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Workshop

CORINE Land Cover 2000

in Germany and Europe and its use for Environmental Applications

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Common Initiative of

Federal Ministry on Environment, Nature Conversation and Nuclear Safety (BMU)

Federal Environmental Agency (UBA)

German Aerospace Center (DLR), German Remote Sensing Data Center (DFD)

On behalf of the Federal Environmental Agency

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Berlin, April 2004

ZUM GELEIT

Wir stehen zu Beginn des Jahres 2004 nur wenige Wochen vor der Erweiterung der Europäischen Union auf zukünftig 25 Mitgliedstaaten. Europäische Politik setzt heute und erst recht in der erweiterten Staatengemeinschaft grenzüberschreitend verlässliche, objektive und vergleichbare Informationsgrundlagen voraus. Das gilt auch und gerade für die Umweltpolitik mit ihren vielschichtigen Wechselbeziehungen zu anderen Politikbereichen. Dies machten die europäischen Staats- und Regierungschefs schon in der Schlusserklärung anlässlich ihres Gipfeltreffens in Göteborg im Juni 2001 deutlich: „We are determined to furge a common and co-ordinated approach to the complex and changing global environment in which we live and the new challenges we face."

Die Erdbeobachtung und insbesondere die Satelliten-Fernerkundung sind ein Kernelement zur Gewinnung von grenzüberschreitenden harmonisierten Daten über den Zustand von Umwelt und Natur. Die Bedeutung der satelliten-gestützten Daten wird auch in der Schlusserklärung des Weltgipfels zur nachhaltigen Entwicklung, Johannesburg 2002, explizit festgehalten. Die Staatengemeinschaft verpflichtet sich „... to promote the systematic observation of the earth, atmosphere, land, oceans, by ... increasing the use of satellites ... to produce high quality data." Und an anderer Stelle: „... to promote the development and wider use of earth observation technologies including satellite remote sensing, ... to collect quality data on environmental impacts, land use and land use change."

Die von der Europäischen Umweltagentur gemeinsam mit den Mitgliedstaaten nach etwa 10 Jahren nun zum zweiten Mal durchgeführte Erhebung von Daten zur Landbedeckung und Landnutzung ist ein hervorragendes Beispiel für die problemorientierte Anwendung von Satelliten-Fernerkundung. Lieferte CORINE-Landcover zu Beginn der neunziger Jahre erstmals einen europäisch harmonisierten Blick auf die Landbedeckung – und dies bereits damals weit über den Bereich der EU-Staaten hinaus -, so lassen sich nun auf der Grundlage der aktuellen Auswertungen Vergleiche und Rückschlüsse auf Veränderungen ziehen. Besonders bemerkenswert erscheint mir, dass die Daten bereits gut zwei Jahre nach ihrer Erhebung bereitgestellt werden konnten, um sie in den verschiedensten Anwendungen des Umweltmonitorings zu nutzen. Die ersten Ergebnisse dieser Auswertungen werden in den Beiträgen zu diesem Workshop präsentiert.

Die Nachfrage nach den Daten, ihre intensive Nutzung in den verschiedensten Bereichen der Umweltpolitik, der Wissenschaft und auch der Umweltforschung belegen, dass CORINE-Landcover als regelmäßiger Service etabliert werden sollte. Mit der gemeinsamen Initiative der Europäischen Kommission und der Europäischen Raumfahrtagentur zum Aufbau eines Globalen Beobachtungssystems für Umwelt und Sicherheit GMES (Global Monitoring for Environment and Security) bietet sich eine hervorragende Gelegenheit, diesen Service aufzubauen. Möge dieser Workshop ein weiterer Schritt auf dem Weg hin zu einem internationalen, koordinierten Erdbeobachtungssystem sein.

Besonderer Dank und Anerkennung für ihr Engagement im Rahmen des Projektes gebührt Birgit Mohaupt und Manfred Keil, die auch diesen Workshop vorbereitet und organisiert haben.

Hartmut J. Streuff

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn

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The organisers would like to thank all the authors of presentations and posters. They have contributed their experiences and their knowledge, making the workshop successful for all participants.

Special thanks go to the chairpersons who were well prepared to chair the five sessions and share their experiences with us:

Hartmut Streuff	– Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany
Chris Steenmans	– European Environment Agency (EEA)
Thomas Stratenwerth	– Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany
Heinz-Detlef Gregor	– Federal Environmental Agency (UBA), Germany
Michael Bilo	– Federal Agency for Nature Conservation (BfN), Germany
Günter Strunz	– German Aerospace Center (DLR), Germany

The workshop would not have been possible without the support of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the European Environment Agency (EEA) and the European Commission (via the joint European project). Thanks go to the persons responsible in BMU, especially to Hartmut Streuff, to the project leaders at the EEA, Chris Steenmans and Adriana Gheorghe, as well as to the Commission Directorates involved: DG Regional Development, DG Agriculture and DG Environment.

Last but not least we thank all participants for attending and discussing the topic on land cover issues together with us.

The editors

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DANKSAGUNG

Der Workshop wurde vom Umweltbundesamt (UBA) und dem Deutschen Fernerkundungsdatenzentrum (DFD) des Deutschen Zentrums für Luft- und Raumfahrt e. V. (DLR) organisiert.

Hiermit möchten die Organisatoren den beteiligten Autoren für Ihre Präsentationen und Posterbeiträge danken, insbesondere für die rechtzeitige Übersendung zum Workshop. Das ermöglichte die Zusammenfassung in einem Tagungsband und erleichterte den Teilnehmern das Verständnis auf dem Workshop.

Besonderer Dank gilt den Sitzungsleitern der auf dem Workshop behandelten fünf Themenbereiche:

Hartmut Streuff – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)

Chris Steenmans – Europäische Umweltagentur (EEA)

Thomas Stratenwerth – Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU)

Heinz-Detlef Gregor – Umweltbundesamt (UBA)

Michael Bilo – Bundesamt für Naturschutz (BfN)

Günter Strunz – Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)

Ohne Unterstützung des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit (BMU), der Europäischen Umweltagentur (EEA) sowie der Europäischen Kommission (EC) für das gemeinsame, europäische Projekt CORINE Land Cover 2000 wäre der Workshop nicht möglich gewesen. So richten wir unseren Dank an die Verantwortlichen im BMU – Hartmut Streuff, in der EEA – Chris Steenmans, Adriana Gheorghe und an die beteiligten Generaldirektionen der Kommission für Landwirtschaft, Regionalpolitik und Umwelt.

Nicht zuletzt möchten wir uns bei den so zahlreich erschienenen Teilnehmern für ihr großes Interesse und ihre Aufmerksamkeit bedanken. Haben sie doch durch ihre Diskussion den Workshop aktiv begleitet und bereichert.

Die Herausgeber

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Umweltbundesamt (UBA), Berlin

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WORKSHOP RESULTS

ORAL CONTRIBUTIONS

Objectives and Status of CLC2000 in Europe and Germany

Applications using CLC in Europe

River Basin Management

Chair: T. Stratenwerth - BMU

Air quality, Soil and Ecosystems

Chair: H.-D. Gregor - UBA

Nature Conservation, Regional Planning

Chair: M. Bilo - BfN

CONTENT

Aims of the Workshop

Germany and 29 further European countries participating in the European programme on update of CORINE Land Cover (CLC 2000) will finish the update of the first inventory of CLC 1990 in 2004.

Land cover and land cover change have a huge influence on the environment and human health. It is one of the main indicators for environmental pressures caused by human activities. The data sets derived from CLC2000 enable ecological assessments on the basis of quantitative data for regional and European wide environmental planning. The updating is based on a harmonised classification scheme and an interpretation method which is consistent across Europe. Together with the first inventory CLC1990, the common data bases allow the analysis of the state and trends of land cover / land use and its changes in Europe.

Countries are supported by the European Commission (EC) programme Image & CORINE Land Cover 2000 (I&CLC 2000) which is led by the European Environment Agency (EEA) together with the European Topic Centre on Terrestrial Environment (ETC TE).

The German CLC2000 project funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Environmental Agency (UBA) is being carried out by the German Remote Sensing Data Center at the German Aerospace Center (DFD/ DLR) and is now in its final stage. First results of the update have already been used within several environmental applications, e.g. for the implementation of the Water Framework Directive (WFD) and first experiences have already been made.

The workshop was organised together with the EC/ EEA and BMU and intended to give an overview on the objectives and the status of CLC2000 update. The description of the methodological guidelines for a European wide harmonised update shows which data can be expected at the end of the project in which 30 countries have taken part.

Alongside the presentations of CORINE Land Cover applications at the European and national level, the usefulness and limitations were planned to be shown and discussed. Applications have been developed for river basin management, air quality, soil protection and ecosystems as well as for nature conservation and regional planning.

A main aspect of the harmonised survey of information on land use is a consistent implementation of international obligations from state and national up to European level. Harmonised data sets across Germany such as CLC are very important for common implementation of international regulations which have to be implemented mostly by the 16 Federal States.

On the basis of the contributions which are presented in this workshop document and the discussions during the workshop, the intention was to explore and summarize further user requirements for future developments on land cover information.

The objectives of the workshop can be summarized as follows:

- To give an overview of the aim of the joint project carried out by the European Commission and European countries (EU member states as well as accession countries)
- To give a short overview on the European and national parts of the joint project for understanding the dimension of harmonisation
- To describe the new data set at an early stage of its usage
- To give an overview of the status of the German project
- To report on experiences and to give indications for possible usages of CLC
- To show how to generate high quality environmental information by combining CLC with other data
- To discuss and explore further user demands on land cover information
- To show and to discuss future possibilities for developing an operational service on land cover information which can offer harmonised land cover information which is needed

With respect to these objectives the organizers asked for contributions for presentations and posters with our first announcement in August 2003. Many contributions reached us and it was not an easy task to choose from them. The selection of presentations and posters was done by a national steering committee consisting of representatives from BMU, UBA and DLR-DFD, with the intention to meet the expectations and interests of a broader audience.

Birgit Mohaupt-Jahr

Federal Environmental Agency (UBA), Berlin

Zielsetzung des Workshops

Deutschland sowie 29 weitere europäische Staaten sind am gemeinsam mit der Europäischen Kommission und der Europäischen Umweltagentur durchgeführten Projekt zur Aktualisierung der Landnutzung CORINE Land Cover 2000 gegenüber der Ersterfassung CORINE Land Cover 1990 beteiligt. Für einen Großteil der beteiligten Staaten werden die Erhebungen Ende 2004 verfügbar sein.

Die Landnutzung ist eine der wichtigsten Eingangsdaten zur Bewertung von Umweltstress verursacht durch menschliches Handeln. Mit den Informationen von CORINE Land Cover ist es möglich, quantitative Aussagen über stoffliche Belastungen auf Mensch und Umwelt abzuleiten und sie bei der regionalen und europäischen Umweltplanung und Entwicklung zu berücksichtigen. Die Erhebungen innerhalb nationaler Projekte basieren auf einem europaweit harmonisierten Klassifizierungsschema und einer einheitlichen Erfassungsmethode. Mit der harmonisierten Aktualisierung sind nun neben der Analyse des Umweltstatus und Trendaussagen möglich.

Die nationalen Projekte werden durch das europäische Programm Image & CORINE Land Cover 2000 unterstützt und durch das European Environment Agency (EEA) mit seinem European Topic Centre on Terrestrial Environment (ETC TE) koordiniert.

Die deutsche Erfassung wird im Auftrag des UBA und des BMU finanziert aus dem Umweltforschungsplan vom DFD/ DLR durchgeführt und befindet sich in ihrer letzten Phase. Erste Ergebnisse wurden nach Prüfung durch das ETC TE bereits versandt, um erste Testanwendungen zu implementieren, insbesondere zur Umsetzung der EU Wasserrahmenrichtlinie.

Der mit der EU / EEA und BMU gemeinsam veranstaltete Workshop zu bisherigen Ergebnissen und deren Nutzungen in Umweltanwendungen hatte zum Ziel, das Anliegen der Aktualisierung auf nationaler und europäischer Ebene darzustellen, die Aktualisierung der Daten gegenüber der Ersterfassung 1990 und das harmonisierte Vorgehen vorzustellen.

Anhand der Präsentationen aus mehreren europäischen Staaten sollten Nutzungschancen und -grenzen aufgezeigt werden. Die Anwendungsgebiete dieser Beispiele sind u.a. Flussgebietsmanagement, Luftreinhaltepolitik, Boden-, Ökosystem- und Naturschutz, Regional- und Transportplanung.

Ein wesentlicher Gesichtspunkt der mit der EU / EEA und den Mitgliedstaaten harmonisierten Aufnahme der Landnutzungsinformation ist die konsistente Umsetzung von internationalen Verpflichtungen von der nationalen bis hin zur Europäischen Ebene. Harmonisierte Landnutzungsdaten stellen für eine abgestimmte Umsetzung der in Deutschland z.T. in der Hoheit der Bundesländer umzusetzenden Verpflichtungen eine essentielle Datengrundlage dar.

Auf der Basis der auch im Tagungsband enthaltenen Langfassungen der Vorträge und der während des Workshops eingeräumten Diskussionsmöglichkeiten sollten der Nutzerbedarf formuliert und der künftige Forschungs- und Entwicklungsbedarf herausgearbeitet und diskutiert werden.

Die Ziele des Workshops können wie folgt kurz zusammengefasst werden:

- Überblick über das Anliegen und die Zielrichtung des mit den Europäischen Staaten und der EU / EEA gemeinsam durchgeführten Projekts
- Beschreibung des Europäischen sowie des nationalen Projektteils und des Harmonisierungsprozesses
- Beschreibung der Daten der Änderungen / Aktualisierung zu einem frühen Zeitpunkt mit der Verteilung der ersten Ergebnisse und im Vorfeld beabsichtigter Nutzungen
- Überblick über den Status des deutschen Projektes
- Aufzeigen des Nutzungspotentials der Daten auf der Basis von bewertenden Erfahrungsberichten über Nutzungen
- Darstellen der Möglichkeiten zur Erzeugung höherwertiger Informationen auf der Basis von Verknüpfungen mit weiteren Informationen
- Erarbeiten und Zusammenfassen heutiger und künftiger Nutzeranforderungen
- Präsentation von und Diskussion über Entwicklungen zur Etablierung von operationellen Diensten, welche die benötigten Landnutzungsinformationen zu vertretbaren Kosten zeitnah und kontinuierlich anbieten können

Mit dieser Zielrichtung erbaten die Organisatoren im August 2003 bei einem breiten Nutzerumfeld mögliche Beiträge. Die große Resonanz von Beiträgen machte die Auswahl nicht leicht. Ein Programmkomitee bestehend aus BMU, UBA und DLR-DFD bemühte sich, mit der Auswahl von Präsentationen und Posterbeiträgen dem großen Angebot und dem Interesse der Teilnehmer zu entsprechen.

Birgit Mohaupt-Jahr

Umweltbundesamt (UBA), Berlin

WORKSHOP RESULTS

Workshop Conclusions and Recommendations

1 Objectives of the Workshop

Within the European programme CORINE Land Cover 2000 (CLC2000) member states are currently updating their national CORINE Land Cover data sets based on a harmonised classification scheme and an interpretation method which is consistent across the continent. Together with the first inventory, CLC1990, the common data bases allow the analysis of the status and trends of land cover / land use and their changes in Europe.

Land use and land use change have a huge influence on the environment and human health. They are one of the main indicators for environmental pressures caused by human activities. The data sets derived from CLC2000 enable ecological assessment for national and European wide environmental planning on the basis of quantitative data.

The German CLC2000 project funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and by the Federal Environmental Agency and carried out by the German Remote Sensing Data Center is now in its final phase. In some European countries CLC2000 has been finished and the other participating countries are well on the way. By the end of 2004 about 80 % of the whole area of participating countries will be inventoried. Data of the update have already been used for several environmental applications, such as for the implementation of the Water Framework Directive.

The workshop gave an overview of the objectives and the status of CLC2000 for both the national and the European parts of the joint project. Recent applications of the CLC database on European and national scales were presented with respect to river basin management, air quality, soil protection and ecosystems, as well as for nature conservation and regional planning. Alongside the presentations of CLC applications the usefulness and limitations of the database were shown and discussed. The workshop was concluded by presentations and discussions on future developments. In this context the joint initiative of the EU and ESA on Global Monitoring for Environment and Security (GMES) is of high relevance. One of the cross-sectoral topics of GMES is land use and land use changes. Some of the user requirements are expected to be met by services which are currently being developed within the ESA funded GMES Services Element (GSE) projects.

2 Usefulness of CORINE Land Cover

The applications showed that in general CORINE Land Cover can support the assessment of the pressures and impacts caused by human activities at national and European scale. The main advantages compared with other data can be summarized as follows:

- The CLC classes are of high relevance for the assessment of the status and trends in the environment and nature conservation.
- The classification system and the inventory method is harmonised across Europe. This is very important for the consistent implementation of European regulations at a national level.

- The mapping scale is appropriate for national and European applications. Due to their high quality and reliability, the data were even used for some regional applications.
- Applications showed that higher level information can be derived from CLC by combination with additional data sets, such as soil maps or statistical information.

3 Limitations of usages and user demands

Several users addressed the topic that higher spatial and temporal resolutions as well as more thematic details for some of the CLC classes are desirable for various environmental applications. During the workshop a table of user requirements was elaborated (included in these proceedings). For instance, to fulfil the European and UNECE regulations on air, soil, and water quality at national level, a further differentiation especially for arable land and artificial surfaces is desired. Moreover, a spatial resolution of 5 ha (in some classes 10 ha) and a temporal repetition of about 5 years are desirable. For the fulfilment of requirements defined by the Kyoto protocol land cover information at a very high resolution on forest and arable areas is needed (0.1 - 1 ha), which currently can not be fulfilled by CLC data.

In general the limited usability for regional and local scales was mentioned. On the other hand, it was recommended to use CLC in combination with additional local data reflecting the local heterogeneity of the landscape. For regions with relatively high homogeneous landscape CLC can provide adequate information in comparison with the disadvantages of other data sets. Some presentations of German users dealing with regional and local tasks, e.g. the assessment of nature conservation resorts, showed that for this kind of application CLC was also suitable because no better homogeneous data sets are available on national level in Germany.

For the implementation of European regulations, such as UNECE, as well as for European studies a continent-wide CLC data set is needed. Especially for Switzerland and Norway as well as for part of Russia comparable data sets should be made available in the near future.

It was discussed that with the higher spatial resolution of some classes, a better representation of linear structures as rivers and roads would be possible. However, this information can be also derived by using other available thematic data, if they are fitted to CLC. CLC should be seen as one of several valuable information layers which should be combined with others, as needed. These other data sets should be also made available in a harmonised, georeferenced and seamless form across Europe. It was suggested to build up a Pan-European network of basic data such as CLC, soil maps, digital elevation models, etc. which could be done under the INSPIRE umbrella.

4 Research and development needs

It was concluded from this workshop that in future CLC should be improved for some classes, e.g., urban structures, arable land and forests, to enhance the usability for some environmental and cross-sectoral applications. This should be fulfilled mainly in national programs, but these improvements are partly relevant as well in European and even in global contexts. Some applications showed that they are tackling with local or regional tasks but in harmonisation with a European or global point of view. Respecting this a harmonised procedure seems to be necessary. Higher resolution data sets have been already produced, sometimes with a 4th level CLC classification scheme, e.g. in Hungary, Luxembourg and Poland.

The relevant common research and development needs are summarized as followed:

- To extend the CLC concept on the whole continent. More countries, e.g. Norway, Russia, and Switzerland, should be integrated into this European wide initiative.
- To carry out studies to analyse and determine which of the demands are really essential, which classes are adequate and which spatial and temporal resolutions are necessary to tackle the above mentioned tasks.
- To harmonise those demands which were found out as important and which are needed for the national implementation of agreed international regulations.
- To define a common standard with respect to proposed classes at level 4 or 5 of CLC for the main regulations at the European level, e.g. for the WFD, UNECE Convention on Air Pollution, and for the European Soil Protection Initiative.
- To develop scenarios to provide more enhanced information (at partly higher thematic differentiation, at higher spatial resolution, at a higher temporal resolution) at reasonable cost.
- In order to obtain the required information continuously and at an appropriate cost, it is desirable to develop semi-automatic approaches for the interpretation and mapping process and to test the operability of these approaches in different landscapes in Europe.

In the framework of the GMES initiative and in particular within some of the ESA GSE projects, several products and services related to land use mapping and monitoring are being developed. Therefore, with respect to the further improvement of CLC, these GSE services are of high relevance. Several institutions, which are involved in CLC are also integrated in GSE projects as core users to define their requirements and to validate the developed services at an early stage. These services should be taken into account for the further development of CLC.

Co-ordination of CLC improvement for the implementation of European regulations should be taken over at the European scale by the EEA together with its European Topic Centre on Terrestrial Environment (ETC TE). On the national scale the National Reference Centres on CORINE Land Cover (NRC CLC) should be involved. As German NRC the UBA has already coordinated the user demands at the federal level during the past. At the state level further involvement of the relevant user groups is necessary.

Workshop-Ergebnisse und Empfehlungen

1 Ziele des Workshops

Innerhalb des europäischen Programms CORINE Land Cover 2000 (CLC2000) der Europäischen Kommission und der Mitglieds- und Beitrittsstaaten erfolgt derzeit die Aktualisierung der Landnutzung nach einem europaweit harmonisierten Klassifizierungsschema und einheitlicher Methodik. Zusammen mit der Ersterhebung CORINE Land Cover 1990 (CLC1990) sind mit dieser Aktualisierung Analysen der aktuellen Landnutzung und Landbedeckung sowie deren Umweltauswirkungen und Trends in Europa möglich.

Die Landnutzung und deren Änderung sind wichtige Eingangsdaten zur Bewertung von Umweltstress, verursacht durch menschliches Handeln. Ein wesentlicher Gesichtspunkt der harmonisierten Kartierung der Landnutzung ist die konsistente Umsetzung von internationalen Verpflichtungen im Umweltbereich auf der nationalen wie auf der europäischen Ebene.

Die Aktualisierung in Deutschland, die im Auftrag des UBA und des BMU aus dem Umweltforschungsplan finanziert und vom DLR durchgeführt wird, ist in ihrer abschließenden Phase. Die bereits erfassten Regionen wurden nach Prüfung durch das ETC-TE bereits an interessierte Nutzer versandt, um erste Untersuchungen und Anwendungen zu ermöglichen, insbesondere zur Umsetzung der europäischen Wasserrahmenrichtlinie. Bis Ende 2004 werden ca. 80% der Gesamtfläche der 30 beteiligten europäischen Staaten erfasst sein und für Anwendungen zur Verfügung stehen.

Der Workshop gab zunächst einen Überblick über die Ziele und den aktuellen Status des europäischen Projekts im Gesamtkontext sowie des nationalen Projektes in Deutschland.

In weiteren Themenblöcken wurden verschiedene Anwendungen von CLC-Daten für europäische, nationale und regionale Fragestellungen behandelt, beispielsweise für das Management von Flusseinzugsgebieten, die Luftreinhaltepolitik, den Boden-, Ökosystem- und Naturschutz sowie die Regional- und Transportplanung. Dabei wurde die Nutzbarkeit von CLC bewertet und anhand der Nutzeranforderungen weiterer Forschungs- und Entwicklungsbedarf herausgearbeitet.

Im letzten Themenblock wurden zukünftige Entwicklungen vorgestellt. Von hoher Relevanz ist hierbei die gemeinsame Initiative der EU and ESA zum Thema „Global Monitoring for Environment and Security“ (GMES). Eines der Querschnittsthemen in GMES stellt die Landnutzung und deren Änderung dar. Es ist zu erwarten, dass einige der Anforderungen der CLC-Nutzer durch die Produkte und Dienstleistungen erfüllt werden können, die derzeit im Rahmen der GMES Services Element (GSE) Projekte entwickelt werden.

2 Nutzungspotential der CORINE Land Cover Daten

Die Anwendungen und Erfahrungen unterstrichen die generelle Nutzbarkeit von CLC für europäische und nationale Fragestellungen hinsichtlich der Analyse von Umweltauswirkungen und des Umweltstresses auf Mensch und Umwelt.

Die wesentlichen Vorteile der CLC-Daten können wie folgt zusammengefasst werden:

- Das Klassifizierungssystem bildet neben reinen Bedeckungsklassen auch Landnutzungsklassen mit Relevanz für Analysen der stofflichen Belastung und deren Wirkungen auf Mensch und Umwelt ab.
- Das Klassifizierungssystem und die Erfassungsmethode sind europaweit harmonisiert Dies ist besonders wichtig für die konsistente, nationale Umsetzung von internationalen Verpflichtungen.
- Der Erhebungsmaßstab ist geeignet für nationale und europäische Auswertungen. Aufgrund der hohen Qualität und der flächendeckenden Verfügbarkeit wurden auch Einsatzmöglichkeiten für einige regionale Anwendungen untersucht und analysiert.
- Die meisten Anwendungen zeigten, dass in Kombination mit zusätzlichen Daten, wie z.B. Bodendaten oder statistischen Daten, höherwertige Informationen ableitbar sind.

3 Grenzen der Anwendbarkeit und Nutzeranforderungen

Verschiedene Nutzer sprachen den Aspekt an, dass höhere räumliche und zeitliche Auflösungen wie auch eine weitere, thematische Untergliederung von einigen CLC Klassen für verschiedene Umweltanwendungen wünschenswert seien. Während des Workshops wurde eine Tabelle dieser Nutzeranforderungen für nationale Aufgabenstellungen erstellt (diese ist in dem vorliegenden Tagungsband enthalten). So ist zum Beispiel eine weitere Differenzierung für Ackerland und versiegelte Flächen wünschenswert, um europäische und UNECE Vereinbarungen zur Luftreinhaltung, zum Bodenschutz und zur Gewässergüte national erfüllen zu können. Des Weiteren sind eine räumliche Auflösung von 5 ha (in einigen Klassen von 10 ha) und eine zeitliche Wiederholrate von mindestens 5 Jahren wünschenswert. Zur Erfüllung der Anforderungen hinsichtlich Landbedeckungsinformationen in Bezug auf das Kioto-Protokoll ist eine sehr hohe räumliche Auflösung für Waldgebiete und Ackerland von 0.1 ha bis 1 ha notwendig, die zur Zeit nicht mittels CLC Daten zu erfüllen ist.

Es wurde auch die eingeschränkte Nutzbarkeit der Daten für regionale und lokale Maßstäbe angesprochen. Es wurde empfohlen, CLC-Daten in Kombination mit zusätzlichen lokalen Daten zu nutzen, um dadurch die lokale Heterogenität der Landschaft besser abbilden zu können. Für Regionen mit einem relativ homogenen Landschaftsbild kann CLC eine adäquate Information im Vergleich mit anderen Datensätzen auch hier liefern. Einige Präsentationen von deutschen Nutzern, die sich mit regionalen und lokalen Aufgabenstellungen, wie der Bewertung von Landschafts- und Naturschutzgebieten beschäftigten, zeigten, dass für diese Art von Anwendungen die CLC-Daten ebenfalls geeignet waren, insbesondere da keine besseren harmonisierten Daten auf der nationalen Ebene in Deutschland verfügbar sind.

Für die Umsetzung der europäischen Richtlinien sowie für europaweite Studien wird ein kontinentweiter Datensatz von CLC benötigt. Insbesondere für die Schweiz und Norwegen und auch den europäischen Teil von Russland sollten in naher Zukunft vergleichbare Daten verfügbar gemacht werden.

Es wurde diskutiert, dass mit der höheren Auflösung einiger Klassen eine bessere Repräsentation linearer Strukturen wie von Flüssen und Straßen möglich wäre. Diese Information kann jedoch auch aus anderen verfügbaren und passfähigen Datenquellen abgeleitet werden. CLC sollte als eine von verschiedenen Informationsebenen gesehen werden, die mit anderen je nach Bedarf kombiniert werden kann. Diese zusätzlichen Daten sollten ebenfalls in einer harmonisierten, georeferenzierten und flächendeckenden Form über Europa verfügbar gemacht werden. Es wurde vorgeschlagen, ein pan-europäisches Netzwerk von Basisdaten wie CORINE Land Cover, Bodenkarten und digitale Geländemodelle aufzubauen, was unter dem Dach der INSPIRE Initiative gemacht werden könnte.

4 Anforderungen an zukünftige Forschungs- und Entwicklungsaufgaben

Um die Anforderungen in einigen der genannten Anwendungen besser erfüllen zu können, wäre neben der höheren räumlichen sowie zeitlichen Auflösung eine weitere Differenzierung in einigen Klassen, z. B. bei den landwirtschaftlichen und urbanen Flächen sowie den Waldflächen, wünschenswert. Dieses sollte hauptsächlich in nationalen Programmen umgesetzt werden, wobei die Verbesserungen zum Teil auch im europäischen und im globalen Kontext relevant sind, was ein harmonisiertes Vorgehen notwendig erscheinen lässt. Eine Kartierung auf der Basis einer CLC Level 4 Klassifizierung wurde beispielsweise in Ungarn, Luxemburg und Polen durchgeführt.

Einige Anforderungen an zukünftige Aktivitäten können wie folgt zusammengefasst werden:

- Erweiterung der CLC-Kartierung auf ganz Europa durch Einbeziehung weiterer Staaten z.B. Norwegen, Russland und der Schweiz;
- Analyse der Anforderungen, die als wichtig erachtet werden, derzeit aber durch die CLC-Klassen und andere Datensätze nicht erfüllt werden können, sowie Spezifikation der entsprechenden räumlichen, thematischen und zeitlichen Auflösungen;
- Harmonisierung der Anforderungen, die national wichtig sind für die Umsetzung internationaler Verpflichtungen;
- Definition eines gemeinsamen Standards für CLC Level 4 und 5 unter Berücksichtigung der Anforderungen z.B. der Wasserrahmenrichtlinie, der UNECE Konvention zur Luftreinhaltung oder der europäischen Bodenschutzinitiative.
- Entwicklung von Szenarien, wie eine mögliche zukünftige Erweiterung von CLC (Enhanced CORINE Land Cover) umgesetzt werden könnte;
- Entwicklung von operationellen, semi-automatischen Methoden mit dem Ziel, die Satellitendatenauswertung zu unterstützen, um damit die benötigte Umweltinformation effizienter, zeitnaher und kostengünstiger zur Verfügung zu stellen;

Im Rahmen von GMES werden in den von der ESA finanzierten GSE-Projekten verschiedene Produkte und Dienstleistungen im Bereich der Landnutzungskartierung entwickelt. Diese Arbeiten sind von sehr hoher Relevanz für die zukünftige Weiterentwicklung von CLC. Einige an CLC2000 beteiligte Institutionen sind in verschiedene GSE-Projekte als Nutzer eingebunden und können somit die Entwicklung der Informationsprodukte maßgeblich beeinflussen. Diese Servicedienste sollen die Kompatibilität zu CLC berücksichtigen.

Die Koordination der zukünftigen Weiterentwicklung von CLC mit dem speziellen Anspruch der nationalen Umsetzung von internationalen Vereinbarungen sollte weiterhin durch die EEA und das ETC-TE erfolgen. Auf nationaler Ebene sollten die „National Reference Centres“ beteiligt werden. Das UBA hat diese Koordinierungsfunktion beispielsweise für Deutschland übernommen und die Nutzeranforderungen auf Bundesebene koordiniert. Zukünftig ist auch eine stärkere Einbindung der Interessen der Bundesländer erforderlich.

Workshop Report

Introduction

Welcome

H.-D. Gregor on behalf of the president of the federal Environmental Agency (UBA) and H. Streuff on behalf of the German Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) welcomed the 108 participants from 16 European countries.

Land use and land use change are two of the most important indicators for pressure on the environment. The harmonisation of this basic information becomes more and more important for European wide implementation of environmental regulations on sustainable development. With respect to the results of the definition phase of the joint ESA and EU Commission initiative GMES (Global Monitoring for Environment and Security) the CLC data could be seen as one core service.

The great number of participants underlined the interest in the CLC data set and its use in environmental applications. The representatives of the European Commission (EC) and the European Environment Agency (EEA) were welcomed; both institutions are actively involved in the CORINE Land Cover programme.

Mr. Gregor and Mr. Streuff thanked the organisers for the preparation and wished all participants a fruitful discussion and a successful meeting.

Aims of the workshop

The objectives and the agenda of the workshop were introduced by B. Mohaupt-Jahr (UBA, Berlin). The workshop aimed at giving an overview of the objectives and the status of the CLC2000 update. The methodological guidelines for a European wide harmonised update were briefly described in order to show which data can be expected to be available by the end of the project, in which 30 countries take part. Applications have been developed for river basin management, air quality, soil protection and ecosystems as well as for nature conservation and regional planning.

On the basis of the workshop contributions and discussions, further user requirements are to be explored and summarized for future development of land cover information.

B. Mohaupt-Jahr mentioned the broad interest in the topic, making the decision about which presentations should be made not an easy one, and expressed the hope for fruitful discussions. She thanked all the authors of presentations and posters as well as the chairpersons for their contributions and for their sharing experiences with the participants and making the workshop successful. Last but not least, she thanked the BMU for the opportunity to carry out this workshop and the EEA for its active role in supporting the member states.

Session I: Objectives and Status of CLC2000 in Europe and Germany

Chair: H. Streuff – BMU

Mr. Streuff highlighted the aims of the session: giving a short description of the background within EEA's tasks and the role of the European Topic Centre "Terrestrial Environment" (ETC/TE) and summarizing the needs for CLC within environmental applications at European and national levels.

C.Steenmans (EEA) gave an overview on the applications and the needs for fulfilling tasks of the EC and of the EEA. CLC is used in applications mainly for environmental planning (16% of the applications), spatial planning (15%), nature conservation (10%), agriculture (8%) as well as for tourism, transport, soil quality, urban planning, risk assessment, coastal protection and water management. Examples based on land use information given by CLC for sealing development, population trends, flooding frequency, storm and fire events were shown.

Within future activities biodiversity loss and habitat fragmentation maps will be produced. CLC provides basic information for the environmental status report of the EEA. CLC is also a cross-cutting indicator for agricultural development and the European Soil Protection Initiative. He referred to the links between CLC, INSPIRE and GMES.

Last but not least he briefly presented information on the European joint project I&CLC2000: 30 countries are involved; about 100 organisations with nearly 120 man-years take part; about 12 M € are invested, shared 50% by the EC and 50% by the participating countries. On the occasion of the 10th anniversary of the EEA, results of the I&CLC 2000 programme will be highlighted.

S. Kleeschulte (ETC/TE) explained the role of the European Topic Centre on Terrestrial Environment (ETC/TE) which is led by the University of Barcelona. One task of the ETC is to coordinate the Image 2000 project and also the Technical Team for CLC 2000. The Image 2000 project covers satellite data purchase and geo-rectification using a digital elevation model. This was already done during the past with a mean accuracy of <25 m.

The CLC 2000 Technical Team (under the leadership of J. Büttner) is responsible for education and training on updating process. By the end of 2004, 80% of the whole area of the participating countries is expected to be available.

Twelve products, national as well as European integrated data sets, on satellite mosaics, change covers and updated CLC2000 data will be available. A common Internet based distribution system is planned before implementation. A report on the common project and applications of CLC data will be available by the end of 2004.

B. Mohaupt-Jahr (UBA, Berlin) gave an overview of the structure and the content of the national German project as well as of CLC itself. The German CLC2000 project funded by BMU and UBA and carried out by the German Remote Sensing Data Center is now in its final phase and is planned to be completed by late summer 2004. Sub-contractors EFTAS, GAF, and Infoterra are involved with interpretation and mapping of the changes based on their experience of the first inventory and regional know–how.

The method of updating was briefly explained to illustrate what kind of data can be expected. UBA had a special interest in launching and leading this project. Land use information is an important parameter for several environmental applications, e.g., for the implementation of the Water Framework Directive, for the effect-based approach which is used within the UN-ECE Convention on long-range trans-boundary air pollution (LRTAP) and for applications in soil protection.

M. Keil (DLR, DFD) gave an overview of the interpretation and mapping methods and on the status of the German CLC2000 project. Several examples were given for the products and on significant changes between 1990 and 2000, e.g., in the region of Berlin and in the former brown-coal mining district of Lausitz. As one main resulting experience, he pointed out the importance of integrating multitemporal satellite data for the differentiation of arable and pasture land. The use of additional satellite scenes will improve the assessment of pasture land in comparison to the primary assessment of CLC1990.

By comparing the resulting area statistics of CLC and the official area statistics in the two federal states of Brandenburg and North Rhine - Westphalia, he discussed the problems of comparison caused by the generalization procedures and the minimal cartographic units (25 ha, for changes 5 ha) in CORINE Land Cover. The full CLC2000 coverage of Germany will be available in late summer 2004.

The question of the data policy was raised: C. Steenmans and B. Mohaupt-Jahr replied that all products, national as well as European, will be available at marginal cost. B. Mohaupt-Jahr explained that it is important to collect information on possible usage and to get feedback from users. Hence the member states and the EU/ EEA agreed on a data dissemination procedure: all users have to fill in a data agreement form before the data will be provided. EEA for Europe and UBA Berlin for Germany intend to distribute the data via an Internet tool. With respect to commercial usage it was suggested by H. Streuff to keep in mind the different usages and to distinguish between usage for an institution's own purposes or for commerce, where data is sold and must be paid for.

Session II: Applications using CLC in Europe

Chair: C. Steenmans – EEA

The chair thanked the organizers for preparing this workshop as a platform to present national as well as international experiences on CLC applications. This issue was covered in the session by giving European examples. He pointed out that it is very important to inform a broad audience about possible and successful usage of this kind of information.

Jaap Slootweg (Coordination Center for Effects, RIVM) introduced the structure and the tasks of the UNECE Convention on Long-range Transboundary Air Pollution. He stressed the importance of consistent results between various models applied under the Convention, especially those which model and map critical loads (carried out by National Focal Centres and coordinated by CCE) and land-use specific deposition rates. Depositions and critical loads are compared to assess ecosystem specific air pollution risks and form the basis of emission reduction policies under the UNECE Convention as well as the EU National Emission Ceilings Directive. Ideally the same land use data set should be used for all tasks under the Convention; however, presently CLC (and compatible national data) and the SEI data set (produced by Stockholm Environment Institute at York) are used. CLC was recommended for critical load mapping by an earlier study which compared several European wide land use data sets, e.g., PELCOM, FAO, SEI and CLC. A sensitivity analysis based on a comparison study between SEI and CLC is presently being carried out. This serves as a basis for deciding whether the inconsistencies caused by using different land use information are acceptable or not. This comparison method was explained in detail. Results are expected for spring 2004.

By *A. Ciolkosz (Institute of Geodesy and Cartography, Warsaw)* a short overview of several application examples in Poland was given. CLC was a basis for assessing damages in the area of the 'Black Triangle' caused by air pollution (effects of sulphur). The flood impacts of 1997 in the Odra river basin were investigated by combining ERS-2 SAR images of the flooding period and CLC data. He explained that for several use the user demands were not fully met, specifically those concerning regional and local scales. CLC was improved with the addition of a 4^{th} level. Some classes were further distinguished and linear structures, e.g., roads, rivers etc., were supplemented for map representations. For regional applications, CLC on a minimal mapping unit of 4 ha was started in some regions.

G. Banko (UBA Wien) reported that the update of the CLC 1990 is an ongoing process in Austria. Although the CLC inventory is produced to fulfil European tasks, the CLC data are used within national environmental applications as well. The UBA Vienna took the decision to make available the CLC data at level 2 via the Internet techniques. Since distributed by Internet, more and more users have been asking for the data also at level 3 and for background material. He referred to two main changes of land cover / land use: The area of the biggest glacier decreased by 70 ha due to climate change. During the last few years a larger number of golf courses were established.

Session III: River Basin Management

Chair: T. Stratenwerth - BMU

Since the coming into force of the EC Water Framework Directive in December 2000, river basin management in the European Union has mainly been interpreted as implementing the directive. The directive requires that an analysis of the characteristics of the river basin districts and of the anthropogenic pressures and their impacts on the ecological status of the waters as well as an economic analysis of the water uses has to be carried out until the end of 2004.

The assessment of non-point-source pollution is one of the major issues in the context of this analysis. Three of the four presentations in this session of the workshop provided the audience with results from studies using CLC data sets for modelling nutrient inputs into surface waters. The fourth presentation dealt with the use of CLC data sets in the context of probability based regionalised risk assessments of pesticide application.

H. Behrendt (Institute of Freshwater Ecology and Inland Fisheries) tested for the Danube River Basin the possibilities of bridging the gaps in the CLC coverage of the Danube River Basin by combining CLC data sets with other land cover or land use data sets like USGS land cover map and the comparability of CLC data with data provided by official statistics.

The observed deviations between estimations based on CLC data and those based on other data sets were beyond acceptable limits. He recommended to improve particularly the regional coverage of CLC but also the quality of the CLC data sets.

H. Bogena (Research Centre Jülich) focused in his presentation on the dis-aggregation of diffuse nitrogen surpluses from agriculture calculated for administrative districts using the CLC categories in the context of modelling the impact of policy measures on diffuse pollution taking into account also economic feasibility and social acceptability. The study proved the need for more detailed and differentiated data. A more detailed and more precisely defined set of sub categories for agricultural land in the CLC data set was recommended.

W.-G. Pagenkopf (IIMAPS) analysed the consequences of replacing CLC 1990 data by CLC 2000 data as a source for land use/land cover parameterisation in the MONERIS model. The comparison was done for about 500 sub-catchments of the Elbe basin. The calculations showed that differences at the level of the category “agricultural areas” for most of the sub-catchments are too small to verify consequences for emission estimates in the applied emission model. However, the picture is different at the level of subcategory “non-irrigated arable land” where changes are more significant. As emission models are mainly using total agricultural area for the parameterisation of non-point paths, these differences may have consequences for modelling.

B. Röpke (University Giessen) reported on a study assessing the regional variability of the risk to surface water from pesticide application. CLC data are used in the applied GIS-based decision support system for identifying the probable target areas for pesticide application. Again the results of the modelling could be improved by more detailed and differentiated CLC data sets.

The common message from the four presentations was the call for enlarging CLC coverage of the European river basins and for more detailed and differentiated data sets. On the other hand, the usefulness and availability of CLC was evident in comparison with other data sets like soil maps and digital elevation models. However, as was highlighted during the discussion, the respective improvements for CLC would mean a large additional effort. Therefore, it was recommended to focus efforts to enlarge CLC coverage on only a few particularly relevant categories, like differentiation of arable land and urban fabric. Concerning the need for more differentiated and detailed data it was suggested to approach also the authorities responsible for official statistics with a view to obtaining a better spatial resolution of administrative data.

Session IV: Air Quality, Soil and Ecosystems

Chair: H.-D. Gregor - UBA

An interesting selection of reports was given in this session. They informed participants about the application of CLC in the framework of two Conventions on Air Pollution. One is the Convention on LRTAP. Mrs. Mohaupt-Jahr referred to it in her speech on UBA applications and Jaap Slootweg elaborated on it in his talk also. The other is the Climate Change Convention, and in particular its Kyoto Protocol. CORINE is of particular importance for signatories in fulfilling obligations of both international agreements.

The other 2 papers dealt with erosion.

A study of the workshop document reveals that the authors had to identify a number of additional aspects to be considered. But they showed ways to get around the problems which were presented or identified other sources of information which could be tapped. If additional research is needed, it must be decided in time, who is expected to “pay the bill”.

A. Schlutow (Öko-Data) described the role CLC plays in fulfilling obligations of the UN ECE LRTAP Convention, in the context of the critical loads approach for acidity, eutrophication and heavy metals. The participants were shown how this works on a national basis in Germany. CLC is also essential, it should be added for mapping critical levels of ground level ozone. Of course these activities are conducted on a UN ECE wide basis, at present 25 European countries out of 49 parties to the convention participate in this activity.

One of the main factors influencing the susceptibility of a region to soil erosion is land cover discussed in two reports:

M. Erhard (Research Centre Karlsruhe) presented results of inter-comparisons of statistical and CLC Land Cover data and results of calculating soil erosion risks for Germany. He clearly identified benefits gained from CLC data, but also pointed at some uncertainties in these data as well as limitations for some specific applications.

He made it very clear that for some applications CLC is the only data source available.

T. Cebecauer and co-workers also work on erosion processes. They were able to compute the erosion risk for the whole of Slovakia by adding necessary parameters to the CLC database and finding ways to parameterise them for input to soil erosion modelling, which proved quite difficult, because of local and regional heterogeneities.

But as soil erosion assessment needs uniform approaches, uniform databases like CLC will always be important for providing input.

R. Benndorf (UBA Berlin) informed participants about those provisions of the Marrakesh accords and deduced reporting obligations for land use / land use change and forestry (LULUCF) activities which are relevant for CLC issues. She also detailed the amount of information requested.

A. Gensior (Federal Agricultural Research Centre) added information on the development, composition and establishment of a soil carbon stock inventory for the total agricultural area of Germany, including a comprehensive archive of all generated data. He showed the unique role CLC has played in his work, but also pointed out the limitations, especially in providing data in the requested (extremely high) resolution.

