

**STATISTICAL COMMISSION and
ECONOMIC COMMISSION FOR EUROPE**

**COMMISSION OF THE
EUROPEAN COMMUNITIES**

CONFERENCE OF EUROPEAN STATISTICIANS

EUROSTAT

**Joint ECE/Eurostat Work Session on Methodological
Issues of Environment Statistics**
(Ottawa, Canada, 1-4 October 2001)

WORKING PAPER No. 23

ORIGINAL: ENGLISH

AGRI-ENVIRONMENTAL INDICATORS, CONCEPTS AND FRAMEWORKS

**FAO'S HANDBOOK ON THE COLLECTION OF DATA
AND COMPILATION OF AGRI-ENVIRONMENTAL INDICATORS**

Paper submitted by FAO *

* Prepared by P. Narain, Senior Officer, Statistics Division, FAO, Rome

Agriculture has an important place among various economic activities, not only because it is a principal user of natural resources but also because it is a user as well as a producer of eco-products (marketable products, recreation, maintenance of species, environmental quality, etc.). It has been recognised time and again that the per capita arable land is progressive declining. Water resources, in contrast to land resources, are abundant globally, but these are not evenly distributed and some countries face the constraint of absolute scarcity. The intense pressure on land and water resources often leads to their misuse. The area under cultivation is being expanded by cultivating marginal lands (including sloping lands), that have been deforested. To obtain higher production levels, measures are being taken to improve yields per hectare but these involve the application of heavy dosages of agricultural chemicals, and expansion of irrigation, which, unless managed properly, can have adverse environmental consequences. Thus, the extensive use of fertilisers is often linked to eutrophication of water bodies, soil acidification and potential of contamination of the water supply with nitrates. The problem of excessive use of nutrients is confined to developed countries and some developing countries only. In fact, in many parts of the developing countries, nutrients being applied per hectare are too low to replace those that are removed by crops. The multiplication in the use of pesticides in response to the rising pest problem is also having a negative impact on the environment. The management of water resources too is posing problems in many areas. In water scarce areas, water abstracted from aquifers is accompanied by a relatively low rate of recharge. This puts a tremendous stress on available water resources. In several other areas where irrigation is practised without adequate drainage, over-watering often results in waterlogging and salinization. The impacts of climate change on agriculture and the ecosystem are becoming additional sources of concern.

This phenomena and concern has been recognised by many individuals and national as well as international organisations and a large amount of work has been done to develop environmental indicators and accounts. The impetus for developing environmental indicators was provided largely by the adoption by the United Nations Conference on Environment and Development held in 1992 of a broad action programme for sustainable development called Agenda 21. The OECD, the World Bank and the UNDP are among the principal agencies that have been involved in the development of such indicators. A number of other agencies have also been concerned with the measurement and assessment of the environment.

FAO is the principal source of many kinds of natural resource data. Several other agencies also maintain important databases on land and its qualities. However, the programme for the development of agri-environmental indicators is particularly beset with several methodological and data-related problems. For this purpose large amount of data are required and some of them can be accessible only through technical monitoring. Therefore, the pace of progress is not only uneven but also inadequate, particularly in developing countries. It has been recognised that while some countries are facing problem in selecting appropriate indicators to meet their requirements, others find it difficult to define the type of data that are needed for compiling the indicators. The FAO's present handbook meets these dual objectives.

This handbook is by no means an attempt at presenting an inventory of agri-environmental indicators. The Handbook makes a review of existing work done in the field of agri-environmental indicators and prepares a suggestive list to initiate the work. However, focus of the Handbook is on collection of data and therefore part of the Handbook is devoted to statistical techniques and concepts and definitions that are useful for collecting data for

compiling the indicators. The Annex 1 gives the contents of the Handbook and Annex 2 the list of selected indicators. It is proposed to release the Handbook by the end of the current year.

