriculture and irrigation with sewage effluents.

Source: Environmental Hydrology Activities - Israel
IAEH Activity Report
Stuart Wollman
Consultant Environmental Hydrologist

Italy:
There is no national monitoring about groundwater pollution. (EEA, 1997)

Emilia-Romagna: http://www.regione.emilia-romagna.it/geologia/acque1.htm.

Milano: Nitrate pollution: From 31 sampling sites 22% have concentration under 20 mg/l, 45% have concentration between 20 and 30 mg/l, 25% have concentration between 30 and 40 mg/l, 7% have concentration between 40 and 50 mg/l. www.provincia.milano.it/ambiente/progettispeciali/pub

Marche*:* 54 towns of this region have nitrate levels in over 50 mg/l www.greensite.it

Pianura Veneta: The provinces of Treviso, Vicenza and Padova are the most problematic zones. **Source**: Agencia Regionale per la Protezione Ambientale, Area Tecnico Scientifica, Osservatorio Regionale Acque.

Umbria: Some problems have been detected.
www.regione.umbria.it/cridea/spazioambiente/numero02/pag17.pdf

Veneto: Several polluted points in this region.

Jordan:
In **Jordan**, it has been estimated that, as the population continues to grow and industry and agriculture continue to develop, demand for water will exceed availability in the near future (Ahmad, 1989). An important factor is the geographical distribution of population: while domestic needs are intrinsically modest (a few cubic meters per person per annum) the concentration of population through urbanization has created problems - this is the case in the Amman-Zarqa area where some 60 percent of the national population are concentrated.

Lebanon:
Akkar Plain (North Lebanon): 14 of the main 15 wells had N concentration over 50 mg /l, the maximum was 163 mg/l. **Source:** Cahiers d'études et de recherches francophones / Santé. Vol. 9, Numéro 4, Juillet-Août 1999 : 219-23, Etudes originales. Authors: Jalal Halwani, Baghdad Ouddane, Moumen Baroudi, Michel Wartel

Malta:
No data available.

Morocco:
Pollution caused by fertilizers is evaluated up to 8.500 tm of Nitrogen. 8-10% of Nitrogen is washed. Nitrogen Pollution has been detected in the Tadla aquifer. Prevision for the future indicates rising of nitrate levels in several watersheds 54-60 mg /l. Bassins of the Tensift, Loukkos and the Oum-ER-Rbia. Predictions indicates Nitrogen run-off will increase 64 % between 1992 and 2020.
http://www.minenv.gov.ma/

Palestine:
In the Tulkarm area, the concentration of nitrate in some wells is up to 105 mg/l.

The situation is worse in the Gaza Strip. In the northern part of the Gaza Strip, the nitrate concentration is up to 150 mg/l, in wells in the Khan Younis area, up to 350 mg/l. The nitrate concentration in the domestic well in Khan Younis Refugee Camp is 600 mg/l.
The main sources of nitrate pollution are fertilizers, wastewater and cesspits.

Source: MEETINGS, 4 February 1999, Water Crisis in Palestine - Scenarios for Solutions Speaker: Mr. Fawzy Naji Participants: Kirsty Wright, Canada Fund; Matthes Bubbe, Friedrich-Ebert Stiftung (FES); Sue Heher, South African Representative Office; Michel Rentenaar, Netherlands Representative Office; Judeh Majaj, East Jerusalem YMCA; Mohammed Abu Khdeir, Al-Quds Newspaper; Hari Politopoulos, European Commission; Neil Bollard, European Commission; Ibrahim Sh'uban, Lecturer, Al-Quds University; Elaine Kelley, Washington Report on Middle East Affairs; Julie Trottier, Researcher; Dr. Alfred Abed Rabbo, Bethlehem University; Br. David Scarpa, Lecturer; Bo Johanesson, TIPH; Fabio Fortuna, TIPH; Cristina Perozzi, TIPH; Dr. Marwan Abu Zalaf, Al-Quds Newspaper; A. Ibrahim, TIPH; Sawsan Baghdadi, Program Assistant, PASSIA; Dr. Mahdi Abdul Hadi, Head of PASSIA.