Session V: Nature Conservation, Regional Planning

Chair: M. Bilo - BfN

The session on Nature Conservation and Regional Planning was characterized by a broad area of applications. As a common line in all presentations, the harmonization aspect of CLC was obvious for thematic issues as well as for administrative issues. Remote sensing data can help to overcome the situation of inhomogeneous planning data.

K. Voigt (ARCADIS Consult GmbH) showed that CLC data can be used to assess border-crossing activities of nature conservation in a biosphere reserve. Five federal states of Germany participate in the UNESCO biosphere reserve “Flusslandschaft Elbe”. A comparison of CORINE land cover data of 1990 and 2000 allowed spatial and temporal comparisons of land use development.

J. Feranec et al. (Slovak Academy of Sciences) demonstrated by their paper the application of CLC1990, CLC2000 and change data for the identification of long-term and short-term changes using the example of the Skalica district in western Slovakia. Long-term changes and the development of landscape were analysed by comparing the natural (reconstructed) landscape and land cover according to CLC2000. Dynamics of short-term changes were assessed by comparing of CLC1990 and CLC2000. In addition, CLC data were used to evaluate landscape diversity in Slovakia.

G. Meinel and S. Siedentop (Leibniz-Institute of Ecological and Regional Development) reported on experiences with CLC1990 and CLC2000 data for monitoring urban land use and urban sprawl. They discussed the information potential of CLC data as a nation-wide dataset, in comparison to regional surveys (in Saxony) based on other data sources like land cover classification by IRS-1C/1D data. Limitations exist mainly because of the relatively large minimum cartographic units of 25 ha and (for changes) 5 ha.

The lecture by *K. Kruse (Planungsgruppe Ökologie + Umwelt GmbH)* showed as an example for cross-thematic use of CLC-data its use for environmental risk assessment within the update of the Federal Transport Infrastructure Planning (“Bundesverkehrswegeplan”). During that activity with high political relevance CLC data were used for transport administration as well as nature conservation administration to optimize the transport infrastructure and to minimize the impact on natural resources.

An interesting discussion between speakers and the plenum developed concerning the questions of accuracy, comparability and quality of land cover data in general. It seems to be necessary to tackle this problem and to give more practical information on how to handle these questions in the practical use of CLC data. Especially in a comparison of CLC1990 and CLC2000 the comparability of data has to be analyzed carefully.

Session VI: Future Developments

Chair: G. Strunz - DLR

The last session of the workshop focussed on future developments. In this context the GMES initiative on Global Monitoring for Environment and Security is of high relevance. GMES is a joint initiative of the European Commission (EC) and the European Space Agency (ESA) to establish a European capacity for the provision and use of operational information in support of EU policies for environment and security.

At the beginning of the session the chairman introduced GMES and pointed out the two complementary activities of the EC and the ESA, which include the EC thematic projects in the EU 6th research and development framework programme and the ESA GMES Services Element projects (GSE). Within GSE several projects focus on services related to land use mapping and monitoring. Two of these GSE projects (SAGE and Forest Monitoring) were presented in this session.

F. Jaskolla (Infoterra) introduced the SAGE project, which addresses the European Water Framework Directive (WFD) and the European Soil Thematic Strategy (STS). The service portfolio integrates remote sensing based land use and land cover information together with in-situ data and additional georeferenced data into quantitative models. The aim is to provide improved land use information more frequently and for large areas as well as dedicated hot-spot mapping with high thematic details relevant for the above mentioned environmental directives.

T. Häusler (GAF AG) presented the Forest Monitoring project. The aim is to implement operational land use and forest monitoring services, which support policy and management requirements resulting from international conventions and agreements on climate change, sustainable forest management and protection of biodiversity. This includes, e.g., services and information products for reporting on greenhouse gases and on the Clean Development Mechanism of the Kyoto Protocol, as well as various information products which are used as inputs to national forest information systems.

In both GSE projects CORINE Land Cover plays an important role. It has been shown that GSE services are compatible with the CORINE nomenclature. Therefore, some of the GSE services could serve as a CORINE level 4 or 5 products with enhanced thematic and spatial resolution. The integration of GSE services and CORINE would considerably increase the number of users and provide considerable benefits and synergies.

R. Backhaus (DLR) showed the results of a study entitled “Requirement analysis of the utilisation of satellite-based Earth observation systems for environmental policy (SATUM)”. This study, which was undertaken on behalf of the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety, analyses legally binding tasks of federal environmental administration authority and points out possible contributions based on satellite remote sensing. As one of the outcomes of the study, it was shown that an enhanced CORINE Land Cover product could significantly support several monitoring activities, e.g., in the field of nature protection and biodiversity.

Summarizing, it can be stated that CORINE Land Cover data will continue to play an important role as basic information for various land related analyses. For the further development of products and services, the GMES initiative and the related GSE projects are especially relevant. The integration of these services is important and will lead to considerable benefits for the future development of operational services and products related to land use and land cover mapping and monitoring.

Summary of User Requirements on Future National Land Cover Surveys

Environmental issues	Relevant CLC classes (in brackets: CLC keys)	Major requirements (thematic / spatial, temporal)
Water management (implementation of EU Water Frame-work Directive)	– Artificial Surfaces – Agricultural Areas	– Thematic differentiation of artificial surfaces (degree of surface sealing 20% (30%) - 50%, 50%-80%, >80%) – Differentiation of crops: Cereals; root crops (sum of potato, sugar beet and corn); oil seeds – Differentiation in all-seasons ground cover / not all-seasons ground cover
		– Spatial: 5 ha to 10 ha – Temporal: at least every 5 years, in coordination with statistical surveying – Temporal resolution starting 2004, 2013, 2019 for WFD
Soil protection	– Urban areas / artificial surfaces (1xx) – Agricultural areas (211, 221, 222, 231, 242, 243)	– Substance input / Erosion: thematic differentiation of agricultural areas (corn, wheat, rye, barley, sugar beets, potatoes) – Thematic differentiation of artificial surfaces (degree of surface sealing)
		– Spatial: 10 ha for agricultural crops, 5 ha to 10 ha for artificial surfaces – Temporal: every 5 years – Temporal: for agricultural areas up to 1 year by combination with other data sources to get the crop rotation
Air pollution (effects on sensitive ecosystems)	– Forest (324, 31x) – Natural grassland (321) – Moors and heath land (322) – Peat bogs (412) – Inland waters (51x)	– Mixed forest: Share of coniferous and broad-leaved forest – Semi-natural ecosystems: on humid and dry areas – Transitional woodland / shrub: Degeneration of forest, regeneration, succession areas – Peat bogs: Upland and flat bogs – Water bodies: Natural and artificial – Estimation of Deposition Rates: Vegetation Height
		– Spatial: 5 ha to 10 ha – Temporal: 5 years

Climate protection (carbon sinks)	– Essential agricultural areas (2xx) – Forests and semi-natural areas (3xx) – Inland wetlands (41x) – Necessary 1xx, 5xx	– Further differentiation within forest, agricultural and wetland classes – Thematic differentiation of pastures (231) and natural grassland (321) into dry and fresh / wet grassland areas
		– Spatial resolution: 0.05 (0.1) ha – 1 ha →CORINE is not suitable! – Temporal resolution: 5 years
Nature protection and biodiversity	– Forests (31x) – Agricultural areas (2xx) including pastures – Natural Grassland (321) – Inland wetlands (41x) – Inland waters (51x) – Biotope and land use types	– Thematic differentiation of forest (natural / semi natural forests; hard- / softwood / wetland forest) – Thematic differentiation of natural grassland (321←> 231)
		– Spatial resolution: up to 5 ha (up to now not suitable for accurate planning) – Temporal resolution: 5 years
Spatial environmental and landscape planning	– Artificial surfaces (1xx) – Transport units (122, 123, 124)	– Differentiation within artificial areas – CLC Limited value for regional planning
		– Enhanced spatial resolution for artificial surfaces (5 ha) – Enhancement of spatial resolution in general (10 ha ?) – Enhanced temporal resolution (5 years)

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ORAL CONTRIBUTIONS

European perspective on the joint I&CLC2000 project

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Abstract

The CORINE Land Cover database is a multi-purpose product for a wide range of applications at National and European level. It responds to the user needs of a European common land cover reference dataset for environmental policy development. 30 European countries who are partners of the European Environmental Information and Observation Network (EIONET) are mapping land cover consistent across Europe using the standard CORINE Land Cover methodology. Satellite imagery from the year 2000 (IMAGE2000) is used as a reference baseline for collecting European wide harmonized information on land cover and land cover changes of the past decade (CLC2000). 2004 is the year when the I&CLC2000 project is expected to be finalized for the majority of the countries involved. The results of the I&CLC2000 project will be used within the European Environment Agency new 5 year strategy 2004-2008 (EEA, 2003). The EEA Annual Management Plan for 2004 and the work plan of the European Topic Centre on Terrestrial Environment include a number of applications based on the first I&CLC2000 results and concrete activities related to the launch, the dissemination and the use of the data.

1 Identifying the needs

From the start of the project and all along its development, a considerable attention was given to the identification of user needs, in connection with policy processes and consequently identification of possible applications (Table 1).

A survey was carried out in 1999 by EEA on the main domains where the first CORINE Land Cover data base was and is currently used with particular attention to the extent of use for environmental purposes. The survey results were based on several thousands of requests for European Land Cover data received by EEA (distributed via CDROM or the EEA website upon request under certain conditions) over the past years.

The most frequent domains of CORINE Land Cover data usage appeared to be land management, nature conservation and water management. CORINE Land Cover information is used as well for sectoral analysis in agriculture, forestry, spatial planning, and to a lesser extent in transport, tourism and coastal management. Several research projects and education programmes are making intensively use of the data. According to the survey results, the development of spatial indicators based on land cover or land use changes is still in its infancy, but the demands towards developing such indicators are increasing.

As an overall assessment the findings also showed that the business sectors of telecommunication, navigation and infrastructure development are the main commercial users at present at national levels. The main problems for commercial applications are related to the access to data (not uniform regulated and scattered in terms of institutional responsibilities) and lack of proper awareness and dissemination of information.

Tab. 1: European needs on harmonized land cover information

European Needs	**Information users/ Policy framework**	**Analysis/Assessment land cover information needs**
Assessing impacts of policy against regional development perspectives, spatial planning	Regional planning (ESDP, ESPON, Structural Funds)	territorial analysis land cover, land use and land quality assessment land cover changes landscape assessment.
Assessing impacts of agriculture policies on the environment	Agricultural and environmental policy (CAP reform, Nitrate Directive, UNCCD)	land cover changes landscape indicators watershed analysis for water use, fertiliser input soil cover management, conservation practices.
Strategy on integrated coastal zone management	Environmental policy (ICZM)	land use and land cover change along coastal zones.
Implementation of biodiversity conventions, habitats and protected sites	Environmental policy (Habitats Directive, UNCBD)	development NATURA2000 habitat mapping land cover and land use changes; habitat fragmentation; pressure on designated areas;
Integrated watershed analysis	Environmental policy (Water Framework Directive)	support to the development of watershed indicators.
Assessment of air emission and air quality measures	Environmental policy (Air quality directives, IPCC, UNFCCC)	estimates CO_2 sinks/sources; land cover around measurement stations re-allocation of air parameters to land cover;
Strategic environmental assessment of trans-European transport networks, Transport and Environment Reporting Mechanism	Transport and environmental policy (Common Transport Policy, SEA)	land take fragmentation of habitats, partitioning of land tranquil zones pressure on protected areas.

The I&CLC2000 project started in 2000 and involved from the very beginning the relevant European Commission services as both funding entities and beneficiary of the results together with the participating countries. In this respect the Directorate Generals on Environment, Agriculture, Regional Policy, Research and Eurostat were assisting EEA and the Joint Research Centre in steering this activity along all project phases. A Steering Committee was established acting as a strong policy drive, promoting and using the project results in many relevant EU policy processes. It is important therefore to stress the fact that the use of preliminary I&CLC2000 results started already in early 2003, more than one year before project completion.

2.2 Input to new EU initiatives

Several actions listed in the priorities and thematic strategies of the 6th Environmental Action Programme will make intensively use of IMAGE200 and CLC2000 products such as:

- Urban environment thematic strategy, especially information related to urban sprawl and urban green space
- Soil protection thematic strategy for monitoring and assessing soil erosion, sealing, contamination and halting desertification
- Reference data for the development of a European Spatial Data Infrastructure (INSPIRE) and implementation of Global Monitoring for Environment and Security (GMES) as part of Europe's space policy.

2.3 Sectorial integration

The expected results of I&CLC2000 were identified also as a valuable input to the sectorial integration process initiated under the Cardiff process. Going beyond environment the outputs of this project will assist other policies and related processes in areas such as:

- Impact of agricultural policy on the environment where CLC2000 is used as input to several agri-environment indicators as proposed by OECD and EC COM(2001)144 (soil erosion, land cover change, high nature value farming areas, impact on habitats and biodiversity, landscape diversity, topological change)
- Input to the Transport and Environment reporting Mechanism TERM report (EEA, 2001) by providing information on fragmentation by transport infrastructure, land take and pressure on designated areas.

Furthermore the research area is using the I&CLC2000 results for a broad range of environmental domains such as biodiversity, climate change, soil degradation or in support to various processes such as land use modelling, desertification, etc.

3 Socio-economic impact of the project

By carrying out the data collection in 30 European countries, the project was heavily relying on the local expertise at both national and regional levels. National teams were set up in each country, their number reflecting country specificity, management approach, or local autonomy. More than 100 national and regional institutions are currently involved in the project execution across Europe and over 120 person/years dedicated to the production of the CLC2000 inventory. Considerable expertise was built and expanded over the past years together with a valuable networking partnership and platform for exchange of knowledge.

In financial terms the I&CLC2000 project amount over 12 million euro and was co-funded on a 50/50 shared cost basis by the European Community and each participating country. In financial terms only Turkey and Croatia were not following this approach, where the project is being funded under different EU funding mechanisms (Life, twining, special EU support for Turkey). Although these countries have a different EU funding, the project methodology, technical characteristics and dissemination policy were consistent with the rest of Europe.

4 Conclusions

The new I&CLC2000 project established from the beginning a clear and consistent dissemination policy across all participating country. The results will be available free of charge for non-commercial purposes and a dissemination campaign is already launched to make the results known and encourage their wide use. EEA and JRC will play a central role in the dissemination of the results. At the same time each country has been given unlimited use of all the results and rights to decide on commercial exploitation. It is the strength and the step ahead made by this new project comparatively with the first CLC inventory.

The availability of European wide consistent information on land cover changes based on a systematic mapping of changes over the past decade is significantly increasing the use of CORINE Land Cover data as a multi-purpose product for a wide range of applications at European level. It responds to the needs of having a reference dataset for the beginning of the new millennium.

Long term European monitoring of land cover should remain linked to the national land cover mapping activities and global land cover monitoring. It should be based on pre-defined and well-established methodological rules. For the future more scientific research is needed on generalization and aggregation rules to facilitate the interoperability between regional, national and global levels.

The further development of the CLC2000 results is already addressed under the GMES framework where several projects are in place to explore next steps in information development (i.e. Geoland, Ladamer, Forest monitoring, SAGE, GUS).

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The CLC 2000 project in Germany and environmental applications of land use information

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Abstract

In this contribution an overview is given on the current status of the German project CLC 2000 and on its organisational structure. Besides that the CORINE Land Cover data set and the method for its production will be described briefly. Based on an overview of important environmental applications at UBA using the CLC information the chances and the limitations of CLC products and its usage are discussed in order to formulate requirements for future developments.

The 2000 update of the first inventory (CLC 1990) will be available for EU member states as well as for the accession countries in 2004. This is especially important for the implementation of European environmental regulations at a national level, based on harmonised methods and information. The first inventory carried out during the 1990s and the update is based on a harmonised method described in two technical guidelines. A nomenclature of 44 land use classes for Europe was agreed. The general method is based on satellite images and requires an interpretation and digitalisation of land use classes with a minimum size of 25 ha and a minimum width of linear structures of 100 m. In the update land cover changes of a minimum size of 5 ha have to be taken into account. Following the main rule, new areas with a minimum size of 25 ha or with a minimum width of 100 m have to be digitised for the new CLC 2000 data set.

The first results of the German project are available and were already sent to test users. The resolution in time and space as well as the definition of the land cover classes are useful for many environmental applications. Nevertheless experiences show that some improvements should be reached within further research and developments, especially within the project for developing operational services on land use information within the Global Monitoring for Environment and Security (GMES).

1 Introduction

Land use and its changes are one of the most important basics for the estimation of the pressure on human health and the environment. Humans act with traffic, industrial and agricultural management on different land use categories. The dimension and the spatial distribution of pollutants and their effects on ecosystems depend on human activities and ecosystems properties both visible in land use information.

Most of the European and world wide agreed regulations for environmental protection and human health have to be implemented at national or regional scale but have to be based on harmonised or comparable methods and information. Therefore since the 80^s a European wide harmonised nomenclature and inventory method for land cover/ land use information was agreed within the European programme on *C*o-*OR*dination of *IN*formation on the *E*nvironment – CORINE Land Cover (CLC). Among the five main land cover classes (artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and water bodies) divided into 44 sub-classes many categories of land use classes were defined which are relevant for environment, nature and landscape protection.

During the 90^s, the first inventory CORINE Land Cover 1990 (CLC 1990) for most of the European countries was carried out coordinated by the European Environment Agency (EEA). After finishing the joint European project for Updating CLC 2000, the revised CLC 1990, the changes after 10 years and the CLC 2000 products on land cover information will be available for 30 European countries (see project descriptions of the countries, EIONET, 2003).

The CLC 2000 project was run in a co-operation of European Commission (EC) and European Environment Agency (EEA) with their member and accession states.

The first German inventory of CLC 1990 was finished in 1996. Subsequently a study of an updating methodology was supported by the German project also. This was especially important for Germany because many changes took place in the eastern part of Germany after the economic and social unification. Besides the implementation of already agreed European regulations the priorities in environmental policy were laid on sustainable development based on environmental indicators which can only be expressed by showing trends of pressures and impacts on environment and human health. That's why a common first updating was planned to be carried out after 10 years based on satellite data of the vegetation period around 2000. The EEA with its European Topic Centre for Terrestrial Environment (ETC TE) and the Joint Research Centre (JRC) in Ispra started by the work on the "Technical Guide For Updating" (EEA, 1997) and by creating structures to manage the common project on updating. With respect to this, the German updating was planned together with the EEA at an early stage.

2 The German Project for Updating CORINE Land Cover – CLC 2000

2.1 Organisational Structure and Time Schedule

The German project was established just in time with the European project. It has been started in May 2001 supported by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU), under the project leadership of the Federal Environmental Agency (UBA) and the German Remote Sensing Data Center (DFD) at German Aerospace Center DLR Oberpfaffenhofen (see Figure 1: organisational structure). The UBA has involved the main contract partner DLR as a scientific and organisational coordinator and to carry out several tasks of pre-processing, the quality assurance and quality control and the integration of CLC2000 for Germany.

BMU and UBA as well as DLR are working together as National Steering Committee. UBA represents Germany in the European Steering Committee. The subcontractors which are involved proving their experiences on CLC 1990 and their regional knowledge are basically contracted with the interpretation of the Landsat TM images and the mapping of changes by comparison of 2000 with 1990 Landsat TM images including unavoidable corrections of CLC 1990 interpretation.

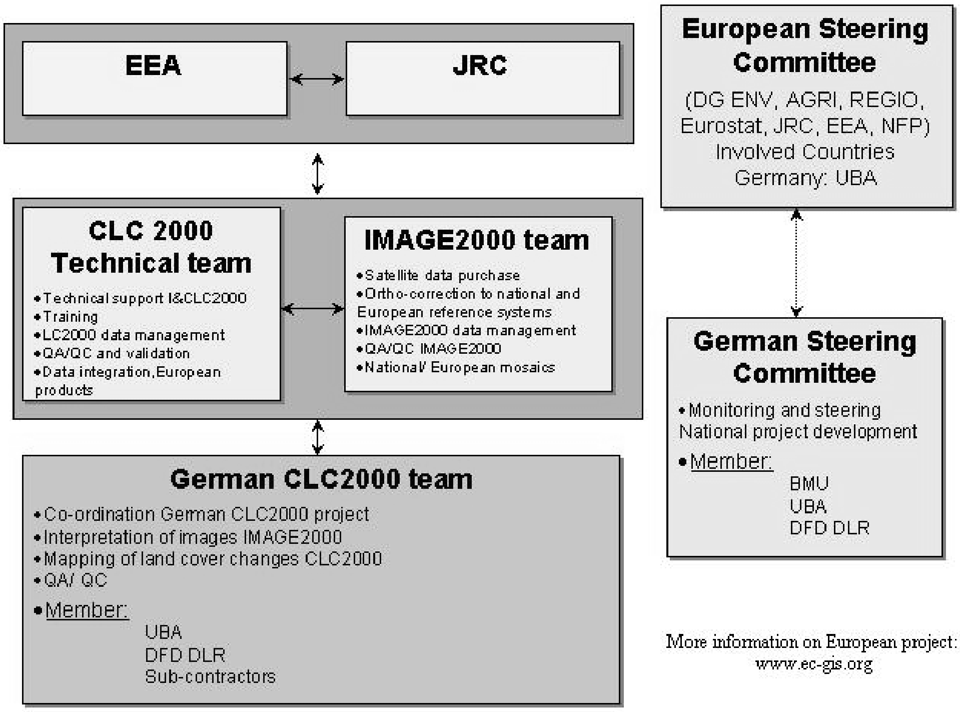

Fig. 1: Organisation structure of the German Project

The results of the first phase covering the eastern part and north-western part of Germany (see Figure 2: lots 1 – 3) have been sent to users already for testing, especially for the implementation of the Water Framework Directive (WFD), for which member states are obliged to analyse the pressures and impacts in 2004.

The whole inventory was planned to be finished by the end of 2003. Now it is expected to be ready during the third quarter of the year 2004 because the needed finances are available only since January of 2004.

Most other countries will also finish their projects during the year 2004. The EU and the participating countries agreed to deliver the national as well as the integrated European products for non-commercial usage at marginal costs.

The national CORINE products will be published and delivered by CD ROM and it is also discussed to implement an internet based GIS application. The European products are planned to be published and delivered by an internet tool also.

2.2 Description of CORINE Land Cover Methodology and Dataset

The national products are the vectorised revised CLC 1990 data set, the change layer and the vectorised CLC 2000 data set. It is a strong command not to change the land use class definitions to ensure that the real changes are visible based on a uniform method. Some additional attributes under the agreed definitions for CLC 1990 were agreed between the CLC 2000 Technical Team and the national teams.

From the 44 classes nomenclature 36 land use classes are relevant for Germany (see – figure 3), e.g. permanently irrigated land does not exist in Germany. The so called "three level classification" system contains the main land cover classes at level 1 (artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands, and water bodies) which are subdivided into more detailed subclasses at levels 2 and 3.

Most categories play a special role as indicator for environmental pressure, e.g. the 2.2 permanent crops; 2.2.1. vineyards - for substance inputs caused by usage of pesticides on hilly areas where the erosion potential and the run off is very high. From the land cover information the dimension of pollutants deposition can be estimated, e.g. deposition values are higher on forests than on arable land.

The CLC 1990 product was digitised based on satellite images of Landsat TM 5 of the vegetation period for the years 1989 – 1992. The mapping scale was 1:100 000, the minimum size of a interpreted area is 25 ha and for linear structures a minimum width of 100m was required. More information on method of the first inventory is given in European Commission (1994).

The CLC changes are detected by comparison of the images which were used for the first inventory (1989 – 1992) with the images of Landsat TM 7 for the updating period (1999 - 2001) after fitting the images from the first inventory to the new geo-rectification of the updating process (see figure 4 – method of updating). Following the methodological guidance changes of existing land use classes are mapped with a minimum size of 5 ha respecting that new change polygons need a minimum size of 25 ha – the method is explained in detail in EEA (1997).

The CLC 2000 product is based on an overlay of the CLC 1990 and the CLC change cover. Additional information on the interpretation and mapping method is explained in the following paper (Keil et al., 2004).

UBA is responsible for research to offer independent analyses and recommendations for political decision-making with the goals to protect and maintain natural resources, also as an act of responsibility towards future generations, to advance sustainable development and to promote environmental protection. Further more UBA coordinates the harmonised implementation of most of the international environmental regulations. In this contribution only some examples are selected and discussed for which the application of land use information is the most important input information, e.g. for the Water Framework Directive (WFD), the European Soil Protection Initiative, the UN ECE protocols on air pollution, the nitrate directive, and the UN Framework Convention on Climate Change and Kyoto Protocol (UNFCCC KP). Spatial analyses of pressures on ecosystems, e.g. by substance inputs and their effects caused by human activities, is a main tool to fulfil these reporting obligations.

The main objective of the Water Framework Directive (WFD) is to reach a “good status" of water bodies in the European Union (EU) by 2015. Prolongations and lower objectives have to be well founded to the European Commission, but no deterioration is allowed. In order to reach these aims, the WFD forces member states to install planning and management in their river basins and to co-operate one with the other in case of shared basins. The public has to be consulted and economic considerations have to be included. Countries are obliged to report on analyses of pressures and impacts and risk of failing the objectives as well as on management decisions to devoid failings in future continuously, the first time on the risk of failing by 2004. The Federal Working Group on Water (LAWA) has recommended to use CLC for the task to analyse impacts of diffuse pollution and land use patterns. Additionally for cases where higher spatial resolution is needed, the national 1:25.000 ATKIS data set could be used. That’s why the Federal States have already got the first data of the update to test and to develop the needed application. From CLC the dimension of pesticides, nitrogen and heavy metal inputs into surface and groundwater can be estimated by application of substance transport models on urban and agricultural areas. Water experts demanded to create subclasses at level 4 to describe some of these areas in more detail.

The objectives of the European Soil Protection Initiative are to assess soil conditions in Europe and to monitor changes, e.g. due to sealing, urban sprawl, pollution, degradation and erosion.

Since the 80^{s} the effect-based approach on critical loads and levels for ecosystems was implemented into the framework of the UN ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) (more information on that convention - see *www.unece.org*). UBA has the leadership of the International Co-operative Programme on Modelling and Mapping Critical Loads and Levels and their exceedances under the Convention (ICP M&M – see *www.icpmapping.org*). For the effect-based approach which is used to agree abatement strategies there is a need for information on the location and description of areas which have to be protected and for the estimation of land use specific depositions. After a comparison study on available data sets on land use information carried out by the CLRTAP Coordination Centre on Effects (POSCH, et al., 2001) it was recommended to use CLC in the countries in which it is available, and otherwise to use PELCOM[1]. Ecosystems as pollutant receptors should be defined with the help of the EUNIS classification for estimation of ecosystem specific critical loads to be able to model biological effects. This was done for Germany by overlaying CLC with soil data of the soil map BÜK1000 of the Federal Institute for Geo-

[1] PELCOM: Pan-European Land Cover Monitoring; Aterra, Wageningen, Netherlands 1999

sciences and Natural Resources (BGR). Most of the participating countries set the priority to protect sensitive terrestrial ecosystems (incl. forests). In Germany nearly 30% of the whole area are covered by forests and semi-natural ecosystems which are wished to be protected. Additional data on tree species and tree height are very important for the derivation of deposition rates. This is not given by CLC yet.

National reporting obligations for UNFCCC and Kyoto Protocol (Art. 3.3, 3.4) require land use information on forest area, forest area change and land use change of af-, re- and deforestation to estimate the carbon stock and carbon stock changes based on the 1990 status. An annual estimation based on regular, geographical assessments is needed. For this task CLC is not sufficient enough.

These applications show that CLC information is useful especially to produce high valuated information in combination with other data. In some cases a more detailed description for selected land cover classes below the level 3 of CLC is desirable to estimate the substance input rates, e.g. caused by the agricultural management of special crops. For some applications a higher resolution in space and time is needed.

Because the limited budget for the updating project these requirements could not be realised up to now. This was one reason that UBA is involved as a core user in the projects on Global Monitoring for Environment and Security (GMES) with the main issues land use/ land use changes. The aim of the GMES project is to develop fast-response operational services to offer land use information with higher resolution in time and space, and with more detailed information on selected land use classes for lower costs. One of the tasks of this project is to compare the modelling results based on CLC with the results based on higher resolved land use information within a cost-benefit analysis. These results should be taken into account for further research and development activities on land use information services.

4 Conclusions

CORINE Land Cover covers the region of 30 European countries and allows harmonised applications for political decision processes with respect to sustainable development. For the implementation of many national and international environmental regulations, land use information is one of the most important data sets.

CORINE Land Cover and its changes will be available for most of the 30 involved countries by 2004 based on a harmonised method for interpretation and digitalisation of Landsat TM images.

CORINE Land Cover offers the most useful and practicable harmonised data set for environmental applications. The combination with statistical data and other spatial data, e.g. soil data, lead to high quality information which can be effectively used to estimate the dimension of environmental pressure and its trends.

For some applications a higher resolution in space and time as well as a more detailed description of some land use classes is desirable to enhance the usefulness. This benefit justifies the cost of the project. But it is important to discuss further research possibilities to produce such a data set via a more operational service with respect to the real needs and future requirements.

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Coordination and technical implementation of CLC2000

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Abstract

The objective of the European Environment Agency (EEA) is to provide policy makers with timely and relevant environmental information. Regarding land cover, the EEA aims to provide those responsible for and interested in European policy on the environment with qualitative and quantitative land cover (LC) data, which is consistent and comparable across the continent. As part of the EEA mandate, the CORINE Land Cover (CLC) database initiated by the Commission in 1985 should be further maintained and regularly updated. Consistent geo-referenced LC information has been identified by different national and European policies as a key database for integrated environmental assessment.

In order to reach this goal EEA and the Joint Research Centre (JRC) launched the IMAGE2000 and CLC2000 Project (I&CLC2000), which includes the updating of the CLC database. The satellite image 'snap shot' of Europe (IMAGE2000) is the principal material to undertake the updating of CLC database for the year 2000 (CLC2000) and to identify main LC changes occurring in Europe within the period 1990-2000. The project is also extended to several other European countries, 10 of which being new members of the European Communities from 1st May 2004. The ETC/TE has the responsibility to coordinate and supervise national CLC2000 activities as well as to contribute to the promotion of the use of the data.

Today, CLC is recognised by decision-makers as a fundamental reference data set for spatial and territorial analyses. Within the European Commission Services, such as DG-Regional policy, DG-Environment and DG-Agriculture, as well as in EEA and its European Topic Centres (ETCs) there is a growing need of using spatial analysis for integrated environmental assessment. The dissemination and use of the I&CLC2000 products is defined in an agreement between the EEA, the European Commission and the participating countries. The database, which will be finished by the end of 2004, covers about 4,5 million km2 with 25 ha spatial resolution. CLC-changes database has 5 ha spatial resolution.

1 Background

From 1985 to 1990, the European Commission implemented the CORINE programme (coordination of information on the environment). During this period, an information system on the state of the European environment was created (the CORINE system) and nomenclatures and methodologies were developed and agreed at EU level.

At the Dobris Conference in 1991 the European Environment Ministers requested that the programme should be applied to the central and east European countries covered by the EU Phare programme. Through the support of the Phare programme, the CORINE databases were implemented in the 13 eligible countries.

Following the European Council regulation to set up the European Environment Agency (EEA) and the establishment of the European environment information and observation network (EIONET), the responsibilities of the CORINE databases (and their updates) rely now on the EEA.

The CLC90 inventory and its updates are key reference data sets, which will provide the basis for the development of spatial analysis and integrated environmental assessment. CORINE land cover is now recognised by decision-makers as reference data for spatial and territorial analysis at different territorial levels. Within the European Commission services such as Regional Policy DG, Environment DG and Agriculture DG as well as in the EEA and its European Topic Centres (ETCs), there is a growing need to use spatial analysis for integrated environmental assessment.

The need for an updated CORINE land cover database was expressed by several users at national and European level. Preparatory work to update the CORINE land cover database for the reference year 2000 started in 1999. The I&CLC2000 project is based upon a number of key elements: lessons learnt form earlier CORINE land cover projects, a current list of user needs, the options available for satellite images and the processing and management requirements for the vast amount of data collected. The overall aim of updating is to produce the CLC2000 database and the CORINE land cover change database between the 1990s and 2000. To guarantee full coverage and to maximise consistency with the previous inventory, the I&CLC2000 project calls upon existing local expertise and requires access to both the ancillary data and the satellite data used for the first CORINE land cover inventory.

The I&CLC2000 project consists of two main components which are interconnected:

- IMAGE2000: covering all activities related to satellite image acquisition, ortho-rectification and production of European and national mosaic; and
- CLC2000: covering all activities related to detection and interpretation of land cover changes.

2 IMAGE2000

The IMAGE2000 component for the EU-15 member states of the I&CLC2000 project is centrally coordinated by the Joint Research Centre (JRC) in Ispra. The ortho-correction of the image data has been contracted to Metria, Sweden, for EU15 countries, and GISAT, Czech Republic, for Accession countries.

The geometric correction of the satellite images is done using information from the satellite scene meta data to create first an *a-priori* acquisition model. Secondly, control point observations are used to refine the *a-priori* values of the orbit and attitude model parameters. Corrections to the *a-priori* model parameters are determined by least squares adjustment of the control point observations. A minimum of 16 ground control points for each full scene is digitised from maps, provided by the member countries.

In the ortho-correction, parallax errors in spatial positioning caused by oblique viewing are corrected. A Digital Elevation Model (DEM – based on the DMA DTED Level 1 database, approx. 90m resolution) is used to determine the parallax size. The DEM is first resampled to the image output space, and the terrain displacement vector is then calculated for each output pixel. In the resampling of the scene, the original image is transformed to the desired frame, pixelsize and map projection, taking into account the acquisition model and parallax corrections. The resampling kernel used is cubic convolution.

In the quality control of the final product the corrected scene is divided into 9 quadrants, and for each quadrant one control point is digitized from maps and compared with the location of the corrected scene. RMS for all 9 points should be less than 25 meters.

The geometric accuracy of the IMAGE2000 data has been validated by external quality control.

3 CLC2000

For the implementation and the follow-up of the progress, the CLC2000 technical team has been set up. This team is composed of several experts with a long-standing history in photo-interpretation, remote sensing and database management, in particular in connection to the CORINE Land Cover nomenclature and methodology. Most experts have already been involved in the creation of CLC90 at national and European level.

In order to assure a homogeneous quality of the CLC2000 production process a number of activities have been set up by the CLC2000 technical team.

3.1 Training

On the outset of each national CLC2000 project, training for the national interpreters can be requested. The CLC technical team agrees with the national project leader on the date and agenda of the training session. It is encouraged to discuss national particularities in order to reach agreement on any variation from the CLC standard methodology.

Normally the training agenda includes the following issues:

- Overview on the European CLC2000 Project
- Systematic CLC90 corrections
- CLC Nomenclature
- Methodology for updating - theoretical background
- Methodology for updating - practical examples
- Field checking
- Quality Assessment
- Interchange photo-interpretation tool
- Presentation of the I&CLC2000 national project (given by a country representative)
- Assessment by Technical Team of some already available photo-interpreted map sheets.
- Technical training in using InterChange photo-interpretation tool, developed by FÖMI (optional, if the country requested).

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Examples and experiences of the update interpretation process for CLC2000 in Germany

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Abstract

The German part of the European-wide programme CORINE Land Cover 2000 (CLC 2000) is led by the Federal Environmental Agency (UBA) and the German Aerospace Center (DLR). Within the project, three final products are generated: the dataset CLC2000 (land use and land cover in the reference year 2000), the revised dataset CLC1990, and the dataset of changes between 1990 and 2000. These data will enable to introduce up-to-date land use and land cover information for environmental assessment, planning and modelling on a European and nation wide, and partially, regional level.

The paper gives an overview on the German CLC2000 project and its present status. A short overview on the project structure and the applied methods of mapping and updating is given. The resulting products are described and experiences from the interpretation process are discussed. The results of CLC2000 are compared to official land cover statistics. Some examples of significant changes are presented, which refer to urban regions, regions with mining activities, agricultural areas, and protected areas. Finally, the status of the project is summarised and conclusions are drawn.

1 Introduction

In the framework of CORINE Land Cover (CLC) a European wide data base of land cover is being generated and regularly updated, which covers the EU countries and the new EU accession countries. The mapping is based on a harmonised classification scheme and interpretation method in the scale of 1:100,000. It comprises 44 land cover classes at a minimum mapping unit of 25 ha (EEA, 1997; EEA, 2000). Under the lead of the European Environment Agency (EEA) and in co-ordination with the participating states the first inventory was carried out in the project CLC1990 referring to the year 1990.

Currently, the project CLC2000 is in progress, which will provide a European wide update of the land cover data base for the reference year 2000 and the mapping of changes in comparison to CLC1990. The minimum mapping unit for these changes is 5 ha. The European CLC2000 project is managed by EEA through the European Topic Centre for Terrestrial Environment ETC-TE (Kleeschulte, 2004). The processing of the satellite data is done by the IMAGE2000 team under supervision of the Joint Research Centre (JRC) of the European Commission.

2 The German CLC 2000 project

2.1 Project tasks and organisational structure

The German CLC2000 project is part of the European project and is funded by the German Federal Environmental Agency (UBA) and by the European Union. The project start was in May 2001. The German Federal Environmental Agency is the responsible and leading institution for the German national project. On behalf of UBA, the German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) co-ordinates and manages the German subproject within the national team. The organisational structure of the German project is shown in Fig. 1 and described in Mohaupt-Jahr, Keil (2004).

The main tasks in the project are: the pre-processing of the CLC1990 data, the selection of suitable satellite scenes for 2000, the interpretation and mapping of land cover in 2000 and of changes in comparison to CLC1990, the integration and validation of data and the preparation of final products for delivery on CD-ROM and via internet. For interpretation and mapping tasks, several companies are involved on a contractual basis.

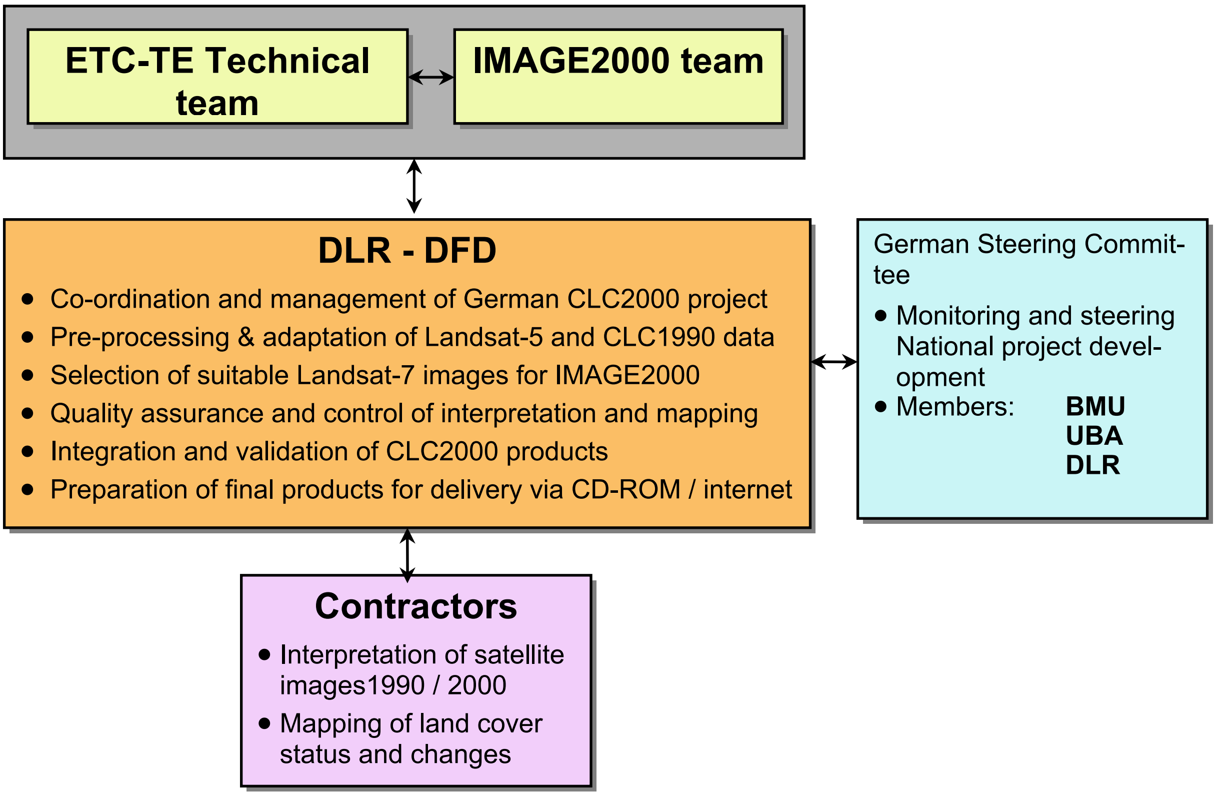

Fig. 1: Tasks and project structure in the German CLC2000 project

2.2 Methodology

The reference basis for CLC2000 is the land cover data set CLC1990, which had been created under the responsibility of the German Federal Statistical Office (Deggau et al., 1998). For Germany 37 land cover classes are relevant, which are listed in Fig 2.

The pre-processing of CLC1990 is necessary in order to adapt the CLC1990 vector data and satellite images of 1990 to the improved ortho-rectified satellite data of Image2000. The geometric adaptation of vector data was done by a rubber-sheeting approach and was finished for Germany in summer 2003. The complete coverage of Germany required 32 Landsat scenes. All scenes that were selected for the IMAGE2000 processing were acquired within the major vegetation cycle from May to September. Altogether, 19 scenes could be chosen from the reference year 2000, 9 scenes are from 1999 and 4 scenes from 2001.

The interpretation and mapping was done by on-screen digitizing in a GIS environment, comparing the Landsat images of 1990 and 2000 overlaid with CLC1990 as main information source. Besides that other reference data like digital topographic maps 1:25,000, urban maps and aerial photographs were used. In order to be able to reconstruct the status in CLC1990, no polygons were moved or removed in case of changes, every change was documented by additional polygons and additional attributes for 1990 and 2000. During the interpretation and mapping process in-situ field surveys have been performed by the contracted companies and DLR as well.

The working units for the interpretation work are map sheets 1:100,000. In order to check the interpretation consistency between different maps, metadata on the working units including information on interpreters, reference data and particularities are registered and stored together with the output products.

To ensure a compatible interpretation in the different lots of Germany and within Europe, two training meetings for the interpreters were performed in co-operation with the technical team of ETC-TE (Kleeschulte, 2004). During these meetings, a slight adaptation of the interpretation rules for some CLC classes was necessary in co-ordination with the technical team. Thus, e.g. in the CLC1990 interpretation in Germany parts of street-along villages have been grouped to one polygon if the distances between settled parts were below 100 m. According to the new nomenclature of CLC2000, a grouping of settlement parts has to be done for distances below 300 m (EEA, 2000). This interpretation rule had been adapted on a European level to include more dispersed settlements in some regions of Eastern Europe. This made it necessary to re-interpret the settlement classes for CLC1990 to avoid artificial changes by differences in the interpretation rules.

Up to now (12/2003), the interpretation has reached a coverage of about 75 % of Germany. About 60 % of the area of Germany has been checked and accepted in two verification meetings by the technical team of ETC-TE. The integration of ETC-TE recommendations and of internal quality check results is on the way. A validation of the results by additional reference data, e.g. from the European LUCAS project (EC, 2002), is planned for spring 2004.

2.3 Products

Three main products are generated within the project: the product CLC2000 (land use and land cover in 2000), the product CLC change (changes between 1990 and 2000) and the product revised CLC1990. These are generated as seamless nation-wide products. Moreover, it is envisaged to provide the results also in units of map sheets 1:100,000. Figure 2 shows the two main input datasets (Landsat 5 and Landsat 7) and the three final products of CLC2000 for the example of the map sheet of Bremen.

estimate in CLC. On the other hand, the category of agriculture shows an over-estimate in relation to statistics. This can partly be explained by the incorporated transport units in this CLC category, but also by small settlements below 25 ha mainly integrated in the arable land category. The percentage of mineral extraction sites fits very well in both.

Summarizing, it can be stated that the CLC mapping rules lead to over-estimates on the large-area and compact classes and on under-estimates of small-area and finely distributed classes.

Tab. 1: Comparison of proportions of main land cover classes of CLC2000 in the federal states of Brandenburg and North Rhine-Westfalia with the official statistics (StaBa, 2003)

CLC Category	**Brandenburg**		**North Rhine–Westphalia**	
	CLC2000 in %	**Statistics 2001 in %**	**CLC2000 in %**	**Statistics 2001 In %**
Artificial Surfaces	**6.6**	**9.3**	**15.4**	**21.3**
Urban fabric, industrial, commercial	5.3	4.3	13.5	12.2
Mineral extraction	0.66	1.19	0.60	0.56
Agriculture	**53.3**	**49.8**	**59.2**	**51.0**
Arable land	42.4	36.3	44.6	34.9
Pastures	10.7	10.7	14.5	14.6
Forests, Semi-natural Areas	**37.9**	**35.4**	**24.6**	**25.5**
Forests including transitional woodland /shrubs	36.6	34.9	24.3	24.8
Wetland	**0.25**	**0.02**	**0.06**	**0.08**
Water Bodies	**2.1**	**3.4**	**0.7**	**1.8**
Areas of other use	-	2.1	-	0.5
Sum	100.0	100.0	100.0	100.0

3 Examples

The amount of changes resulting from the CLC interpretation differs in various regions in Germany. Especially in the New Federal States significant changes of land use and land cover have been mapped. These changes also reflect the political and economical developments following the German reunification. On the one hand, the changes comprise increased areas of urban fabric (enlargements of settlements and commercial areas) especially at the periphery of larger localities. On the other hand, significant changes are visible in the context of the closure of lignite mining areas and military training areas, followed by re-cultivation or succession processes. Further changes resulted in the agriculture areas. In the following chapters some examples for changes in urban areas and mining districts are given, and the overall trends in two federal states are discussed.