The agri-environmental indicators listed in this handbook will need adequate testing at the country-level and sub-country level before they can be used for wider application. Moreover, insofar as developing countries are concerned, the relevant data must be refined and co-ordinated to ensure the required monitoring of the environmental conditions and the computing of the related indicators.

ANNEX 1: TABLE OF CONTENTS

CHAPTER I : INTRODUCTION

- The Issue
- The structure of the report

CHAPTER II : RECENT EFFORTS TO DEVELOP AGRI-ENVIRONMENTAL INDICATORS

- History
- Frameworks for environmental indicators
- UN Commission on Sustainable Development (CSD)
- Efforts made by the OECD to develop agri-environmental indicators
- Initiatives taken by the World Bank
- Involvement of other agencies
- Conceptual framework proposed for the development of agri-environmental indicators
 - Definition of indicator
 - Driving Force–State–Response (DSR) framework
 - Criteria for establishing agri-environmental indicators
- Priority areas or issues that agri-environmental indicators should address

CHAPTER III : IDENTIFICATION OF AGRI-ENVIRONMENTAL INDICATORS RELATED TO SELECTED ISSUES

- Issue No. 1 – Sustainable use of land for agriculture
 - A. Land use change
 - B. Intensification of agriculture
 - C. Change in land condition
 - D. Society’s response to ameliorate the situation
- Issue No. 2 – Sustainable use of water for agriculture
 - A. Status of a country’s overall water resources
 - B. Status of areas experiencing depleted water resources and falling groundwater levels
 - C. Status of areas where irrigation is practiced without adequate drainage and groundwater levels are rising
- Issue No. 3 – Sustainable use of nutrients for agriculture
- Issue No. 4 – Sustainable use of pesticides for agriculture
- Selection of indicators – an example of developing regional indicators

CHAPTER VI. : COLLECTION OF DATA

- Concept of statistical data
- Main sources for core data
 - (a) Administrative Sources
 - (b) Statistical Censuses and Surveys
 - (c) Data collection using satellite system and remote sensing techniques
- Data integration for creation of an information system

CHAPTER V : SURVEY TECHNIQUES

- Use of available environmental information from different sources
 - 1.1 Crop estimation surveys
 - 1.2 Agricultural census
 - 1.3 Cost of cultivation studies
 - 1.4 Some other surveys/studies
- Methodological issues relating to sampling designs
 - 2.1 Introduction
 - 2.2. Post-stratification
 - 2.3 Adaptive sampling for pollution ‘Hot Spots’
 - 2.4 Multiple frames
 - 2.5 Links between various types of reporting units
- Small Area Estimation Techniques

- 3.1 Some small area estimation methods
- 3.2. Small Area Statistics (SAS) in agriculture in relation to environment

Bibliography

ANNEX 1 – AGRO-ECOLOGICAL ZONES CLASSIFICATION AND MAJOR CONSTRAINTS

1. Zones Classification
2. Important features of each of the nine agro-ecological zones
3. Koeppen Climate Classification System

ANNEX II - LIST OF AGRI-ENVIRONMENTAL INDICATORS

ANNEX III – LAND USE, LAND COVER AND SOIL DEGRADATION

1. Basis for Land Classification
 2. Land Cover Classification
 - 2.1. FAO's Land Cover Classification System (LCCS)
 - 2.2. Coordination of Information on the Environment Programme of the European Commission (CORINE)
 3. Land Use Classification
 4. Classification of Soil Degradation
 - 4.1. Measurement of Soil Degradation
- Statement 1 – CORINE Land Cover Nomenclature
- (a) Hierarchical structure
 - (b) Nomenclature definitions
- Statement 2 – Various land use or land cover terms found in a comparative study of three contrasting countries