According to the Palestinian Water Authority, the current fresh water deficit in Gaza City is expected to increase dramatically by the year 2000.Extensive use of chemical fertilizers and pesticides in agriculture is causing contamination of groundwater with chemicals such as nitrates and sulfates.

The PWA says the groundwater used by Gazans is supplied from more than 3,700 wells. Of these, only 1,732 are registered. Only two areas of good fresh water comply with WHO standards (of nitrates less than 50 p.p.m. and chloride less than 250 p.p.m.), according to a report by the Water Division of the Ministry of Agriculture in 1995. The PWA has signed a contract with the French and Palestinian Company of Lyonnaise Des Eaux/Khatib & Alami to improve the water quality and quantity in the Gaza Strip through water recycling and other technical assistance.

Source: Gaza Water Crisis Worsening by Asya Abdul Hadi from the PALESTINE REPORT, MAY 16 1997, VOL 2 NO 49

Slovenia:
The primary supply of water in Slovenia consists of groundwater and water from springs. Nitrate pollution of ground water is one of the most serious environmental issues the country is now facing. Chemicals used in industry and agriculture plus urban wastes constitute most of this pollution. In 12 of the main groundwater sources in the country, the amount of nitrate exceeds the allowable level (50 mg/liter) for drinking water. The nitrogen balance for the nation was calculated as nitrogen inputs (from mineral fertilizers, animal wastes, and deposition from atmosphere) minus nitrogen uptake (by crops and ammonia losses to the atmosphere). Results show that on average, nitrogen input from mineral fertilizers were low, although input from organic manure was quite high. The high surplus levels are mainly caused by animal production. In regions with limited growing conditions for crops, a small increase in livestock population can cause high nitrogen surpluses. These regions can be identified as vulnerable for nitrogen leaching into groundwater. As a result of this, restrictions for the application of chemical fertilizers and animal wastes on hilly regions have to be implemented in order to ensure a sustainable water supply. Until strict regulations are enforced, high levels of nitrate contamination from leaching into ground water can be expected in regions with a high concentration of animal husbandry.

Source: Maticic, Brane. 1999. The impact of agriculture on ground water quality in Slovenia: standards and strategy. Agric. Water Manag. 40: 235-247.

The quality of underground water shows an upward trend in the quality with regard to the content of nitrates and pesticides in the samples taken. In 1993 43% of the samples had nitrates contents over 50 mg/l. In 1996 29 % of the samples where over 50 mg/l.

The pollution of the coastal sea results from intensive activities on the land, mainly from the Italy side. With regard to the concentration of nutrients, the coastal sea can be classified into mezzo to eutrophic

Source: MEPP Hydrometeorological Institute of Republic of Slovenia

Syria:
Water scarcity is not the only problem. Pollution usually is part of the water resources issue, and can indeed be the main problem. Overpumping of aquifers for irrigation has brought about saltwater intrusions in the coastal plains.

Tunisia:
No data available.

Turkey:
The Electricity Survey Administration (EIEI) has estimated that 500 million tonnes of sediment is delivered to rivers and lakes each year along with 9 million tonnes of nutrients. Ad hoc surveys of groundwater quality indicate the following problems: sewage infiltration from poorly maintained sewage networks; leaching from solid waste dumps; toxic industrial chemicals; pesticide and fertilizer contamination; and salinisation from over extraction e.g. in the Lakes area **(OECD, 1999)**.

Monitoring of ground water is poor.

Elazig-Uluova: Groundwater nitrate pollution (% of 12 sampling sites and nitrate concentration in 1996): 17 % under 10 mg/l, 83 % between 10 and 25 mg/l, 0 % between 25 and 50 mg/l and 0 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

Erzurum: Groundwater nitrate pollution (% of 18 sampling sites and nitrate concentration in 1996): 33 % under 10 mg/l, 22 % between 10 and 25 mg/l, 11 % between 25 and 50 mg/l and 33 % over 50 mg/l. **Source:** Technical report No 22, EEA 1999.