3.1 Urban Changes

The mapped changes in the urban regions reflect increasing settlements, new industrial and commercial areas as well as new transport infrastructure. For example, the widely enlarged airport of Leipzig is one of the dominant changes between 1990 and 2000 in the Leipzig region (Keil et al., 2003).

An interesting result of the urban change patterns was found for the larger region of Berlin, which is also characterised by many regional development processes. With reference to the EU projects MOLAND / MURBANDY (Lavalle et al., 2002), two buffer zones were defined around the kernel zone of Berlin. Urban sprawl mainly happened in the outer buffer zone (24.13 km²) and in the inner buffer zone (25.10 km²) outside the kernel zone of Berlin in the surrounding State of Brandenburg (Fig. 3, Tab. 2).

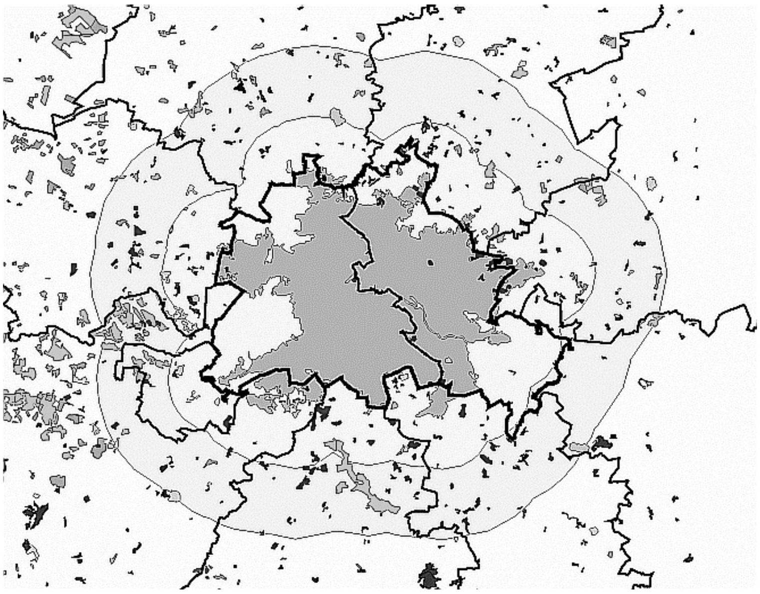

Fig. 3:
Land use changes in the region of Berlin (nine grouped change classes as in Tab. 1) between 1990 and 2000, presented in three zones

Example of Urbanisation:
Kernel zone*:
4,27 km² (0,67%) added
Buffer zone* up to 6,2 km:
25,10 km² (2,20%) added
Buffer zone from 6,2 to 15 km:
24,13 km² (1,48%) added

* Kernel zone und buffer zone due to the definition in the EU-Project MOLAND

In the outer zone the extensification of agriculture shows the highest percentage of the changes (Tab. 2).

Tab. 2: Area statistics for nine grouped change categories in three zones of the Berlin region (buffer zones according to the MURBANDY/MOLAND definition)

Change Class	**Kernel zone in %**	**Buffer zone up to 6.2 km in %**	**Buffer zone 6.2 - 15km in %**
No change	**98.90**	**95.07**	**93.98**
Intensification of agriculture	0.00	**0.28**	**0.51**
Extensification of agriculture	0.08	**1.03**	**2.82**
Af-/reforestation	0.01	**0.68**	**0.41**
Forest loss	0.00	0.06	0.29
Urbanisation	**0.67**	**2.20**	**1.48**
New mineral extraction area	0.06	0.00	0.17
Re-cultivation	0.00	0.00	0.01
New water bodies	0.00	0.00	0.00
Other changes	0.28	0.68	0.34
Sum	**100.00**	**100.00**	**100.00**

3.2 Changes in mining districts

One region connected with very large changes is the region of “Lausitz” in the South-eastern part of Germany, near to the border to Poland. The region is one of the largest brown coal mining districts in Germany. After the German re-unification many of the open pits have been closed and transformed, e.g. by re-cultivations or by creation of artificial lakes. Table 3 shows the result of changes in the area of two map sheets 1:100,000 near the border to Poland, grouped into nine change classes. The overall changes in about 12 % represent one of the highest values in Germany (Kiefl et al., 2003). Most significant are changes by re-cultivation (22.5 %), new water bodies (9.5 %), and afforestation / reforestation (23.9 %). This is partly due to the sequence of closed mining areas, but also due to the closure of military training areas with woody succession states in the protected areas. The changes to new extraction areas (9.5 %) point out remaining mining activities in the nineties. One main change contribution (16.8 %) is due to extensification processes in agriculture by set-asides and conversion from arable land to pasture land. Urbanisation contributes about 5.4 % of changes.

Tab. 3: Area statistics of classified land use changes in the map sheets C4750 Hoyerswerda and C4754 Niesky

Change Class	**Area (ha)**	**Percentage on the whole area (%)**	**Percentage on the changed area (%)**
No change	**253023**	**88.07**	
Intensification of agriculture	1109	0.39	3.24
Extensification of agriculture	5757	**2.00**	**16.80**
Af- /reforestation	8175	**2.85**	**23.86**
Forest loss	1301	0.45	3.80
Urbanisation	1841	0.64	5.37
New mineral extraction area	3413	1.19	9.96
Re-cultivation of open pit mines	7710	**2.68**	**22.50**
New water bodies	3237	1.13	9.45
Other changes	1723	0.60	5.03
Sum	**287289**	**100.00**	**100.00**

3.3 Trends of change in two Federal States of Germany

In this chapter the temporal trends of CORINE Land Cover in the two federal states of Brandenburg and North Rhine-Westphalia are analysed. Both federal states have a similar size, the new federal state of Brandenburg about 29477 km², the old federal state of North Rhine-Westphalia about 34081 km² (StaBA, 2003). Brandenburg is mostly flat with a more rural character, but surrounds the federal state of Berlin and profits from the urban dynamics of the Berlin region. North Rhine-Westphalia is the federal state with the most inhabitants in Germany and includes the industrial regions of Rhine and Ruhr, with mountainous areas up to 800 m. For both federal states, the percentages of selected CLC categories in 1990 and 2000 as well as the relative change are shown in Table 4.

In Brandenburg, the combined sub-classes of urban fabric and industrial/ commercial showed a higher growth than in North Rhine-Westphalia (+6.0% against +4.7%), which is mainly due to the urban sprawl in the region of Berlin. The increase of artificial surfaces, main CLC category 1, shows a similar value for both federal states, with North Rhine-Westphalia having a higher value of +5.5%. One reason could be the increase of mineral extraction sites which show a (relative) decrease in Brandenburg, with large parts of the brown coal mining areas in a re-cultivation state. In agriculture, both federal states show an increase of pasture land against arable land, with a much higher relative change in Brandenburg. The main category of forests and semi-natural areas reflects the high portion of closed (military) training areas and mineral extraction areas in Brandenburg with increasing succession and re-forestation states.

Tab. 4: Percentages of relative changes of the main land cover classes between the revised CLC1990 and CLC2000 in the federal states of Brandenburg and North Rhine-Westphalia

CLC Categories	**Brandenburg**			**North Rhine-Westphalia**		
	CLC1990 revised in %	**CLC2000 in %**	**relative change in %**	**CLC1990 revised in %**	**CLC2000 in %**	**relative change in %**
Artificial Surfaces	**6.3**	**6.6**	**+ 4.8**	**14.6**	**15.4**	**+ 5.5**
Urban fabric, industrial, commercial	5.0	5.3	+ 6.0	12.9	13.5	+ 4.7
Mineral extraction	0.89	0.66	- 25.2	0.52	0.60	+ 15.7
Agriculture	**53.9**	**53.3**	**- 1.1**	**60.0**	**59.2**	**- 1.3**
Arable land	43.8	42.4	- 3.2	45.7	44.6	- 2.4
Pastures	9.6	10.7	+ 11.5	14.3	14.5	+ 1.4
Forests, Semi-natural areas	**37.5**	**37.9**	**+ 1.1**	**24.7**	**24.6**	**- 0.4**
Forests including transition woodland / shrubs	35.8	36.6	+ 2.2	24.3	24.3	0.0
Wetland	**0.26**	**0.25**	**- 3.8**	**0.06**	**0.06**	**0.0**
Water Bodies	**2.0**	**2.1**	**+ 5.0**	**0.6**	**0.7**	**+ 16.7**
Sum	**100.0**	**100.0**		**100.0**	**100.0**	

4 Summary and Conclusions

The project CLC2000 is currently in process and will provide a European wide update of the land cover database for the reference year 2000 as well as the mapping of land cover changes in Europe during the last decade in comparison to CLC1990.

The German subproject of CLC2000 has started in 2001. Currently, the mapping of Germany is almost finished; the final results for the complete coverage of Germany will be available in late summer 2004. Three main products will be provided by the CORINE land cover update, i.e. the CLC2000, the CLC change and revised CLC1990, which represent unique harmonised information on land use and land cover for the EU member countries.

The current mapping results already show a number of significant changes in land use between 1990 and 2000. Especially in the category of artificial surfaces (urban fabric, industrial/commercial, mineral extraction sites) significant changes have been mapped. In several regions also larger changes within agriculture areas and within natural vegetation areas were surveyed.

CORINE Land Cover is currently the best available European wide data set on land cover and land use for environmental evaluations. For some applications, however, a higher spatial, thematic or temporal resolution is desirable. Further research and development activities are necessary to improve the efficiency of CLC mapping and to allow for a more frequent and more detailed CLC mapping in future.

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A method for comparison of land cover information for the analysis of European air pollution effects

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Abstract

Reliable information on land cover in Europe is necessary for the assessment of (cross border) ecosystem effects caused by European emission reduction policies. Critical loads, i.e. deposition of air pollutants below which impacts do not occur according to current knowledge, are computed and geographically mapped. The quality and cross border consistency of land cover information contributes to the reliability of critical load values and their geographical location. Therefore, the reliability of land cover information is important to support robust comparisons of air pollution reduction alternatives. A way to test the reliability of land cover information is to compare different sources.

This paper describes the methodology to compare European land cover maps, in relation to the computation of critical loads and exceedances thereof. The method will be applied on three currently available maps. The CORINE land cover database is generally considered to be the best available information, but has a limited extend. This map is compared to PELCOM, derived from NOAA-AVHRR satellite data and ancillary data, and a land cover map compiled by SEI based on soil maps, combined with agricultural and other data. The comparison can support the extension of the CORINE map, covering most of (pan)-Europe. Results presented in this paper focus on the harmonisation of land cover categories.

1 Introduction

Land use/land cover databases are important to identify and assess ecosystems at risk of air pollution. Parties to the Convention on Long-range Transboundery Air Pollution (LRTAP) negotiate to reduce national emissions of air pollutants such as sulfur dioxide, nitrogen oxides, ammonia, volatile organic compounds (VOCs), heavy metals and persistent organic pollutants (POPs). Its structure facilitates close collaboration between scientific research, policy development and international negotiations. This collaboration has been used for the development of international agreements such as the 1999 Gothenburg Protocol (UNECE) and for the 2001 European Commission Directive on National Emission Ceiling of certain atmospheric pollutants (Directive 2001/81/EC).

The Coordination Center for Effects (CCE) is part of the structure of the Convention. The mandate of the CCE consists of developing methodologies and databases of effects based approaches, like the critical load concept, and collecting and assessing national and European data used for these methods. The CCE is the programme center of the International Coorperation Programme (ICP) Modelling and Mapping, also part of the structure of the Convention, which oversees the collaboration with about 25 National Focal Centers (NFCs).

The European database of local, ecosystem-dependent effects is part of integrated assessments of alternative strategies to reduce depositions in Europe. Next to the effects the integrated assessments also includes modelling of atmospheric transport and deposition of the pollutants. Land cover is a part of ecosystem definitions, and therefore has an impact on the critical load, but has also an impact on other elements of the integrated assessments.

A common set of land cover definitions together with the availability of a European land cover map helps to

a) Interpret and understand both "stock-at-risk" and ecosystem dependent exceedences
b) Compare the contributions of the NFCs and stimulate the cross-border consistency.
c) Prepare a European background database, equivalent to the NFC-contributions to be able to fill the gaps for the countries that did not submit a contribution.
d) Model the transport of air born pollutants.
e) Increases the consistency in integrated assessments.

An earlier study into the usefulness of existing land cover databases (P.A.M. de Smet, J.-P. Hettelingh, 2001) narrowed the comparison to the CORINE land cover database (Version 12/2000 extended coverage), Pan-European Land Cover Monitoring (PELCOM) and the Land Cover Map of Europe of the Stockholm Environmental Institute (SEI). All three have been updated since, making an update of the study needed.

In order to identify a common land cover data set we will start to compare the available maps. All of the maps have been created with different objectives and different sources leading to different classifications and different resolution and co-ordination systems. Therefore the following procedure is used:

1) Select the land use / land cover categories to make the comparison for, and reclassify the three maps accordingly.
2) Transform the maps to a common projection and a common scale.
3) Apply Kappa statistics to assess the similarity of the maps.

These three steps are described in chapter 3, 4 and 5. Chapter 2 introduces the maps,

In this paper no strict distinction is made between land cover and land use.

2 Short description of the land cover maps

2.1 CORINE

The CORINE land cover map is the result of the ongoing CORINE Land Cover project of the European Environmental Agency (EEA). The version 12/2000, used in this comparison, covers the EU-15 and the AC-13 countries (with the exception of Cyprus, Malta, and Turkey), Albania, Andorra, Bosnia and Herzegovina, Macedonia and the coastal zone of Tunisia and Northern Morocco.

The map consists of national contributions, most of which used Landsat and/or SPOT satellites, aerial photographs and other data sources to distinguish the 44 categories. The 100 meter grid has been made available for the work under the convention. This map is by far the most elaborate and accurate of the three maps, and is used as reference map, the 'truth' for the comparison. (http://dataservice.eea.eu.int/dataservice/)

2.2 PELCOM

The 1-km pan-European land cover database is based on the integrative use of multispectral and multitemporal 1-km resolution NOAA-AVHRR satellite data and ancillary data. PELCOM is a three years project accepted as a shared cost action under the Environment & Climate section of the European Union's 4th framework RTD programme. The methodology developed in the PELCOM project is based on combining both unsupervised and supervised classification approaches. The training samples are derived from selected homogeneous areas of the CORINE land cover database. The spectral characteristics of each training sample are used to determine class boundaries and pixel assignments in the supervised classification into the 15 categories used. (http://cgi.girs.wageningen-ur.nl/cgi/projects/eu/pelcom/public/index.htm)

2.3 SEI

The SEI land cover map was originally developed for use in modelling of the impacts of various air pollutants at a continental scale. Its classification reflexes the attempts to identify an ecologically meaningful cover type and/or dominant species across Europe. Several datasets are utilized, among which PELCOM, various soil maps and other maps from international organisations related to agriculture.
(http://www.york.ac.uk/inst/sei/APS/projects.html)

3 Land cover classification and translation of existing categories

To improve on the uniformity of the ecosystem definitions for the work under the convention a study was conducted to used classifications. The European Nature Information System – EUNIS (Davies and Moss, 1999) is a hierarchic classification system developed by the European Topic Centre for Nature Conservation that uses a common framework with links to other classifications. A subset of level 1 and level 2 was found applicable and easy to use for the work under the convention. (Hall, 2001). The EUNIS system aims at defining ecological habitats, taking into account what species are present, but also incorporates features of the landscape. However the selected subset overlaps strongly with the land cover categories used in the maps. The mismatches between the categories of the land cover maps and EUNIS were solved by

1) extending the EUNIS list (distinguishing irrigated and non-irrigated arable land),
2) assigning a category to the most relevant EUNIS category (e.g. 'Coniferous forest' from PELCOM only to G3 in EUNIS, and not to B1, B2 or G5, that also contain conifers) and
3) distributing one category to two, or exceptionally 3 EUNIS categories with inverse weights. The weights of these distributions are determined by expert judgement.

4 Transform the maps to a common projection and a common scale

The land cover maps have each their own geo-reference system. In order to compare them a common projection, co-ordination system and resolution has to be used. The common projection definition and co-ordination system is based on the map that is used for integrated assessment of alternative strategies to reduce depositions in Europe originates form the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) (http://www.nilu.no/projects/ccc/index.html)

A grid resolution of 250 m. is used. This is sufficient to describe the land cover elements for studies on a European scale.

5 Application of a fuzzy set approach to assessing similarity of categorical maps.

5.1 Comparing maps in general

Comparing maps is most often done by creating a contingency matrix or by Kappa statistics. Each cell of a contingency matrix gives the number of raster cells classified in a particular category in one map and a particular category in the other map. Given k categories, i and j the indexes of the categories in the maps and n the number of raster-cells, a contingency table looks like:

Tab.1: Example of a contingency table

		map J (j=columns)				Total
		1	2	…	k	
map I (i=row)	1	n_{11}	n_{12}	…	n_{1k}	n_{1+}
	2	n_{21}	n_{22}	…	n_{2k}	n_{2+}
	…	…	…	…	…	…
	k	n_{k1}	n_{k2}	…	n_{kk}	n_{k+}
Total		n_{+1}	n_{+2}	…	n_{+k}	n

With

$$n_{i+} = \sum_{j=1}^{k} n_{ij}$$

$$n_{+j} = \sum_{i=1}^{k} n_{ij}$$

and n = total number of cells.

Kappa gives the similarity of the maps and adjusts for the chance that cells are equal by chance a priori to the comparison (p_e).

$$kappa = \frac{sim - p_e}{1 - p_e} \text{ with } sim = \frac{1}{n}\sum_{i=1}^{k} n_{ii}$$

If we neglect the autocorrelation of the maps this chance p_e can be calculated from the histograms of the maps. Kappa equals 1 with perfect agreement and nears zero when the agreement is random. More can be found in Cohen, 1960 and in Monserud and Leemans, 1992.

The land cover maps in this comparison are compiled with different objectives resulting in different classifications. The harmonisation of the classifications will most likely result in category definitions that do not match completely. Another important issue is the needed precision in location. For studies on a European scale, small errors in location will not effect the conclusions.

To incorporate the similarity for related categories and for small location errors a methodology developed by the Research Institute for Knowledge Systems (RIKS) is used. This methodology applies fuzzy set theory to kappa statistics, not only for the vagueness between categories, as used in several earlier studies, but also for fuzziness in location. The method is briefly described in the next paragraphs.

5.2 Applying fuzziness in classification

Normally a category is represented in a raster as number, usually an integer. To introduce the vagueness of categories, each category is described as a vector of k numbers with values ranging between 0 (no relation) and 1 (identical). The fuzziness of all categories can be expressed in the fuzzy Category Vector with k elements describing the membership of all categories each category. Table 2 shows an example of the change from the original approach without fuzziness in the 'Crisp Vector' to a Fuzzy Category Vector.

Tab. 1: Exsample of a Crisp Vector and a Fuzzy Category Vector for four categories

Category	Original representation	Crisp Vector	Fuzzy Category Vector
Broad leaved Forest	1	(1, 0, 0, 0)	(1, 0.2, 0.1 ,0)
Coniferous Forest	2	(0, 1, 0, 0)	(0.2, 1, 0.1, 0)
Other vegetation	3	(0, 0, 1, 0)	(0.1, 0.1, 1, 0.3)
grass land	4	(0, 0, 0, 1)	(0, 0, 0.3, 1)

5.3 Applying fuzziness in location

The fuzziness of each raster-cell is extended for the fuzziness in location by involving all neighbouring cells in the vicinity. To give cells directly neighbouring more weight then the cell at a greater distance a function describing the membership is needed. Results of this function should range between 1 for distance 0 to 0 for cells outside the sphere of influence. For each raster-cell the Fuzzy Category Vector of the cells in the vicinity are combined by calculating the fuzzy union of all the cells multiplied by their respective distance based membership. The highest contribution of all participating cells for each category is used in the vector that is used in the cell comparison with the other map.

If we consider for example two neighbouring cells with the categories 'grass land' and 'coniferous forest' from table 1. Let us assume a function for describing the membership to 1 for distance 0, 0.5 for distance 1, and 0 otherwise. The impact of the 'grass land' cell on the cell with forest is none for the memberships for both forest categories, but 0.5*1 for grass land and 0.5*0.3 for other vegetation. The resulting Fuzzy Vector is (0.2, 1, 0.15, 0.5).

5.4 Calculating fuzzy similarity and Kappa-fuzzy.

When comparing the fuzzy vectors of two corresponding cells from the two maps, the similarity of neighbouring cells would increase the similarity of the cells at hand. This can be avoided by the following procedure. The fuzzy vector of one cell is multiplied by the crisp vector of the other cell and the similarity is set to the highest contribution of each category. This is also done the other way around, and then the minimum of the two is used.

By applying fuzzy set theory the similarity increases in most cases, but also the chance that cells are more or less equal has increased. A way to describe the additional change is described in A. Hagen (2002). This article describes the complete method in more detail. Another, but elaborate way of calculating the a priori chance of similarity is by Monte Carlo analysis. If the randomly generated maps would simulate the spatial auto-correlation this way could also adjust for this phenomena.

6 Results

The categories of the CORINE, PELCOM and SEI map were translated to 32 EUNIS categories from the first and second level. Table 3 shows the differences and similarities between the definitions of the PELCOM and the CORINE classification. The SEI classification is too extended to be included in this table for this paper.

The objective of a comparison depends strongly on the purpose of the project, and this purpose determines the categories to compare. The classification is too detailed for a general comparison. Therefore the categories are clustered ones more according to table 3, reducing the number of categories to the most relevant ones. The colour shading of tables 2 and 3 match with each other.

Tab. 3: List of aggregated categories as used to compare the maps, with constituent EUNIS categories.

description	EUNIS codes
Water	A, B, C, C1, C2
Grasslands, fens, bogs, heath land, scrubs ...	C3, D, D1, D2, DX
Coniferous, mixed and other woodland	G, G3, G4, G5
Broadleaved woodland	G1, G2
Unvegetated inland habitats	H
cultivated agricultural	I, II
Non-Irrigated arable land	IN
Urban	J

All the maps have been transferred to the geo-reference system of EMEP, and re-sampled to a 250m grid. The results for the comparison between CORINE and PELCOM and between CORINE and SEI will consist of

1) a contingency matrix
2) a map of Kappa-fuzzy for each EMEP 50*50 grid
3) a table with Kappa for each category separate.

Tab. 4: List of categories used in this study (based on EUNIS) and the reclassification of CORINE and PELCOM.

EUNIS code and description		Corine categories (fraction[2])	Pelcom (fraction)
A	Marine habitats	421, 422 ,423, 521, 522, 523, 523	92
B	Coastal habitats	331	
C	Inland surface waters habitats	511, 512	91
C1	Standing water		
C2	Running water		
C3	Littoral zone of inland surface waterbodies		
D	Mire, bog and fen habitats	411, 412	80
D1	Raised & blanket bog		
D2	Valley mires, poor fens, transition mires		
DX	Other mire, bog and fen habitats		
E	Grassland and tall forb habitats	321, 323(1/2)	20
E1	Dry grasslands		
E2	Mesic grasslands	141(1/3), 142(1/3), 231	
E3	Seasonally wet & wet grasslands		
E4	Alpine & sub-alpine grasslands		
EX	Other grassland and tall forb habitats		
F	Heathland, scrub and tundra habitats	322, 323(1/2), 324	50
F2	Arctic, alpine & sub alpine scrub		
F3	Temperate & mediterranean montane scrub		
F4	Temperate scrub heathland		
FX	Other heathland, scrub and tundra habitats	221	40(1/2)
G	Woodland and forest habitats and other wooded land		
G1	Broadleaved deciduous woodland	222, 311	12, 40(1/2)
G2	Broadleaved evergreen woodland	223	
G3	Coniferous woodland	312	11
G4	Mixed decidious and coniferous woodland	313	13
G5	Lines of trees, small anthrop. Woodlands, …		
H	Inland unvegetated or sparsely vegetated habitats	111(1/4), 112(1/2), 131(1/2), 132(1/2), 133(1/2), 332, 333, 334, 335	60, 70
I	... cultivated agricultural, hortic. ... Habitats	141(1/3), 142(1/3), 241, 242, 243, 244	
II	Irrigated arable land	212, 213	32
IN	Non-Irrigated arable land	211	31
J	Constructed, Industrial and other artificial habitats	111(3/4), 112(3/4), 121, 122, 123, 124, 131(1/2), 132(1/2), 133(1/2), 141(1/3), 142(1/3)	100

[2] Some categories are distributed over more then one category. The fraction of the original (Corine or PELCOM) category to the EUNIS category is given in brackets.

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Practical application of the CORINE Land Cover database in Poland

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Abstract

CORINE Land Cover database created in 1990 has been used for different environmental application in Poland. Information stored in that database was applied in assessing of the damage of geographical environment in the area known as the “Black Triangle”. It was also used in assessment of damage caused by the flooding in the Odra river catchment in July 1997. Also models for determining less favoured farming areas (LFA) and for assessment of crop development have been partly based on data stored in the CORINE Land Cover database. However the CORINE Land Cover database did not meet the expectations of a number of users and in some cases it had to be modified by increasing the geometrical resolution and by introduction some linear elements.

1 Introduction

Satellite images have been used to elaborate land use map of Poland when first Landsat images reached the Polish Remote Sensing Centre. The first land use map based on visual interpretation of Landsat MSS images was published in 1984 at the scale 1:500 000. Legend of the map comprised 10 land use classes. The second map based again on visual interpretation of Landsat TM images at the scale 1:250 000 was elaborated at the beginning of ’90. Legend of that map comprised 23 land use categories. Results of satellite images interpretation were converted into digital format. Only data representing forests was used to publish a map of forest distribution in Poland at the scale 1:500 000. Both maps did not meet the requirement of many institutions to have up-to-day information on land use in the whole country with sufficient accuracy. In 1992 the Polish Remote Sensing Centre proceeded to elaboration of land cover data base in the framework of UE CORINE Land Cover project. Within one year the database was completed and has been applied to a number of projects.

2 Monitoring and protection of environment

One of the first application of the CORINE Land Cover database was a project of assessing the influence of industrial plants on the environment in southwestern Poland, in the area where the borders of Poland, the old East Germany and Czechoslovakia met. This was one of Europe's major regions for the extraction of brown coal, and there were a large number of power plants using this fuel on both the Polish and German sides of the border. The emissions of particulates and gases from these power plants combined with emissions of pollutants from other European countries reaching as far as Poland to produce such catastrophic destruction of the geographical environment that the area became known as the "Black Triangle".

Range and complexity of activities aimed at improvement of the environment state in "Black Triangle" region implied close co-operation of Poland, Germany and the Czech Republic. Rational management of the region as well as systematic protection and reconstruction of natural environment are possible only, when full access to information is ensured. To facilitate the proper management of the region geographic information system (Black Triangle GIS) has been designed and implemented.

This system provided processed information necessary for decision making in the region and prediction consequences of particular decision and observed processes. The air pollution model, hydrological model and non point source water pollution model were incorporated into the Black Triangle System for supporting the environmental policies and strategies. For all above-mentioned models land cover data was essential. This data have an impact on infiltration, evapotranspiration and of size runoff. CORINE Land Cover data of the level 3 and level 4 have been used in all models.

One of the most spectacular applications of CORINE Land Cover Database took place in 1997 during the flooding in the Odra river catchment in July 1997. To control the situation during a flood event and to evaluate damage to urban, rural and hydrotechnical infrastructures, as well as to plan and introduce preventive measures, the local and regional decision makers required timely information about the water level and extension of flood. Low and medium clouds restricted flying altitude of reconnaissance aircraft. Due to unfavourable weather conditions satellite working in optical part of electromagnetic spectrum were unable to image the whole area covered by water. Only the satellites carrying synthetic aperture radar (SAR) instrument could collect data independently on weather and light condition. Images taken by European Space Agency (ESA) satellite ERS-2 have been used in the study. They covered the whole Odra River Basin from the border between Poland and the Czech Republic up till the mouth of the river to Baltic Sea.

Visual interpretation has been used to distinguish the water recorded in microwave satellite images. The satellite images were enhanced and filtered to facilitate the interpretation. The interpretation of satellite images resulted in delimitation of maximum extent of water in the whole Odra River Basin. This information has been loaded into database of the Odra Catchment Geographical Information System for further processing and analysis.

The spatial database of the system comprises several thematic layers and the accuracy of stored data oscillates from the scale 1:50 000 to 1:200 000. To assess the flood damage in the Odra River Basin only six layers has been used: CORINE Land Cover, geology and geomorphology, digital terrain model, transportation network, administration division and flood 1997 extent.

Analytical GIS tools enabled determination of the area affected with flood in particular administration division, as well as computing the area of each land use category covered with water. The results of analysis were presented in the form of colour maps at the scale 1:300 000, diagrams and tables and provided within two weeks to the regional authorities responsible for flood hazard.

Tab. 1: Area covered with water in the Odra River Basin

CORINE Land cover nomenclature	Flooded area (km^2)
Urban fabric	52,0
Industrial, commercial and transport units	5,1
Mine, dump and construction sites	1,9
Artificial, non-agricultural vegetated areas	15,6
Agricultural areas	379,7
Permanent crops	2,2
Pastures	365,8
Heterogeneous agricultural areas	79,1
Broad leaved forest	167,1
Coniferous forest	42,0
Mixed forest	24,9
Inland wetlands	7,0
Total	**1142,4**

Six voivodships located in the Odra River Basin had been affected by flood. Water submerged the most extensive areas in Opole and Wroclaw voivodships. There was also the biggest damage to urban fabrics. More than 23 sq. km of densely built-up areas and almost 3 sq. km of heavily industrialised area was flooded. The specification of land use classes covered by water has been presented in table 1. Investigating of the extent of flood on the background of geomorphologic map one can come to conclusion, that the water did not overflow floodplains. The investment in the area of floodplain was the main reason of such vast damage caused by flood

The disastrous summer 1997 inundation in the Odra River Valley has stimulated the interest of the European Commission in the flood protection problems of this transnational catchment. The Space Application Institute of the Joint Research Centre in Ispra (Italy) jointly with some other institutions had undertaken the Flood Risk Assessment Pilot Project, which aims at developing and implementing a rainfall-runoff model for flood prediction and prevention measures in the Odra River Valley. Flood susceptibility of an area depends not only on precipitation level and stream characteristics, but also on land cover and land use practices in the basin. Forests, especially those in the upper sections of rivers, help to retain the water from torrential rains and the melting of mountain snows. Organisation of agricultural activities along the river also significantly influences the water budget. This is why land use/land cover information is one of the required inputs for a hydrological model. Institute of Geodesy and Cartography in Warsaw together with the Institute of Geography, Wrocław University undertook a task to elaborate databases presenting land use and land cover in Odra Catchment in historical and recent times using old maps and documents as well as recently acquired satellite images on the base of which the land use/cover information has been derived. This was a Polish contribution to development of that model. The study has been performed for the catchment of the Odra River, excluding the catchment of its largest tributary – Warta.

The study of the land use changes in the Odra River catchment has been based on analysis of historical 19^{th} maps and satellite images acquired by Landsat. Five major land cover categories corresponding to CORINE Land Cover nomenclature – Level 1, (built-up areas, agriculture areas, forests, wetlands, water bodies) have been recognised on the basis of historical maps. Later on the CORINE Land Cover category: *agricultural areas* has been split into two parts: arable lands and pastures. The results of interpretation of Landsat TM images from the 1990-ies (CORINE Land Cover) and Landsat MSS images of the 1970-ies have been aggregated to embrace the same 6 land use categories. Historical maps used for interpretation were in different scales, different cartographic projections and from different periods (1830 – till 1895). The ground resolution of satellite images used in the investigation of the land use differed significantly (MSS pixel represents 6400 m^2, while TM pixel represents only 900 m^2). All these factors influenced geometrical and graphical accuracy of results. Notwithstanding, the difference between the total areas of the Odra Basin computed from interpretation of 19th century maps and that computed from satellite images does not exceed 0.08%.

In spite of the fact that the source data was not fully comparable and did not allow for profound analysis of land use changes during the surveyed period, the most important facts, as well as trends, could, however be identified. Arable lands and forests have been the predominant land use categories in the Odra River Basin throughout the ages. The most important changes in the Odra River catchment between the middle 19th century and the1990s are best characterised by the following numbers:

- decrease of the area of arable lands by 4 752 km^2
- decrease of the area of meadows by 1 090 km^2,
- increase of the area of forests by 3 107 km ^{2},
- increase of the area of settlements by 3 033 km^2.

One is thus entitled to say, that the changes in land use between middle 19th century and the end of 20th century occurred on the area of about 6 000 km^2, e.g. on less than 10% of the total area of the Odra River Basin.

During this period, the area of forests has increased by 17.6%, in spite of the recent ecological disasters, such as the situation in the Black Triangle. The quality of forests has changed considerably: the introduction of spruce monoculture resulted in lowering the susceptibility of forests to air pollution, in man introduced stands, due to reduced undergrowth, the water retention capabilities decrease and the run-off from the mountain forests dramatically increases.

Analysis of land use based on information obtained from historical maps and satellite images suggests that both the means of using the land and the distribution of the main types of use (forests, arable lands, meadows, built-up areas, waters and marshes) in the Odra River catchment had not undergone major change. This confirms the supposition that land use in the area – as looked at on the regional scale and shaped hundreds of years ago (in the 13th - 15th centuries) – is an exceptionally stable configuration.

3 Spatial planning

CORINE Land Cover database has again been used in elaboration of land use maps for spatial planning at regional level. The CORINE Land Cover database did not meet the regional authority requirements and has to be improved both geometrically and thematically. The same satellite images have been used to reinterpret land use classes. Several additional classes were distinguished. The class 1.1.1. (continuous urban fabric) was divided into two subclasses; class 1.1.2 (discontinuous urban fabric) was also divided into two subclasses; class 1.2.1. (industrial and commercial units) was divided into three subclasses.

The definition of the most questionable land uses class 2.4.2. – complex cultivation pattern – has been limited to dispersed rural settlements. Linear features such as: rivers, roads, railways and administrative division borders have supplemented the maps. Fig. 1. illustrates one of the land use map at the original scale 1:200 000 based on CORINE Land Cover.

To meet the requirements of the regional and local planners the Institute of Geodesy and Cartography has elaborated the fourth and fifth level of land use classes corresponding to CORINE Land Cover nomenclature and hierarchy. The aerial photographs at the scale 1:26 000 have been used as source of land use information. The new project of the Institute resulted in elaboration of several maps at the scale1:50 000 A geometrical resolution of the maps is 1 ha. Linear features are also presented on the map.

4 Agriculture

The application of satellite derived indices for drought detection and monitoring of vegetation conditions have been applied in Poland by the Polish Remote Sensing Centre in co-operation with NOAA/NESDIS Satellite Research Laboratory in Washington. The NOAA/AVHRR-base reflectance in the visible and near infrared wave bands and the Normalized Difference Vegetation Index as well as brightness temperature, registered in thermal bands of AVHRR, have been used in crop monitoring techniques. Since the pixels for which both indices were calculated represent areas larger than agricultural plots in Poland the problem of analysis of usefulness of low-resolution satellite data in characterisation of agricultural areas was investigated. Landsat TM derived map of land cover in Poland was used to determine the arable lands. The detail analysis revealed that the vegetation indices computed for the agricultural areas determined on the basis of CORINE Land Cover database represent sufficiently areas used for crop production in Poland. The Polish Ministry of Agriculture and Rural Development as well as Central Statistical Office have accepted satellite remote sensing as a one of the sources of valuable information on crop stage, their development and potential yield. Since 1998 every decade in the course of vegetation period the satellite derived information on crop stage and potential risk in their development are provided for both ministries. The Polish agriculture has to adapt to new realities and further changes in terms of market evaluation, market policy and trade rules. Such adaptation, including changes in Polish agricultural policy according to the requirements of the European Union, needs structural adjustment of rural areas. The EU gives financial support for the economic and social conversion of rural areas facing structural difficulties. One of the supporting forms is focused on less-favoured farming areas (LFA), with the permanent natural handicaps resulting in higher production costs. Farmers in less-favoured areas may be supported by compensatory allowances.

The Ministry of Agriculture and Rural Development asked the Institute of Geodesy and Cartography to participate in the delimitation of LFA according to the EU regulations and preliminary Polish conditions. It was obvious that the most modern recording methods such as geographical information systems, digital mapping, remote sensing techniques and automated data processing should be used. The Institute has designed and established LFA oriented GIS system. One of the thematic layers of the system is CORINE Land Cover. This gives us information where agriculture areas are located and together with DTM and quality of soils allows delimiting less-favoured farming areas.

Austrian experiences with the supply and demand of CORINE Land Cover data

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Abstract

As no comparable land cover data exists for Austria, the dissemination of CORINE land cover 1990 data have triggered a variety of national applications. Austria the close relations between the supply and demand of geographical data were obviously coming apparent, when in 2003 the Federal Environment Agency took the decision to enable a free access to the data. For non-commercial purposes the CORINE Land Cover GIS-data on level 2 were made available via web-based techniques free of distribution and data costs. The interest of the user community reached approximately 100 downloads within the first 2 month. Users were just committed to report on the application field they intend to use the CORINE data. The experiences from this user contacts enabled the Federal Environment Agency to define the requirements for the further development of the CORINE Land Cover programme. Although the CORINE Land Cover program has been designed to fit in the requirements resulting from European wide questions, the availability of the data have triggered a variety of national applications as well.

1 CORINE Land Cover in Austria

1.1 Project Characteristics

The CORINE Land Cover dataset for Austria contains 27 the 44 classes of the official nomenclature. The satellite scenes for CORINE 1990 have an acquisition date between 1985 and 1986 (Aubrecht, 1998). Thus the changes detected in CLC 2000 describe the landscape development of the last 15 years. In total Austria consists of approximately 15.000 polygons thus giving an average size of the CORINE polygons of 560 ha. The largest CORINE-polygon (211 arable land in lower Austria) however amounts to 3.822 km2 and represents almost five percent of the Austrian territory. The updating process (CLC2000) is ongoing and by January 2004 more than 75% of the Austrian territory could be finalised.

The operational phase of the CORINE interpretation includes the revision of the CORINE 1990 data and the interpretation of changes 1990-2000 (Bossard et al., 2000) and started in September 2002. As real changes in land use and land cover are quite rare in Austria, the interpretation works concentrates on the revision of the CORINE 1990 data. Significant improvements had to be made with regard to the thematic quality (class 1 “Artificial surfaces” and especially for class 112 “Discontinuous urban fabric”), as most of the small settlements in Austria have been underrepresented in the CORINE 1990 database.

The geometric quality of the CORINE 1990 data has been improved substantially during the updating process. No systematic shift was detectable throughout the CORINE 1990 database, however local distortions made up often more than 200m. The large local distortions result from the applied methodology of the CORINE 1990 project. The lines drawn on transparencies were scanned often month later than the interpretation itself. Thus a shrinking of the transparencies in addition to overlaying inaccuracies may have led to such large distortions. To correct these unsystematic distortions a “rubber sheeting” method was applied using 4.245 point pairs between CORINE 1990 and IMAGE 2000 data and a linear interpolation between the point pairs. Approximately 20 points per single map sheet (ÖK50) were selected.

1.2 Land cover changes 1985 - 2000

At the scale of CORINE Land Cover the landscape changes in Austria are quite small. The minimum area size of 5 hectares for mapping changes in Austria is seldom reached. Most landscape dynamics take place between this threshold. Due to the small structured landscape the current developments of land cover/land use changes like extensification of lower productive agricultural soils as well as intensification on higher productive soils take place in Austria as well, but on a finer scale than CORINE land cover is able to detect it. Therefore the interpretation of changes and the comparison with other countries have to be made very carefully taking into consideration the strict implementation of the harmonised methodology.

However the major land cover changes detected so far reflect quite well the current agenda of political and environmental decision making. On the one side major changes occur in the alpine areas due to the melding of the glaciers. Taking on of Austrias largest glaciers – the Pasterze at the Grosslgockner – the CORINE data set show a decrease of 70 ha or more than 25% for the glacier tongue of the total glacier. Comparable data in Austria as part of the continuous glacier monitoring show mostly only the decrease in the length of the glacier. Within the last 15 years the glacier shrank by 360m (10% of total length). At least the CORINE land cover dataset documents this trend in climate change, whereas discussions on the causes are an ongoing scientific debate.

The second major land cover change in Austria results in difference to the first one not from global activities and developments, but from very local ones. The trends in tourism to provide adequate landscapes and infrastructure has led to the establishment of more than 150 golf courses in Austria, the majority of these within the last 15 years. In average one golf course is appearing every 24*24 km^2.

As the distribution of CORINE land cover data on level 2 was only the first step in this process the Umweltbundesamt offers since January 2004 a complete new data set for free download via the web: the Austrian Landsat TM Mosaic – referred to as IMAGE 2000 Austria – with a resolution of 100*100m^2. As third data set an example of CORINE level 3 data is currently available.

The next steps until end of 2004 will include the full coverage of Austria by CORINE level 3 data as well as higher resolution satellite image mosaics. As soon as the European products are available and all the dissemination rights are clarified they will be made available, either using a direct download or by providing the link to the central service utility currently under common development of EEA and the Joint Research Centre (JRC).

The link to download the CORINE Land Cover data and IMAGE 2000 data is
http://gis.umweltbundesamt.at/download/

3 Web-based data distribution

3.1 Analyses of the current situation & requirement definition

A traditional data provision via CD-ROM had a couple of negative side effects for our agency. The data manipulation costs within the agency were quite high, because each request triggered a processing chain starting with the recording of the user needs, to the extraction and compilation of the data, burning the datasets on CD-ROM, ensuring that the customer accepts the licence, sending a bill and finally checking the receive of the payment.

Such a traditional data dissemination process binds a lot of resources which could be better used for productive work. Therefore the Agency turned to an automatic intuitive cost effective way to disseminate environmental datasets to the customers. The requirements were:

- Ensure that the user accepts the licence
- collect information about our customers (contact info, information on data usage, etc.)
- grant the right for data download.

In a further future step we will move towards an e-micro payment system, which will allow us to charge for data downloads in order to refinance the infrastructure necessary for the maintenance of the service.

3.2 How does it work?

Our customers are guided through the whole registration process via intuitive user-friendly assistants (Figure 4). In the case that not all required information is provided, the assistant shows a self explaining error message (Figure 5) beside or below the respective input field.

Once the user has finished the required input on the registration forms, an email containing a hyperlink is mailed to our customer. With this link the selected datasets can be downloaded within twelve hours. This ensures that even if a user passes the link to a third party, the link would be invalid after twelve hours.

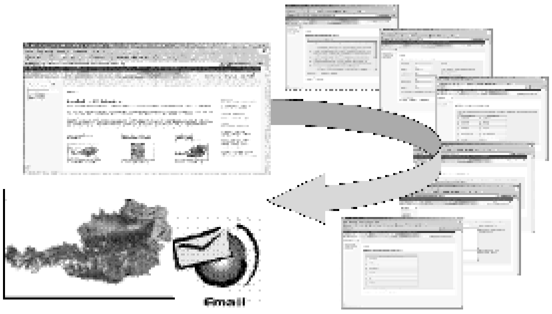

Fig. 4: Registration process

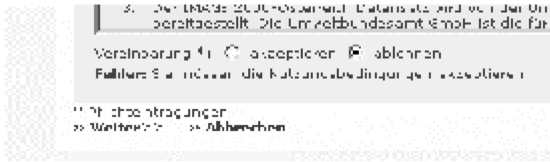

Fig. 5: Error message

4 User profiles and applications

Within the first year of the establishment of the web-based service 175 users have downloaded the CORINE Land Cover data on level 2. From the information provided during the dissemination process a clear picture of the user profile and the variety of applications can be drawn.

4.1 Who are the users of CORINE Land Cover

The data dissemination of the data for non-commercial purposes aims to reach a wide distribution mainly in the R&D-sector. As can be seen from figure 6, the dissemination policy reached the right people, because almost 50 % of the users origin form universities or schools. As this interest has been expected beforehand, a bit surprising is the next largest groups. Private internet users account for almost one fifth of the total downloads. They are the most active ones concerning contacts with the data provider. Both general interest in the technique itself and the potential to use it in daily life have led private internet users to download the data.

Each of the following three user groups accounts for approximately 10 % of total downloads: Public institutions, potential resellers (service providers) and internal users of the Federal Environment Agency. Especially for public institutions the limitation of the download to CORINE nomenclature level 2 hampers the usage in further applications.