ANNEX IV: DEFINITION OF WATER RELATED TERMS

ANNEX V – AGRI-CHEMICALS

1. Pesticides
 - 1.1 Classification used by the FAO
 - 1.2 Data limitations
 - 1.3 Data collection
 - 1.4 The WHO Recommended Classification of Pesticides by Hazard and guidelines to classification
 2. Fertilizers
 - 2.1 Definitions and Classifications - Essential nutrients
 - 2.2 Conversion Factors for Major Nutrients
 - 2.3 Forms of fertilizers.
 - 2.4 Nutrient content and fertilizer grade
- Statement 1: Extracts from FAO's Questionnaire on Pesticide Consumption and Trade
Pesticides Trade Questionnaire
- Statement II : List Of Major Plant Protection Products and common names

ANNEX VI: ILLUSTRATIVE STRUCTURE OF BLOCKS FOR COLLECTION OF DATA FOR PROXY INDICATORS

ANNEX VII: REMOTE SENSING TECHNOLOGY

ANNEX II - LIST OF AGRI-ENVIRONMENTAL INDICATORS

| Issue/Indicator [†] | Level [‡] | Method used for data collection [§] |
|--|--------------------|--|
| Issue No. 1 Sustainable use of land for agriculture | | |
| 1. <u>Land use change - Driving Force indicator</u> | | |
| 1.1. Change with time in the distribution of land by land use type. | N/SN | S |
| 1.2. Change with time in the distribution of land by land cover type. | N/SN | S/T |
| 2. <u>Intensification of agriculture - Driving Force indicators</u> | | |
| 2.1. Change with time in the intensification of agriculture as depicted by increase in the use of major inputs – fertilisers, pesticides, high yielding variety/improved seed, and irrigated water. | N/SN | S |
| 2.2. Change with time in the rate of growth of yield per hectare of important crops. | N/SN | S |
| 3. <u>Change in land condition - State indicators</u> | | |
| 3.1. Changes in the land area eroded by (i) water and (ii) wind (in ha per year) | SN/W | S/T |
| 3.2. Trend in the amount of soil removed by (i) water and (ii) wind (in tons per hectare per year) | SN/W | S/T |
| 3.3. Trend in the incidence of sedimentation levels in rivers or behind dams | SN/W | T |
| 3.4. Trend in the deposit of sediment in coastal areas | SN/W | T |
| 3.5. Trend in the area affected by terrain deformation (in ha) (e.g. gullies and dunes) | SN/W | T |
| 3.6. Trend in soil nutrient depletion | SN/W | S/T |
| 3.7. Trend in nutrient loss caused by the removal of top soil | SN/W | S/T |
| 3.8. Change in the impact of soil nutrient depletion on agricultural productivity | N/SN | S |
| 3.9. Change over time in salinization (in the extent of area affected in ha) and in the severity of salinization | N/SN | S/T |
| 3.10. Change over time in the extent of area waterlogged (in ha); in the depth of stagnant water (in metre); and in the duration of waterlogging in a year / season. | SN/W | S/T |
| 3.11. Change over time in percentage area on which compaction or crusting is frequently observed | SN/W | S |
| 3.4. Change over time in the number of agricultural machinery (tractors and harvester- threshers) in use | N/SN | S |
| 4. <u>Society's response to ameliorate the situation - Response indicators</u> | | |
| 4.1 Number and proportion of local governments to which resource management has been devolved | N/SN | A |
| 4.2 Number and proportion of local communities to which resource management has been devolved | N/SN | A |
| 4.3 Number and type of farmer organisations / association / clubs promoting soil conservation practices and or treating lands suffering from salinity, etc | N/SN | A |
| 4.4 Extension efforts to promote soil conservation and other land improvement practices, and risk management strategies | N/SN | A |
| 4.5 Number of farmers participating in soil conservation and other land improvement technologies promoted by government, e.g. soil conservation structures, soil conservation tillage, use of special inputs (manure, lime), etc | N/SN | S |
| Issue No. 2 Sustainable use of water for agriculture | | |

[†] Indicators with star sign (*) were also identified by World Bank (See W. B,1995, p. 40)

[‡] Indicates the level at which compilation of the indicator is analytically recommended. N denotes national, SN the sub-national and W the watershed level.