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OECD (1999), Environmental Performance Review Turkey

Water Resources Issues in the Arab States Region
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Groundwater quality and quantity in Europe - Data and basic information. Technical report No 22
Scheidleder, J. Grath, G. Winkler, U. Stärk, C. Koreimann and C. Gmeiner, Austrian Working Group on Water; P. Gravesen, Geological Survey of Denmark and Greenland; J. Leonard, International Office for Water; M. Elvira, Centro de Estudios y Experimentación de Obras Públicas; S. Nixon and J. Casillas, Water Research Centre; T. J. Lack, ETC-IW Leader.
© EEA, Copenhagen 1999 112 pp.
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UNEP, 1996. State of the Marine and Coastal Environment in the Mediterranean Region. MAP Technical Reports Series No. 100, UNEP, Athens, 156 pp.

Annex 10

Processes of ammonia volatilisation and NO_x emission related to the use of agricultural fertilizers

10.1 Sources of ammonia and NO_x

Ammonia emissions from agriculture occur from animal husbandry (housing, storage of the wastes outside the building, grazing and application of the wastes), application of fertilizers to crops and grasslands fertilized crops and stubble burning of agricultural residues (Van der Hoek, 1998).

80-95% of the total emissions in Europe originates from agricultural practices. Animal excreta contribute over 80% and emissions from use of fertilizers contribute less than 20% of the total ammonia emissions of agricultural origin in Europe (Van der Hoek, 1998).

The EMEP-CORINAIR Atmospheric Emission Inventory Guidebook (European Environment Agency) recommends the following default ammonia emission factors for the application of fertilizers to crops and grasslands:

ammonium sulphate, 8%

ammonium nitrate, 2%

calcium ammonium nitrate, 2%

anhydrous ammonia, 4%

urea, 15%

monoammonium phosphate, 2%

di-ammonium phosphate, 5%

other complex NK, NPK fertilizers, 2%

nitrogen solutions (mixed urea and ammonium nitrate), 8%

10.2 Effects of volatilised ammonia and NOx

Atmospheric ammonia is linked to soil acidification and eutrophication, which affects the exchange of other trace gases such as CO_2, CH_4, N_2O and NO, providing links to radiative forcing and photochemical oxidant production (Sutton *et al.*, 1998). Ammonia may also reduce atmospheric visibility through enhancing aerosol formation (Sutton *et al.*, 1998).

There are still substantial uncertainties regarding the ecological impact of atmospheric ammonia. There is literature describing changes in moorland vegetation from heathland dominated by *Calluna* or *Erica* to rough grasslands, changes in forest ground flora, fungi and tree "vitality" (Sutton *et al.*, 1998).

10.3 The role of the BEPs on abating ammonia volatilisation and NO_x emission

For many of the BEP in most countries there is little experience of practical implementation and country-specific cost data are hard to come by. Moreover, actual costs will be farm-specific, depending on factors such as location, farm size, and the size and distribution of the fields (Sutton *et al.*, 1998).

Generally, the cost curves per unit (%) of abated ammonia emission follow an exponential form. Fortuitously, the measures with the greatest abatement potential are often among the most cost-effective, and are similar for all the countries despite considerable variation in applicability. Low emission land application techniques for both slurries and solid wastes often contribute over half the total abatement potential at low cost. The cost analysis made by Cowell and Apsimon (1998) showed that, for the 39 considered countries, certain measures where consistently cost-effective. These include all low emission application measures, low-technology coverings for slurry storage and urea substitution.

A further complication in the assessment of the potential ammonia abatement is the degree of uncertainty involved in all aspects of the calculations, which is generally felt to be considerably greater than for SO_2 or NO_x. This derives partly from inherent complexity and variability in the actual behaviour of ammoniacal compounds in uncontrolled environments. Similar uncertainties apply to the efficiency of abatement measures in the variety of circumstances in which they will be implemented in reality, and even to the applicability of measures. Another source of uncertainty derives from the scarcity of specific data, both in terms of experimental research results for different systems and conditions, and statistics characterising the nature of livestock management systems in particular countries. At present, the vast majority of research on ammonia emissions and abatement techniques has been confined to north-western Europe.

In general, enforcing compliance will be extremely difficult where there are very large numbers of small-scale independent sources (i.e. farms).

Annex 11
Glossary

11.1 Terminology

Best Management Practices: BMP. is a term used in the United States of America and Canada to describe agricultural and production guidelines that consider both profitability and water quality. BMPs include practices for the management of pests, nutrients and waste; vegetative and tillage practices, such as contour farming, cropping sequence and windbreaks; and structural practices, such as terraces, grade stabilization and sediment control basins. By incorporating a BMP or combination of BMPs into a farming system, a producer can transform a farm operation into a Best Management System for agriculture.