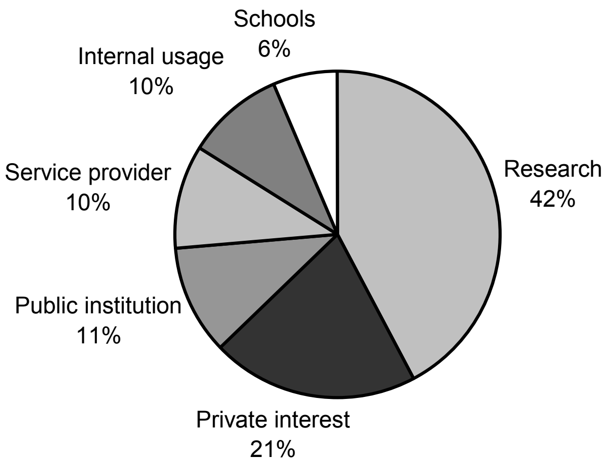

Fig. 6: Distribution of users according to different sectors (N=175)

4.2 What for is CORINE data used?

Once knowing the sector the users origin from, the question in which context the data are used raises up. A similar trend can be observed compared to the background of the user groups. The usage of the data for education, teaching, demonstration and research makes up more than 50 % of the total data usage. Concerning the specific thematic areas nature protection has to be mentioned before all the others. As the experiences from the previous users (before the web-based dissemination) have already shown, the CORINE land cover data are mainly used for modelling habitat quality for a variety of species.

Again the private usage of CORINE land cover forms with 9 % a not neglect able part in the thematic applications. The general applications within GIS demonstrate the need for a spatial data infrastructure. Within this group land cover data are not used in a specific project oriented way, but as a basic information layer to feed a variety of projects. Surprising is the high percentage of people mentioning a general interest in the data. Until now CORINE land cover data were expected to be used only by a few user groups with a special interest. This could be shown on the last example, the application in the field of spatial planning. With 4 % this group fits quite well the expected and intended applications. Beyond the remaining group (15 %) applications in water, soil, telecommunication, marketing, geography and climate can be found.

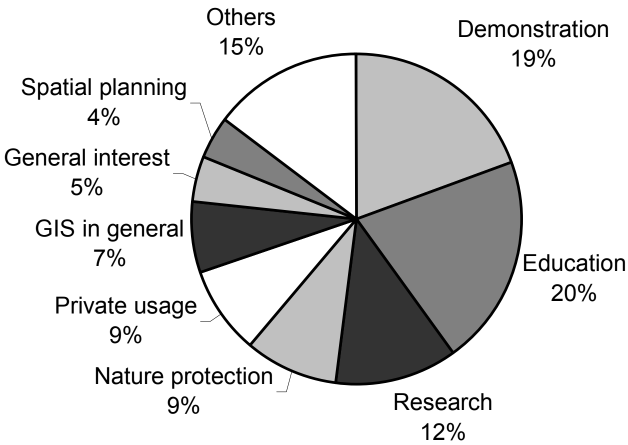

Fig. 7: Distribution of download according to thematic area (N=175)

4.3 Selected applications

On international level CORINE data are currently discussed being used as main information source for the description of protected areas in regard to land cover classes according to the EUNIS-classification. The CDDA (common database on designated areas) held by the EEA should contain information on the proportions of each EUNIS class at least on level 2 of the EUNIS nomenclature. A cross-reference between the CORINE classes and the EUNIS classes exists, however this assignment is a one-to-many relationship. The usage of additional data (e.g. soil data) can improve this assignment substantially (Nagel et al. 2004).

On national level one application is mentioned not because of their scientific value, but their value for the daily use of CORINE land cover data. In the province of Tyrol CORINE data are used for the public bus system. At each bus stop a sign board informs on the location of the bus route within Tyrol. The CORINE data are used as background image to enable an easy and fast orientation (see Figure 3).

But on national level the CLC-products are not only used on a rather coarse scale. The usage of the IMAGE 2000 satellite scenes for the calculation of indicators on landscape level bridge the gap from the coarse scale to finer scales. To evaluate the effect of agri-environmental measures, on of the basic questions is how the measures are affecting the landscape structure expressed by the spatial variation of crop types. At a finer scale than CORINE land cover information were extracted from the satellite images to enable the calculation of landscape indicators like patch density, patch size to more aggregated indicators like the Shannon diversity index.

5 Conclusions and Recommendations

5.1 Is CORINE fulfilling user's needs?

Data providers often claim to be able to satisfy the user's need. But as could be shown from the experiences of Austria the user's need is no constant factor anymore. The users are flexible to adapt their needs within a certain range according to the supply of data. It is not only the existence of a certain data type, but - often more important for the practical use - it is the availability of the data in combination with an international used standard that drives the user needs.

The user needs for land cover data were expressed just recently during a workshop in Vienna (http://ivfl.boku.ac.at/workshop/). The main conclusion was that users tend to investigate the availability of datasets that cover most of their needs before investing in new base data. Therefore it is not surprising that the CORINE land cover data are even used for scales they have never been designed to. A thorough information shall therefore be provided by the data producers to avoid a misuse of the data.

5.2 Future development

As could be shown by the variety of applications the priorities for the further development of CLC-products should be the

- complete European coverage (including Switzerland and all the Balkan countries), the
- guarantee of a constant quality, and the
- refinement of geometrical and thematic issues.

In terms of thematic improvements the distinction of one more sealing class (30-50, 50-80, 80-100 % sealed surface) instead of two classes (30-80, 80-100) is desirable. The agricultural classes "211 arable land" and "231 pastures" can only be interpreted with more reliability if multi-temporal images would be used. In addition out of the Austrian experiences it would be helpful to further differentiate the complex class "242 complex cultivation patterns" into one arable dominated class and one pasture dominated class. The same is partly true for class "243 agricultural land with areas of natural vegetation". Due to the small structured landscape in Austria and the relative large minimum mapping unit (25 hectares) these classes raise problems in the environmental applications, because they represent large areas and the differentiation between arable and pasture land is highly important for the impact analysis.

The temporal repetition should be kept by 10 years. Priority should be given to a faster production process. For the analysis of the effect of soil sealing and land consumption as one of the most urgent pressures of land cover change a minimum mapping unit between 3-5 hectares would be needed.

The current ongoing initiatives and projects funded by the European Space Agency (ESA) and the European Commission in the frame of GMES (global monitoring for environment and security) provide an excellent base for the further development of a refined land cover service. However to guarantee the constant monitoring the concept of CORINE land cover aiming at a scale of 1:100.000 should be continued.

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Harmonised land cover data for the estimation of nutrient inputs in European river systems – The example of Danube River

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Abstract

One important database for the modelling of the nutrient inputs into a river system and to the sea is the knowledge of the land use. For this task the CORINE land cover map can be used. This map is available for most of the European countries but not for all. Regarding the European Seas (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea and Norwegian Sea) the CLC map covers only 61% of the catchment area. For the European river systems larger than 50000 km² this portion is only 55 %. Especially for the large transboundary river systems in southern and north eastern Europe (Danube, Daugava, Narva, Nemunas, Newa, Vistula) the CORINE land cover map covers only a part of the whole catchment (20 % to 89%). Therefore a main question is, can be other land use database used for the estimation of land cover or have to be the CLC enlarged database for these regions and river systems.

Furthermore, the CORINE land cover map gives the possibility of the transformation of the data on land use intensities – like nutrient surplus on agricultural area – from administrative units (countries, districts, municipalities) to the river basins and their subcatchments. Consequently a further second question is, are the CLC land cover data comparable with the land use data given in the statistics for the administrative units.

Both questions were investigated within the last three years for the catchments of the Danube the second largest European river system. It could be shown that the application of a more raw but complete dataset for the land cover like the USGS land cover map with a resolution of 1km grid for the areas in the Danube basin where CLC is not available can lead to large deviations caused by the lower resolution and not harmonised land cover classes.

Furthermore, the comparison between the land use of the administrative units and the CLC land cover map shows significant deviation already at the country level. The estimation of the agricultural area due to CLC can deviate to the official statistics between +38% (Slovenia) larger and – 17% (Romania) which could be caused by the different time periods and especially by the differences between land cover and land use.

The study illustrates that an enlargement of the CLC land cover map to the areas outside of the EU-countries is necessary for a quantitative good estimation of the sources of nutrient inputs into the large European river systems and seas. But also the quality of the CLC map has to be improved so that this data is better to compare with the land use data from administrative levels.

1 Introduction

Within different national and European projects the use of harmonised digital land cover databases was one important pre-requisite for the modelling of nutrient emissions into river systems and to the seas. For land use classification the CORINE land cover map which is consistent across the continent can be used due to its harmonised classification scheme and interpretation method. This map covers nearly all European countries, but because of missing data for some European countries, information on land use cannot be worked up from the CORINE land cover map for the whole of river systems and seas. Regarding the European Seas (Table 1) the CLC map covers only 61% of the catchment area. As shown in Table 2 for selected European river systems larger than 50000 km² the portion covered by CORINE land cover map varies in large ranges between 0 % (Don and Dnepr) and 100%.

In the following an approach will be presented how the CLC1990 data can be used for the modelling of nutrient emissions in the river system of the Danube for the period 1998-2000 and how land use informations can be derived for the areas where CLC data are missing.

Tab. 1: Area statistics of actual availability of CORINE land cover map for European seas.

Sea	Area	Area of CLC3	Area of CLC3	Area of CLC2*	Area of CLC2*
	[km²]	[km²]	[%]	[km²]	[%]
Atlantic	1087798	977458	89.9	977458	89.9
Baltic Sea	1740362	859386	49.4	859386	49.4
Barent Sea	557962	26372	4.7	26372	4.7
Black Sea	2391670	658700	27.5	660542	27.6
Caspian Sea	2870200	0	0.0	0	0.0
Mediterranean Sea	1140483	847461	74.3	858839	75.3
North Sea	723068	550929	76.2	582860	80.6
Norwegian Sea	152848	432	0.3	2453	1.6
White Sea	720646	5301	0.7	5301	0.7
European Seas**	**7236229**	**3894366**	**53.8**	**3939517**	**54.4**

* including Switzerland (only CLC2)
** European Seas without Barent Sea, Caspian Sea and White Sea
CLC3, CLC2 CORINE Land Cover at hierarchical level 3, respectively 2.

Tab. 2: Area statistics of actual availability of CORINE land cover map regarding major river systems in Europe.

River system	Catchment area	Area CLC*	Area CLC*	Area CLC2**	Area CLC2**
	[km²]	[km²]	[%]	[km²]	[%]
Danube	801499	636978	79.5	638820	79.7
Dnepr	513620		0.0	0	0.0
Don	430854		0.0	0	0.0
Newa	284191	56894	20.0	56894	20.0
Vistula	190189	169826	89.3	169826	89.3
Rhine	182198	154360	84.7	182198	100.0
Elbe	146876	146876	100.0	146876	100.0
Odra	118474	118473	100.0	118473	100.0
Loire	114981	114982	100.0	114982	100.0
Rhone	97571	90041	92.3	97571	100.0
Douro	96988	96955	100.0	96955	100.0
Nemunas	95057	51049	53.7	51049	53.7
Daugava	87831	25728	29.3	25728	29.3
Ebro	85273	85247	100.0	85247	100.0
Garonne	79701	79698	100.0	79698	100.0
Tejo	78721	78706	100.0	78706	100.0
Kizil Irmak	77504		0.0	0	0.0
Po	74000	69963	94.5	74000	100.0
Seine	73192	73191	100.0	73191	100.0
Dnestr	72801	254	0.3	254	0.3
Guadiana	66995	66984	100.0	66984	100.0
Yuzhnyy Bug	63705		0.0	0	0.0
Sefid	60399		0.0	0	0.0
Sakarya	57024		0.0	0	0.0
Narva	56454	21217	37.6	21217	37.6
Guadalquivir	55973	55952	100.0	55952	100.0
Kuban	54900		0.0	0	0.0
Evroz	52892	39150	74.0	39150	74.0
Kemijoki	51017	49447	96.9	49447	96.9
Göta alv	50281		0.0	42466	84.5
All >25000 km²	**4643701**	**2437166**	**52.5**	**2478413**	**53.4**
All >50000 km²	**4271162**	**2281971**	**53.4**	**2323218**	**54.4**
All >75000 km²	**3481527**	**1905813**	**54.7**	**1943023**	**55.8**
All >100000 km²	**2782882**	**1398389**	**50.2**	**1428069**	**51.3**

*hierarchical level three, **hierarchical level two

2 CORINE Land Cover and harmonisation procedures for other land use information

2.1 Modelling approach and databases

The modelling approach of GIS oriented models like MONERIS (Behrendt et al. 2000; Behrendt et al. 2003) needs as spatial input data especially for the calculation of nutrient emissions from diffuse sources information on land use distribution. For the application of the model within the Danube river basin the CORINE land cover databases with a spatial resolution of 100 x 100 m (CLC1990, version2/2000) and 250 x 250 m (for the part of Switzerland) were used. The land use categories of the three hierarchical levels were aggregated to the classes: urban area, agricultural area, forest, wetland, open area, open mining areas and water bodies (Table 3). Croatia, Serbia and Montenegro, the Ukraine and Moldova are not included in these data bases, that means at least for the Danube river basin that about 20% of the catchment area (165.500 km²) is not covered by the CORINE land cover map. Therefore it was necessary to consider other land use information covering the whole catchment area. Additional information on land cover was taken from the USGS (*United States Geological Survey,* GLCC - Version 2, 1997) and used to identify land use classes in these countries according to CORINE land cover. The spatial resolution of the USGS land cover (USGS LC) map is 1000m x 1000 m (based on 1-km AVHRR data spanning April 1992 through March 1993).

Tab. 3: Aggregated land use classes of CLC for the calculations with the model MONERIS.

Land use classes used in calculations	CORINE[1] Land Cover (CLC) classes (aggregated)*	CORINE[1] Land Cover (CLC) classes (aggregated)**	USGS[2] Land Cover (USGS-LC) classes (aggregated)	mixed USGS[2] Land Cover (USGS-LC) classes (distributed)
Urban area	111, 112, 121, 122, 123, 124, 141, 142	11, 12, 14	100	
Agricultural area	211, 212, 213, 221, 222, 223, 241, 242, 243, 244	21, 22, 23, 24	211, 212, 213, 280, 311	290, 330
Forest	311, 312, 313	31	411, 412, 421, 422, 430	290
Open area	321, 322, 323, 324, 331, 332, 333, 334, 335	32, 33	321, 770, 900	330
Wetlands	411, 412, 421, 422, 423	41, 42	620, 610	
Water surface	511, 512, 521, 522, 523	51, 52	500	
Exploitation area	131, 132, 133	13	-	

[1]Source: *http://reports.eea.eu.int/COR0-landcover/en/tab_content_RLR*
[2]Source: *http://edcdaac.usgs.gov/glcc/eadoc1_2.html*
* hierarchical level three, ** hierarchical level two

2.2 Harmonisation procedure of land use information

The problem was to assign the land use categories of the USGS map to land use categories of CLC for the catchment parts of the Danube River Basin where CLC was not available. Despite the fact that the spatial resolution of the USGS land cover map is lower, a transformation procedure of land use information was necessary especially for the mixed classes of the USGS landcover map like cropland/grassland mosaic and cropland/woodland mosaic, into the aggregated classes used for the modelling calculations. As a first step the land use classes of the two databases were compared to find similar land use categories and the differences between the classes. Table 3 shows which landuse categories from USGS-LC were aggregated respectively distributed in correspondence to the CLC classes.

From the description of the land use categories it seems to be possible to assign the single classes like urban area, forest, wetlands and water directly to CLC classes. For all these categories of land cover a comparison of the area at catchment level was done for the part of the Danube River Basin where both databases were available. Figure 1 shows as an example the relationship between urban area for the catchments according to CLC and to USGS. The main reasons for the systematical under-estimation of the urban area according to USGS LC the lower spatial resolution. Based on the function resulted from this analysis, a correction for the urban area after the aggregation at catchment level was done. A com-

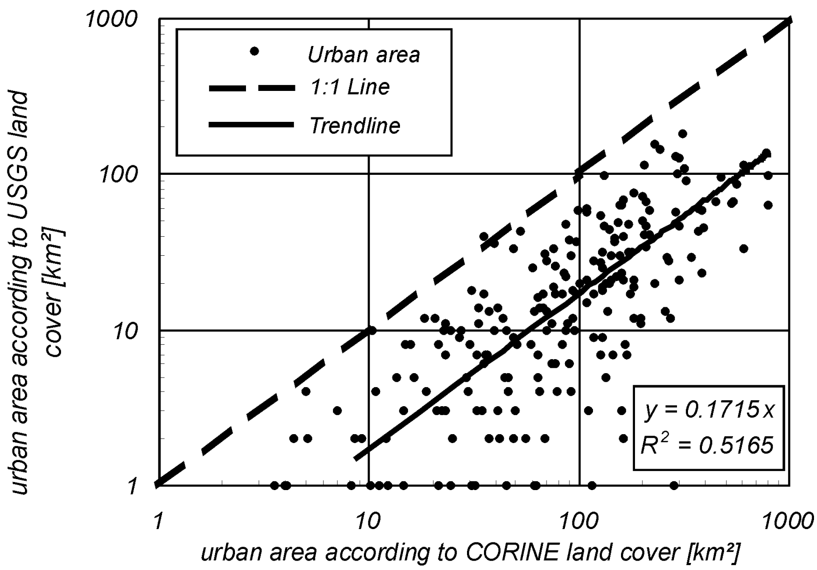

Fig. 1: Comparison of urban area according to CLC and USGS-LC at catchment level within the Danube River Basin.

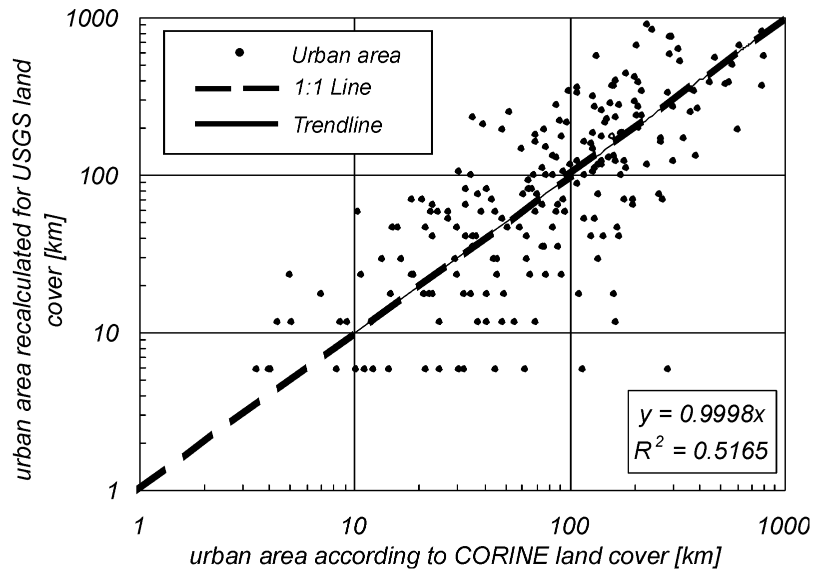

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Fig. 2: Comparison of urban area at catchment level according to CLC and USGS-LC recalculated for the Danube River Basin.

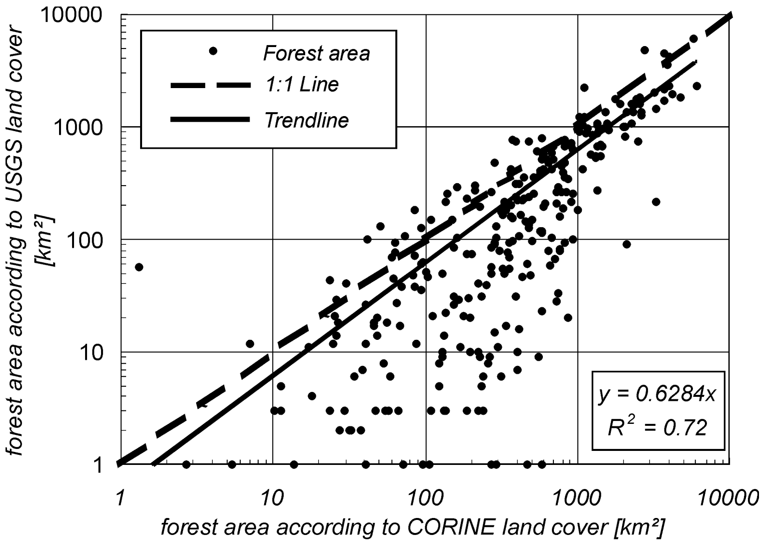

Fig. 3: Comparison of forest area according to CLC and USGS-LC at catchment level within the Danube River Basin.

parison of the recalculated urban area from the USGS-LC with the urban area from CLC is shown in Figure 2. The correction leads to an increase of the urban area and of the regression coefficient, but the estimated urban area remains lower, due to the lower spatial resolution of USGS Land cover map.

For the forest area a similar comparison was done as shown in Figure 3. It can be seen that the forest area is also underestimated for most of the catchments. As the mixed classes in USGS-LC are covering great parts, especially the category cropland/woodland mosaic, another procedure was necessary to distribute the parts of the mixed classes to individual classes of CLC. For this purpose the share of all classes within the investigated catchments were determined for both databases and searched for the variation of land cover changes with the altitude and precipitation. It was found that the portion of arable land in comparison with the other land use classes like pasture, forest, grassland and agricultural area with natural vegetation was related to altitude (see Figure 4). This relationship was used to transform the information of the mixed classes of land cover from the USGS database into individual classes according to CLC land cover based on the percentage from the analysis which shows the portion of arable land in comparison with other land use classes within the different altitudes. For each investigated catchment with only USGS land use information the portion of the mixed classes on the total catchment area were divided into single classes with the share of each calculated according to the percentages.

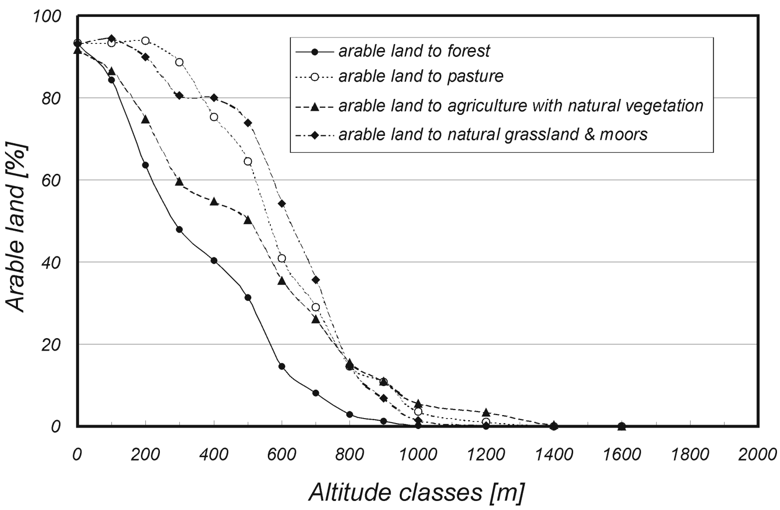

Fig. 4: Variation of land use with altitude based on CLC and DEM.

Therefore the classes aggregated to agricultural and forest area within the catchments comprises additional shares from the mixed classes. Figure 5 shows the comparison between the forest areas after the recalculation. The forest area recalculated for catchments where only the USGS-LC was available comprises the forest area according to this category (see Table 3 and Annex 1) and the respective share from the mixed class

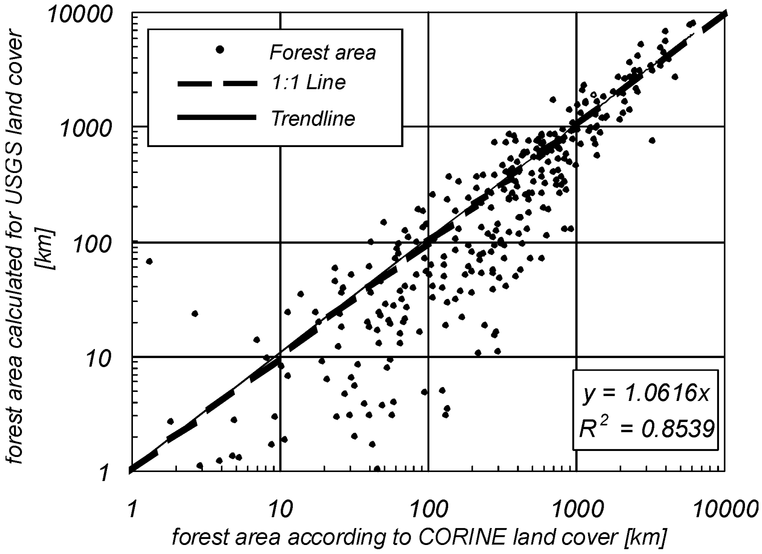

Fig. 5: Comparison of forest area according to CLC and USGS-LC calculated at catchment level within the Danube River Basin.

cropland / wood-land mosaic. As it can be seen this procedure leads to a low overestimation of the forest area and the correlation coefficient is higher. Differences which occurred in the sum of all land use classes due to this procedure were eliminated by according the shares of the difference to each category using the percentage of the respective class at the total catchment area.

During the project work an updated version of CLC1990 was available including the territory of Bosnia-Herzegovina. For the Bosnian catchments of the Danube it was therefore possible to compare the results of the calculations of land cover based on USGS with the area of aggregated land use classes according to CLC. The differences are considerable high without any harmonisation procedure (Table 4). For urban area occurs an underestimation of USGS-LC in comparison to CLC of 96% and for forest of 36%. After the harmonization procedure and recalculation of the areas the percentage of deviation could be improved for urban areas with 20%, but still remains highly underestimated.

Tab. 4: Comparison of area statistics for land use for the Bosnian Danube catchments based on CLC, GS-LC and calculated with the harmonisation procedure.

Landuse **Categories**	**CLC**	**USGS**	**USGS calculated**	**Conversion factors**	**Deviation USGS calculated from CLC**	**Deviation USGS from CLC**
	km²	**km²**	**km²**		**%**	**%**
Urban area	471	20	117	5.83	-95.8	-75.2
Agricultural area	15904	5513*	10859		-65.3	-31.7
Forest	19143	12217	27058		-36.2	41.3
Open area	1989	0	0	17.79		
Wetland	13	0	0	0.44		
Water surface	109	76	61	0.81	-30.0	-43.7
Exploitation area	92					
Mixed classes		20187				
Not classified	567					
other areas		283	283			
Sum all areas	38288	38296	38288			

* without considering cropland/woodland (this is part of the mixed classes)

In contrast to this the result for forest is a considerable overestimation of about 40% which is higher then the underestimation without the harmonization procedure (Table 4). This leads consequently to errors in the nutrient emission calculations and their regional distribution, one must be aware of. The comparison of the agricultural area from the two databases is difficult because of the share from different mixed classes. Even though one can state that after the recalculation the agricultural area is underestimated by about 30%.

3 The use of CORINE land cover map for nutrient balance evaluation

The share of agriculture land estimated from the harmonised database as described above was used for the transfer of the nitrogen surplus calculated for the agricultural areas on the national or district level to the individual river catchments. The nitrogen surplus per hectare agricultural land have to be calculated by the use of agricultural data on fertilizer application, livestock numbers, harvested crops and agricultural land, which are only available for administrative areas.

On the other hand the CLC map is the only data source to transfer these estimates to the river catchments. If the agricultural area based on land use statistics and CLC is not the same for the individual administrative units a correction is necessary. At the country level a comparison between the agricultural area according to CLC and land use statistics was possible for Germany, Austria, Czech Republic, Slovakia, Hungary, Slovenia, Bosnia, Romania and Bulgaria. As shown in Figure 6 the difference between the database of CLC and the official national statistics for the countries varies from –17 % to +38 %. The highest differences occur for Germany (+22 %) and Slovenia (+38%). This is probably due to the fact that the statistical data considers mainly the used agricultural area, which can be smaller than this land cover category identified from satellite images. But the reverse case can not be explained by this fact. From the comparison it can be concluded that a correction procedure have to be considered for all countries. If it is assumed that the total amount of nitrogen surplus for the countries is constant, the correction can be done and the transfer of the results from national statistics to the CLC database can be done by the consideration of the ratio between the agricultural area according CLC and the agricultural area according to national statistics. This correction can be understood as the distribution of the total amount of nitrogen surplus to the total agricultural area identified by CORINE land cover database.

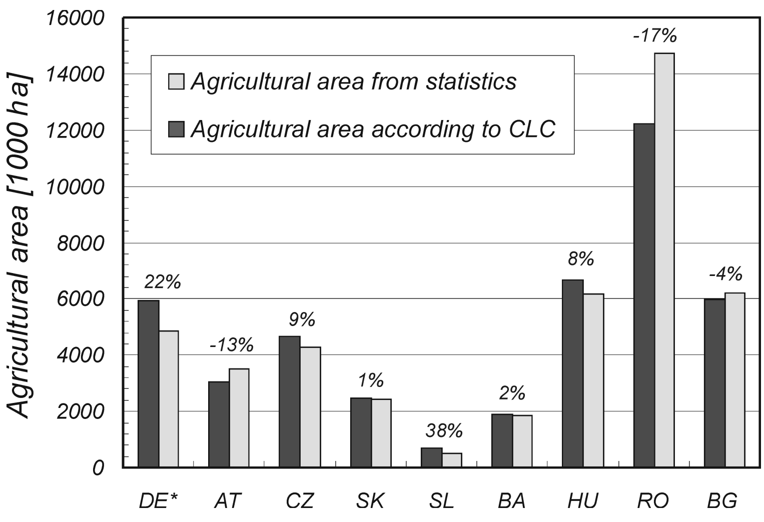

Fig. 6: Statistics of agricultural areas according to CORINE land cover and national statistics.

The consequence of the implementation of the correction factor is that the nitrogen surpluses calculated using the CLC are especially for Germany and Slovenia much lower than calculated according to the data from national statistics. On the other hand the nitrogen surplus increases for Austria, Romania and Bulgaria because the agricultural area estimated from CLC is smaller than the data published in the national statistics for these countries (see Schreiber et al. 2003).

4 Conclusions

The investigations have shown that it seems to be difficult to compare the results between countries, using CLC, for special thematic issues as shown for nitrogen surplus on agricultural land which was derived from national statistics, if the difference in the basic data is not taken into account. On the other hand CLC is actually the only database which allows the transformation of data on land use intensities into the catchment level for a transboundary European river basin like the Danube with a catchment area of about 803,000 km² and 13 contributing countries. Therefore it is urgent from our point of view to harmonise the published statistics for the land use and land cover between the different countries of Europe and to continue the adjustment of the CORINE land cover on the basis of statistical information.

Moreover the Bosnian example shows that the substitution of the CLC data set by other land cover maps like the USGS-LC grid map can lead to considerable high errors even after using harmonization procedures. It is obvious that not only the spatial resolution leads to such deviations, but also the identification and assignment to different land cover categories. It seems to be that the establishment of correction factors or functions based on an analysis for the whole Danube does not properly reflect the regional patterns due to the largeness of the Danube catchment area with its high variations in altitude and climate. Therefore it is perhaps more feasible to look at regional patterns, considering neighbouring catchments in combination with statistical information.

Acknowledgments

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Annex 1: Description and Codes of land use classes for CLC and USGS databases.

CORINE[1] Land Cover (CLC) classes (aggregated)**	CORINE[1] Land Cover (CLC) classes (aggregated)*	CORINE Description[1]	USGS Value	USGS Description[2]	USGS Code
11	111, 112	Urban fabric	1	Urban and Built-Up Land	100
12	121, 122, 123, 124	Industrial, commercial and transport units			
13	131, 132, 133	Mine, dump and construction sites			
14	141, 142	Artificial non-agricultural vegetated areas			
21	211, 212, 213	Arable land	2	Dryland Cropland and Pasture	211
22	221, 222, 223	Permanent crops	3	Irrigated Cropland and Pasture	212
23	231	Pasture	4	Mixed Dryland/ Irrigated Cropland and Pasture	213
24	241, 242, 243, 244	Heterogeneous agricultural area	5	Cropland/Grassland Mosaic	280
			6	Cropland/Woodland Mosaic	290
			7	Grassland	311
			9	Mixed Shrubland/Grassland	330
31	311, 312, 313	Forest	11	Deciduous Broadleaf Forest	411
			12	Deciduous Needleleaf Forest	412
			13	Evergreen Broadleaf Forest	421
			14	Evergreen Needleleaf Forest	422
			15	Mixed Forest	430
			8	Shrubland	321
32	321, 322, 323, 324	Shrub and/or herbaceous vegetation associations	19	Barren or Sparsely Vegetated	770
33	331, 332,333, 334, 335	Open spaces with little or no vegetation	24	Snow or Ice	900
41	411, 412	Inland wetlands	17	Herbaceous Wetland	620
42	421, 422, 423	Coastal wetlands	18	Wooded Wetland	610
51	511, 512	Inland waters	16	Water Bodies	500
52	521, 522, 523	Marine Waters			
			10	Savanna	332

Use of CORINE land cover data for modelling water balance and nitrogen fluxes in the river Ems and the river Rhine

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1 Background

In Germany, considerable progress has been achieved towards the improvement of water quality. However, diffuse water pollution, a source largely attributed to agricultural production, continues to be of concern. As described by Goemann et al. (2003), a wide range of problems concerning nutrient pollution of water bodies are prevalent in river catchment areas. It is to be expected that political measures towards a solution of these problems will have different effects on the reduction of nitrogen in the different water bodies.

The REGFLUD-project, commissioned by Germany's Federal Research Ministry (BMBF), addresses the problem of reducing diffuse pollution from agricultural production. The objective of the project is the development and application of multi-criteria scientific methods, which are able to predict diffuse pollution in river basins. As study areas the river Ems and Rhine basins were selected, as they cover a variety of landscape units with different land cover, hydrological, hydrogeological and socio-economic characteristics.

The applied model system consists of an agricultural sector model (RAUMIS), a water balance model (GROWA) and a residence time/denitrification model (WEKU). By the coupling of these models, the efficiency of measures is evaluated, taking into account both socio-economic conditions as well as natural site conditions. This helps to improve the definition of relevant indicators for the detection or classification of "hot-spot" regions.

This paper focuses on the role of CORINE land cover data for both, the analysis of the water balance in the two river catchment areas and the disaggregation of diffuse nitrogen surpluses from administrative districts on the CORINE land cover categories. As CORINE land cover data is not used for the model analysis of the transport and the retention of nitrogen in soil and groundwater the related model results are not considered in this paper.

2 Use of CLC data for modelling nitrogen leaching from soils

Tempus Agricultural nitrogen surpluses are quantified using the agricultural sector model RAUMIS (Henrichsmeier et al., 1996). Agricultural statistics with data, e.g. on crop yields, livestock farming and land use, are used to balance the nitrogen supplies and extractions for the agricultural area. The long-term nitrogen balance averaged over several vegetation periods is calculated considering the organic nitrogen fertilization, the mineral nitrogen fertilization, the symbiotic N-fixation, the atmospheric N-inputs and the N-extractions with the crop substance. As a rule, the difference between nitrogen supplies, primarily by mineral fertiliz-

This formula is based on the method of Renger & Wessolek (1996) which was derived from extensive field experiments for determining the actual evapotranspiration for various forms of soil cover. The soil cover enters in eq. 1 via the land-use-specific coefficients of regression a…e, which are listed in Tab. 2.

Tab. 2: Land cover specific regression coefficients for the determination of real evapotranspiration according to Renger & Wessolek (1996).

CLC class	a	b	c	d	e
Arable land	0,08	0,39	153	0,12	-109
pasture	0,10	0,48	286	0,10	-330
Coniferous forest	0,29	0,33	166	0,19	-127
Deciduous forest	0,047	0,047	0	0,02	430,1
Open spaces	0,074	0,074	0	0	59,2

For a general, i.e. area-wide, application several extensions are developed and implemented (Wendland & Kunkel, 1999) to calculate the real evapotranspiration in hilly (Golf, 1981) or urban areas as well as for regions close to the groundwater table. In addition, it is ensured that the calculated level of real evapotranspiration, on the one hand, does not exceed the maximum evapotranspiration and, on the other hand, does not fall below the level of precipitation for sites with deep water tables.

4.1 Model extensions for urban and groundwater effected areas using CLC data

The influence of pavement in urban regions on real evapotranspiration and groundwater recharge is considered in the GROWA model as follows:

$$ETr_{sealed} = ETr_{RW} - f_v \cdot G \qquad \text{eq. 2}$$

The correction factor f_V is determined by a comparison between the real evapotranspiration calculated according to eq. 1 for a hypothetically unpaved situation and the evapotranspiration resulting after for the Berlin area Wessolek & Facklam (1997) A value of 3.44 was thus found for f_V. According to ATV-DVWK (2002), fractions of paved area were derived using the CORINE nomenclature (Tab. 3).

Tab. 3: Degree of sealing of CLC land cover classes for urban areas according to ATV-DVWK (2002) and factors for the modification of real evapotranspiration levels.

CLC class	Land cover classes	Degree of sealing [%]	G [mm/a]
1.1.1	Continuous urban fabric	80	275,2
1.1.2	Discontinuous urban fabric	35	120,4
1.2.1	Industrial, commercial and public	85	292,4
1.2.2	Road and rail networks	50	172,0
1.2.3	Port areas	80	275,2
1.2.4	Airports	30	103,2
1.3.3	Construction sites	20	68,8
1.4.2	Sport and leisure facilities	15	51,6

For sites close to the groundwater table, the application of eq. 1 leads to an underestimation of the real evapotranspiration level, since water is constantly available for the evapotranspiration process due to capillary rise. It is therefore assumed here that the real evapotranspiration corresponds to a maximum evapotranspiration:

$$ETr_{gw} = ET_{\max} \qquad \text{eq. 3}$$

The maximum evapotranspiration (ET_{max}) represents a modification of the potential evapotranspiration, which reflects an evapotranspiration value attainable under the theoretical condition of a pasture (see tab. 2). The actually attainable evapotranspiration level of other land use forms, however, can clearly deviate from this value. The maximum evapotranspiration can be lower or higher than the potential evapotranspiration, depending on the type and height of vegetation. The maximum evapotranspiration is calculated from the potential evapotranspiration (ET_o) using a parameter f (ATV-DVWK, 2002):

$$ET_{\max} = f \cdot ET_o \qquad \text{eq. 4}$$

The values for the parameter f were determined via regression equations as a function of land use, vegetation height and available field capacity of the soil on the basis of lysimeter and gauge data for different site conditions (ATV-DVWK, 2002). The relations for calculating the parameter f after ATV-DVWK (2002) are listed in Tab. 4. The parameters z_B (average vegetation height of the plant stand) and UA (average rotation age of the plant stand) were estimated on the basis of the land use categories of CORINE (see Tab. 2).

Tab. 4: Equations for calculating the parameter f (eq.4) for determination of evapotranspiration rates for groundwater affected sites.

Land use classes	Equations
Urban fabric	f = 0.8
Open spaces	1_{nFK} # 8.5 Vol.% Ψ f = 0.8 1_{nFK} ∃ 8.5 Vol.% Ψ f = 0.0186A1_{nFK}+0.6419
pasture (12 cm)	1_{nFK} # 11 Vol.% Ψ f_{12cm} = 0.0125A1_{nFK}+0.7108 1_{nFK} ∃ 11 Vol.% Ψ f_{12cm} = 0.2866Aln(1_{nFK})+0.6419
pasture (varying)	5cm < z_B # 20cm Ψ f_k = 0.0676Aln(z_B)+0.8321 z_B ∃ 20cm Ψ f_k = -0.7A10^{-5}Az_B^2 +0.37A10^{-2}Az_B+0.9661 f = f_k(z_B)Af_{12cm}
Arable land	f = 0.221Aln(1_{nFK})+0.431
Deciduous forest	**Sandy soils** (1_{nFK} # 16 Vol.%): UA # 90 years Ψ f = 0.84+0.25A10^{-2}AUA+0.508A10^{-3}AUA^2-0.233A10^{-4}AUA^3+0.422A10^{-6}AUA^4-0.3494A10^{-8}AUA^5 +0.10946A10^{-10}AUA^6 = f_{SL1} UA > 90 years Ψ f = 1.038+0.49A10^{-3}AUA+0.155A10^{-5}AUA^2-0.1686A10^{-8}AUA^3 = f_{SL2} **Loamy soils** (1_{nFK} > 16 Vol.%): UA # 90 years Ψ f = 1.05Af_{SL1} UA > 90 years Ψ f = 1.05Af_{SL2}
Coniferous forest	**Sandy soils** (1_{nFK} # 16 Vol.%): UA # 130 years Ψ f = 0.8+0.2694A10^{-1}AUA+0.63924A10^{-3}AUA^2-0.8052A10^{-5}AUA^3- UA > 130 years Ψ f = 1.35+0.108A10^{-2}AUA+0.178A10^{-5}AUA^2 = f_{SL2} **Loamy soils** (1_{nFK} > 16 Vol.%): UA # 130 years Ψ f = 1.03Af_{SL1} UA > 130 years Ψ f = 1.03Af_{SL2}

4.2 Separating direct runoff from groundwater runoff in the GROWA model

In order to separate direct runoff from groundwater runoff a runoff separation is performed in the GROWA model on the basis of static base runoff fractions (BFI values), which describe groundwater runoff as a constant fraction of the total runoff. The BFI values define groundwater runoff as a function of certain area properties, inter alia hydrogeological, topographic and soil-physical characteristics.

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Consequences of updated CLC data for modelled non-point P-emissions into selected German catchments

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Abstract

The quantitative modelling of nonpoint-pollution into surface waters depends to a high degree on the distribution of Land Use / Land Cover (LULC) in the river catchments. The favourite data source for LULC-parameterization within the Nutrient Quantification Tool (NQT) MONERIS, when applied to German and European catchments, was and is the CLC1990 dataset. To evaluate the relevance of classification changes between the CLC2000 and CLC1990 datasets for nutrient quantification a first analysis was done for a representative set of catchments. The CLC-changes appeared to be significant only for small subsample of the 491 catchments selected at the 100 km² size scale of the Elbe basin. The catchments with significant CLC-changes indicate stronger impacts on the modelling of emissions due to erosion and surface runoff than on emissions parameterised mainly by total agricultural area.

1 Introduction

Many empirical tools used for the quantification of nutrient emissions into surface waters (NQT) are based on parameters calculated from mean area properties of the catchments under interest. The CLC classification in its 1990 realization is the most reliable, comparable and affordable dataset for the large scale parameterization of land use in these models. With the availability of CLC2000 the question arises whether and how CLC based LULC-mapping will introduce quantitatively significant changes of catchment-related mean model-parameters.

The parameterization approaches of the NQT MONERIS are typical representatives for the use of LULC in this kind of tools. As the means for evaluating the sensibility of MONERIS to LULC-changes its parameters used for the quantification of phosphorus emission from agricultural areas are selected herein. To match the analysis with catchment structures relevant for planning and reporting for the Water Framework Directive (WFD) a set of catchments in the River Basin District Elbe was generated containing all rivers with at least 100 km² catchment size.

2 Methods

2.1 Analysed CLC-categories

The parameterization of land use is done according to the preprocessing procedures of model-parameters used for quantification of phosphorus emissions in MONERIS (BEHRENDT et al., 1999). The parameters are calculated from a preliminary version of CLC2000 (DLR, October 2003) and compared against parameter values derived with identical methods from CLC1990 (StBA, 1997). The latter dataset serves as the reference because it was used as the main source for LULC-quantification in all 3 overview analyses done with MONERIS for Germany and the time-periods 1985, 1995 and 2000.

The comparison of selected CLC-classes from both datasets is done for all polygons in the selected catchments and evaluated against their role for the quantification approaches.

The first focus is directed on changes of the fraction of *Class 2* (*LEVEL1*- "agricultural areas") in every subcatchment, because all nonpoint emissions from agriculture are with different strengths proportionally related to this parameter. The second type of analysis is related to subcatchment-changes of *Class 211*–fractions ("non irrigated arable land") in more detail because this parameter is important to quantify the sum of emissions due to erosion and surface runoff, being important sources for P-input into surface waters.

2.2 Spatial reference

In accordance with WFD orientations for future catchment planning and reporting a subdivision of the Elbe basin on the 100 km² catchment size scale was applied. Following the WFD guidelines 529 subcatchments were constructed from basic watershed geometries for the German part of the Elbe basin, resulting in a mean catchment size of 151 km².