[§] A indicates administrative sources, S the statistical enquiry (Census/Sample Survey) and T the technical/scientific methods

| Issue/Indicator [†] | Level [‡] | Method used for data collection [§] |
|--|--------------------|--|
| 1. <u>Assessing the status of a country's overall water resources - Driving Force indicators</u> | | |
| 1.1 Volumes of internal renewable water resources | SN/W | T |
| 1.2 Volumes of total (global) renewable water resources of a country | N/SN | T |
| 1.3 The incidence of flooding | N/SN/ W | S |
| 1.4 Volumes of water withdrawals | SN/W | T |
| 1.5 The level of groundwater and changes therein | SN/W | T |
| 2. <u>Assessing the status of areas experiencing depleted water resources and falling groundwater levels - Driving Force indicators</u> | | |
| 2.1 Volumes of abstractions of groundwater resources exceeding groundwater recharges | SN/W | T |
| 3. <u>Assessing the status of areas experiencing depleted water resources and falling groundwater levels - State indicators</u> | | |
| 3.1 Falling groundwater tables* | W | T |
| 3.2 Reports of tubewells drying up* | N/SN | A/S |
| 3.3 Reports of rising costs of digging tubewells from greater depths | SN/W | S |
| 3.4 An increasing trend towards monocropping, away from multiple cropping, due to insufficient irrigation water | N/SN | S |
| 3.5 Reports of diversion of cultivable areas to unirrigated crops or less water-intensive crops | N/SN | S |
| 3.6 Reports of yields falling below those in other areas with sufficient irrigation water | N/SN | S |
| 4. <u>Assessing the status of areas experiencing depleted water resources and falling groundwater levels - Response indicator</u> | | |
| 4.1 Implementation by government of policies, or promotion of extension efforts to stimulate water-use efficiency | N/SN | A/S |
| 5. <u>The status of areas where irrigation is practised without adequate drainage and groundwater levels are rising - Driving Force indicators</u> | | |
| 5.1 Practising canal irrigation without adequate drainage and water management | SN/W | S |
| 5.2 Under-pricing of irrigation water or of energy for water pumping | N/SN | A |
| 6. <u>The status of areas where irrigation is practised without adequate drainage and groundwater levels are rising - State indicators</u> | | |
| 6.1 Reports of excessive seepage of water from canals or water course | SN/W | A/S |
| 6.2 Rising water tables* | SN/W | T |
| 6.3 Appearance of areas of water-logging* | N/SN | S |
| 6.4 Increasing salinization of soil* | N/SN | S/T |
| 6.5 Appearance of salt on the surface* | N/SN | S/T |
| 6.6 Abandonment of lands because of excessive salinity | N/SN | A/S |
| 6.7 Reports of crop yields falling over time or being below the levels expected by farmers | N/SN | S |
| 6.8 Number of village communities and / or health personnel reporting water quality problems resulting from poor water control and poor drainage in irrigation projects | N/SN | A/S |
| 7. <u>The status of areas where irrigation is practised without adequate drainage and groundwater levels are rising - Response indicators</u> | | |
| 7.1 Implementation of schemes by government for providing adequate drainage and ensuring proper maintenance; improving water management practices, particularly discouraging over-watering; improving maintenance of canals and on-farm ponds and reducing seepage from water courses; undertaking soil reclamation schemes. | N/SN | A/S |
| 7.2 Increased cultivation of salt-tolerant crops, or water intensive crops | N/SN | S |
| 7.3 A review of policies about the pricing of irrigation water or of energy for water pumping | N/SN | A |