This expression is also used in others fields than agriculture, like tourism.

Best Environmental Practices: The term B.E.P. is also used in the U.S.A., Canada, and Australia, but does not refer to agriculture. The term is used to describe practices in others sectors than agriculture, like education, tourism or industry, that respect the environment.

Good Agricultural Practices: G.A.P. has the same meaning that BMP, but is a term used in the European Community and FAO, and can be applied in any agricultural sector, fresh produce, crop and livestock production. FAO also uses the term **Good Farming Practices**, which means the same

Concerting fertilisation, some of the good agricultural practice that the EU member states are implementing:

1. periods when the land application of fertilizer is inappropriate;
2. the land application of fertilizer to steeply sloping ground;
3. the land application of fertilizer to water saturated, flooded, frozen or snow-covered ground;
4. the conditions for land application of fertilizer near water courses;
5. the capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the groundwater of liquids containing livestock manures and effluents from stored plant materials such as silage;
6. procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, that will maintain nutrient losses to water at an acceptable level."
7. land use management, including the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops;
8. the maintenance of a minimum quantity of vegetation cover during (rainy) periods that will take up the nitrogen from the soil that could otherwise cause nitrate pollution of water;
9. the establishment of fertilizer plans on a farm-by-farm basis and the keeping of records on fertilizer use;
10. the prevention of water pollution from run-off and the downward water movement beyond the reach of crop roots in irrigation systems.

11.2 Glossary

Biuret: It is a by-product of urea manufacture. It is toxic to plants mostly in foliar applications and at seedling stage.

Catch crop: Crop grown not for commercial purposes, it is ploughed into the soil well before sowing the main crop.

Cover crop: Crop introduced after the main crop in a rotation schedule.

Drip irrigation: A method of irrigation in which water is applied at high frequency, thus the elapsed time in days from the start of one irrigation to the start of the next of the same field is short, a few days or every day. Also only a fraction of the surface is normally watered. Water is applied through drips.

Gravity irrigation: A method of irrigation in which water is applied to the land whether as a broad stream or down furrows. The term, therefore, applies to flood irrigation, irrigation by surface flooding and furrow irrigation.

Intercropping: Different crops that grow in the same field at the same time. Usually, one of the crops, is a leguminous crop which fixes N symbiotically and thus reducing the needs for mineral N in the system.

Leaching fraction: Amount of water that percolates through the root zone related to the amount of water applied. The leaching fraction can be important because is a method to control salt balance in soil, thus to control soil salinity.

Nitrification inhibitors: They are different compounds which inhibit nitrification and which are mixed with conventional mineral fertilizers.

Slow release nitrogen fertilizer: There are three main groups of slow release nitrogen fertilizers according to the strategy used in lowering the rate of transformation to mineral nitrogen. One is to coat conventional nitrogen fertilizers as urea, the second is to use products of low solubility as urea condensed with aldehydes and the third is to mixture conventional fertilizers with nitrification inhibitors as dicyandiamide.

Sprinkler irrigation: A method of irrigation in which water (under adequate pressure) is sprinkled over the land through sprinklers. Also called “spray irrigation” and sometimes referred to as “overhead irrigation”.

Starter fertilizer: Starter fertilizer is a small dressing of fertilizer (ca. 10 kg nutrient/ha) placed very near to the seed or transplant, which is in addition to the normal broadcast fertilizers (Costigan,1988. id=1191). Potential osmotic effects limit the total amount of N than can be applied as a starter fertilizer. Normal rates are about one third of the normal broadcast fertilizer application. Most starter fertilizers are banded about 5 cm to the side and 5 cm below the seed row or around the roots of transplants. Ammonium phosphate solution is one of the most widespread liquid nitrogen starter fertilizer.

Water holding capacity: It’s a biological classification of water soil content which considers that the water available to plants is the water soil content between two situations: thus between the maximum water content in the soil when macroporosity is fulfilled by air and the minimum water content under below mesophytic plants cannot absorb water from soil.

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