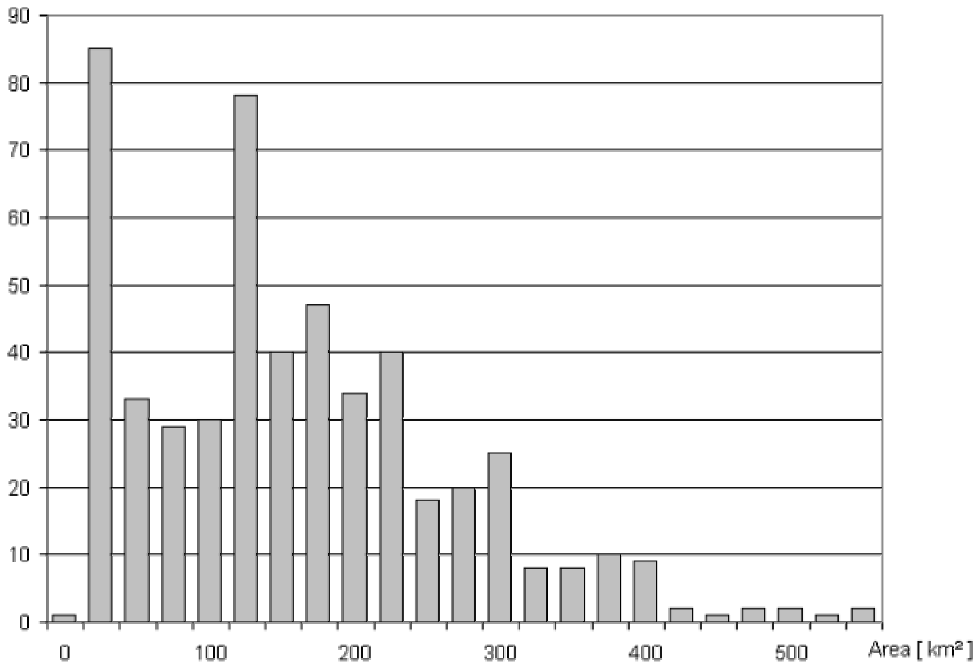

Fig. 1: Histogram of subcatchment sizes used for analysis in Elbe-Basin

This resulting spatial resolution is significantly larger than in Elbe catchment subdivisions applied in former emission analyses done with MONERIS for the river Elbe in the context of Germany-wide evaluations. Because the larger sample guarantees higher statistical representativeness and the general suitability of MONERIS-methodology at this catchment sizes has been proven in several projects this catchment structure with an about 4-fold increase of the number of analysed subcatchments is well suited for the tests within this study. Very small subcatchments (< 10 km²) resulting from the formal catchment division principles were not included in this analysis. The total number of catchments used is 491.

2.3 Geostatistical analyses

The intended sensitivity like analysis of NQT on LULC-changes requires evaluating the changes of the *absolute fractions* of selected CLC-classes within the overall LULC-distribution in the tested catchments. The calculated changes are obtained as differences between the fractions that any CLC-class of interest has in the dataset for year 2000 minus their values in the 1990 dataset. (This approach results in numerical values of change that are smaller than the relative changes of the particular classes itself within the reference areas.) To enable a systematic evaluation all calculated changes are grouped into 1%-stepped histograms of catchments with given percentages of calculated LULC-changes in it. On top of these 1%-classes two additional, merely arbitrary, “significance levels” are added for descriptive reasons at 3% and 5% of class-fraction-changes in a catchment. Fraction changes below 3% per catchment are regarded to be “not significant”, changes between 3 and 5 % indicate “possible influence” and changes above 5% are considered to have “significant” effects on calculated emissions.

3 Results

3.1 General characteristics of changes

As a guideline for evaluating the significance of LULC-changes at catchment scales an overview change-statistics at the CLC3-level for the whole dataset was performed (table 1). It filters out the most frequent unidirectional fraction changes between 1990 and 2000 occurring in the polygons of the analyzed CLC2000-dataset.

Tab. 1: Ranking of unidirectional changes of CLC3 (classified area 118.000 km²).

Unidirectional CLC3-changes	Affected area (km²)	Affected fraction [%]
211 → 231	1245,92	1,06
231 → 211	474,20	0,40
211 → 242	331,52	0,28
211 → 112	302,00	0,26
222 → 211	271,51	0,23
211 → 121	223,91	0,19
321 → 324	211,75	0,18
242 → 231	155,18	0,13
131 → 333	151,05	0,13
211 → 312	101,11	0,09

The most significant unidirectional changes occur between the different subcategories of agriculturally used areas. Within the “top ten” of changes 3 types represent changes between agricultural and non-agricultural land uses, all indicating losses of agricultural area to other categories. The second relevant indication from the ranking table is the dominance of changes between the arable land class (211) and other third-level-classes (7 out of 10).

3.2 Changes of ‘total agricultural area’ fraction

In a spatially differentiated analysis the changes of the fraction of agricultural land use are evaluated for every subcatchment and the number of catchments for every 1%-change interval is counted. As expected from the general statistics (table 1) the losses of CLC-2 dominate the wins for the catchments of the Elbe river. For almost 90 % of the analyzed subcatchments however the agricultural area differs less than ± 1% between CLC1990 and CLC2000. Emission estimates in these subcatchments will practically not be affected within the accuracy limits of the emission models. Changes of more than the first significance level are found in 16 subcatchments and only in 6 catchments (about 1% of the sample) the changes exceed the significance level for expected influence on emission estimates.

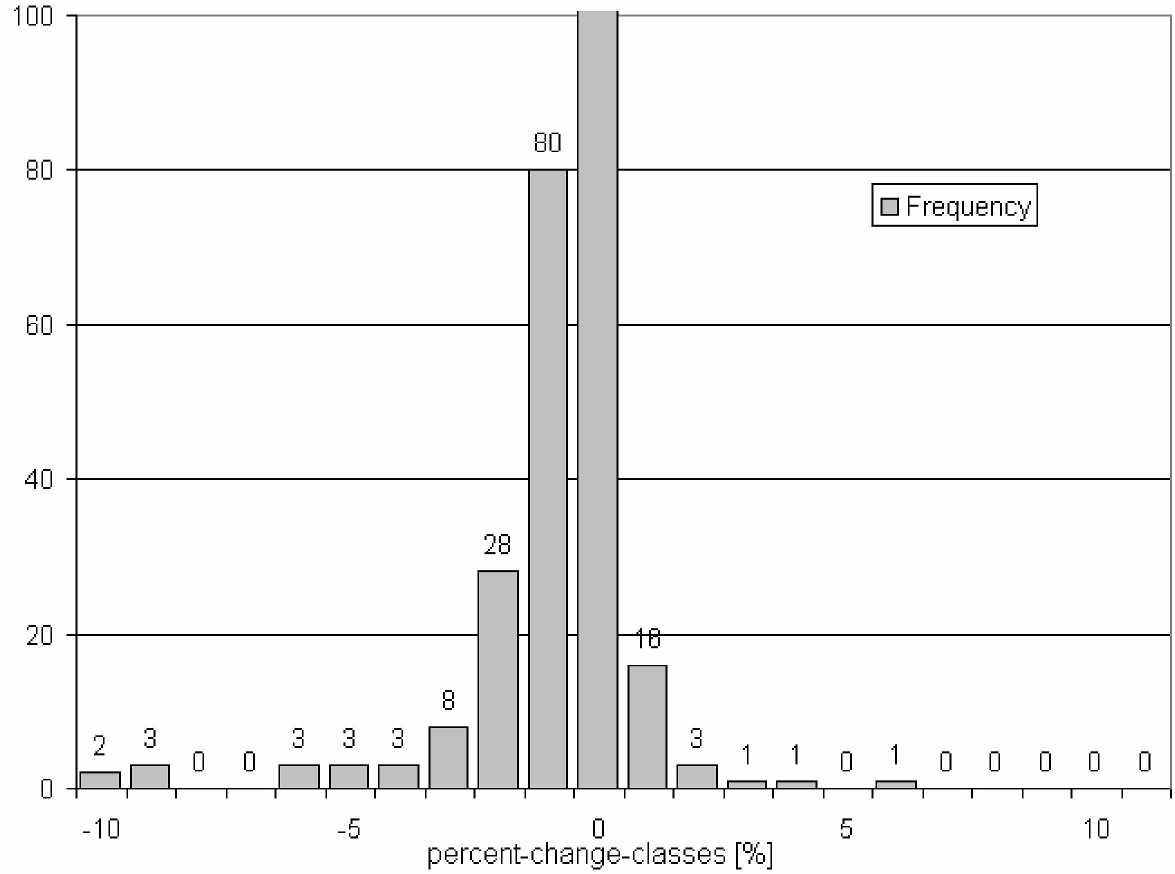

Fig. 2: Histogram of catchments with different intensity of CLC2-fraction-changes

3.2 Changes of 'arable land' fraction (211)

Table 1 indicates the dominating role of land use changes between arable land and other agriculturally used areas within all changes registered between CLC1990 and CLC2000 in Elbe subcatchments. These changes occur as losses or wins of arable land with comparable intensities. To get a deeper insight into the behaviour of changes at catchment scales both directions of change (losses and wins) are evaluated separately within all catchments (see figure 3). With this assumption for 81 out of the 491 Elbe-catchments unidirectional changes of the arable land fraction exceed the first significance level in the period between 1990 and 2000 and for 40 subcatchments (almost 10 % of the sample) even the second level is exceeded. These numbers indicate a high intensity of changes compared to the CLC2-changes.

For the NQT-relevant parameters however only the net balance of arable land changes is evaluated. After balancing wins and losses in every subcatchment the numbers of catchments with changes above the first and second significance levels reduce to 12 and 9 (about 2 %) respectively. These numbers are larger than for the changes of agricultural area but it becomes clear that the susceptibility of an empirical NQT to LULC-changes derived from both CLC datasets is very selective with respect to the catchment under consideration, at least in the Elbe basin.

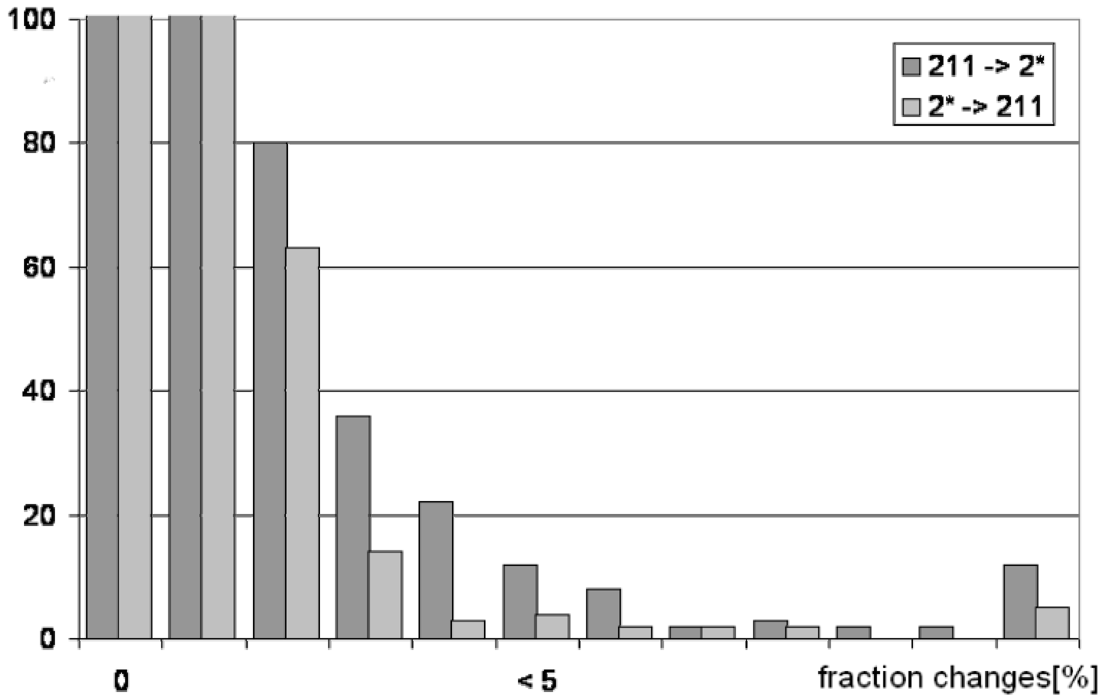

Fig. 3: Unidirectional fraction changes of 'arable land' in Elbe subcatchments

4 Discussion

Only for a small number of catchments within the Elbe basin changes of LULC-fractions between CLC1990 and CLC2000 datasets are found to induce significant influence on the quantification of P-emissions from agricultural areas. For the remaining catchments the observed differences are up to an order of magnitude smaller than the mean differences occurring when calculating the same LULC-parameters from alternatively from different sources of information (BEHRENDT, 2003).

Further analysis is necessary to decide, whether the small catchment number affected by significant CLC-changes reflects the real importance of land use changes in the Elbe catchments during the 1990-ies for its use in NQT's. Especially the question of changing intensities of agricultural land uses within the same CLC-classes has to be considered.

The significant CLC-changes, where detected on catchment scale, suggest that a stronger impact on emission modelling can be expected for the relative changes of emissions due to erosion and surface runoff than for the changes of emissions dependent in the model on the fraction of total agricultural area in the catchment only.

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Significance of land use data for risk assessment pesticide pollution in German river basins

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Abstract

Pesticide exposure and resulting surface water contamination was assessed with national coverage for all regions of Germany classified as agricultural land, according to the CORINE land-cover (CLC) dataset. Pesticide load from diffuse sources and resulting predicted environmental concentrations in surface waters (PEC_{sw}) were modelled by DRIPS - *Drainage Spraydrift and Runoff Input of Pesticides in Surface Waters*. Model simulations were conducted for all pesticide applications of 59 common active ingredients (a.i.) in nine field crops in the year 2000. Model results were compiled in 19116 maps (1 km x 1 km) indicating the land use specific spatially differentiated hazard potential of respective pesticide application scenarios.

1 Introduction

Application of pesticides on agriculturally used land often causes unelaborated contamination of non-target areas bordering the treated fields. The exclusion adverse damage of non-target ecosystems though, is a mandatory requirement for pesticide registration. An accurate determination of the actual target area is the basis for modelling the risk involved in pesticide usage. Recent high resolution land use data such as the CORINE land cover dataset 2000 is inevitable for this purpose.

Pollution of surface water-bodies by non-point sources, such as agriculturally used plant protection products can cause severe impacts on non-target organisms in aquatic ecosystems and for human health, if threshold levels of specific active ingredients (a.i.) are exceeded. To maintain high surface water quality standards the contribution of various diffuse sources of input – here surface runoff, tile drainage and spraydrift – has to be assessed for a.i. in order to reduce their impact on the ecosystem.

Modelling the environmental fate of pesticides grew to be the focus of research activity within the European Union in the context of pesticide registration, being a rather inexpensive and effective alternative to monitoring campaigns. User-friendly Decision Support Systems (DSS), like DRIPS, offer authorities and producers easy access to models generally providing powerful tools for regional risk-assessment.

The predicted environmental concentration in surface waters PEC_{sw} is commonly used by stakeholders to judge the hazard potential of a pesticide. The European Directive 91/414/EC on plant protection products requires manufactures of a.i. to supply PEC_{sw} for products to pass registration. In the current registration procedure a substance needs to pass a single 'worst case' scenario based on laboratory experiments to be considered non-toxic. This practice generally lacks to adequately account for the heterogeneity of the agricultural areas the a.i. is applied in. Spatially distinguished PEC_{sw} scenarios provide a more realistic basis for risk assessing a substance's behaviour in various landscapes. The probability based risk assessment tool DRIPS supplies regionally distributed PEC_{sw} on a catchment scale with a spatial resolution of 1 km^2.

2 Data

The basic aim of the DSS DRIPS is to serve as a risk assessment tool providing spatially distributed information on diffuse pesticide pollution and resulting PEC_{sw}. Hence, the majority of the parameters required for model simulations are implemented as a set of grid and vector maps conforming to the map "administrative boundaries of Germany 1:1 Mio" (IFAG/BKG, 1996). The CLC dataset is employed as the basis to identify agricultural areas in their regional distribution for land use- specific model calculations on cropland (classes: 211, 242, 243), vineyards (class: 221), and orchards (class: 222). Non-spatially distributed data such as the a.i. parameters DT50 and Koc are stored in dBASE database format. Pesticide application parameters, such as dosage and substance date, have to be specified by the user, before executing a model run.

3 Models

3.1 Runoff

The amount of a substance to be dislocated by surface runoff water essentially depends on the period of time elapsed between pesticide application and actual occurrence of a runoff-producing rainfall event (Mills and Leonard, 1984). To quantify the fraction of the applied chemical in the runoff water (1) the threshold level of the rainstorm causing surface runoff, (2) the probability of its occurrence, (3) the volume of surface runoff as well as (4) the concentration of the active substance in the runoff water has to be determined.

1. It is assumed that rainfall events of 10 mm in 24 h or larger are sufficient to trigger surface runoff (Huber *et al.*, 2000).

2. The mean probability of runoff-producing rainfall occurrence with a given volume and duration in a certain period is determined by the Gumbel-Distribution (Gumbel, 1958). Gumbel distribution functions of 60 min and 24hrs, the latter with separate datasets for summer and winter, are available in DRIPS to predict the probability of a runoff occurrence. The time interval between pesticide application and the occurrence of a rainstorm – which is important to determine the substance's degradation – can be derived from the Gumbel data by a probability density function according to Mills and Leonard (1984). Furthermore, a seasonal variation factor was implemented, to account for the more variable frequency of rainstorm occurrences in the summer season (Auerswald, 1996).

3. The calculation of the runoff volume caused by a runoff-producing rainfall is based on the USSCS's curve-number-method (SCS, 1990). The curve numbers were modified according to Lutz (1984) in order to adapt the SCS-CN-method to Central European conditions.

Required data to obtain the curve numbers are land use and hydrological soil properties considering the current soil cover at the time of an event are required.

4. The pesticide concentration in runoff water at the beginning of a rainstorm highly depends on the substance's decay as well as the retention capacity of the crop and soil it was applied on. Degradation can be calculated with a first-order decay function returning the fraction of the pesticide's initial load, considering the time interval between application and a rainstorm (Mills and Leonard, 1984). Decay is controlled by a breakdown coefficient depending on the chemical's half-life *DT50*. A probability density function returns the fraction of the initial load of the pesticide available on the soil surface for translocation with runoff water by considering the time interval between application and a rainstorm with a certain probability of occurrence mentioned earlier on (Mills and Leonard, 1984).

Furthermore, the fraction of the substance available for runoff translocation is reduced by absorption in the plant cover present at the time of application. A factor representing the degree of plant cover of crops in specific climatic zones at a certain stages of maturity was considered in the model approach (Bach *et al*., 2000).

Only a portion of the remaining runoff-available pesticide load is expected to be found in the runoff-suspension during a rainstorm event. That is the fraction of the substance subject to desorption processes within the first centimetres of the topsoil. Consequently, the model only calculates pesticide displacement for the liquid phase. Erosion is not taken into account. A semi-empirical approach was adopted from GLEAMS (Leonard *et al.*, 1987) where the soluble amount of the runoff-available pesticide load can be extracted with a desorption-coefficient. An instant balance of a substance between the liquid and solid phase is presupposed. The desorption coefficient can be derived empirically from the distribution coefficient *Kd*, which in turn can be obtained from the linear organic carbon partition coefficient and the content of organic carbon in soil (CREAMS/GLEAMS: Leonard *et al.*, 1987).

The fraction of the initial pesticide load remaining after desorption has to be expected as surface water input as a result of a runoff-producing rainstorm event.

3.2 Leaching

Germany's registration authorities make use of the model PELMO by Klein *et al.* (1997) for assessing the risk of pesticide displacement via leaching. To conform to registration standards, PELMO was adopted in DRIPS as the model of choice to estimate the quantity of pesticides transported by leaching water. PELMO is used to simulate the displacement of a substance to 0.8 m depth. At that depth, the leachate is expected to enter a tile drainage system - if installed on the land – or be subject to further vertical translocation. In the latter case, the pesticide ultimately reaches the ground water body, if it does not fully degrade along the way. The input of pesticides into surface waters from the ground water body is considered to be negligible in Germany (Bach *et al.*, 2000). Hence, pesticide input via leaching is only calculated for drained areas. A grid cell map of Germany's drained areas is provided by Behrendt *et al* (1999).

In the same manner as for the runoff, it is presupposed that only the share of a pesticide, which is not subject to foliage-interception is transported in the leachate. Since PELMO does not consider interception, a factor representing the degree of plant cover in specific climatic zones at a certain stages of maturity is used for adjustment. The remaining PELMO result is the actual fraction of the initial dose found in the leachate at 0.8 m depth. The solution is expected to enter a tile drain at that depth leading towards a surface water body nearby.

3.3 Drift

Surface water input of a sprayed pesticide via direct drift, is expected for the fraction of the substance, which is not reaching the target area but is directly blown into an adjacent stream. Generally, pesticide loss by drift is significantly higher for fruit- or grapevine plantations than for field crops. This is mainly due to different spraying-techniques, like the use of boom sprayers in field crops and air blast sprayers in grapevine plantations (Ganzelmeier *et al.*, 1995). DRIPS uses the drift tables published by Germany's Federal Biological Research Center for Agriculture and Forestry (BBA) as a basis for estimating the fraction of a substance displaced by spray drift. The tables are also used by registration authorities to set up spraying-distance requirements for pesticides. Different tables are available for 90th, 70th and 50th percentiles providing separate spray drift values for fruit, grapevine and field crops - each for two phenological zones and for specific proximities of surface water and site of application (BBA, 2000).

The degree of expected pesticide input via drift highly depends on the proximity of the next surface water body to the sprayer. No sufficient set of data providing information about the exact location of smaller ditches – being the most common type of surface water body in agriculturally used land – is available for Germany. The mean drainage density of the river network is used alternatively to judge the probability of a substance reaching a surface water body via drift. A grid map available in DRIPS was derived from the Hydrological Atlas of Germany (HAD) by Huber *et al.* (2000). The amount of pesticide input also depends on the width of the river. Larger water bodies are susceptible to higher amounts of deposition. However, most larger streams have adequate buffer zones shielding pesticide input to some extent. Unshielded small ditches are frequently found in agriculturally used areas prone to receive frequent deposition. A factor accounting for stream-width with different values for 1st and 2nd order (and higher) streams (definition of Strahler, (1957) was implemented in DRIPS.

3.4 PEC

In order for stakeholders to judge the hazard potential of new substances on aquatic-ecosystems PEC_{sw} are required as part of a three tired approach for pesticide registration within the European Union (FOCUS, 2001). PEC_{sw} generally reflect the cumulative inputs of a substance from the area of application in a river-stretch by diffuse sources. For instance PEC_{sw} values at the outlet of a river-catchement represent the sum of all non-point source inputs estimated in the catchment. Due to the heterogeneity of different catchments in terms of their environmental parameters (soil, precipitation, land use etc.) controlling pesticide dislocation, PEC_{sw} are expected to show significant variation, if applied nationwide. Therefore, spatially distinguished estimations of PEC_{sw} are required to adequately judge the environmental impact of a substance in nature. DRIPS will provide PEC_{sw} estimation for more than 400 catchments distributed all over Germany for any pesticide with known chemical properties. The basis for PEC_{sw} calculation is the expected mean daily inputs (E) of an a.i. within these catchments estimated by the previously discussed pathways of entry. The ratio of the mean daily input into various types of surface water bodies characterized by their daily discharge (Q) yields the predicted environmental concentration (PEC_{sw}) of the respective surface water body:

PEC_{sw} = E/Q [1]

To provide PEC_{sw} estimates on a catchment scale, discharge data of the gauging stations of each catchment outlet were needed. Time series of continuous daily discharge data were gathered for more than 200 gauging stations with a 30 year record from 1971 to 2000.

Representative mean daily/monthly discharge values were derived from this time series for each catchment. However, in order to also supply PEC_{sw} for the remaining ungauged catchments discharge data had to be estimated. For this purpose, flow duration curves (FDC) were set up from the available time series for gauged stations. FDC's are cumulative frequency curves of daily discharges during a year representing the proportion of time that a particular discharge is equaled or exceeded during the period of observation (LeBoutillier and Waylen, 1993).

Statistical analysis of long time series of daily discharge data allows correlating annual flow frequency characteristics with physical parameters of the respective catchment, such as size, topography, morphology, geology, precipitation, drainage density (Searcy, 1959). Hence, FDC's can be used to calculate the discharge of ungauged catchments from gauged catchments with similar site-specific characteristics. Physical parameters are raised and attributed to all catchments available in the DSS. FDC's can be assigned to ungauged catchments belonging to the same discharge-class as gauged ones.

Two options are available in DRIPS to estimated PEC_{sw} resulting from pesticide dislocation by either surface runoff, tile drainage or spraydrift: (i) monthly PEC_{sw} average (ii) probability of PEC_{sw} distribution for selected catchment and month. Option (i) produces an output map with average PEC_{sw} values attributed to each of the 400 catchments. The simulation is based on median monthly discharge values (Q) of each catchment.

Option (ii) produces a line graph of the probability distribution of PEC_{sw} for selected months. Various percentiles (5^{th},25^{th},50^{th},75^{th},95^{th}) of discharge data are available for PEC_{sw} estimation.

This option provides a basis for probabilistic risk assessment of any a.i.'s behaviour within a catchment with defined physical features. The simulation of the probability of a substance to pass set thresholds under realistic conditions can help stakeholders to establish new regulations and producers to check the compliance of newly developed substances with existing laws.

4 Results and discussion

PEC_{sw} values are a commonly used in environmental risk assessment for estimating the effects of the cumulative diffuse pollution of an a.i. on aquatic life. Producers of pesticides have to obligatorily determine PEC_{sw} for new substances to pass the European registration requirements, as specified in the EU Directive 91/414/EC. The current registration procedure only determines whether or not an a.i.'s PEC_{sw} exceeds a set 'worst case' values. Regionally differentiated PEC_{sw} scenarios would provide a somewhat more realistic basis to judge a substance's environmental impact within the various agroecological regions it is applied in. The FOCUS 3rd tier approach (FOCUS, 2001) featuring ten standard scenarios representative for the EU's main agroecological regions is a step towards regionalized risk assessment of diffuse pollution on an EU scale.

On a national scale, the DSS DRIPS is available providing producers and stakeholders with regionally differentiated PEC_{sw} scenarios of for the territory of Germany. Models implemented in the DSS already comply with Germany's registration requirements for the pathways of tile drainage (PELMO) and spray drift (BBA drift tables). The graphical user interface offers easy modification of the essential model parameters to run different scenarios. Full GIS integration of the model approaches offers a spatially discriminated visualization of the model results of loads and PEC_{sw} on maps with 1 km^2 resolution for the manifold agroecosystems of Germany. DRIPS is a time- and cost-effective DSS to assess the probability of pesticide contamination of surface waters and the resulting initial concentration of the pesticide in surface water bodies.

Due to the regional scale of the model approach, results do not accurately predict concentrations of pesticides found in on-site measurements. This DSS is rather aimed to produce scenarios for a first-screening of the hazard potential of plant protection products. The probability based model approach enables the user to vary environmental- and substance parameters in order to produce scenarios ranging from the conservative "worst case" assumption up to more or less "realistic" conditions. The scenarios can be used by chemical companies to confirm compliance with existing threshold values or for stakeholders to set up new thresholds. Model results such as frequency distributions of PEC_{sw} can serve as a basis to identify areas prone to high contamination by diffuse pollution. Field campaigns could be initiated at these areas, if simulated products are already in use. Results maps could be employed by stakeholders to establish regional instead of national threshold values for pesticide registration. DRIPS was developed to serve as a qualitative risk assessment tool for estimating the land use dependent hazard potential of pesticides in surface waters for the territory of Germany.

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CORINE Land Cover Application for Assessment and Mapping of Critical Loads of Sulphur, Nitrogen and Heavy Metals in Germany

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Abstract

In the framework of the UNECE Convention on Long-range Transboundary Air Pollution Germany provides critical loads data of acidity and nutrient nitrogen to the International Cooperative Program on Modelling and Mapping Critical Loads & Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping). An important step in this work is the geographical identification and characterisation of sensitive receptor areas. The German National Focal Centre of ICP Modelling and Mapping elaborated methodologies to localise habitat classes according to the EUropean Nature Information System (EUNIS) based on information from CORINE Land Cover in combination with the General Soil Map of Germany, and information on climate, and land use systems. The European critical loads database is nowadays an essential scientific input to the derivation of optimised air pollution control strategies.

1 Introduction

In Germany as well as in other European countries the assessment of critical loads of sulphur and nitrogen and trends in their exceedance serve as a conceptual base for air pollution control strategies. Efforts have also been made to extend this approach to heavy metals. The term "critical load" in this context means a quantitative estimate of an exposure to one or more pollutants (provided in terms of pollutant input to the ecosystem per area and time unit) below which significant harmful effects on specified sensitive elements of the environment do not occur, according to present knowledge. In the case of nitrogen oxidised as well as reduced compounds contribute to the total deposition of acidity, which exceeds critical loads in many of these ecosystems. Both they also cause negative effects through eutrophication. Sensitive elements of the environment or ecological receptors are identified applying the CORINE Land Cover. It enables to localise habitats according to the hierarchical classification of EUNIS. Ecosystem characteristics influencing their sensitivity can be attributed to these geographical units by Geographic Information Systems (GIS).

2 Application of CORINE Land Cover in the calculation of critical loads

Critical loads of sulphur and nitrogen, both contributing to acidification of ecosystems, and their exceedances were derived and mapped in a large scale exercise for forest soils (deciduous, coniferous and mixed forest), natural grassland, acidic fens, heathland and mesotrophic peat bogs in Germany. Preliminary critical loads of cadmium and lead have also been calculated for these ecosystems, and in addition for agricultural soils. The methods to calculate critical loads of heavy metals are still in development.

Each ecosystem has its specific sensitivity against the air pollutants of interest, which is expressed by the critical load value. To identify this, the geographical information from CORINE has to be overlapped with spatial information on soil and climate. In combination with the General Soil Map of Germany (BUEK 1000, Hartwich et al. 1995) and climate data (DWD 2000) conclusions on the vegetation structure of the land cover types can be drawn and the net biomass production can be derived. The annual yield in biomass, which is harvested or intended for harvest at a later point in time (e.g. forest trees), combined with the plant specific concentration of nutrients (including base cations) as well as heavy metals in the harvestable parts of the plants enables the calculation of the element net uptake, which is considered as one of several sinks for air pollutants in the calculation of critical loads.

The habitat classification system EUNIS describes ecosystem types using information on abiotic and biotic parameters of the site. The EUNIS classification is, however, not geo-referenced. Therefore the task was to assign indirectly areas of Germany to EUNIS habitats, based on geo-referenced information on soil, climate and land cover from available related digital maps. The following digital maps are used for mapping of ecosystem types covering whole Germany:

- CORINE – Land Cover
- BUEK 1000

From CORINE the following ecosystem characteristics can be obtained:

- EUNIS-Code-main classes (Level 1 and 2), i.e. land-use dependent main vegetation complexes

From BUEK 1000 can be drawn:

- the climate/altitude class from the seven soil regions lumping together soil units of coastal areas , lowlands, plains and hilly regions, loess areas, mountain regions, high mountain regions, anthropogenic soils (examples in Annex 1)
- acidity status, base saturation and nutrient pool (Annex 1)

From the **geographical overlap of units of the BUEK 1000 and CORINE classes** the expected vegetation can be derived with high probability.

The **EUNIS** habitat classification contains information on :

- climate region and/or altitude, in which the EUNIS class does occur,
- nutrient status and/or status of acidity or base saturation, which is preferred by the vegetation of the EUNIS class,
- vegetation unit (plant community or characterising species), whereby the characterising species always at the same time provides the name for the related plant community, so that the plant community can be derived even, if only the characterizing plant species are named in the EUNIS class description.

By comparison of the data in EUNIS with the characteristics of the site, which can be derived by geographical overlap of BUEK and CORINE, a clear assignment is possible. A limitation is, however, that not all EUNIS classes provide in each case all necessary data on the parameters mentioned above. In these cases assumptions had to be made. These are based on indicator values of the plant communities or characterising species named in the EUNIS class.

Results of attributing selected soil units to classes of climate and altitude as well as the data on nutrient status are lumped together in a table in Annex 1. Annex 2 presents examples of the attribution of vegetation classes to the related combination of soil unit and land cover type according to CORINE Land Cover. Both together enable the derivation of the EUNIS class (see Annex 3).

In the calculation of the national critical load dataset of acidity and nutrient nitrogen (2003) the natural ecosystem types (CORINE-Codes 3.1.3, 3.1.2, 3.1.1.) and the semi-natural grassland vegetation types (CORINE-Codes 3.2.1, 3.2.2, 4.1.1, 4.1.2) are mapped as receptor areas. The methodology enables also the prediction of vegetation communities of intensively used grassland (CORINE-Code 2.3.1) and crop ratios for arable land (CORINE-Code 2.1.1, 2.1.2), which is needed to calculate critical loads of heavy metals for such areas.

By overlapping the CORINE Land Cover with the General Soil Map of Germany areas arise, for which the combination of soil unit and land cover seems to be implausible, e.g. if on the same area CORINE suggests a swamp, while BUEK indicates a regosol from dry sands. These seeming contradictions arise due to the definition of BUEK units as a community of one guiding soil form with other regularly occurring accompanying soil forms (= typical enclaves). Thus, if as in this example, the guiding soil form does not fit to the land cover type, one has to assume that on this area such an accompanying soil form exists. Therefore, in Annex 3 for such places in the matrix a BUEK unit is indicated, of which the guiding soil form corresponds well to that accompanying soil form, which can be predicted with highest probability due to the CORINE Land Cover type. One has to go to this most appropriate guiding soil form of the BUEK legend in the column, and can then easily find out the vegetation type of the accompanying soil form of the BUEK legend.

3 Trends in Critical Loads exceedance and effects

The decrease in sulphur emissions over the past 15 years resulted in a reduced exceedance of critical loads for acid deposition. In the same period the reduction in the emissions of nitrogen oxides and ammonia remained insignificant. Therefore, emissions of nitrogen compounds have become relatively more important and will continue to threaten ecosystem function and stability. This fact, and the acidity already accumulated in the soils, will remain responsible for the continued environmental problems in forest soils and other natural ecosystems in the upcoming decade. Recovery from pollutant stress will often be very slow and may sometimes even take hundreds of years, the risk of environmental damage remains at an unacceptable level.

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Annex 1: Attribution of BUEK legend units to climate and altitude classes and nutrient status (examples)

BUEK 1000 LEGEND		**BUEK-Description according to FAO (1990)**	**Code (FAO 1974)**	**climate zone / altitude calss**	**nutrient status**
1	Podsol-Regosol aus trocke-nen Sanden im Küstenbe-reich	Dystric Regosol from sand dunes	Rd	coast	acidophilic/ oligotro-phic
3	Kalkmarsch aus marinen Ablagerungen	Calcaric and Eutric Gleysols from marine sediments (tidal marsh)	Gc,Ge	coast	calciphilic/ meso-troph-eutrophic
13	Pararendzina aus kalkhalti-gen, lehmigen Hochflut- und Auenablagerungen	Calcaric Regosols / Calcaric Fluvisols from calcareous sandy to loamy sediments of river val-leys	Rc,Jc	river valley	calciphilic/ meso-troph-eutrophic
26	Fahlerde aus sandigen Deckschichten über Ge-schiebelehm	Dystric Podzoluvisols / Luvic Arenosols / Dystric Cambisols from sandy sediments overlying boulder clay	Dd, Ql, Bd	sub-continental lowlands	subneutral/ eutrophic
33	Eisenhumuspodsol aus nährstoffarmen Sanden	Haplic Podzols / Dystric Regosols from dry dystrophic sand deposits	P, Rd	sub-continental lowlands	acidophilic/ oli-gotrophic
36	Tschernosem aus Löss	Haplic Chernozems from loess of the central German low-rainfall area	Ch	sub-continental collin-submontan loess hilly land	subneutral/ eutrophic
53	Braunerde aus basischen und intermediären magmati-schen Gesteinen	Eutric Cambisols from basic and intermediate igneous rocks	Be	temperate-mid European montan middle high mountain areas	subneutral/ eutro-phic
62	Podsolige Braunerde aus lösshaltigen Deckschichten über Sandstein und Quarz	Dystric Cambisols from loess-bearing sediments overlying sandstone and quartzite	Bd	temperate-mid European montan middle high mountain areas	acidophilic/ oligotro-phic
69	Syrosem aus Kalk- und Dolomitgesteinen	Lithic Leptosols of the higher altitude zones of the alps	I	mid European sub-alpine und alpine high moun-tains	calciphilic/ meso-troph-eutrophic

Annex 2: Attribution of vegetation types to combinations of BUEK units with CORINE Land Cover type (examples)

BUEK 1000	pastures and meadows	natural dry grassland	heath-lands and acidic grassland	wet grass-land	mesotro-phic fens	mixed forest (potential natural vegetation)	dec. forest (main tree species)	con. forest (main tree species)	intensively used arable land
CORINE	**2.3.1.**	**3.2.1.**	**3.2.2.**	**4.1.1.**	**4.1.2.**	**3.1.3.**	**3.1.2.**	**3.1.1.**	**2.1.1, 2.1.2**
1	Ammophiletum arenariae	Violo-Corynepho-retum cane-scentis	Empetre-tum nigri	LEG2	LEG6	Betula pendula-Quercus robur (-Pinus sylvestris)	Betula pendula	Pinus syl-vestris	rye, wheat/barlay, 2x fodder crops
3	Puccinellietum maritimae	Poo irriga-tae-Agropyretum repentis	LEG2	Salicornie-tum strictae	Eriophoro-Caricetum lasio-carpae	Salix spec.	Salix spec.	Picea abies	2xwheat, 2xfodder crops, barlay, sugar beet/potato, 2xfodder crops
13	Alopecuretum pratensis	Phalaridetum arundinacae	LEG12		LEG8	Quercus robur-Carpinus betulus, Acer pseudopla-tanus-Fraxinus excelsior	Quercus robur	Pinus sylves-tris	wheat, 2xfodder crops, barlay, po-tato/sugar beet, fodder crops, corn oil seed, rye
26	Koelerietum glaucae	Koelerietum glaucae	Genisto pilosae-Callune-tum	LEG12		Quercus petraea-Quercus robur-Tilia cordata	Quercus ro-bur/petraea	Pinus syl-vestris	rye, wheat/barlay, 2xfodder crops
33	Thymo-Festucetum ovinae	Thymo-Festucetum ovinae	Genisto anglicae-Callune-tum	LEG12	LEG6	Betula pendula-Quercus robur (-Pinus sylvestris)	Betula pendula	Pinus sylves-tris	rye, wheat/barlay, 2xfodder crops
36	Dauco-Arrhenathere-tum elati-oris/Lolio-Cynosuretum	Dauco-Arrhenath-eretum elati-oris/Lolio-Cynosure-tum	LEG44	LEG24		Quercus robur-Quercus petraea-Tilia cordata	Quercus ro-bur/petraea	Pinus syl-vestris	wheat, 2xfodder crops, barlay, po-tato/sugar beet, fodder crops, corn/oil seed, rye
53	Crepido-Festucetum commutatae	Crepido-Festucetum commutatae	LEG52	LEG68	LEG6	Fagus sylvatica, Fagus sylvatica-Quercus robur-Quercus petraea	Fagus sylvatica	Picea abies	wheat, 2xfodder crops, barlay, po-tato/sugar beet, fodder crops, corn/oil seed, rye
62	Avenetum pratensis	Avenetum pratensis	LEG56			Fagus sylvatica-Quercus petraea, Fagus sylvatica	Fagus sylvatica	Picea abies	wheat/barlay, 2xfodder crops, oil seed
69	Seslerietum variae	Seslerietum variae	LEG52			Pinus mugro-Fagus sylvatica	Fagus sylvatica	BergPinus sylvestris	fodder crops

Annex 3: Attribution of EUNIS-classes to the combinations of BUEK-units with CORINE Land Cover classes

CORINE	2.3.1.	3.2.1.	3.2.2.	4.1.1.	4.1.2.	3.1.2.	3.1.1.	3.1.3.	2.1.1/2.1.2	2.2.1/2.2.2	2.4.1/2.4.2/ 2.4.3 / 2.4.4	3.2.4
BUEK-LEG 1000	pastures and meadows	natural dry grassland	heath and acidic grassland	wet grassland	mesotrophic fens	deciduous forest	coniferous forest	mixed forest	int. used arable land	fruit plantations	heterogen. agric. land	wood-bush conversion status
1	E2.11	E1.93	F4.261	D6.16	D5.21	B1.71	B1.71	B1.72	I1.1	FB	X08	G5.62
2	A2.63B	D6.16	B2.51	D6.16		G3.1F	F9.12		I1.1	FB	X08	G5.62
3	A2.63B	C3.25	B2.51	D6.16	D2.31	G3.1F	F9.12		I1.1	FB	X08	G5.62
4	A2.63B	C3.25		A2.561	D2.31	G3.1F	G1.66	G4.6	I1.1	FB	X08	G5.62
5	A2.63B	C3.25	B2.51	A2.561		G3.1F	G1.66	G4.6	I1.1	FB	X08	G5.62
6	E2.11	D2.32	F9.2	D2.32	D2.32	G3.E2	G1.41	G4.1	I1.1	FB	X08	G5.62
7	E2.11	D2.22	E3.52	D5.21	D5.3	G3.E2	G1.51	G4.4	I1.1	FB	X08	G5.62
8	E2.62	E3.43	E3.52	E3.43	D4.1H	G3.42	G1.221	G4.71	I1.1	FB	X08	G5.62
9	E2.62	E3.43		D5.21		G3.42	G1.221	G4.71	I1.1	FB	X08	G5.62
10	E2.62	E3.44		C3.26	D4.1H	G3.42	G1.221	G4.71	I1.1	FB	X08	G5.62
11	E2.62	E3.44	E3.52	A2.63B	D4.1H	G3.42	G1.221	G4.71	I1.1	FB	X08	G5.62
12	E2.11	D4.1G	E3.52	D5.21		G3.42	G1.41	G4.1	I1.1	FB	X08	G5.62
13	E2.62	D5.11	E3.52		D4.1H	G3.42	G1.221	G4.71	I1.1	FB	X08	G5.62
14	E2.62	D5.11		D5.21	D4.1H	G3.42	G1.87	G4.8	I1.1	FB	X08	G5.62
15	E2.62	E3.44	E3.52	D5.21		G3.42	G1.43	G4.71	I1.1	FB	X08	G5.62
16	E2.11	E2.22	F4.262	D2.3D	D5.3	G3.42	G1.87	G4.8	I1.1	FB	X08	G5.62
17	E2.11	E2.22	F4.22	D5.21	D5.21	G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
18	E2.11	E2.22		D5.21		G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
19	E2.11	E2.22		D5.21	D5.21	G3.1F	G1.63	G4.6	I1.1	FB	X08	G5.62
20	E2.11	E2.22	F4.22	D5.21		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
21	E2.11	E1.28	F4.21	D5.21	D4.1H	G3.1D	G1.63	G4.6	I1.1	FB	X08	G5.62
22	E2.11	E3.51	F4.11	D5.21	D5.21	G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
23	E2.11	E3.51	F4.11	D5.21	D5.21	G3.42	G1.63	G4.5	I1.1	FB	X08	G5.62
24	E2.11	E3.51	F4.11	D2.3D		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
25	E2.11	E1.72	F4.262	D5.21	D5.21	G3.42	G1.87	G4.8	I1.1	FB	X08	G5.62
26	E2.11	E1.72	F4.262	D5.21		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
27	E2.11	E1.28	F4.262	D5.21		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
28	E2.11	E2.22	F4.11	D5.21	D5.3	G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
29	E2.11	E2.22	F4.11	D5.21	D5.3	G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
30	E1.23	E1.23		D5.21	D5.21	G3.1C	G1.61	G4.6	I1.1	FB	X08	G5.62
31	E2.11	E1.72	F4.262	D5.21	D5.3	G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
32	E2.11	E1.72	F4.262	D5.21		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
33	E2.11	E1.72	F4.22	D5.21	D5.21	G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
34	E2.11	E1.93	F4.262	D5.21		G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
35	E2.11	E1.28		D2.3D		G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
36	E2.11	E2.22	F4.262	D2.3D		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
37	E2.11	E2.22				G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
38	E2.11	E3.43				G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
39						G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
40	E2.11	E2.22	F4.262	D2.3D		G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
41	E2.11	E2.23		D2.3D		G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
42	E2.11	E2.22	F4.262	D2.3D	D5.21	G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
43	E2.11	E3.43	F4.262			G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
44	E2.11	E2.23	F4.262			G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
45	E2.11	E2.25	F4.262	D2.3D		G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
46	E2.11	E2.25	F4.262	D2.3D	D5.21	G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
47	E2.11	E2.23	F4.262		D5.21	G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
48	E2.11	E3.43				G3.42	G1A.16	G4.71	I1.1	FB	X08	G5.62
49	E2.11	E1.26	E3.41	D5.21		G3.1C	G1.66	G4.6	I1.1	FB	X08	G5.62
50	E2.11	E1.27	E3.41	D5.21		G3.1C	G1.66	G4.6	I1.1	FB	X08	G5.62
51	E2.11	E2.23	E3.41	D5.21	D4.1H	G3.1C	G1.66	G4.6	I1.1	FB	X08	G5.62
52	E2.11	E4.51	E3.41	D5.21	D4.1H	G3.1D	G1.66	G4.6	I1.1	FB	X08	G5.62
53	E2.11	E2.23	E3.41	D5.21	D5.21	G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
54	E2.11					G3.1C	G1.66	G4.6	I1.1	FB	X08	G5.62
55	E2.11	E2.23	F4.21	D5.21	D5.21	G3.1D	G1.61	G4.6	I1.1	FB	X08	G5.62
56	E2.11	E4.51	F4.21			G3.1D	G1.63	G4.6	I1.1	FB	X08	G5.62
57	E2.11	E2.23	F4.21	D5.21		G3.1C	G1.61	G4.6	I1.1	FB	X08	G5.62
58	E2.11	E3.43	F4.21			G3.1C	G1.63	G4.6	I1.1	FB	X08	G5.62
59	E2.11	E4.51	F4.21	E3.43	D5.21	G3.1D	G1.63	G4.6	I1.1	FB	X08	G5.62
60	E2.11	E2.23	F4.21	D5.21		G3.1C	G1.61	G4.6	I1.1	FB	X08	G5.62
61	E2.11	E2.23	F4.21	D5.21	D5.21	G3.42	G1.87	G4.8	I1.1	FB	X08	G5.62
62	E2.11	E2.23	F4.21			G3.1C	G1.61	G4.6	I1.1	FB	X08	G5.62
63	E2.11	E2.23	F4.21	D5.21	D5.3	G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
64	E2.11	E3.43	F4.21	E3.43		G3.1C	G1.65	G4.6	I1.1	FB	X08	G5.62
65	E2.11	E4.51	F4.21			G3.1C	G1.65	G4.6	I1.1	FB	X08	G5.62
66	E2.11	E4.51	F4.21			G3.1C	G1.65	G4.6	I1.1	FB	X08	G5.62
67	E2.11	E4.51				G3.1C	G1.65	G4.6	I1.1	FB	X08	G5.62
68	E2.11	E4.41	E3.41	D5.21	D5.21	G3.1B	G1.66	G4.6	I1.1	FB	X08	G5.62
69	E2.11	E4.43	E3.41			F2.41	G1.66	G4.8	I1.1	FB	X08	G5.62
70	E2.61	E1.72	F4.262	D5.21	D5.21	G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
71	E2.61	E1.93	F4.22	D5.21		G3.42	G1.91	G4.4	I1.1	FB	X08	G5.62
72	E2.11	C3.21	E3.52	C3.21	D5.21	G3.E6	F4.22	G4.8	I1.1	FB	X08	G5.62

Using CORINE Land-Cover and Statistical Data for the Assessment of Soil Erosion Risks in Germany

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Abstract

Detailed geo-referenced information about current land use is essential for estimating the impact of management and cultivation on processes like soil degradation or carbon sequestration. Land-use maps can be created by combining statistical data about crop growth on arable land and the CORINE land-cover map. Further the inter-comparison of statistical and CORINE land-cover data allows the controlling of the quality and consistency of the data. In this paper we present a method to distribute statistical data for creating land-use maps, discuss the quality of the data, describe a method to modify land-cover maps based on the concept of the 'most-likely' land-use, and discuss results of calculating soil erosion risks for Germany.