| Issue/Indicator [†] | Level [‡] | Method used for data collection [§] |
|---|--------------------|--|
| Issue No. 3. Sustainable use of nutrients for agriculture | | |
| 1. <u>Use of organic matters and macro/micro nutrients - Driving Force indicators</u> | | |
| 1.1 Change over time in the content of organic matter, macro-nutrients (nitrogen phosphorous, potassium) and micro-nutrients (zinc, baron, manganese, etc) in the soil | SN/W | S |
| 1.2 Use of chemical fertilisers/micro-nutrients | N/SN | S |
| 1.3 Change over time in the amount (in kilograms) of nutrients applied per hectare of arable land, as well as (where the necessary crop related information on the usage of nutrients is available) trend in the application of nutrients per hectare of land under important crops and comparison of nutrients used with recommended dosages | N/SN | S |
| 1.4 The above information broken down into three important nutrient components - Nitrogen (N), Phosphorous (P ₂ O ₅) and Potassium (K ₂ O) | N/SN | S |
| 1.5 Change over time in the amount of nutrients applied per hectare of arable land, broken down into main types of nutrients – fertilisers, manure, sewage sludge, and crop residue resulting from leguminous crops in rotation with other crops. | N/SN | S |
| 1.6 Change over time in the use of micro-nutrients such as sulphur, zinc, boron and manganese | N/SN | S |
| 1.7 Extent of nutrients balances (i.e. total withdrawal of nutrients from the soil in the form of nutrient content of the outputs from harvested and fodder crops minus total inputs of nutrients from the application of fertilisers, manure, etc.). | N/SN | S |
| 2. <u>Use of organic matters and macro/micro nutrients - State indicators</u> | | |
| 2.1 Increase over time in degradation of cultivated fields resulting from deficiency of nutrients, lack of balance in the use of N, P and K, or excessive depletion of micro-nutrients | N/SN | S |
| 2.2 Growth in yields in some areas not fully reflecting enhanced applications of nutrients. | N/SN | S |
| 2.3 Extent of eutrophication of water bodies, soil acidification resulting and contamination of water supply with nitrate resulting from excessive levels of nutrients in the soil | N/SN | S/T |
| 2.4 Extent of gaseous nitrogen losses adding to the total emissions of nitrous oxides and contributing to problems of climate change | N/SN | S/T |
| 3. <u>Use of organic matters and macro/micro nutrients - Response indicators</u> | | |
| 3.1 Implementation by government of policies, e.g. price policies, and credit policies to promote balanced applications of nutrients, as well as to ensure that dosages applied are neither too low nor too high. | N/SN | S |
| 3.2 Extension efforts including demonstrations on farmers' fields to promote the required levels of nutrients. | N/SN | S |
| Issue No. 4. Sustainable use of pesticides for agriculture | | |
| 1. <u>Use of pesticides - Driving force indicators</u> | | |
| 1.1 Use of pesticides | | |
| (i) Use of pesticides, in tons, of active ingredients for the entire cultivated area and per hectare of cultivated area. | N/SN | S |
| (ii) The above information broken down into different types, ranging from less harmful to highly toxic. | N/SN | S |
| 1.2 Cultivate area, in hectare, covered by integrated pest management (IPM) techniques. | N/SN | S |
| 2. <u>Use of pesticides - State indicators</u> | | |
| 2.1 Extent of loss of non-target species and build-up of pesticide resistance to target species | N/SN | S |
| 2.2 Extent of water contamination through both runoff and leaching into groundwater. | SN/W | S/T |

| Issue/Indicator [†] | Level [‡] | Method used for data collection [§] |
|---|--------------------|--|
| 2.3 Extent of public health problems faced by farm workers because of direct exposure to pesticides. | N/SN | A/S |
| 2.4 Extent of public health problems faced by consumers resulting from impairment of drinking water supply by pesticide residues and contamination of food. | N/SN | A/S |
| 3. <u>Use of pesticides - Response indicators</u> | | |
| 3.1 Review of government policies in order to remove or reduce subsidies on pesticides | N/SN | A |
| 3.2 Review of policies providing subsidised agricultural credit for pesticide purchases, or charging discriminatory low tariffs on pesticide imports | N/SN | A |
| 3.3 Extension efforts to promote the adoption of IPM techniques | N/SN | A/S |
| 3.4 Development and release of pest-resistant varieties. | N | A |