1 Introduction

Detailed information about land use and land-use change is essential for estimating soil degradation risks, carbon sequestration and other processes which are related to the management and cultivation of land. Soil erosion for example strictly depends on the management of arable land. It is irreversible and shows a significant impact on the productivity of cultivated land, on natural soil functions, on the eutrophication of surface water and neighbouring biotopes and consequently has economic impacts. As a first step in the country wide assessment of physical soil degradation, accurate information about management related impacts on erosion is required.

The CORINE land-cover map delivers detailed information about the spatial distribution of land-cover classes but does not specify the crop type grown on arable land. Therefore CORINE land-cover was combined with statistical data of crop growth distribution per administrative unit. The resulting land-use map allows the assessment of actual land-use related soil erosion risk for Germany on a very detailed level.

2 Methods

Before creating land-use maps CORINE land-cover data was compared with the ‘land survey statistics’ of the year 1996 (StBA, 1997). To reduce differences in land-cover GIS based algorithms were developed for converting land-cover classes. Conversion rules are based on probabilities of the ‘most likely’ land-cover class defined by the underlying environmental conditions as listed in Table 1. Land-cover classes were converted according to the differences between CORINE and the ‘land survey statistics’ district by district and according to the availability of other convertible land-cover classes. All calculations were performed on 250 x 250m grid cells.

Tab. 1: Criteria for the conversion sequence of land-cover classes according to the ‘most probable’ land cover for improving the representation of arable land (simplified scheme according to Erhard et al., 2002).

Step No.	***CORINE land-cover class***		***Criteria for conversion per administrative district***
	From	To	
1	All ‘non-forest’ land cover classes[1)]	Urban areas and settlements	Nearest neighbourhood: Cell is converted to urban area if majority of cells within a 3 x 3 cell matrix is covered by settlements
2	Mixed classes (forest and/or arable land and/or grassland)	Forest or arable land or grassland	Maximum likelihood: Most probable land-cover due to soil quality, elevation, slope, aspect, groundwater table, annual mean temperature
3	All land cover classes[1)]	Traffic (streets railways)	Conversion in proportion to the fraction of each land cover class per administrative district
4	Wetlands	Grassland	Cells with maximum depth of groundwater table
5	Grassland	Arable land	Overlay: valuation index of the field (German soil taxation index), slope < 7° (- 15°)[2)], groundwater table (> (20 cm -) 80 cm, mean annual temperature >(6° -) 8° Highest values on a relative scale 0-100 per administrative district were converted to arable land

1. except water bodies, barren land and coastal areas
2. values represent standard limits, values in brackets are only used if no grassland was available for conversion within these standard limits

The modified land-cover map was then used to distribute the crop statistics per administrative district (StBA, 1999) on the class ‘arable land’. Instead of fixed crop rotations, crop data were distributed randomly to simulate crop rotation according to the statistical data.

Soil erosion risk per grid cell of arable land in relation to soil conditions (K-factor), slope (LS-factor), rainfall erosivity (R-factor) and land-use (C and P-factor) was calculated for Germany with the Universal Soil Loss Equation (USLE; Wischmeier & Smith 1978; see Figure 1). For Germany, empirical USLE-parameters from Schwertmann et al. (1987; LS-, P- and C-factor) and Sauerborn (1994, R-factor) where used. The K-factor per soil unit and the spatial distribution of the soil units were provided by the Federal Institute for Geosciences and Natural Resources (BGR). For climate and phenology, data from the German Weather Service was available (DWD, 2001). The Cropping (C-) factor was then calculated, combining empirical values of the USLE equation, phenological data - to estimate the length of the cultivation period for the crops - and the mean value of 12 iterations of the land-use maps with randomly distributed crop statistics.

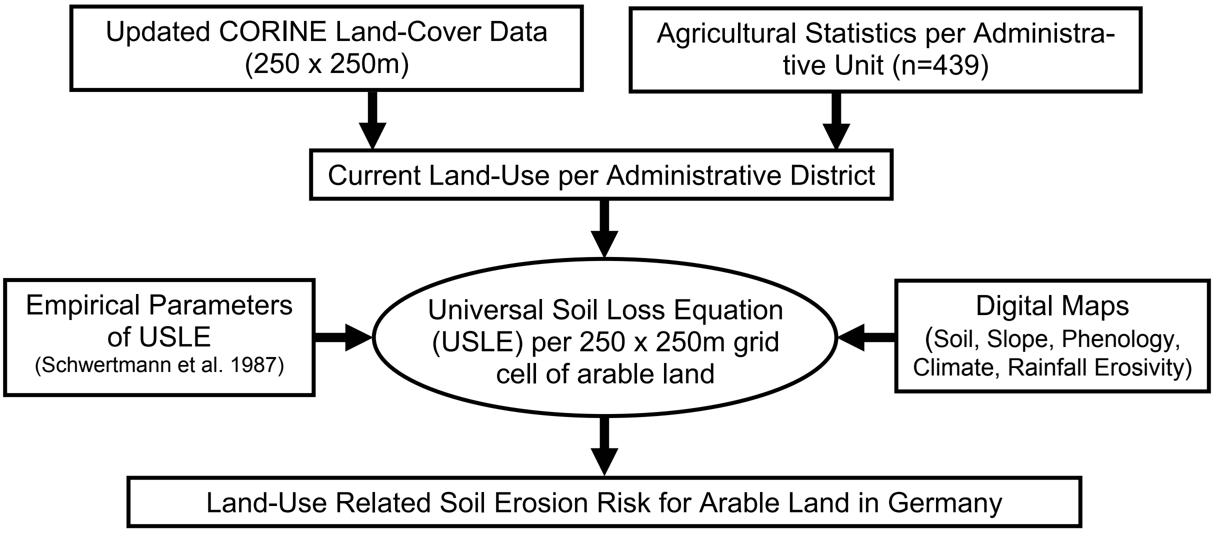

Fig. 1: Flow chart for calculating land-use related soil erosion risk in Germany.

Land and soil management mainly affect the soil conservation (P) and cropping (C) factor of the equation. The method allows to study the impacts of different land-use and management strategies on soil erosion and delivers relative trends according to changes in land-use and management on regional level. This is needed for large scale (national and European) integrated assessments focusing on the protection of soil functions, impacts on water quality and their relation to agricultural policies. These assessments could back up the development of respective indicators for reporting on the state of the environment and the review on areas at risk.

3 Results

About 138.000 km^2 or 39 % of the area in Germany are used as arable farm land (Table 2). The comparison of CORINE and 'land survey' data shows a significant overestimation for arable land (about +5.000 km^2) but an underestimation for grassland (about -18.000 km^2), urban areas (-3.000 km^2), and water bodies (-4.000 km^2) in the CORINE land-cover map including a total difference in both data sets of 6.600 km^2 or 1,9%. The underestimation of grassland may be explained by errors in the classification of satellite data. Most of the remaining discrepancies might be related to the lack of linear elements such as streets, rail tracks and small rivers in CORINE. Further units with areas less than 0,25 km^2 are not recorded in CORINE. This might also contribute to the differences between both data sets, especially in areas with high landscape fragmentation. By applying the algorithms for land-cover conversion the overall differences could be reduced significantly (Table 2) especially for arable land, grassland and forests. Nevertheless in many cases there are distinct differences left between both data sets mostly in the small administrative units. In most cases these are larger cities where the fraction of 'non-urban' land-cover is very small and therefore not enough land is available for conversion. These districts also include the land-cover classes with the highest errors (see Table 2, urban area, orchards and water). Figure 2 shows the remaining differences for arable land and forests. The coincidence between both data sets increases with the size of the administrative units which is also correlated with an increasing fraction of 'non-urban' areas in these districts.

duce the input of soil material and nutrients into the water bodies of a certain catchment. These values are very sensitive to the accuracy of the 'land-cover' classes depicted in the underlying land-cover map and in this example also dependent on the size of the administrative units. Large districts with high amounts of arable land can show high erosion rates even if average rates per hectare are small. This can be seen in the map of the cumulative values of actual erosion risk per administrative district (Fig. 4). Because large proportions of land are used as arable land, values of cumulative erosion are relatively high in the northeast and the northwest of Germany. In contrast values are relatively low in large parts of the mountainous areas, where the actual erosion risk per hectare is high but the area of arable farmed land is small because of unfavourable growing conditions for crops in these areas.

As result digital maps of actual erosion risk in high spatial resolution are available for Germany and can be applied for monitoring and reporting. The approach can be used to study potential impacts of changes in soil management as well as changes in crop rotation on the soil erosion rate. Target values, e.g. maximum tolerable erosion rates per administrative district can be defined. In scenarios measures can be studied to achieve these targets at its best. However, the numbers presented here demonstrate how land management can affect soil erosion by water. The absolute values strictly depend on the temporal and spatial resolution of the input data especially on the spatial resolution of the elevation data. Therefore the quality of the input data is crucial if absolute values are discussed and targets are defined.

4 Conclusions

In general the presented method for generating land-use maps can be used to derive input parameters for all land-use related processes where information from statistics and geographical distribution of land cover needs to be combined (e.g. to evaluate the increase in built up areas) as well as for the estimation of uncertainties in the data sets.

CORINE delivers land cover data in high spatial resolution and classification. Therefore and because if its availability at very low costs it can be considered as the best available land-cover data set for investigations on sub-national up to pan-European scale. Nevertheless the systematic underestimation of urban areas, water bodies and grassland combined with the overestimation of arable land, the missing of linear structures and elements with an area of less than 0,25 km^2 restricts the use of CORINE data especially for water and nature protection related issues. This is also the case for the carbon accounting related to the ‘Kyoto - protocol’.

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CORINE land cover in the context of soil erosion assessment at a regional scale

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Abstract

Soil erosion is a complex process determined by mutual interaction of numerous factors. The aim of erosion research at regional scales is a general evaluation of the landscape susceptibility to soil erosion by water, taking into account only main factors influencing this process. One of the main factors influencing the susceptibility of a region to soil erosion is land cover. This study describes the soil erosion assessment of Slovakia at a regional scale (1:500 000) using the USLE model and the CORINE land cover (CLC) database. The land cover/management factor (C factor) was derived from the CLC database by assigning the individual classes the appropriate value. In the second step, the C factor values for arable land (class 211) were refined using statistical data on the mean crop rotation and the acreage of particular agricultural crops in the districts of Slovakia.

1 Introduction

Soil erosion by flowing water on slopes is a complex process determined by mutual interaction of numerous factors. Recent developments in methodological approaches, hardware and software integrated into geographic information systems (GIS) allow to model soil erosion at different scales and levels of complexity. To assess the environmental risk of soil erosion, extensive data sets are necessary, describing both natural conditions and human activities in the landscape.

The aim of erosion research at **regional scales** is a general evaluation of the landscape and its susceptibility to soil erosion, taking into account only main factors influencing the process. Therefore, the erosion assessment at regional scale is usually based on empirical models or expert evaluation. Results of this assessment are maps showing areas with varying susceptibility to the soil erosion.

In the 1990s the development of computer and GIS technology as well as emerging availability of comprehensive GIS databases (relief, soil, land cover) enabled to apply formalised assessments based on empirical models. The mostly applied model is the USLE (Wischmeier and Smith, 1978), and its modifications. The model combines factors describing relevant landscape properties influencing soil loss. Some of these properties can be mapped using remote sensing techniques and converted to USLE factors in GIS (see Bocco, Valenzuela, 1988; Lantieri et al., 1990; Pilesjö, 1992, Šúri et al. 1997b). For example, Briggs et al. (1992) report such a project for Mediterranean regions of the European Communities. This project is cited also as a first large-scale application of the CORINE land cover database that is presently already covering the territory of most European countries (see Heymann et al., 1994).

The objective of this study is to describe a methodology of soil erosion assessment of the territory of Slovakia (49 030 km^2) at a regional scale (1:500 000) using modified USLE model, the CORINE land cover (CLC) and GIS.

2 The soil erosion assessment approach

The assessment of soil erosion is based on principles defined by the Universal Soil Loss Equation (USLE, Wischmeier, Smith, 1978). This model and its modifications (e. g. RUSLE, Renard et al., 1997) are still widely applied in many countries, including Slovakia, for local scale studies. A set of experiments was done to adapt this model to the geographical conditions of the Czech and Slovak Republics (see e.g. Pasák et al., 1983; Alena, 1991). As this model is developed for erosion assessment at local scale, some modifications are necessary, to be applied at regional level, because of lower information content of available data. The assessment of the actual soil erosion (E_A) for whole Slovakia was based on the following formula:

$$E_A = R.K.L.S.C \qquad (1)$$

The input parameters (factors) refer to:

R *rainfall erosivity* computed as the total kinetic energy of a given rainfall event multiplied by its maximum 30-minute intensity

K *soil erodibility* that is function of soil properties - soil texture in our case;

L.S *potential of relief* computed from slope length (L) and steepness (S);

C *land cover/management* that takes into account differences in density and structure of the vegetation cover, reflecting its protective influence and also the methods of land management.

A detailed description of these factors can be found in many papers. We derived the R, K, L.S factors using the methodology described in (Šúri et al., 2002).

3 CORINE Land Cover database

Land cover/management (C factor) was determined from the CLC database and agricultural statistical data describing crop percentage and rotation for given spatial units.

The CLC database is not primarily meant for soil erosion modelling, therefore the determination of the C factor is not straightforward. We have considered several issues influencing assignment of the appropriate C factor values. Among the most important were the minimum area of a mapping unit and heterogeneity of individual CLC classes (e.g. 242, 243, 324) in respect to soil erosion.

Tab. 1 Land cover/management (C factor)

Land cover/ management	C factor	CORINE land cover classes	Area	
			[km^2]	[%]
High	0.001–0.010	14x, 231, 31x, 32x, 41x	23 566.7	48.0
Moderate	0.100	243	5 115.1	10.4
Low	0.165–0.335	211, 242	16 967.6	34.6
Very low	0.350–0.550	22x, 333, 334	439.5	0.9
Not considered	-	11x, 12x, 13x, 331, 332, 51x	2 959.1	6.0
Total			49 048.0	100.0

About 48% of the country has land cover with high soil conserving efficiency (forests) that mostly coincides with areas having high potential erosion risk (Table 1). This means that uncontrolled timber exploitation or forest degradation by pollution can create conditions for very severe erosion that can result in complete soil loss. On the other hand, in Slovakia there is a high percentage of areas with land cover having very low soil conserving efficiency (34%). Part of this land is situated in flat plains, where the water erosion is not active, but large portion of them is situated in regions with high potential erosion risk with respect to natural conditions, where the inadequate cultivation approaches or crop rotations result in accelerated soil erosion.

5 Conclusions

As regards to the future progress in the regional soil erosion assessment, the important steps should be done in improvement of those primary datasets that are not available in the required scales and quality. The contemporary activities related to the land cover mapping are a challenge to refine the scale and temporal variability of the C factor. One of the first experimental attempts to map land cover at a scale of 1:50 000 using the CLC nomenclature at the 4th level is reported by Feranec, Oťaheľ (1999). The temporarily changing landscape processes could be monitored by periodically updated land cover data. At present the two land cover databases are available for the whole country, representing late 1970s and early 1990s respectively (see Feranec et al, 2000) and in the 2004 the CLC2000 database representing the state of the landscape in the year 2000 will be available. The data on crop rotation for arable land can be updated from statistical yearbooks. The availability of these data as well as the prospective new mapping activities enable to improve assessments of changes in actual soil erosion. In European Union, the project CLC2000 is putting a good base for monitoring the state of landscape and makes precondition for assessment of environmental risks such as soil erosion. The CLC database prepared by unified approach for whole Europe serves important prerequisite for environmental risk assessment in the pan-european context, allowing also comparisons among different countries.

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Evaluating considerations of CORINE Land Cover usage for reporting obligations on Kyoto LULUCF

Part one: Monitoring Requests Arising by the Kyoto Protocol

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Abstract

In the first part of the presentation, the reporting and monitoring requests arising by the Kyoto protocol are described.

Annex I (industrialised countries) have strict reporting obligations under both the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP). Only the latter ones will be described. Article 3.3 and 3.4 of the Kyoto Protocol contain provisions on how to utilise land use, land use change and forestry (LULUCF) activities for meeting the commitments of an Annex I country under the KP.

Article 3.3 covers net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human induced land use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990. Article 3.4 opens the door for inclusion of additional human induced activities, related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land use change and forestry categories. Definitions and modalities on how to implement Art.3.3 and 3.4, are covered in the Marrakech Accords (MA).

Definitions and modalities for afforestation and reforestation project activities under the Clean Development Mechanism (CDM) were recently decided at the ninth Conference of the Parties to the UNFCCC (COP9) in December 2003. Those definitions and modalities take into account the special features of sinks resulting from LULUCF activities such as non permanence of CO_2 removals, uncertainties in respect to monitoring those removals, difficulties in proving direct human induced influence of the carbon stock change and additionality of the activities.

The provisions of both the MA and of COP 9 with regard to LULUCF activities are explained.

1 Introduction

Sinks are mentioned in several articles of the United Nations Framework Convention on Climate Change (UNFCCC). The definition is given in Art.1.8 where it states: “sink” means any process or activity or mechanism which removes a greenhouse gas (GHG), an aerosol or a precursor of a GHG from the atmosphere.

In the Kyoto Protocol (KP, Art.3.3, 3.4) Parties were allowed to use only those sinks which result from direct human-induced land use, land-use change and forestry activities(LULUCF) for meeting their commitments.

The Marrakesh Accords (MA) enclose provisions on allowed LULUCF activities and their definitions and modalities. The last gap of provisions was closed recently at the ninth session of the Conference of the Parties in December 2004, where rules and procedures for afforestation and reforestation activities in the Clean Development Mechanism (CDM) were adopted.

This paper will concentrate on the provisions of the MA and the deduced reporting obligations for LULUCF activities which are relevant for CORINE land cover issues.

2 Provisions of the MA

The commitment of the Annex I Parties as formulated in Article 3.1 of the KP aims at *reducing* the overall emissions of GHG's by at least 5% below 1990 levels in the commitment period 2008 to 2012. In the negotiation process in Kyoto 1997 this commitment target was already fixed before the decision was taken, on how to utilise LULUCF activities in order to meet the commitments of Annex I Parties. Those decisions were discussed and adopted under time and the pressure to succeed. When the decisions of the KP were analysed later it turned out that the scale of the allowed LULUCF activities have the potential to undermine the KP. The unlimited use of LULUCF activities would have been generated so many carbon credits, making policy and measures of Parties in the energy sector superfluous. In other words, no reduction in GHG emissions would have encouraged, what is in fact the aim of the KP. To reduce the amount of potential LULUCF credits the provisions for LULUCF activities of the MA became rather complicated, for instance; several activities are distinguished, Parties are allowed to choose single activities, and different caps are introduced with strong implications to the monitoring rules and obligations.

2.1 Land use, land-use change and forestry (Decision 11)

The basic provisions for LULUCF activities are contained in the Annex to decision 11 of the seventh Conference of the Parties (FCCC/CP/2001/13/Add.1). Only those ones with implications to monitoring duties are mentioned and explained.

First of all the treatment of LULUCF activities is governed by eight principles from which the following four are important for monitoring and reporting GHG emissions and removals:

- Sound science is the basis,
- Consistent methodologies are used over time for the estimation and reporting,
- Reversal of any removal is accounted for at the appropriate point in time,
- Removals resulting from: elevated carbon dioxide concentrations above the pre-industrial level; indirect nitrogen deposition; and the dynamic effects of age structure resulting from activities and practices before the reference year have to be factored out.

Forest is defined as a minimum area of land of 0.05-1.0 ha with tree crown cover of more than 10-30% with trees with the potential to reach a minimum height of 2-5 m at maturity *in* *situ*(for complete definition see decision 11). Each Party has to select single values for the above ranges for the first commitment period and shall justify that such values are consistent with the information that has been historically reported.

Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forest.

Reforestation is the direct human-induced conversion of non-forested land to forested land on those lands that did not contain forest on 31 December 1989.

Afforestation, reforestation and deforestation activities that meet the requirements of the decision 11 and which started on or after 1 January 1990 and before 31 December 2012 have to be reported by any Annex I country(Article 3.3 KP).

Revegetation, management of forest, cropland and grazing land are activities that might be chosen to account for by Annex I Party (Article 3.4 KP). It has to be demonstrated that such activities have occurred since 1990 and are human-induced and not already accounted for under Art.3.3. All 3.4 activities except for forest management shall be accounted on a net-net basis (emissions and removals of GHG's in the base year times five, minus emissions and removals of GHG's in the commitment period). Forest management activities are accountable only up to an individual cap for each Party. Article 3.4 activities are not mandatory, countries have to decide which activities, if any, they will elect to account for prior to 1 January 2007.

Generally, five pools have to be reported: above-ground biomass, below-ground biomass, litter, dead wood, and soil organic matter. If it can be demonstrated that a certain pool is not a source this pool can be excluded from accounting. It has to be ensured that areas of land subject to LULUCF activities are identifiable. Once land is accounted for under Art.3.3 and 3.4, emissions and removals of GHG's on this land have to be accounted forever.

Project based LULUCF activities under Article 6 of the KP (Joint Implementation) are subject to the same rules as outlined above and those adopted for Art.6 in general (Decision 17/CP7).

For project based activities under Article 12 of the KP (Clean Development Mechanism), definitions and modalities were adopted recently at COP9 in Milan, December 2003. Activities are limited to afforestation and deforestation activities only, where the same definitions for afforestation and deforestation apply as for Annex I countries. The general provisions for Art. 12 activities (Decision 17) are valid also.

For all project based LULUCF activities, the establishment of baselines, the identification of leakage, the monitoring of actual changes in carbon stocks and GHG's, and the validation that there was no removal of carbon to the atmosphere for the verification and certification report every five years are challenging tasks for monitoring procedures as well.

2.2 Guidelines for reporting

The guidelines for reporting as required under Article 7 of the Kyoto Protocol are contained in the annex of the Decision 22, document FCCC/CP/2001/13/Add.3. This document deals with all information requirements following from the provisions of the MA. The provisions regarding LULUCF requirements can be found in paragraphs 5 to 9. The supplementary inventory information to be reported for LULUCF activities under the Kyoto Protocol is listed in table 1 below.

Particular attention should be paid to the following:

- The obligation to provide information that allows the identification of the areas of land subject to LULUCF activities under Art.3.3 and 3.4 is unique for Kyoto reporting only. For that aim the geographical location of the boundaries of the areas in question has to be given. The wording in the MA intentionally doesn't ask for geo-referenced data. That means that other methods which allow the clear identification of areas of land like reporting procedures with exact geographical designation, existing cartographic maps or others are permitted to be used too.
- For management of cropland, grazing land and for re-vegetation, anthropogenic GHG emissions by sources and removals by sinks for each of the elected activities have to be given as well as the identifiable geographical location of each of the elected activity for each year of the commitment period and for the base year because of the decision of the net-net accounting regime. In particular, the need for reliable and complete data for the base year (mostly 1990) poses some difficulties for Annex I countries as historical data may not be sufficiently available in the necessary quality.
- Obligatorily, Parties have to report on GHG emissions and removals of Article 3.3 activities. GHG emissions and removals of Article 3.4 activities have to be reported only if a Party decided to account for any Article 3.4 activity.

2.3 Good practice guidance for LULUCF (GPG for LULUCF)

The GPG for LULUCF was elaborated as a response to the invitation of the UNFCCC to the Intergovernmental Panel on Climate Change (IPCC) in Decision 11 of the MA.

This guidance is valid for UNFCCC reporting and KP reporting obligations. It encompasses five chapters, where chapter 4 deals with the supplementary information of the KP reporting obligations. This chapter is closely linked to chapter 2 which gives the basis for consistent representation of land area and chapter 3 which provides guidance on the estimation of GHG emissions and removals for the LULUCF sector. Also knowledge of chapter 5 is needed which describes the cross referencing issues like uncertainties, quality assessments, recalculation inter alia.

Six land use categories are distinguished which are forest land, cropland, grassland, wetlands, settlements and other lands. These areas of land use and also the areas of land-use changes have to be indicated. Annual census, periodic survey and remote sensing are possible methods to obtain area data.

Common reporting format tables for UNFCCC reporting were adopted at COP9 in Milan, December 2003(FCCC/SBSTA/2003/L.22/Add.1), the tables for KP reporting will be further considered at the next meeting of the Subsidiary Body for Scientific and Technical Advice in 2004.

Tab. 1: Supplementary information to be reported for the annual GHG inventories during the first Commitment Period according to the Marrakesh Accords (MA)

Information to be reported	*Detailed information*	**Reference in MA**[3]
Approach for geographical location and identification of units of land	Geographical location of the boundaries of the areas that encompass units of land subject to activities under Article 3, paragraph 3 and 4	6 (b)
Description of methodologies used for estimation of GHG emissions and removals	Methodologies given in the IPCC Guidelines on LULUCF, and the principles of the draft decision /-/CMP.1 (LULUCF) should be used and reported including reporting method for lands subject to Articles 3.3 and 3.4, the approach(es) used for land identification, and the tier level(s). National approaches, models, parameters and other related information should be described transparently. The assumptions and methodologies used should be clearly explained to facilitate replication and assessment of the inventory.	See 6 (a)
Justification when	Information on which, if any, of the following pools: above-ground biomass, below-ground biomass, litter, dead wood and/or soil organic carbon were not accounted for, together with verifiable information that demonstrates that these unaccounted pools were not a net source of anthropogenic greenhouse gas emissions.	6 (e)
Changes in data and methods	Any changes in data or methodology since the report of the previous year.	10
Other generic methodological issues	Any additional relevant information on methodological issues, such as measurement intervals, disturbances, inter-annual variability	
Article 3.3 specific information	Demonstration that activities, began on or after 1 January 1990 and before 31 December of the last year of the commitment period, and are directly human-induced; How harvesting or forest disturbance is distinguished from deforestation; For good practice, size and geographical location of forest areas that have lost forest cover but which cannot be classified as deforested.	8 (a) 8 (b)

[3] Entries in this column refer to relevant paragraphs of document FCCC/CP/2001/13/Add.3, pp.21-29.

Article 3.4 specific information	Demonstration that activities, have occurred since 1 January 1990 and are human induced	9 (a)
Estimates for GHG emissions by sources and removals by sinks	For Art. 3.3 activities, and elected Art. 3.4 activities, for all geographical locations in the current and previous years, since the beginning of the commitment period or the onset of the activity, respectively, and for Art. 3.4 activities others than forest management estimates for the base year too, excluding emissions reported under the Agriculture sector of the IPCC Guidelines.	See 6(d) 9 (b)
Uncertainty of emission and removal estimates	Within levels of confidence as elaborated by any IPCC good practice guidance	6(d) footnote 5

3 Conclusions

The LULUCF provisions of the MA pose additional reporting obligations in comparison to UNFCCC reporting needs; the areas of land subject to LULUCF activities have to be identifiable, the land use categories in 1990, the land use categories and land-use changes in 2008 to 2012 have to be identified and reported as well as the GHG emissions and removals in 1990 and in the commitment period on areas subject to management of cropland, grazing land and re-vegetation if elected.

Annex I Party therefore will assess the data availability and quality, research needs, monitoring cost for such reporting as well as the amount of the carbon sequestration of the activity in question before deciding to account for any Article 3.4 activity.

References:

United Nations Framework Convention (1992)

Kyoto Protocol (1997)

Marrakesh Accords FCCC/CP/2001/13/Add.1,2,3; www.unfccc.de

FCCC/SBSTA/2003/L.27; www.unfccc.de

FCCC/SBSTA/2003/L.22/Add.1; www.unfccc.de

Good Practise Guidance for Land Use Land-Use Change and Forestry (2003), Draft will be published by IPCC

Evaluating considerations of CORINE Land Cover usage for reporting obligations on Kyoto LULUCF

Part two: Considerations of monitoring and reporting procedures on soil carbon stock inventories

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Abstract

CLC data were used to calculate soil carbon stock changes in agricultural soils due to land use and land use change (LULUC) to fulfil the international reporting duties of Germany according to the United Nations Frame Work Convention on Climate Change (UNFCCC 1992). The potential of and the requirements on land use and land cover data information will be discussed in comparison with the results of soil survey, "Main Statistics of Land Use" and the "Survey of Area by Actual Use". Considerations on the practical application of CLC data due to monitoring and reporting procedures are discussed.

1 Introduction

To report Land use and Land use change (LULUC) - activities under the United Nations Framework Convention on Climate Change (UNFCCC 1992), articles 3.3 and 3.4 of the Kyoto Protocol (1997) and the European Union directive (2003), the development, composition and establishment of soil carbon stock inventories, reporting structures, methods for estimation, measurement and monitoring of LULUC-activities are necessary. This is done in the context of the research project "Development of a transaction procedure for a continuous monitoring and report system on soil organic carbon in agricultural soils due to Land use and Land use change (LULUC), suitable to fulfil the international reporting duties of Germany on soil carbon stock changes", sponsored by the Federal Ministry of Consumer Protection, Food and Agriculture of Germany. The most important part of this task is to report on emissions and removals of CO_2 in soils associated with land use, land use change and management.

Main job is the generation of a suitable data base system. In order to calculate the changes in soil carbon stocks due to land use change, topographical, climatical and physical soil parameters must be considered. Information on land - use (for example cropland, grassland, forest, orchards etc.), management (full tillage, no tillage etc.) and Input factors (manure, plant residues etc.) for the whole agricultural area of Germany must be collected and updated annually. These reference and specialist data must be georeferenced and digitized in order to be ready for subsequent calculations. All changes in land - use have to be tracked to detect the effect on associated soil organic carbon. Additionally the data base system must contain analytical functions for the detection of changes in land - use activities and models for calculation of subsequent carbon stock changes. Last but not least a comprehensive archive is needed for complete and consistent documentation of all calculations and reports. Additionally the reporting instructions of the Intergovernmental Panel on Climate Change (IPCC 1996) require continuous improvement, update, review and validation of the reporting system. Therefore periodical carbon monitoring is needed.

While the establishment, adjustment, adaptation and implementation of permanent mechanisms and methods is still under work, this year Germany reports for the first time on the Report Sector LULUC. CLC – data were used herein. At present the usage of CLC-data is the only possibility to get georeferenced and digitized land - use data covering whole Germany. This paper reports on experiences using CLC-data in the context of the rules and reporting instructions of the conventions presented above. Potentials, gaps and needs will be shown.

2 Methods

To assign soil units to land classification and administration units, the CORINE Land Cover Data were unified with the German soil map BÜK 1000 (BGR 1997) and a map of county borders. Soil carbon stocks were derived from each resulting unit, due to soil properties and land use. The results were than summarized on county level. Six land use categories are claimed by the reporting instructions at least: forest, cropland, grassland, wetlands, settlements and other land, with some subcategories for example, orchards, vineyards, pastures, meadows etc. These categories are covered by the CORINE Land use classes 1 – 5 (level 1 – 3).

To validate the CLC - data and ascertain land use changes we compared the CLC-data with the results of two official statistical surveys: "Main Statistics of Land Use" (Statistisches Bundesamt 2000) and the „Survey of Area by Actual Use" (Statistisches Bundesamt 2002). Encompassing whole Germany, these surveys are carried out every 4 years. In the intervening time results from 100.000 randomly estimated farms are used to gain this information. The results of all these surveys are not georeferenced and digitized. Additionally the results get aggregated on community level due to data protection legislation. The „Survey of Area by Actual Use" is based on the official land register and should represent the actual area under consideration. The "Main Statistics of Land Use" documents the area under agricultural use, fallow land, number of live stocks and grown field crops. As information is collected using the administrative affiliation of farmers and not the geographical position of their lands, a land use may be counted for an administrative unit which does not occur on its geographical location. Farms smaller than 2 ha are not contained in the class "Main Statistics of Land Use".

3 Results

Figure 1 shows, that the area of land-use classes documented by "Main Statistics of Land Use" are 8 – 10 % smaller compared to those documented by „Survey Of Area By Actual Use". This difference is a systematic error, resulting from the exclusion borders for small farms as mentioned above. In contrast, differences between CLC data and „Survey of Area by Actual Use" data are more heterogeneous. Obviously cropland and heterogeneous agricultural areas are overestimated by CLC – data while grasslands are clearly underestimated.

The sum shows, that the total agriculturally used area of Germany calculated from CLC-data is distinctly larger than that calculated from „Survey of Area by Actual Use“. It amounts to 216000 km^2 compared to 195000 km^2.

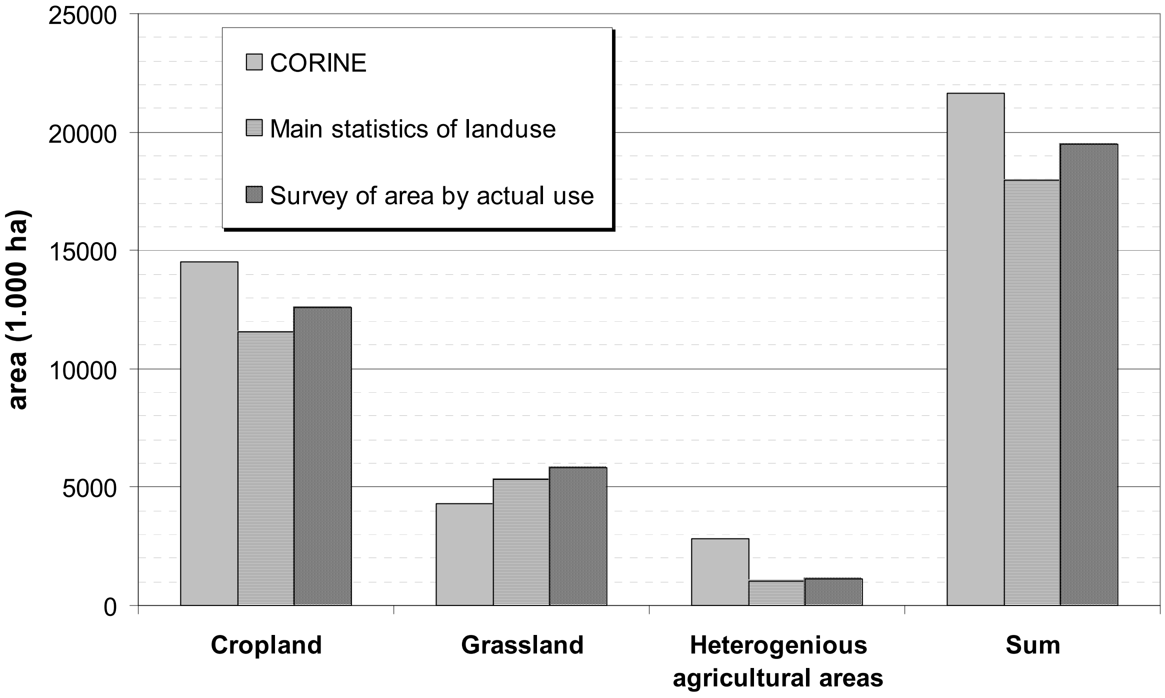

Fig. 1: CORINE land - use class areas compared to those from „Main Statistics of Land Use“ and „Survey of Area by Actual Use“ (areas in 1.000 ha)

Figure 2 elucidates these results and shows the effect on calculation of soil carbon stocks - cropland was overestimated by 15.5 %, heterogeneous agricultural areas by 152 %. Grassland was underestimated by 26 %. Related to soil carbon stocks the difference of the overall sum accounts for about 150 Mt C or 550.000 Gg CO_2 - equivalents approximately.

Another error bears on the detection of wetlands, referring to the reporting instructions. CORINE detects an area of about 1500 km^2 for wetlands, containing peat bogs and inland marshes. Compared to the results from the soil map BÜK 1000 (BGR 1997) a considerable underestimation of the area by a factor more than ten appears (Figure 3).

Organic soils under agricultural use emit CO_2 in great quantities due to peat mineralization as a result of drainage. The emissions from these soils account for 10.500 Gg C, corresponding to 38500 Gg CO_2 – Equivalents.

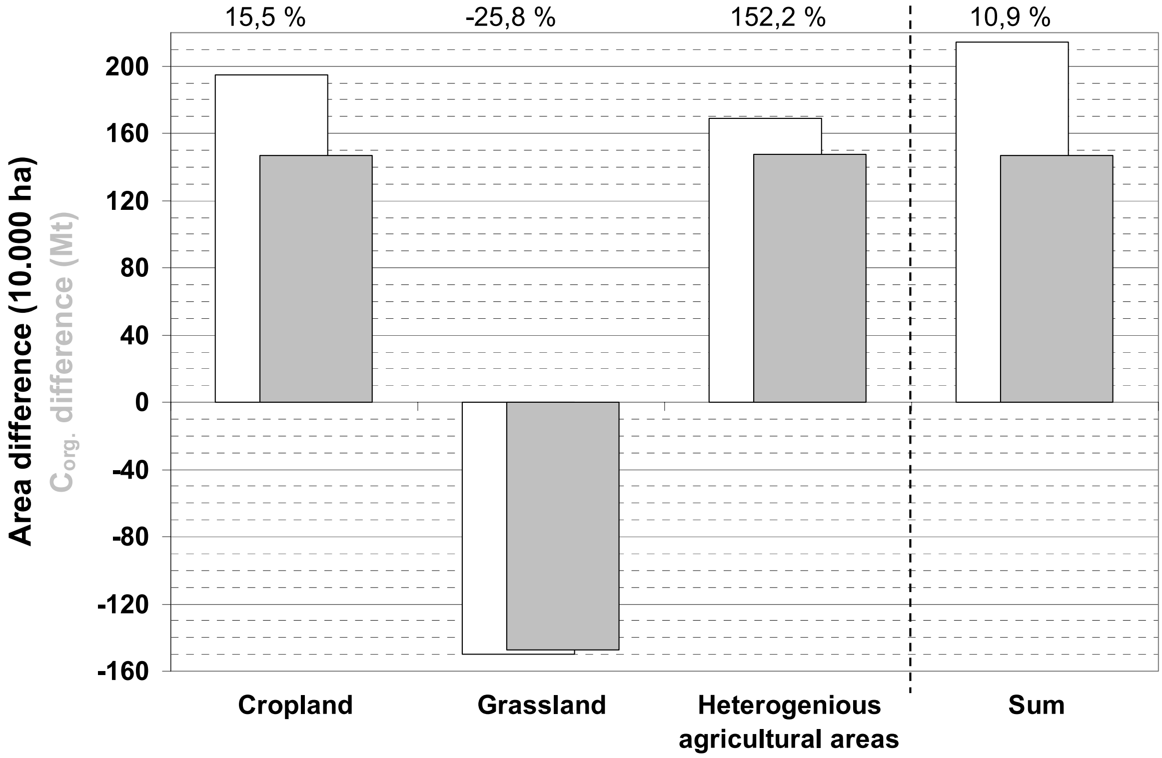

Fig. 2: CORINE land - use class areas compared to those from „Main Statistics of Land Use“ and „Survey of Area by Actual Use“ (areas in 1.000 ha).

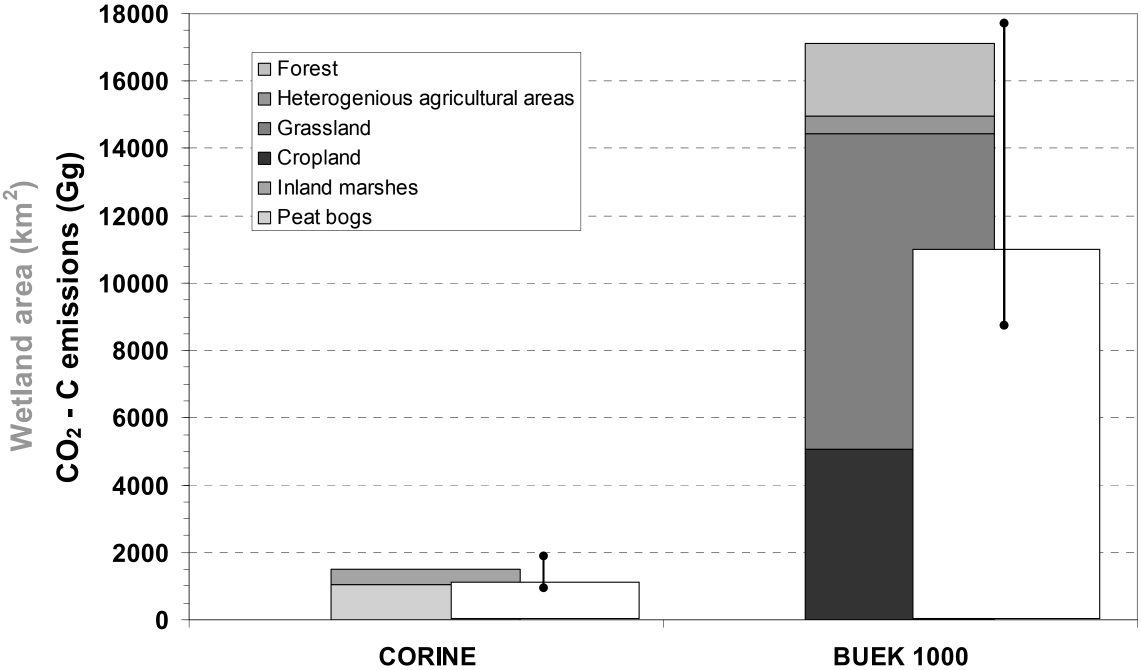

Fig. 3: CORINE wetland areas (km^2) compared to soil map BUEK 1000 (BGR 1997) wetland areas (km^2) and CO_2-C – emissions (Gg) from organic soils under agricultural use.

4 Discussion and Conclusions

The differences in soil carbon stocks mentioned above are considerably, only resulting from different methods to determine areas of different land use classes. The amount of 550.000 Gg CO_2 - Equivalents corresponds to about 55 % of the total German CO_2-Emissions (UBA 2003). This divergence is not acceptable. To meet the German commitments in the context of UNFCCC, Kyoto-Protocol and EU directive, a higher accuracy for the identification of land use classes is required. Additionally the spatial resolution must be improved i.e. for UNFCCC Tier 2 to at least 5 ha, for Kyoto (articles 3.3/3.4) to 0,05 – 1 ha (forest). These requirements are underlined by the results from the organic soils referring to their CO_2-emissions. The 38500 Gg CO_2 – equivalents account for nearly 4 % of the total German CO_2 Emissions. This amount qualifies these emissions to be a key source. A key source is subject to stronger requirements in reporting quality. This refers to spatial resolution and more detailed methods (higher tiers).

The error in determining the wetland area is due to the fact that most of the German peat lands are under agricultural use. Thus CORINE classifies them as croplands and grasslands. The CORINE standard methods of interpretation are more or less useful to differentiate cropland and grassland but they are not suitable for the determination of soil types. Therefore we need additional data to get the required information. In the context of Kyoto Protocol, UNFCCC and EU directive Parties are obligated to report annually. This does not imply a need for annual measurements. Participants are encouraged to develop systems that combine measurements, models and other tools that enables them to report on an annual basis. Therefore updates of the national CLC - data sets are needed; at least every 5 years. Commitment periods cover five years.

Final conclusions: In principle CLC-data comprise the required information referring to identification of land use classes in the context of UNFCCC, Kyoto Protocol and EU directive. No further land use classes are needed. But, if CLC – data should be used in future to cover LULUCF report needs a higher accuracy for identification is needed. Higher spatial (at least 1 – 5 ha) and temporal resolution (3 – 5 yr) are other essential requirements. Additionally auxiliary data and information are indispensable to fill the gaps e.g. the identification of wetlands respectively organic soils as well as management factors.

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1.2 Das Rahmenkonzept für das länderübergreifende Biosphärenreservat

Als Grundlage zur Verwirklichung der zentralen Zielsetzung und zur Entwicklung von Handlungsleitlinien ist für den vielgestaltigen, vielfältig genutzten Naturraum des Biosphärenreservates ein gutachtliches, rechtlich unverbindliches Rahmenkonzept zu erstellen. Aufgabe des Rahmenkonzeptes ist die Erstellung eines integrierten, länderübergreifenden Gesamtkonzepts zur nachhaltigen Entwicklung des Natur-, Kultur-, Erholungs-, Siedlungs- und Wirtschaftsraumes. Gemäß den Anerkennungskriterien des deutschen Nationalkomitees für das UNESCO-Programm „man and biosphere" (MAB) dient es insbesondere

- zur frühestmöglichen Integration der Ziele des Biosphärenreservates in der Landes- und Regionalplanung, der Landschaftsrahmen- sowie der Landschafts- und Bauleitplanung
- als Grundlage für die Erstellung von Pflege- und Entwicklungsplänen, zumindest für besonders schutz- und pflegebedürftige Bereiche
- zur Einbringung der Ziele des Biosphärenreservates bei der Erstellung und Fortschreibung anderer Fachplanungen

Mit dem Rahmenkonzept erfolgt eine Darstellung der wertbestimmenden Merkmale, von gebietsübergreifenden Leitlinien, sich daraus ableitender genereller Handlungsempfehlungen und -prioritäten sowie eines Zonierungskonzeptes für das gesamte Biosphärenreservat „Flusslandschaft Elbe".

Folgende **Leitlinien** für Schutz, Pflege und Entwicklung des Biosphärenreservates „Flusslandschaft Elbe" wurden herausgearbeitet:

- Schutz des Naturhaushaltes und der biologischen Vielfalt
- Entwicklung nachhaltiger Nutzungsformen
- Umweltbildung und Umweltinformation
- Forschung und ökologische Umweltbeobachtung

Diese übergeordneten Leitlinien wurden mit konkreten ressourcen- und nutzungsbezogenen Handlungsempfehlungen untersetzt. Zu ihrer Umsetzung erfolgt eine **Zonierung** des Gesamtraumes abhängig vom Grad des menschlichen Einflusses in folgende Schutzzonen (Tab. 1).

Tab. 1: Aufgaben und Ziele sowie rechtliche Sicherung der drei Zonen innerhalb des Biosphärenreservates

	Kernzone	**Pflegezone**	**Entwicklungszone**
Flächenanteil	≥ 3 %	≥ 10 %	≥ 50 %
(Vorgaben UNESCO)	≥ 20 %		
Aufgaben / Ziele	Naturentwicklung ohne menschliche Nutzung, Ökosystemschutz	Erhaltung und Pflege von Kulturlandschaften, Abschirmung der Kernzone	Lebens-, Wirtschafts- und Erholungsraum, Entwicklung nachhaltiger Nutzungen
Rechtliche Sicherung	Nationalpark oder Naturschutzgebiet (zwingend)	Nationalpark oder Naturschutzgebiet (anzustreben)	Sicherung schutzwürdiger Bereiche durch Schutzgebietsausweisungen

2 Der Einsatz von CORINE Land Cover Daten

2.1 Verwendung von CLC zur Darstellung und Bewertung der Flächennutzung

Im Zuge der Bestandsaufnahme von Natur und Landschaft und zur Ableitung von Handlungsempfehlungen für die Raumnutzung ist eine Darstellung und Bewertung der Flächennutzung des Planungsraumes erforderlich. Die Erarbeitung des länderübergreifenden Rahmenkonzeptes erfolgte auf verschiedenen planerischen Grundlagen (z.B. Landschaftsprogramme, Landschaftsrahmenpläne, Naturparkpläne, Fachgutachten). Die vorliegenden Flächennutzungsdaten der einzelnen Bundesländer sind aus diesem Grund sehr inhomogen und liegen zudem nicht flächendeckend vor. Die Unterschiede der Erfassungsmethodik, der Detailliertheit, der Aktualität, der Klassifizierungen / Nomenklaturen und der Datenformate sowie fehlende Daten machten eine länderübergreifende einheitliche Darstellung der Flächennutzung mit vertretbarem Aufwand nicht möglich.

Die flächendeckend für das Gesamtgebiet einheitlich erhobenen CORINE Land Cover Daten stellten somit für das großräumige Bearbeitungsgebiet und den Arbeitsmaßstab von 1:100.000 eine ideale Datengrundlage zur Darstellung der Flächennutzung zur Verfügung. Die CORINE Land Cover Daten boten einen erheblichen Anwendungsvorteil gegenüber den unterschiedlichen Daten aus mehreren Bundesländern. Im Bearbeitungsgebiet liegen 24 Bodenbedeckungsklassen des CLC 2000 Datensatzes vor, die zu 10 verschiedenen Nutzungstypen zusammengefasst wurden (Abb.2).

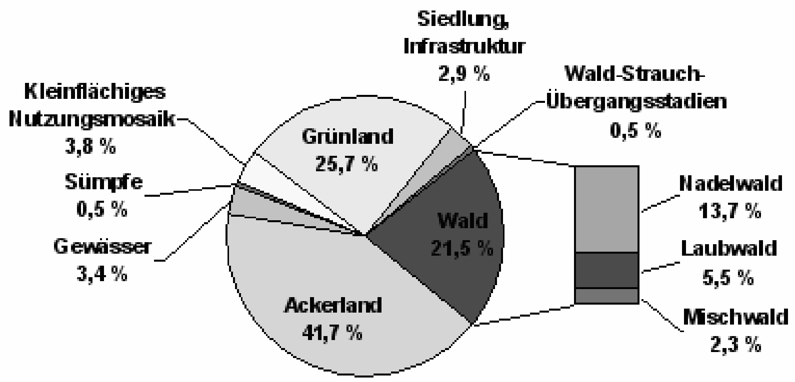

Abb. 2: Anteile zusammengefasster Landnutzungsklassen auf der Basis von CORINE Land Cover 2000

Für die Erarbeitung des Rahmenkonzeptes sind insbesondere die folgenden auentypischen Flächennutzungen von Bedeutung:

- **Wälder**, insbesondere naturnahe Wälder der Auen (Hart- und Weichholzauwälder, Bruchwälder)
- **Grünland**, insbesondere feuchte und wechselfeuchte artenreiche Grünländer der Überschwemmungsgebiete
- **Gewässer**, insbesondere Alt- und Nebengewässer der Elbe sowie Verlandungsbereiche
- **Sümpfe und Moore**

2.2 Vorteile und Grenzen von CLC in der naturschutzfachlichen Rahmenplanung

Vorteile und Einsatzmöglichkeiten von CORINE Land Cover

- Verfügbarkeit flächendeckender einheitlicher Flächennutzungsdaten, insbesondere für großräumige grenzüberschreitende Planungsräume
- Anwendungsvorteil in Bezug auf Flächendeckung und Vergleichbarkeit einheitlicher Daten aufgrund europaweiter Erhebung
- Möglichkeit räumlicher Vergleiche (Vergleichbarkeit der Daten mit anderen Auenlandschaften Europas)
- Möglichkeit zeitlicher Vergleiche (Betrachtung verschiedener Zeitschnitte)
- raumordnerische und naturschutzfachliche Bewertungen für große Betrachtungsräume (z.B. Erfolgskontrolle von Entwicklungsmaßnahmen in Großschutzgebieten)

Grenzen der Anwendung von CORINE Land Cover

- eingeschränkt geeignet für flächenscharfe Planungen mit Arbeitsmaßstäben > 1:100.000
- z.T. unzureichende Passgenauigkeit von Nutzungsdaten und Topographie
- unzureichende Erfassung kleinräumiger Details und Strukturen (z.B. Gewässer, Gehölze)
- eingeschränkte Nutzbarkeit der Daten bei fachlicher Konkretisierung (unzureichende Detailliertheit für naturschutzfachliche Fragestellungen)
- lediglich Unterscheidung in Laub-, Nadel- und Mischwald (von Interesse sind insbesondere seltene naturnahe Wälder wie Au- und Bruchwälder etc.)
- keine Unterscheidung verschiedener Grünlandausprägungen (natürliches Grünland unzureichend erfasst)
- naturschutzrelevante Gewässer und Feuchtgebiete sind aufgrund ihrer Kleinflächigkeit oft in anderen Klassen erfasst

2.2 Anwendungsbeispiel - CLC als Instrument zur Erfolgskontrolle von Entwicklungsmaßnahmen im Biosphärenreservat „Flusslandschaft Elbe“

Die flächendeckend vorhandenen einheitlichen CLC-Daten ermöglichen die Durchführung temporärer Vergleiche der Flächennutzung des Planungsraumes anhand verschiedener Zeitschnitte. In der nachfolgenden Tabelle 2 ist die Entwicklung der Flächennutzung für einzelne Klassen im Biosphärenreservat „Flusslandschaft Elbe“ zwischen 1990 und 2000 dargestellt, aus der sich Entwicklungstendenzen ableiten lassen.

Über einen solchen Vergleich besteht die Möglichkeit Änderungen der Flächennutzung festzustellen und Rückschlüsse auf den Erfolg bereits durchgeführter bzw. die Notwendigkeit zukünftiger Entwicklungsmaßnahmen zu ziehen. CORINE Land Cover stellt somit auch ein Instrument zur Bewertung und Ableitung von Handlungserfordernissen sowie konkreten Zieldefinitionen zur Verfügung.

Tab. 2: Entwicklung der Flächennutzung auf der Basis zusammengefasster Nutzungsklassen von CORINE Land Cover

Nutzungstyp	CLC 1990	CLC 2000	Bemerkung
Wald	73.490 ha	73.900 ha	leichte Zunahme (Waldmehrung)
Acker	150.590 ha	143.200 ha	Abnahme zugunsten Grünland/Wald
Grünland	82.720 ha	87.350 ha	deutliche Zunahme (Nutzungsextensivierung in der Aue durch Rückgang der Ackernutzung)
natürl. Grünland*	1.350 ha	820 ha	Rückgang auentypischen Feuchtgrünlands!
Gewässer	11.640 ha	11.750 ha	Zunahme von Wasserflächen (Vernässung)
Siedlung	8.160 ha	9.950 ha	erhöhte Siedlungstätigkeit! (Versiegelung)

* entsprechend den Biotopkartierungen der Bundesländer beträgt die Fläche an feuchtem und wechselfeuchtem Auengrünland im Biosphärenreservat ca. 23.180 ha (ist in Klasse „natürliches Grünland“ nicht ausreichend erfasst)

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Examples of the CORINE Land Cover database application in Slovakia

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Abstract

The aim of the paper is to demonstrate the CLC90, CLC2000 and CLC90/2000 data application to the identification and assessment of long-term and short-term changes on the example of the Skalica district (western Slovakia) and to evaluation of the landscape diversity in Slovakia. Long-term changes and the development of the landscape in district Skalica were analysed by comparison of the natural (reconstructed) landscape and its present state as represented by the land cover from 2000 (CLC2000). Short-term changes of the landscape and its dynamics were assessed by comparison of CLC90 and CLC2000 land cover databases. Results of analysis and diversity assessment based on application of CLC90 provide the image of landscape structure in Slovakia from the point of view of its spatial fragmentation.

1 Introduction

The CORINE Land Cover (CLC) database of Europe at the original scale 1:100 000 contains the data layer, which characterises its state in the 1990's. In 2004, this database will also contain the additional CLC2000 and the CLC90/2000 layers. Application of this database in combination with other thematic information, with the use of the GIS tools, opens new possibilities to solve various landscape problems not only in the European context but also at regional scales. The aim of the paper is to demonstrate the CLC90, CLC2000 and CLC90/2000 data application to the identification and assessment of short-term changes on the example of the Skalica district (western Slovakia) with area of 357.6 square kilometres, and to the evaluation of the landscape diversity in Slovakia.

2 Landscape changes in the district of Skalica

Natural conditions and human use are two dominant forces controlling formation of the present landscape. The landscape constantly changes under the effect of climatic and hydrological processes and above all under the effect of human activities. Landscape changes are interpreted as a sequence of different physical states of the landscape linked to certain time horizons (Feranec et al. 1997). Landscape changes can manifest through *conversion* – total change of landscape (change of one landscape type into another) or *modification* (Coppin et at. 2003) – gradual, less spectacular landscape change (features of the original state mix with features of the new state of the landscape).

2.1 Landscape change identification

Landscape change identification at regional scale is connected with more detailed diagnosis of natural conditions, in our example with types of natural - reconstructed landscape (hypothetical state without human impact or regulation, Otahel et al 2000), which are part of the legend to its map expression (natural landscape classes printed in bold agree with their codes on the map):

1 Intra-mountain lowland landscape, 11 Accumulation plain landscape with porous ground waters, 111 Fluvial to aeolian-fluvial plains, **1111 Holocene flood plains with floodplain forests on Fluvisols,** 112 Undulated fluvial to aeolian-fluvial plains, **1121 Low terraces and cones with elm floodplain forests to oak-hornbeam to oak-pine forests on Cambisols, 1122 Fluvial-aeolian terraces with oak-hornbeam to oak-pine forests on Cambisols, 1123 Dunes with pine forests on Regosols,** 12 Erosion-accumulation hilly landscape with capillary ground waters, 121 Loess erosion-accumulation landscape, **1212 Loess hilly lands with oak to oak-hornbeam forests on Orthic Luvisols and Luvisols, 122 Polygenetic hilly lands with oak to oak-hornbeam forests on Cambisols**

2 Mountainous landscape, 22 Mountainous erosion-denudation landscape with fissured-layered to fissured-karstic ground waters, 222 Uplands to highlands, **2221 Moderately warm uplands with oak-hornbeam forests on Cambisols to Rendzinas**

The present state of the landscape is represented through CLC2000 (Heymann et al. 1994, Feranec and Otahel 2001). Land cover classes occurring in the district of Skalica (in bold):

1 Artificial surfaces, 11 Urban fabric, **112 Discontinuous urban fabric,** 12 Industrial, commercial and transport units, **121 Industrial or commercial units,** 13 Mine, dump and construction sites, **132 Dump sites,** 14 Artificial, non-agricultural vegetated areas, **142 Sport and leisure facilities**

2 Agricultural areas, 21 Arable land, 211 Non-irrigated arable land, 22 Permanent crops, 221 Vineyards, 222 Fruit trees and berry plantations, 23 Pastures, 231 Pastures, 24 Heterogeneous agricultural areas, 242 Complex cultivation patterns, 243 Land principally occupied by agriculture with significant areas of natural vegetation

3 Forest and semi-natural areas, 31 Forests, 311 Broad-leaved forests, 312 Coniferous forests, 313 Mixed forests, 32 Scrub and/or herbaceous associations, 321 Natural grasslands, 324 Transitional woodland/shrub

4 Wetlands, 41 Inland wetlands, **411 Inland marshes**

5 Water bodies, 51 Inland waters, 511 Water courses, 512 Water bodies

Comparison of the natural landscape databases and its present state characterised by the land cover from 2000 (CLC2000) was used for analysis of *long-term changes* and the landscape development in the district Skalica.

Comparison of the CLC90 and CLC2000 databases was used for identification of *short-term landscape changes* and the landscape dynamics under the effect of social, economic and political influences.

3 Landscape diversity of Slovakia

The CLC90 database provides the complete image of the landscape structure of Slovakia, part of which constitute the following types of land cover: urbanised and technicised areas (with highest effect of control and dynamics of human processes), agricultural areas (cultivated by man with a distinct share of control effects), forest areas (human impact is determined above all by natural conditions). In semi-natural wetlands and water areas, human control appears to be minimum and it respects the self-regulative natural mechanism (Otahel et al. 2002).

Shannon index (Shannon and Weaver 1949) was applied to expression of landscape diversity:

$$H' = -\sum_{i=1}^{n} p_i . \log p_i \ ,$$

where p_i is the share of the area of the i-th polygon (CLC class) in total area of the analysed spatial unit represented by n polygons. Occurrence of several polygons in the same CLC class was taken into account as the combination with repetition i.e. diversity was computed for all polygons which occurred in the analysed spatial unit. Diversity value was determined by the number of polygons (CLC class areas) in the analysed spatial unit independently from their class appurtenance. Landscape diversity in this sense expresses the level of territorial fragmentation.

The important step of the methodology was establishing of the size of spatial unit for which diversity was computed. For instance, by means of the CLC Europe data, landscape diversity was identified applying the regular square grid of 3x3 km (Willems et al. 2000). This grid facilitates the relevant diversity assessment at the regional level.

As the statistical data concerning Slovakia are recorded pursuing territorial-administrative units (districts) and territorial-technical units (UTJ), they were used for computation of landscape structure diversity. Slovakia has 79 districts (the area of the smallest district is 9.67 km^2 and that of the largest is 1,550 km^2) and 3,658 UTJ (the areas of the smallest and the largest UTJ are 0.35 km^2 and 187.54 km^2 respectively). The grid of 10x10 km squares was also used for computation of diversity.

3.1 Assessment landscape diversity in Slovakia

There is a significant relationship between the obtained results of the landscape diversity analysis (Fig. 3) and the basic natural landscape structures of Slovakia. Among the districts, that of Bardejov is characterised by the largest diversity (9.51). In its territory, moderately warm and moderately cold furrows alternate with promontories, uplands to highlands. The lowest diversity was established for urbanised areas (urban districts) of Bratislava and Košice where it moves between 2.15 and 4.82. Landscape diversity is high also in other „basin“ districts of Slovakia: Veľký Krtíš, Žilina, Prievidza, Banská Bystrica, Košice-rural area, Rožňava, Považská Bystrica, Púchov, Brezno, Lučenec, Humenné, Žiar nad Hronom, and Zvolen.

Results of landscape diversity computation for UTJ facilitated even more detailed explanation of the landscape structure in Slovakia. The UTJ in mountainous landscape (Fig. 4) display the highest diversity values (3.5-5.5). They are the consequences of the differentiated land use around dispersed settlements in basins, plains and promontories, as well as of differentiation and alternation of forest and semi-natural land cover classes. Very low values of landscape diversity (0.88-0.95) were assessed for the lowland UTJ of Slovakia, as determined by the prevalence of one land cover class - arable land.

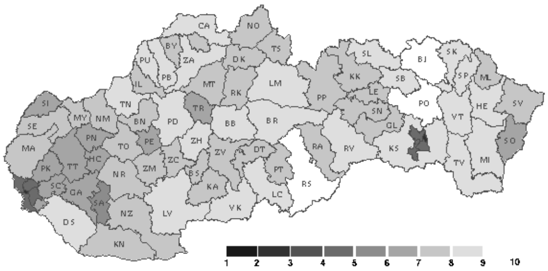

Fig. 3: Landscape diversity by districts of Slovakia

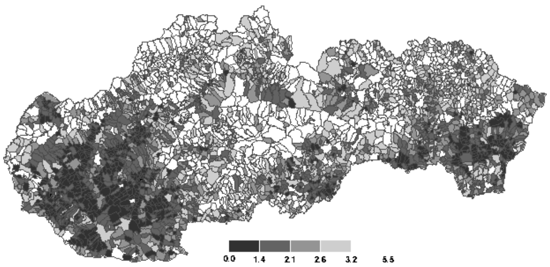

Fig. 4: Landscape diversity by territorial technical units (UTJ) of Slovakia

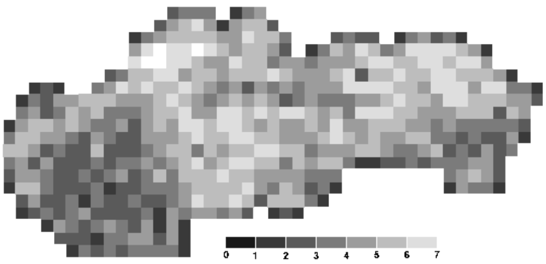

Fig. 5: Landscape diversity by the 10-km grid of Slovakia

An overview of landscape diversity was obtained by means of the 10x10 km square grid (Fig. 5). The highest diversity values (over 6.0) can be identified in the mountainous landscape of the Carpathians which is characterised by distinct heterogeneity of natural conditions in basins and furrows and natural concentration of settlements and human activities. The lowest values of landscape diversity were identified in lowlands and larger basins.

4 Conclusion

Presented results of the CLC90, CLC2000, and CLC90/2000 database application in Slovakia demonstrate that their combination, for instance, with the natural (reconstructed) landscape database can be used for generation of basic information on land cover changes including at the district level.

Diversity analysis and assessment represents yet another area of environmental research where the CLC database is applicable. Landscape diversity of Slovakia in the sense of the applied CLC classes corresponds to the methodology of their mapping (the surface of the smallest area is 25 ha)

Acknowledgements

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CORINE Land Cover 2000 in Nation-wide and Regional Monitoring of Urban Land Use and Land Consumption

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Abstract

Whereas remarkable efforts have been made to implement environmental information systems, the observation of urban land use change within nation-wide or regional monitoring approaches still remains dissatisfying. One key problem is the absence of land use data which allows the analysis of land use trends over longer periods of time and with appropriate spatial resolution. This paper asks to what degree CORINE land cover 2000 (CLC 2000) could fill these data gaps. For this purpose, CLC 2000 is compared to other land use data sources. Some indicators focussing on the measurement of land consumption and urban sprawl are to be exemplified.

1 Background

Following the increasing concern over urban sprawl and its negative implications on environmental conditions and quality of life, it is now widely recognised that it is important to monitor urban land use development in order to facilitate sustainable urban management. The lack of precise information about current land use, land use changes and their driving forces must be acknowledged as one crucial reason for some serious shortcomings of urban management practices such as inabilities in measuring urban growth, time lags in recognizing increasing or decreasing demand for land or lacking information about the effects of urban land use policies and regulations. Political progress towards resource efficient, equitable and ecological urban structures can only be made with contemporary information about the patterns of urban growth and the future demand for land.

Urban land use monitoring carried out by national or regional governments supports different tasks of urban and regional management such as

- analysing current development trends (Where is new development occurring and what are the spatial characteristics or urban growth?),
- analysing the impacts of urbanisation (What are impacts on valued ecological components and the quality of life?) or
- evaluating the implementation of land use plans (What are the effects of policies and regulations aiming at controlling urban growth, especially discouraging further urban sprawl?).

Whereas remarkable efforts have been made to implement environmental information systems, the observation of land use change within nation-wide or regional monitoring approaches still remains dissatisfying. One key problem is the absence of land use data which allows the analysis of land use trends over longer periods of time and with appropriate spatial resolution. Another problem is directly linked to data gaps: there is great concern of land consumption and urban sprawl, but poor definition and measurement hampers discussion about it. As Robert Cervero (2000) stated, "sprawl is like pornography, it is hard to define, but you know it when you see it". Currently most definitions and measuring approaches fail to express the spatial complexity of land use patterns labelled as urban sprawl (Theobald, 2001; Galster et al., 2000).

This paper asks to what degree CORINE land cover 2000 could fill this data gap. It presents a first assessment of CLC 2000 focussing on its capacity to observe the process of land consumption – also termed "land take" (EEA, 2001), "land conversion for urban uses" or "urban sprawl". We are doing this in three main steps. At first general methodological requirements regarding the observation and assessment of land use trends are to be stated. Second we want to ask to what extent CLC 2000 is able to detect total land consumption for urban purposes. An appropriate observation of land use trends presumes a high rate of change detection. The third part presents first results of test data analysis to demonstrate possible applications of CLC 2000 within state-wide and regional monitoring approaches.

2 Methodological requirements

2.1 General requirements

In Germany nation-wide and regional monitoring of land use is operating with different data sources (Figure 1). The official monitoring of regional development carried out by the Federal Office for Building and Regional Planning is based on land register data. Although these data are available area-wide in Germany, their geographical scope is limited due to their spatial dimension through a municipality zonal system (administrative boundaries). But zone-based spatial models do not take account of topological characteristics of land use patterns (Spiekermann / Wegener, 1999). Therefore there is a broad consensus that land use monitoring needs spatially disaggregated data models with vector representation of land use patterns. Such land use patterns are generally being collected on basis of remote sensing data.

However, it must be pointed out that there are certain conditions that have to be fulfilled by the applied database, especially when land use detection is based on remote sensing technologies:

- Multi-temporal land use detection should be realised with the same satellite sensor for image comparison. However, land use mapping is often based on the latest sensor technology because users have advantages due to better spatial resolution. For example Saxony's land use monitoring began on basis of Landsat5-Data in the year 1992/93, whereas the survey for the years 1998 and 2000 used IRS data. Thus the mapping results are not completely comparable, in particular if semiautomatic classification procedures are used (different spectral signatures).
- Furthermore, land use monitoring requires a uniform data collection methodology. That concerns the digitization rules (delimitation of land use classes, minimum mapping units,

generalization rules etc.) and the classification scheme. Otherwise a comparability of monitoring results for different points of time is limited. The classification scheme should distinguish urbanised areas in different land use classes (e.g. residential, industrial, recovery, commercial, traffic use).

- The mapping process should make use of experience from former surveys. A sound data gathering can only be ensured, when the "old" land use map is used as a background data base. This is of special importance in the case of "difficult" land cover classes like urban areas (e.g. where is the border of an airport?)
- The analysis of land consumption requires a high spatial resolution of image data to identify also smaller changes of urban land use patterns. A mapping scale of 1:25.000 with a minimum cartographic unit for urban areas of 1 hectare – like in the MOLAND project (EEA, 2002) – seems to be suitable.
- Land use data should be connectable with statistical data regarding population, employment or housing in order to analyse land use trends in relation to their socio-economic framework. By this means, indicators like the intensity of land use (inhabitants per km² urbanised area, GDP per km² urbanised area) can be derived.

The first three requirements are satisfactorily fulfilled by CLC 2000. Limitations for urban land use monitoring result from the large scale of data collection (1:100 000) and the implemented minimum cartographic unit of 25 hectares. In the future methodological advancements focussing on the spatial resolution of CORINE have to be taken into account. A possible approach would be a more detailed data collection in urban areas according to the MOLAND project. The last requirement addresses problems not caused by CLC 2000 but rather by spatial resolution of statistical data. Although in the meantime socio-economic data sets up to the municipal district level are available in Germany, most data are related to the municipality as a whole.

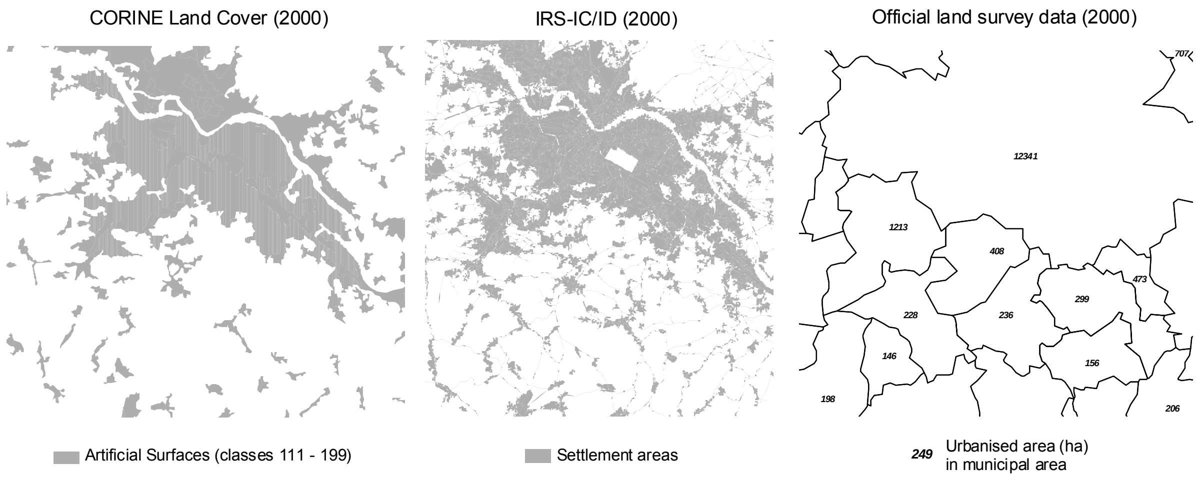


Fig. 1: CORINE Land Cover 2000 in relation to other data sources used for land use monitoring (City of Dresden and its southern environs)

But the mere statement of the amount of newly developed areas in Saxony's total area has rather low informational value because their regional distribution is highly different. A more detailed analysis demonstrates that most of Saxony's urban growth has taken place around the major central cities (Chemnitz, Dresden, Leipzig) and along the large transport corridors (in particular along the motorways A4 and A14) (Figure 2).

Another important attribute of sprawl is the growing distance of newly urbanised areas from the city centre (Lavalle et al., 2002). This indicator can be implemented with one kilometre concentric rings beginning at the CBD (city centre) of the metropolitan region and continuing to its outer periphery. For each concentric ring the proportion of new development has to be calculated (here recorded as hectare new development per km² ringzone). This generalisation of CLC-change data allows land-use change to be compared between large cities and their environs over time. Figure 3 shows that in the case of Chemnitz and Dresden land conversion is highest at the urban fringe (kilometre 5 and 6), but continues towards the rural hinterland. In contrast, the metropolitan region of Leipzig is characterised by a "double peak" at kilometre 9 and 14. The first peak is caused by development next to the inner suburbs of Leipzig. The outer peak demonstrates the massive urbanisation around Leipzig airport caused by large infrastructure projects and industrial development.

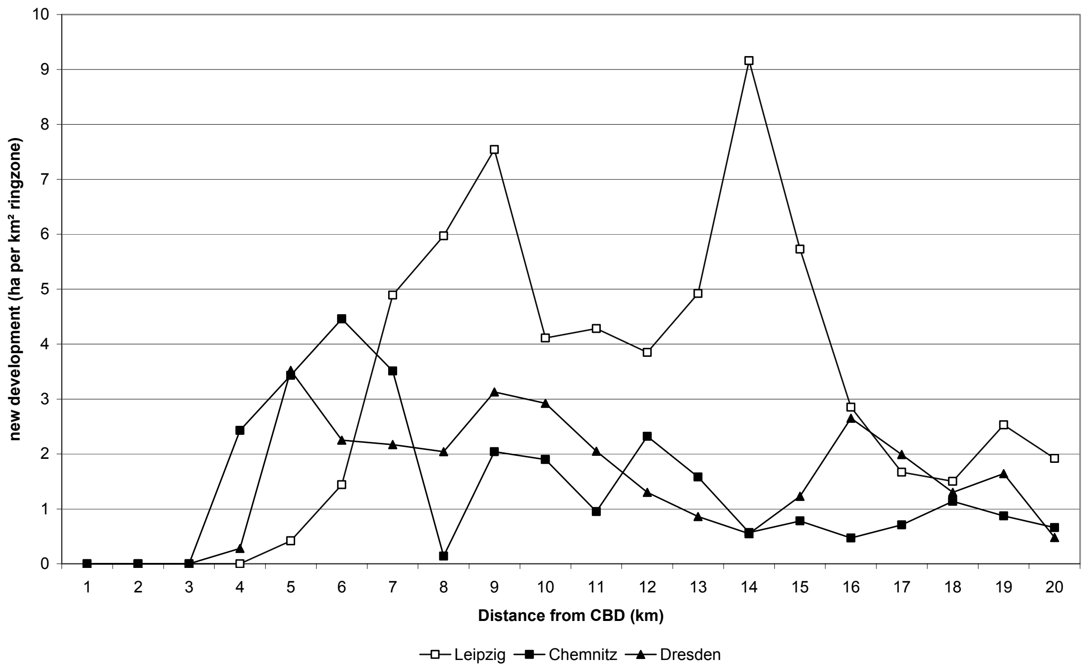


Fig. 3: Distance of newly urbanised areas from the CBD for the three metropolitan regions of Saxony (20-km-radius) (source: CORINE Land Cover 2000)

The sprawl effect of new development on Greenfield sites also depends on the degree of continuity of newly developed areas to already existing urbanised areas. New development can be well integrated into existing settlements (esp. by infill development) but also be discontinuous. In this article we distinguish between four general types of integration characterised by the ratio B of the boundary of new development areas to the boundary of existing settlements (Meinel/Winkler 2003; Meinel//Neumann 2003, Figure 4). This variable B can vary between 0 and 1. The value 0 means that new development is located totally outside existing urban areas (type 4). In contrast, the value 1 indicates new development totally integrated into the already existing urbanised area (type 1). Whereas type 1 and 2 can be positively associated with a compact urban form, type 3 and 4 stand for less sustainable, “sprawling” forms of urban development.

The results for the three large metropolitan regions of Saxony demonstrate the massive sprawling effect of new development in the post-GDR era. In the case of Dresden and Leipzig, a quarter of newly urbanised areas must be attributed as not integrated (type 4). In all regions less than 50 % of new development can be labelled as totally or well-integrated into existing urban areas (type 1 and 2).

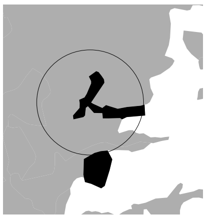
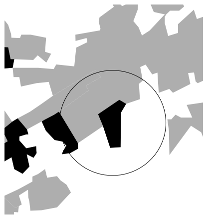
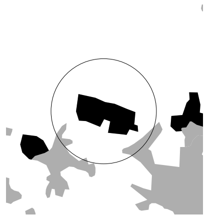
Type	totally integrated (1)		well integrated (2)		less integrated (3)		not integrated (4)	
Example existing urban areas new development								
Ratio of boundary to already existing urbanised areas	2/3 < B < 1		1/3 < B < 2/3		0 < B < 1/3		0	
Metropolitan regions	number (%)	share (%)	number (%)	share (%)	number (%)	share (%)	number (%)	share (%)
Chemnitz	10	16	29	22	45	46	16	17
Dresden	6	7	41	35	41	34	13	23
Leipzig	8	5	40	28	26	45	26	22

Fig. 4: Integration of new development (1990 – 2000) into already urbanised areas in three saxonian metropolitan regions (source: CORINE Land Cover 2000)

4 Conclusions

CORINE land cover 2000 could be used as a complementary database in urban land use monitoring programs. CLC 2000 provides a database with a finer spatial resolution than traditional land register data used in nation-wide and regional monitoring in Germany. Therefore, CORINE offers a more sophisticated picture of the patterns of land consumption in urban regions. Its strengths arise from its capability to support the analysis of location attributes of new development. Many indicators used in the urban sprawl studies can be implemented with CLC 2000. Moreover CORINE offers opportunities to apply more complex assessment methods with ambitious tools like Fragstats and Patch Analyst (see for example Hashim 2003).

Of course there are limitations due to the relatively large minimum cartographic units of 5 ha for land cover changes. In Saxony binding land use plans with an areal extension of less than 5 hectares account for approximately more than 20 % of the total newly developed area. This “masking” of small-scaled development runs a risk of underestimation of sprawl dynamics. On this background it must be clearly stated that the potential fields of CLC-application are mainly directed towards higher levels of urban land use monitoring. For local approaches CORINE 2000 cannot provide a meaningful database.

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Daten zur Bodenbedeckung des CORINE Land Cover (CLC) Programms für die Umweltrisikoeinschätzung im Rahmen der Fortschreibung der Bundesverkehrswegeplanung

Land cover data of the CORINE Land Cover (CLC) Programme for the environmental risk assessment within the update of the Federal Transport Infrastructure Planning

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Abstract

The environmental risk assessment (ERA) supplements the macroeconomic evaluation methodology of the Federal Transport Infrastructure Planning (FTIP) with the qualitative assessment of spatially related environmental risks and conflicts. The present contribution provides an overview of the methodological evolution of the environmental risk assessment (FE-Nr. 96.498/1999) being already implemented in the course of previous Federal Transport Infrastructure Plannings. Moreover it presents the implementation within the ERA of projects selected in the course of the revision / update of the Federal Transport Infrastructure Plan 1992 (FE-Nr. 96.0692/2001). The assessment methodology bases mainly on area criteria that are nation-wide digital available and processable in Geographical Information Systems (GIS). A substantial criterion of spatial resistance for the area coverage of the evaluation of the spatial resistance within the GIS-supported environmental risk assessment is the land cover data of the CORINE-Programme of the EU. Within the ERA the land cover data in the scale 1:100.000 are mainly used for the scale-appropriate evaluation of the biotope value and for the determination of settlement areas. The advantage of a nation-wide availability and comparability of the data base outweighs the disadvantages resulting from the high degree of generalisation of the units due to the rough scale.

1 Umweltrisikoeinschätzung (URE) im Projektbewertungsverfahren der Bundesverkehrswegeplanung (BVWP)

Die BVWP dient der Investitionsrahmenplanung zur Verkehrsinfrastruktur. Hierauf aufbauend werden die Bedarfspläne entwickelt und per Gesetz verabschiedet. Das gesamtwirtschaftliche Projektbewertungsverfahren der BVWP wird um eine fachliche Beurteilung raumbezogener Umweltrisiken und –konflikte ergänzt. Zur Einschätzung der Umweltrisiken und –konflikte erfolgt eine Raumanalyse und –bewertung, eine Beurteilung der Wirkungen des Vorhabens sowie die Ermittlung des „Umweltrisikos“. Die URE dient hierbei der qualitativen Einschätzung der mit jedem einzelnen für die BVWP gemeldeten Vorhaben verbundenen Umweltkonflikte. Die hier beschriebene Anwendung der CORINE-Daten bei der URE stellt die Umsetzung im Rahmen der Überarbeitung / Fortschreibung des BVWP 1992 (FE-Nr.96.0692/2001) dar. Aufgabe der URE ist, die Auswirkungen eines Vorhabens auf die Umweltschutzgüter, wie sie in § 2 Abs.1 des Gesetzes über die Umweltverträglichkeitsprüfung (UVPG) genannt sind, der Planungsstufe der BVWP angemessen zu ermitteln, zu beschreiben und zu bewerten. Der methodische Ansatz der URE bezieht sich primär auf gravierende Umweltkonflikte aus großräumig bedeutsamen ökologischen Funktionszusammenhängen und der Betroffenheit überregionaler (bundes- u. landesweit) bedeutender Gebietskategorien (GÜNNEWIG & HOPPENSTEDT, 2001; PÖU, 2000). Die URE umfasst folgende Analyse- und Bewertungsschritte:

1. Raumanalyse u. -bewertung zur Ermittlung des umweltbezogenen „Raumwiderstandes“,
2. Beurteilung der Wirkungen des Vorhabens durch Bestimmung der „Maßnahmeintensität“,
3. Ermittlung des „Umweltrisikos“.

2 Raumanalyse

Aufgabe der Raumanalyse ist es, die Raumeigenschaften zu ermitteln und aufzubereiten, die aufgrund des geplanten Bauvorhabens zu besonderen Umweltkonflikten führen können. Die relevanten Raumeigenschaften werden dann in einer ordinalen Wertskala hinsichtlich ihres „Raumwiderstandes“ beurteilt (vgl. Abb. 1). Hierzu werden die einzelnen Kriterien entsprechend ihrer umweltfachlichen Bedeutung und der Repräsentanz der angestrebten Umweltziele gewichtet. Prinzipiell bezieht sich die Raumanalyse auf die einzelnen Schutzgüter des UVPG. Die maßgeblichen Gebietsmerkmale haben gleichwohl aufgrund komplexer Funktionszusammenhänge und Wechselwirkungen auch ihre Bedeutung für andere Schutzgüter, so dass sie maßstabsbedingt zusammengefasst werden (GÜNNEWIG & HOPPENSTEDT, 2001).

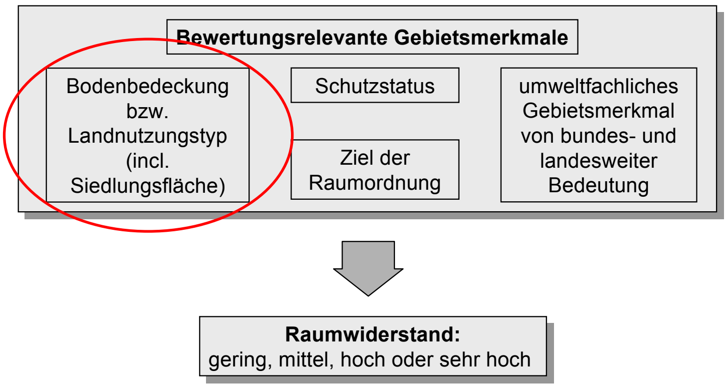

Abb. 1: Gebietsmerkmale und Raumwiderstandsfestlegung (PÖU, 2000).
Site characteristics and determination of spatial resistance (PÖU, 2000).

Die auf der BVWP-Ebene relevanten Kriteriengruppen sind im Wesentlichen:

– ausgewiesene **Schutz- u. Restriktionskategorien** unterschiedlicher Verbindlichkeit: rechtlicher Schutzstatus, umweltbezogene raumordnerische Ziele, ggf. fachplanerische Vorgaben;
– Zustands- und Bedeutungsmerkmale der Schutzgüter; hierzu gehören fachliche Bewertungsmerkmale wie die Unzerschnittenheit von Räumen (BFN, 1999) sowie die **Bodenbedeckungstypen** nach dem CORINE Land Cover-Schlüssel (STBA, 1997; Tab1).

Tab. 1: CORINE-Daten als Raumwiderstandskriterium für die GIS-gestützte Umweltrisikoeinschätzung (Mindestdatenbedarf zur Flächendeckung) (PÖU, 2003).
CORINE Data as criterion of spatial resistance within the GIS-supported enviromental risk assessment (PÖU, 2003).

Themenfeld / Raumwiderstandskriterium	Raumwiderstand
Mensch	
Siedlungsbereich (CORINE)	sehr hoch
250m-Puffer	sehr hoch
Natur und Landschaft	
Bodenbedeckung (Typen nach CORINE)	gering – hoch

3 CORINE-Daten als Basisdatensatz

Zu den Geobasisdaten für die URE zählten neben der topographischen Karte TK 200 insbesondere die Daten zur Bodenbedeckung (CORINE Land Cover Programm der EU (STBA, 1997)), über die eine Flächendeckung der Raumwiderstandsbewertung erreicht wird (siehe Tab. 2).

Tab. 2: Raumwiderstand der Bodenbedeckungstypen nach CORINE (PÖU, 2003).
Spatial resistance of the CORINE Land Cover types (PÖU, 2003).

Bodenbedeckungstypen (CORINE Land Cover)		Biotop-Standortgruppen	Raum-widerstand
Landwirtschaftliche Flächen			
211	Nicht bewässertes Ackerland	Ackerland, intensiv	gering
221	Weinbauflächen	Sonderkulturen	gering
222	Obst- und Beerenobstbestände	Sonderkulturen	gering
231	Wiesen und Weiden	Grünland	gering
242	Komplexe Parzellenstrukturen	Ackerland / Grünland / Sonderkulturen	mittel
243	Landwirtschaft und natürliche Bodenbedeckung	Kombination Ackerland / Grünland / Wald	mittel
Wälder und naturnahe Flächen			
311	Laubwälder	Naturnaher Laubwald/forst	hoch
312	Nadelwälder	Nadelwald/-forst	mittel
313	Mischwälder	Laub-/ Nadelforst	mittel
Strauch- und Krautvegetation			
321	Natürliches Grünland	Grünland extensiv / ungenutzt / montanes Grünl.	hoch
322	Heiden und Moorheiden	extensiv genutzte Biotope trockener Standorte	hoch
324	Wald-Strauch-Übergangsstadien (Sukzessionsflächen)	Junger Laubmischwald	gering
Offene Flächen ohne/mit geringer Vegetation			
331	Strände, Dünen und Sandflächen	Sandflächen im Binnenland, Trockenrasen	hoch
333	Flächen mit spärlicher Vegetation	Trockenrasen	hoch
Feuchtflächen und Gewässer			
411	Sümpfe	extensiv genutzte Biotope feuchter Standorte	hoch
412	Torfmoore	Torfstich	hoch
421	Salzwiesen		hoch
423	In der Gezeitenzone liegende Flächen	u.a. Wattbereiche	hoch
5**	Gewässerläufe, Wasserflächen, Mündungsgebiete, Meere		hoch

Die „Daten zur Bodenbedeckung“ des EU-weiten CORINE-Projektes im Maßstabsbereich 1:100.000 mit insgesamt 44 Bodenbedeckungskategorien werden im Rahmen der URE vorrangig für die maßstabsangemessene Beurteilung des Biotopwertes sowie zur Ermittlung der Siedlungsflächen genutzt. Der Vorteil der bundesweit flächendeckenden Verfügbarkeit und Vergleichbarkeit der Datenbasis überwiegt dabei die Nachteile, die sich aus dem maßstabsbedingt hohen Generalisierungsgrad der Einheiten ergeben (Erfassungsuntergrenze für flächenhafte Objekte von 25 ha, Erfassungsuntergrenze für linienhafte Objekte ab einer Breite von 100 m). Eine für die Bewertung hinreichend genaue Ansprache von Biotoptypen ist damit auf weitergehende Informationen angewiesen. Den CORINE-Daten wurden aus fachlichen Gründen (→ Generalisierungsgrad) nur drei der vier möglichen Raumwiderstandsstufen zugeordnet (gering, mittel, hoch).

Mit den CORINE-Daten zur Bodenbedeckung steht ein für die Aussageschärfe der URE ausreichend aktueller und thematisch genauer Datensatz zur flächendeckenden Bewertung der Bodenbedeckung zur Verfügung. Dadurch werden im nationalen Kontext ökologische Bewertungen und Folgerungen für den BVWP ermöglicht. Es ergibt sich aber ein Bedarf für eine Erhöhung des räumlichen und inhaltlichen Detailierungsgrads für die Fortschreibung der CORINE-Daten. Abstriche in der Qualität der Flächennutzungsdaten ergaben sich insbesondere durch maßstabsbedingte Unstimmigkeiten und durch Nicht-Übereinstimmung mit weiteren Fachdaten (Datensätze der Biotopkartierungen u.a.) aufgrund unterschiedlicher Aktualität und Flächennutzungswandel.

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Integration of enhanced land cover information in the context of the European Water Framework Directive and the Soil Protection Initiative

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Abstract

In order to monitor and improve environmental conditions, the cardinal needs of planners and decision makers on available, reliable and affordable information delivered in time on environmental pressure and stress need to be served. The ESA GMES Service Element "SAGE" lead by Infoterra GmbH addresses European environmental policies such as the European Water Framework Directive (WFD) with the "AquaSAGE" and the Soil Thematic Strategy (STS) with the "SoilSAGE" service development. The service portfolio integrates Earth Observation based Land Cover / Land Use (LULC) information - a so-called "core service" - together with in-situ and other geo-information into quantitative models. It will allow more frequent large-area updates focussed on land cover classes being key model parameters than current comparable approaches (e.g. CORINE Land Cover) plus short-term hot spot monitoring at affordable costs.

1 User Needs

Stakeholders in the domain of environmental monitoring and reporting and spatial planning at all administrative levels require timely available, reliable and affordable information related to land cover and land use and its integration with in-situ and other geo-information in higher level information products and quantitative models. The ESA GMES Service Element "SAGE" led by Infoterra GmbH addresses European environmental policies such as the European Water Framework Directive (WFD) with the "AquaSAGE", and the Soil Thematic Strategy (STS) with the "SoilSAGE" service development. The implementation of the WFD and STS is a major challenge to most legal bodies in charge: The European Commission (EC) will soon request these organisations to deliver spatially disaggregated information on water and soil conditions at national, regional, and local scales in a standardized format. Authorities will thus have to adapt their proven reporting mechanisms to meet these requirements. All SAGE products have been developed by experienced EO based service providers in several European countries, representing different ecozones. In developing the information products, the service providers have been closely cooperating with various national and regional authorities such as national environmental agencies, regional administrations and regional agencies involved in water and soil matters.

many EO users have adopted, the CORINE Land Cover nomenclature is included within the SAGE efforts to improve on the CLC data in the above mentioned respects. That means SAGE will take care that the new land cover data can be brought in relation with CORINE land cover categories. A further important issue regarding the advancement of CORINE type EO based land cover classifications and the derivation of SAGE products is progress in the automation and especially in the man/machine interface. The latter can be considered the most significant means to advance the production of land cover data in terms of cost efficiency and objectiveness, as automated processes alone will always result in limited thematic accuracy and lacking detail of thematic classes.

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Land Use, Land Use Change and Forestry Information for Kyoto Protocol Reporting and Sustainable Forest Management

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Abstract

The main objective of the **G**MES **S**ervice **E**lement **F**orest **M**onitoring (GSE FM) is the implementation of operational land use and forest monitoring services that deliver essential information to users for example, from yearly carbon balance and forest disturbance data to information products that support practical forest and environmental management practices. This is achieved by integrating Earth Observation (EO) applications with ground-based (in-situ) data collection within defined and tested methodological frameworks. Up-scaling and integration of GSE FM at the European level will be carried out within GSE activities that strive to match end-user needs for services with sufficient operational performance, reliability, availability and affordability. GSE FM has a strong focus on various environmental policy foundations. In addition, users have been involved in the development of services since its inception and have helped optimise and adapt the products and services according to changing demands. Consequently, the GSE Forest Monitoring Services are demand and not supply driven. The existing GSE FM partnership (of core users and service providers) is now open to include additional interested parties within an Open Service Partnership. This marks the beginning of the 'implementation phase' of GSE FM that should ultimately create an international network of users and beneficiaries, which supports and sustains a global environmental monitoring system.

1 Introduction

1.1 Background

GSE Forest Monitoring is a unique element of the Global Monitoring for Environment and Security (GMES) Joint Initiative. This is co-sponsored by the European Space Agency (ESA) and the European Commission (EC) with the goal of developing a global monitoring capability for policy makers and other end users. The GSE Forest Monitoring component consolidates services under the priority theme "Land Cover Change in Europe" within the GMES Master Plan.

The European Space Agency (ESA) awarded a contract to a Consortium lead by GAF AG (Germany) to establish and consolidate a GMES (**G**lobal **M**onitoring on **E**nvironment and **S**ecurity) Service Element for Forest Monitoring. This challenging project started in February 2003 and is being executed in two phases each of 10 months duration.

1.2 Objectives

A key objective of the GSE consolidation phase is the definition and demonstration of products and services in close cooperation with end-users.

The main purpose of the service is to provide a global community of end-users in the fields of forest and environmental monitoring with an operational system, which delivers reliable and timely information according to demands and requirements. In addition, the service is designed to support decision-makers in formulating, implementing and evaluating public policies regarding environment and security. Considerable long-term development, scaling up and integration at the European level is anticipated within GSE activities in order to match end-user requirements to services with sufficient operational performance, reliability, availability and affordability. GSE activities strive to combine existing areas of scientific and technical innovation and commercial excellence into an international and integrated network of operational competence.

1.4 GSE Forest Monitoring Partnership

In the initial phase of GSE FM, GAF AG teamed with operational service providers, core users, system developers and research organisations in Germany, Austria, Sweden, France, Finland and Greece. Within the planned targets for the next 2, 5 and 10 years, the intention is to significantly enlarge the number and geographic distribution of users and service partners worldwide.

1.3 Relevance to CORINE LC

During the past decade, the EU has developed and implemented the CORINE Land Cover classification scheme and database (CORINE LC), utilizing the Landsat-TM sensor (Thematic Mapper) as the primary data source. The CORINE LC database is presently being updated within the CLC 2000 project (EEA, 1997; EEA, 2000). The update is based on Landsat-ETM+ data (Enhanced Thematic Mapper), which provide higher image quality mainly due to the additional panchromatic band with 15 m resolution. However, the original classification schema and the nomenclature was kept unchanged. This means that e.g. for the forest classes important parameters such as forest condition and structure are not provided by CLC 2000.

Up to now, CORINE LC has found increasing acceptance within environmental authorities at the European, national and partially, the sub-national (regional) levels. However, more widespread utilization of CORINE LC data and derived information products is clearly impeded by certain shortcomings in terms of spatial, temporal, and thematic resolution. Since any improvements in spatial-temporal resolution and/or thematic differentiation will require compromises between information quality to be gained and the additional effort/expense required, it seems reasonable to focus such efforts on land cover/land use classes of specific importance to environmental monitoring.

The paper gives at first on overview on the GSE FM services. The GSE FM service for national Kyoto Protocol reporting on Land Use Land Use Change and Forestry (LULUCF) is explained in more detail. The mapping results of the CORINE LC and GSE FM with respect to forest classes are compared in a test area in Germany. Finally, an outlook is given on the possible integration and harmonisation of future CORINE LC and the GSE FM mapping.

2 Response to Environmental Policies at National and International Levels

GSE Forest Monitoring supports policy and management requirements within the following major areas:

- Climate Change and Air Pollution
- Sustainable Management and Protection of Bio-Diversity

The standardised services and user-oriented outputs are designed to support the implementation of sound practices and policies within these key areas. Furthermore, the overall service philosophy advocates networking and cooperation amongst users as well as the creation of linkages between interrelated and complementary policies.

The services now available target both end-user needs and the reporting obligations imposed by international conventions and agreements including:

- The UN Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol
- Council Regulations (proposed) for Monitoring of Forests and Environmental Interactions in the EC (Forest Focus)
- The United Nations Forum on Forests
- The UN Convention on Biological Diversity
- Ministerial Conference on the Protection of Forests in Europe
- National Forest Programmes

In addition, the services supply practical information to meet routine forest management requirements such as forest certification, and concurrently support the information needs of National and Sub-National Forest Programmes.

3 GSE Forest Monitoring – Service Portfolio

GSE Forest Monitoring offers a variety of outputs including digital and analogue information, statistics, modelled data and integrated reports that highlight:

- Areas of forests, other land use and changes therein
- Areas of Afforestation, Reforestation and Deforestation
- Forest structure and changes
- Above ground biomass/carbon stock and changes therein
- Forest environmental indicators

The information components are delivered through various products and derivatives grouped into logical families, for example: Ortho-images, Forest Maps, In-situ Inventories etc. These products can be customised into integrated Service Packages to meet specific user requirements in the most efficient and cost-effective manner. Examples include:

- Forest Monitoring Inputs for Greenhouse Gas (GHG) Reporting
- Forest Environmental Indicators
- Sub-National Forest Information Updates
- Land Cover and Change Mapping for Clean Development Mechanisms (CDM)
- Forest Cover Mapping for Cloudy Regions
- National Forest Information System
- Clear Cut Mapping and Monitoring Service

4 The Active Involvement and Commitment of User Bodies

The development of GSE FM information services required a comprehensive review of requirements established under key policy agendas e.g. the Kyoto Protocol, as well as the specific needs of end-user organisations. This review formed the basis for the design and subsequent development of demand-driven services.

End users from representative bodies have committed to GSE Forest Monitoring services over the long term to support both their sustainability as well as the broader GMES objectives that address issues related to environment and security. To this end, they have helped refine information and service needs throughout the development process through continuous on-site testing & validation. This ensures the various adaptations and service packages genuinely respond to user needs. This interactive and progressive process represents a key step towards the integration of new technologies and methodologies into the operational services.

To date, the following user organisations from different administrative levels and geographic locations are actively applying GSE FM services:

National Ministries, Agencies and Institutes

- Federal Ministry of Consumer Protection, Food and Agriculture, BMVEL Germany
- National Observatory of Athens, NOA - Institute of Environmental Research and Sustainable Development, Greece
- National Ministry of Agriculture, Food, Fisheries and Rural Affairs, MAAPAR France
- Federal Environmental Agency, UBA Germany

National & Sub-National Forest Administrations

- Thuringian State Institute for Forest, Game and Fisheries, TLFJF Germany
- The Swedish Forestry Administration including the National Board of Forestry, NBF (Skogsstyrelsen) and the Regional Forestry Boards of Sweden

Private Companies: Forest Project Developers

- Stora Enso Ltd., Finland

5 Service Example Germany: Forest Monitoring Inputs for Greenhouse Gas (GHG) Reporting

National greenhouse gas reporting is an essential requirement of the Kyoto Protocol and demands new information presently not covered by National Forest Inventories or other resources.

The GSE FM service combines EO-derived data with in-situ information derived from a sample-based forest inventory. The EO data provides information presently not available for example, the status or former land use of afforested areas. The EO data provides information in map formats that complements statistics from a national forest inventory. Using EO data in combination with a field inventory increases the accuracy and coverage of results with minimal costs while reducing the margin of error.

The main elements of greenhouse gas reporting includes national summary statistics on forest area, forest area changes within a land use change matrix, totals and changes in stem volumes, biomass and carbon. The information provided is supplemented by an uncertainty analysis that quantifies the level of error and thereby allows a reliable estimate. The combination of EO and in-situ data within the GSE FM approach allows users responsible for reporting under the Kyoto-Protocol to reach the highest levels of reporting confidence. In situations where no national forest inventory is available, the GSE FM services promote the design of an inventory at minimal cost (Köhl, 1994).

The main target group for GSE FM greenhouse gas reporting includes national forestry and environmental agencies with a mandate to deliver national reporting and accounting under the Kyoto Protocol. The principles of the service are illustrated in Figure 2.

6 Comparison with CORINE LC 2000

The service “Forest Monitoring Inputs for Greenhouse Gas (GHG) Reporting” has started in the federal country of Saxony and will be rolled out to entire Germany. A forest mask, a forest type differentiation as well as a change detection of land use classes between 1989/90 and 2002 with a minimum spatial reference unit of 0.1 ha was prepared and delivered to the user (Fig. 3). A comprehensive verification with reference data from forest maps, aerial photo interpretations, and data from the Federal Forest Inventory proofed an accuracy of 98% for the forest area.

The comparison of the forest area mapped by CORINE LC and GSE FM in Saxony shows considerable differences. The main difference - illustrated in Figure 4 - is the due to the minimum mapping areas, which is 25 ha for CORINE and 0.1 ha for GSE FM. A considerable number of forest areas with areas sizes smaller than 25 ha area merely mapped by GSE FM. Moreover, several small non-forest areas that are surrounded by forest are mapped as forest by CORINE and as non-forest by GSE FM.

It is obvious, that the influence of these effects on the map and on map based statistics is depending on the spatial structure of the forest within the landscape. In Saxony these effects mainly equal each other out and the resulting statistical difference is in order of magnitude of 1 % forest area. However, depending on the spatial configuration of forest, the differences can be considerable.

Within the mapping class forest CORINE and GSE FM differentiate main forest types with respect to the proportion of coniferous and deciduous trees. While CORINE characterises large forest areas (regarding the minimum mapping area of 25 ha) as coniferous, deciduous and mixed forest, GSE FM characterises small forest patches of 0.1 ha as a coniferous or a deciduous forest patch. It is again obvious, that this influences both maps and map base statistics (see Figure 1 and 5).

A second effect that influences forest type maps and forest type statistics is also illustrated by Figure 5. Since deciduous forests are more dominant in small forest patches that are not mapped by CORINE, deciduous forests are typically underestimated by CORINE.

Maps and map based statistics on forest can thus differ considerably. If such statistics are produced separately they are not comparable. The effects that lead to the differences cannot be analysed, the results even may seem to be contradictory.

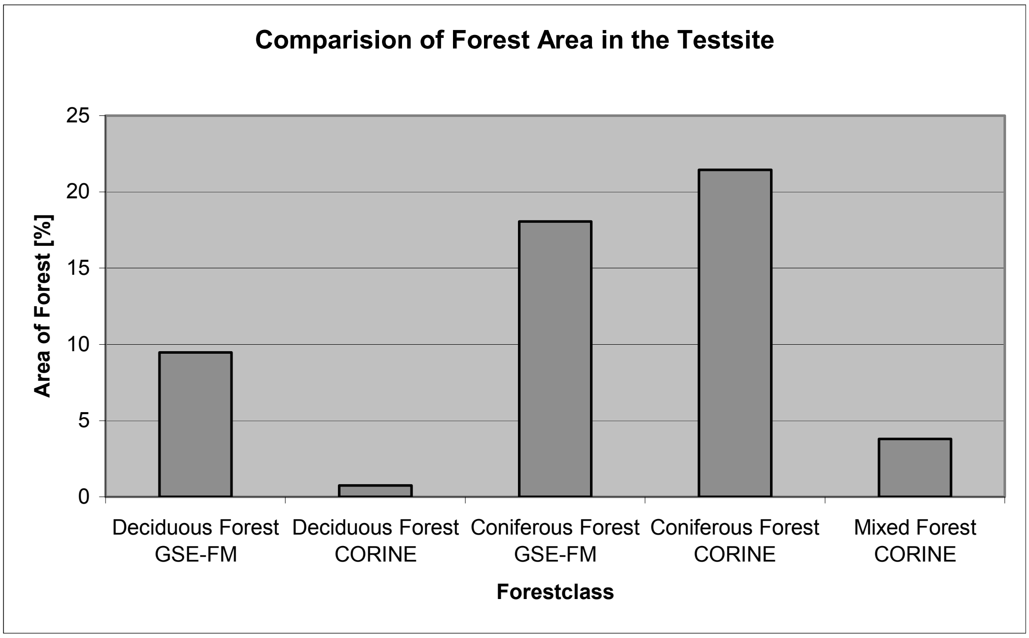

Fig. 1: Comparison of forest type statistics derived by GSE FM and CORINE LC 2000: deciduous forest is underestimated by CORINE if they occur as small patches distributed over large areas.

Since the main difference is the spatial mapping approach, an integration of the two approaches is possible to combine both map types. This could be achieved by introducing a CORINE level 4 or 5 where a higher spatial mapping resolution, i.e. a smaller minimum mapping unit is applied. The statistics will then be comparable since differences that are related to the spatial configuration are fully interpretable. These interpretations will offer even new additional information that is not available by separate information supply and usage.

A smaller mapping unit will furthermore allow a higher differentiation of forest types, since forest stand types often occur on areas that exceed 1 ha but do not reach area sizes that exceed 25 ha.

7 GSE Forest Monitoring Benefits

Clearly, because GSE FM services are closely linked to specific user needs there are numerous benefits that are site and/or user specific. As GSE FM progresses and the user community grows incrementally and gains experience with various services and products, these unique benefits will be closely examined to determine whether there are lessons-learned and possible improvements that have universal relevance to the future evolution of GSE FM. In short, to be fully responsive and relevant to users, GSE FM will always remain a service or 'work in progress.'

However, even at this relatively early stage of GSE FM development and field application, a number of important benefits can be identified including:

- The cost effectiveness of the services offered, which can be otherwise expensive and time/labour intensive if implemented using conventional field based approaches.
- The transparency of services where the underlying methodologies have been thoroughly tested and documented and so, are clearly understood and trusted by the users/beneficiaries.
- A homogeneous (standardised) data-collection methodology for different kinds of forests and other land use from regional-to-local scales allowing meaningful comparisons and spatial harmonisation.
- The ability to produce more accurate estimates of carbon emissions by sources and potential removals by sinks in forests. This is a complex, controversial and politically charged issue with serious fiscal implications, which GSE FM services address and illuminate especially to policy and decision makers.
- At the sub-national level, GSE FM provides well defined, easily updated and highly accurate forest (cover) information. This strengthens (spatial) forest inventory concepts and leads to cost savings during the execution of forest inventories for example, through improved sample optimisation.
- GSE FM has established important benchmarks for the performance and efficiency of its products and services. This allowed their refinement during 2003 and will allow wider operational implementation throughout 2004 and beyond.

Finally and for the first time, GSE FM offers a potentially global standard to meet the complex challenges and user demands of forest monitoring, regardless of the scale or location. Whether this potential standard becomes a de facto global standard, will largely depend upon the readiness of users worldwide to embrace it in the months and years ahead. The indications to date are most positive but growth in the user community will require sustained promotion, focuses resources and (user) support. Although surmountable, the obstacles to developing a truly *global and sustainable* forest monitoring *system* remain substantial – especially in the technical (e.g. infrastructure integration), organisational and political domains.

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Environmental policy requirements for enhanced land use / land use change data products: Perspectives from the SATUM study

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Abstract

On behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), DLR is presently carrying out a study entitled "Requirements Analysis of Utilisation of Satellite-based Earth Observation Systems for Environmental Policy (SATUM)". SATUM encompasses virtually all spatially-related political and administrative issues within the departmental scope of the BMU itself, the Federal Agency for Nature Conservation (BfN), the Federal Office for Radiation Protection (BfS), and the Federal Environmental Agency (UBA), the latter also holding management responsibility for the study project. Preliminary results from a comprehensive review of legally binding tasks of the federal environmental administration reveal major requirements to be focussed on various issues demanding information on land use/land cover changes which can only partially be supplied by CORINE-LC. Scenarios describing an enhanced CORINE-LC basic product as well as additional services will be presented at the workshop. In the context of the SATUM study, these scenarios also serve as reference for an independent efficiency evaluation to be performed by user experts.

1 Introduction

During the past two decades, satellite remote sensing (SRS) has been developed into a powerful monitoring tool to provide spatial information on environmental structures and processes, with emphasis on issues of global change and climate research. Consequently, many SRS utilisation studies have been designed to cover application aspects of environmental research as well as environmental policy. E.g., in 1994 the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Federal Ministry for Education and Research (BMBF, Federal Ministry for Education, Science, Research and Technology) jointly issued the concept study "Satellite Remote Sensing for Environmental Policy and Research: Status, Analysis, Perspectives" (AGFU study; BMU/BMBF 1994). Meanwhile, further developments in environmental legislation on the European and national level have given rise to extended requirements for spatial survey and monitoring. On the other hand, the technical capabilities of satellite remote sensing have been increased by innovative earth observation missions such as ENVISAT. A promising programmatic framework for operational utilisation of these and other capabilities in the field of spatial observation and information is presently being implemented by way of the European initiative Global Monitoring for Environment and Security (GMES).

In view of this situation and in response to a formal parliamentary question addressing the potential of SRS and its utilisation by the German Federal Government, the BMU has inaugurated the study "Requirements Analysis of Utilisation of Satellite-based Earth Observation Systems for Environmental Policy (SATUM)", which is currently being carried out by DLR. SATUM encompasses virtually all spatially-related political and administrative issues within the departmental scope of the BMU itself, the Federal Agency for Nature Conservation (BfN), the Federal Office for Radiation Protection (BfS), and the Federal Environmental Agency (UBA), the latter also holding management responsibility for the study project within the UFOPLAN programme. Overall objectives of SATUM are

- to analyse the demand of the federal environmental administration for utilisation of SRS data, as appropriate for fulfilling legally binding departmental tasks,
- to identify possible improvements in terms of efficiency by use of SRS data,
- to outline a federal data policy position towards relevant European programmes such as GMES and INSPIRE.

The draft final report of SATUM is due end of January 2004

2 Methodology

The present scope of departmental issues of BMU, BfN, BfS and UBA was reviewed by screening departmental organigrammes, website information and informal in-house papers, followed by questionnaire-based interviews with departmental experts. Issues related to spatially extended environmental structures or processes were described together with their legal foundations, the pertinent fields of observation and observation parameters, the monitoring methods and data sources conventionally used, and any shortcomings of the latter. Draft descriptions were iterated with the departmental experts for approval. For the observation parameters required, optional SRS applications were identified. Based on a comparison of conventional monitoring methods and SRS options, scenarios of possible SRS based solutions including cost assessments were described, which will be subject to a formal evaluation process to be carried out by the departmental experts. A more detailed description of the study methodology will be given in the SATUM final report.

3 Preliminary results

As the work on SATUM is still going on, the following results are necessarily of a preliminary nature, and subject to final approval by the customer. From 16 departmental issues identified as potential fields of SRS application, 11 were distinctly related to monitoring parameters describing features of land use and land cover as well as their change over time. As can be taken from Table 1, in 6 of these issues CORINE-LC is (at least partially) being used as a source of spatial information. An additional possibility of operational use of CORINE-LC data was identified for the environmental radioactivity information system operated by BfS. Only two issues were found to be without specific requirements for improvement of the spatial information basis (i.e. on the federal level), viz. flood risk management and landfill data acquisition. Most requirements for improved land use and land cover information are focussing on enhanced temporal and spatial resolution as well as thematic differentiation of specific land use classes. Apart from CORINE-LC, the information on land use and land cover needed by the federal environmental administration is provided either by other federal departments or by federal state authorities.

Tab. 1: Departmental issues and land use/land cover related observation requirements in the federal environmental administration

Environmental issue	Federal environmental authority	Present state source (provision) of data	Monitoring parameters	Major requirements w.r.t. present statemethod
Climate protection (carbon sinks)	BMU, UBA	Federal Forest Inventory (BMVEL, BFH)	Forest area (ARD)	Spatial allocation, data comparability
Air pollution (effects on sensitive ecosystems)	UBA	CORINE-LC	Forest, grassland, heath/bogs, peat, open waters	Enhanced thematic, spatial (5 ha) and temporal (5 y) resolution
Water management (realisation of EU Water Framework Directive)	UBA	CORINE-LC	Urban areas, cropland	Enhanced thematic differentiation (degree of surface sealing, crops (maize, hop)); enhanced spatial (5 ha) and temporal (1 y) resolution for crops
Water management (Monitoring of water protection areas)	UBA	Topical publications (federal state authorities)	Forest area (ARD), agricultural land use, surface sealing	Standardised spatial data base, spatial resolution 5-10 m, temporal resolution 5 y
Water management (flood risk management)	BMU	(Federal state authorities)	Urban areas, agricultural land use	Not specified on federal level
Nature protection and biodiversity	BfN	CORINE-LC; biotope and land use type mapping (federal state authorities)	Living space types, biotope and land use types	Enhanced spatial coverage and repetition (living space types: 6 y)
Spatial environmental and landscape planning	BfN, UBA	CORINE-LC	Urban areas, traffic ways	Enhanced spatial resolution
Landfill data acquisition	BMU, UBA	(federal state authorities, landfill site management)	State of filling, landfill surface area, recultivated area	none
Soil protection	UBA	CORINE-LC, ATKIS	Urban areas, agricultural land use, soil cover	Enhanced thematic differentiation (crops, degree of surface sealing), enhanced temporal and spatial resolution
Environmental radioactivity (disaster management and situation assessment)	BfS	Radio-ecological model ECOSYS, (STABU, DWD)	Land use, agricultural area, grassland, crops, phonological status, leaf area index	Enhanced temporal resolution (annual crop rotation, harvest date), enhanced spatial representativeness
Environmental observation and Federal Environmental Specimen Bank	UBA	CORINE-LC, Landsat-TM	Land use/land cover, land use change, phenology (maximum of vegetation development)	Enhanced spatial and temporal resolution

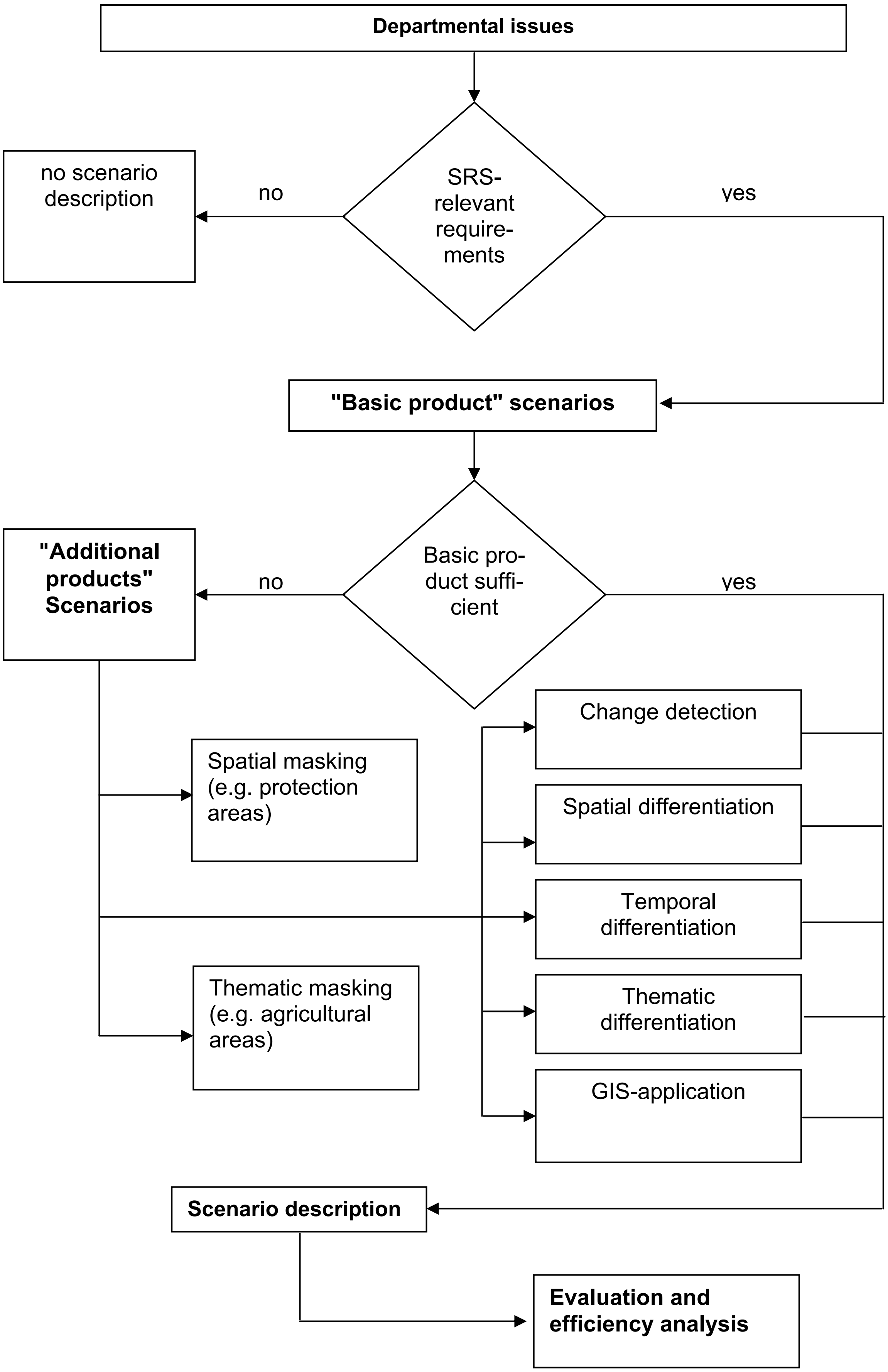

Fig. 1: Derivation of product / service scenario

Potential SRS based solutions for the requirements as identified above were outlined by way of normative scenarios, each of them describing a product or service assumed to be operationally feasible at present or in the near future. In order to cope with the differences in requirement specificity, scenarios were written for basic as well as specific products or services. A diagram outlining this principle of deriving scenarios from departmental requirements is given in Figure 1. The scenarios contain a description of the product/service proposed and an estimated cost frame. Examples will be presented at the workshop.

In order to achieve an independent efficiency assessment, the complete set of scenarios will, together with the draft final report, be distributed to the departmental experts for evaluation. Following a proposition of UBA, the evaluation will be carried out according to the Economic Analysis schedule (*Wirtschaftlichkeitsbetrachtung*) as recommended by the Federal Government Coordination and Consulting Office for Information Technology in the Federal Administration in the Federal Ministry of the Interior (*Koordinierungs- und Beratungsstelle der Bundesregierung für Informationstechnologie in der Bundesverwaltung im Bundesministerium des Inneren, KBSt*). Major evaluation criteria of the schedule are, in relation to the operational costs, the urgency of departmental tasks to be supported by the product or service and its estimated quality in terms of internal and external effects.

4 Outlook

In view of the requirements profile shown in Table 1 it is clear that, in the outcome of SATUM, an improved CORINE-LC product will constitute an outstanding basic scenario (see also Golla, 2000). Additional service scenarios will comprise, among others, change detection–based products to support monitoring activities, e.g. in the field of nature protection and biodiversity, and a service proposal to support the information system of BfS. Service scenarios will also integrate information on products currently being developed within the ongoing GMES projects GSE-SAGE and GSE-FM (see the respective contributions to this workshop)

Subject to the final results of the efficiency assessment process envisaged for the SATUM scenarios it can already be stated that major recommendations of the study will be

- to ensure that an enhanced basic product on land cover (CORINE-LC+) will be part of the operational core services to be offered within GMES,
- to strengthen the efforts for harmonisation of LC related monitoring activities of the federal states,
- to develop sustainable funding mechanisms for a basic LC monitoring service, reflecting the multiple utilisation potential of such a service on the European, national and subnational level, and, in this way,
- to contribute to a coherent and cost efficient LC data base in support of the legal obligations of the federal environmental administration.

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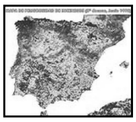
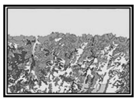
POSTER CONTRIBUTIONS

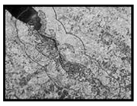
3 Some applications of CLC1990 in Spain



FPI: Fire Potential Index
Evaluation of risk of forest fires in the Mediterranean regions of Chile, Mexico, United States and Spain.



LACOAST: Land cover changes in the Spanish coastal areas.
Evaluation of land cover changes in a coastal strip of 10 km wide between 1975 and 1987.



MURBANDY-Bilbao: Monitoring Urban Dynamics
Monitoring for the analysis, comprehension and modelling of the evolution of land cover in the metropolitan area of Bilbao.

Fig. 2: Examples of applications of CLC1990 in Spain

These are three particular projects of use of CLC1990, but, it has been applied in some other projects with male scale (1:50.000 maximum):

- ✓ Generation of thematic cartography at national level, Land uses map from Ministry of Agriculture
- ✓ Generation of environmental cartography
- ✓ Forest planning, natural resources planning
- ✓ Basin analysis
- ✓ Evaluation of irrigated land areas
- ✓ Agricultural statistics
- ✓ Stratification before low resolution images classification
- ✓ Definition of protected areas
- ✓ Forest biomass studies with energetic purposes
- ✓ Climatic change (drains problematic)
- ✓ Projects of sustainable development of forest lands
- ✓ National Forestry Inventory

4 Future uses of CLC2000

Due to the improvement of the geometric and thematic quality of CLC2000 in relation to the previous database, the future CLC2000 could be use not only for applications at European or National level, as it has happened up to now, such us: planning or impact assessment of new big infrastructures, studies of landscape, climatic change, sustainable development, desertification, etc, but also in several applications with bigger scale required such us real integration with medium scale topographic cartography or more detailed studies at regional or municipal level.

5 Conclusions

The future CLC2000 can be use for applications also at regional level and not only national or European due to the improvement of the database as the final users have been involved from the beginning.

Nevertheless it would be good for next updating the integration of existent larger scale databases and also the improvement of the geometric accuracy using images with more resolution and its temporal component using multitemporal scenes and trying to have less time between the date of the images (2000) and the date of end of the final database (2004).

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I&CLC2000: Characteristics of the Belgian workflow

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Abstract

During the CORINE Land Cover first interpretation process (in the years 1994-1995), the Belgian national team used, with approval of the EEA, a Minimum Map Unit (MMU) of 10 ha instead of 25 ha and very poorly respected the minimal width of 100 m.

The aim of the CLC2000 project consists in updating this land cover database. Due to the geometric and thematic specific situation described above, it is necessary to adapt the CLC1990 data before starting the updating process. During this phase, a human interpreter reviews the interpretation of the CLC90 data and corrects not only the too small polygons (generalisation phase) but also the misinterpreted areas. It appears that the way the polygons are corrected is very important and can, in some cases, impact on the CLC2000 final data.

In some cases, it appeared that the interpreter has not only to correct the CLC1990 data on the basis of rules (MMU of 25 ha and minimal width of 100 m) and definitions of the CORINE nomenclature, but has to take into account the situation in 2000 in order to interpret the «original» situation

Concerning the use of the data, NGI has not many information about it. However, we know that the CLC1990 product was mainly used by universities (for land management studies) and by the mobile telephony operators (for wave diffusion models).

1 Background

During the years 1994 and 1995, National Geographic Institute of Belgium (IGN) participated at the European Environmental Agency's (EEA) project CORINE Land Cover. The southern part of the country presents some specific landscape characteristics. The main aspect is that majority of the villages in this region are less than 25 ha.

For this reason, we obtained from the EEA technical team to reduce the minimum map unit (MMU) from 25 to 10 ha (NGI, 1995).

This has big impact over the workflow for CLC2000 due to the fact that more than 30% of the CLC90's polygons are less than 25 ha.

2 Creation of the change database and CLC2000

In 1994-1995, NGI Belgium interpreted Landsat data, Spot data and ancillary documents to produce the CORINE land cover database. Since 2002, we started to revise the data to produce CLC2000 and a CHANGE database, containing the real changes between CLC90 and CLC2000. The first step is to generalize the to small (less than 25 ha) or to narrow (less than 100m width) polygons of CLC90. This is done by revising the whole data interactively, with CLC90 images in background. In the same time, the local geometric deformations and the thematic accuracy are checked.

In a second step, the CHANGE database is generated by image comparison between the CLC90 images and the I2000 product. Only the real changes greater than 5 ha for limit changes and greater than 25 ha for new polygon are delineated.

In the last phase, we generate the CLC2000 layer by overlaying CLC90 with CHANGE. The result, however, is not fully compliant with CORINE criteria because some resulting polygons are less than 25 ha. A CLC2000 generalisation process is thus necessary.

During this process it appears two important points. The first consequence is that the generalisation creates a difference between CLC2000 and CLC90 + CHANGE. It is then possible that some change results into a new polygon containing a code different from the CLC90 code or the CHANGE code. The second consequence is that it can appear some impossible change, resulting from generalisation of code in CLC90 and updating process. We can illustrate this point by an example: we had an extraction site in 1990 (code 131). This site had less than 25 ha and was then generalised into a contiguous urban area (code 112), according to the priority list mentioned in the Belgian final report (NGI, 1995). But in 2000, this same area was rehabilitated into "natural" site and the code has then to be modified into 242 or 243. This code had to be generalised (it still has less than 25 ha !).According the priority list, the new code was cropland (code 211). If we consider the pure rules of CORINE we thus have an impossible CHANGE of 112 → 211. A solution is to "correct" CLC90 and generalise the small polygon not respecting the priority rules. Another solution (what we choose) is to create a CHANGE polygon containing a CLC90 code different of the code in CLC90 DB.

3 Use of the CLC90 and CLC2000 data

A specificity of the Belgian National Geographic Institute is that it has very little contacts with the environmental actors because of the federal structure of Belgium. NGI is a federal institute and environment is a regional competence. Due to this fact, we do not have much information over the application developed with CLC90. For CLC2000, we will certainly be more informed thanks to an enhanced distribution policy.

3.1 The telecommunications

The CLC90 project ended in Belgium in 1995. It was the time for expansion of the cell phone networks. These phones use networks of relays antennas using microwaves and it was necessary to establish the antennas at optimal places. The CORINE land cover contained information at a compatible scale and detail level and was then a key data for the set up of the networks, coupled with D.E.M.

3.2 The environment

The CLC90 database was given to almost all Belgian universities, in the frame of different research project. We, however, received very little feedback from them. We know that the CLC data were used for landscape studies or for indicators developments. CLC was also very often used as background data for different kind of application like ecological habitats studies.

3.3 Planned applications for CLC2000

For CLC2000, some universities already asked us when the data would be deliverable in order to update some of their old project. We expect collect a lot of information about the planned applications in this occasion.

On already known application will be done in the coastal studies frame by a private Belgian company (GIM). The goal is to develop indicators based on different parameters of the CLC2000 polygons and their code. These indicators will enable the measure of some coastal environmental variables.

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National CORINE Land Cover mapping at scale 1:50.000 in Hungary

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Abstract

The standard CORINE Land Cover (CLC) database (scale 1:100,000) covers most of the EU Member States and accession countries and is used to support policy making at a European level. National applications however require a more detailed land cover database. As part of Hungary's preparation to join the European Union, a CLC mapping programme at scale 1:50,000 has been implemented. The standard (level-3) CORINE Land Cover nomenclature was enhanced to include nearly 80 level-4/5 classes. Ortho-rectified SPOT-4 satellite images taken in 1998-99 and visual photo-interpretation on computer screen have been applied to provide high positional accuracy. The 4 ha minimum mapping unit (1 ha for water) provides enhanced geometric detail. Internal and external quality control procedures are other key elements to yield a high quality database. The paper highlights the European co-operation aspects, as well as the technical novelties of the CLC50 project. Some of the applications of CLC50 are also described.

1 THE EU'S CORINE LAND COVER PROJECT

The basic aim of the CORINE Land Cover project is to provide an inventory of the Earth surface features for managing the environment. Computer assisted visual interpretation of satellite images has been chosen as the preferred mapping technology. The choice of scale (1:100,000), minimum mapping unit (25 ha) and minimum width of linear elements (100 meters) represents a trade-off between the costs of production and the details of land cover information derived (European Commission, 1993).

The CORINE Land Cover project has been implemented in most of the EU countries as well as in the 13 PHARE partner countries in Central and Eastern Europe and in two countries of North Africa (Morocco and Tunisia). The acquisition years of the satellite imagery used to derive the CLC100 database vary for the participating countries. A new project, called IMAGE2000 and CLC2000, is being undertaken recently to update the standard CLC database based on satellite imagery giving a "snap shot" of Europe for the year 2000 (Steenmans, 2000). The complete updating of CLC, known as CLC2000 is expected to be completed in 2004.

4 CONCLUSIONS

As a fulfilment of the government resolution on the “Development of environmental information systems” the implementation of the CORINE Land Cover database at scale 1:50,000 has been finished. The database supports Hungary’s accession to the EU in various programmes, such as the planning of sustainable agriculture, rural development, agri-environment and nature protection.

The CLC50 project has direct links to the standard European CORINE Land Cover project, however most elements of the methodology were upgraded according to the present level of technology in geo-data processing. The CLC50 nomenclature has been developed from the standard (level-3) nomenclature and includes nearly 80 level-4 and level-5 classes that have been adapted for Hungarian conditions.

Ortho-rectified SPOT-4 satellite images taken in 1998-99 and computer-assisted photo-interpretation allow for high positional accuracy of de-lineation. The 4 ha size minimum mapping unit (1 ha for lakes) provides enhanced geometric details. A rigorous internal supervision and an external quality control are other key elements of producing a high quality database.

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ANNEX: CLC50 NOMENCLATURE (V1.3)

1 ARTIFICIAL SURFACES
1111 Areas of urban centres
1112 Areas of ancient cores
1121 Discontinuous built-up areas with multiflat houses prevailingly without gardens
1122 Discontinuous built-up areas with family houses with gardens
1123 Discontinuous built-up areas with greenery
12111 Industrial and commercial units
12112 Agro-industry
12113 Education and health facilities
1212 Areas of special installations
1221 Road network and associated land
1222 Rail network and associated land
1232 River and lake ports
1233 Shipyards
1234 Sport and recreation ports
1241 Airports with artificial surfaces of runways
1242 Airports with grass surfaces of runways
1311 Open cast mines
1312 Quarries
1321 Solid waste dump sites
1322 Liquid waste dump sites
1331 Construction sites
1411 Parks
1412 Cemeteries
1421 Sport facilities
1422 Leisure areas
1423 Recreation settlements

2 AGRICULTURE AREAS
2111 Arable land with large fields
2112 Arable land with small fields
2113 Greenhouses
2121 Permanently irrigated arable land
2131 Rice fields
2211 Vineyards
2221 Orchards
2222 Berry fruit plantations
2223 Hop plantations
2226 Wild willow plantations
2311 Intensive pastures, degraded grassland without trees and shrubs
2312 Intensive pastures, degraded grassland with trees and shrubs
2421 Complex cultivation patterns without scattered houses
24221 Complex cultivation patterns with scattered houses
24222 Farmsteads
2431 Agricultural areas with significant share of natural vegetation and with prevalence of arable land
2432 Agricultural areas with significant share of natural vegetation and with prevalence of grasslands
2433 Agricultural areas with significant share of natural vegetation and with prevalence of scattered natural vegetation
2434 Agricultural areas with significant share of ponds and with prevalence of scattered natural vegetation
2435 Agricultural areas with significant share of permanent crops and with presence of scattered natural vegetation

3 FORESTS AND SEMINATURAL AREAS
3111 Broad-leaved forest with continuous canopy, not on wet area
3112 Broad-leaved forest with continuous canopy, on wet area
3113 Broad-leaved forest with discontinuous canopy, not on wet area
3114 Broad-leaved forest with discontinuous canopy, on wet area
3115 Plantations of broad-leaved forests
3121 Coniferous forests with continuous canopy
3125 Plantations of coniferous forests
3131 Mixed forests created by alternation of single trees with continuous canopy
3135 Mixed forests created by alternation of stands of trees with continuous canopy
3139 Plantations of mixed forests
3211 Natural grassland prevailingly without trees and shrubs
3212 Natural grassland with trees and shrubs
3241 Young stands and clear-cuts
3243 Bushy woodlands, natural regeneration areas
3244 Forest nurseries
3245 Damaged forests
3313 River banks
3321 Bare rocks
3331 Sparse vegetation on sands or loess
3332 Sparse vegetation on rocks
3333 Sparse vegetation on salines
3341 Burnt areas

4 WETLANDS
4111 Fresh-water marshes
4113 Saline (alkali) inland marshes
4121 Explored peat bogs
4122 Natural peat bogs with scattered trees and shrubs

5 WATERS
5111 Rivers
5112 Channels
51211 Natural water bodies with continuous water supply
51212 Natural, temporary, salt affected water bodies
51221 Artificial lakes, reservoirs
51222 Fish ponds

General introduction of the technical realisation of CORINE Land Cover Updates as well as Experiences and case studies of the German lots 3-5 interpreted by EFTAS Remote Sensing GmbH

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Abstract

The interpretation and digitisation of land cover changes are the central part of the CORINE LAND COVER 2000 project.

This presentation gives especially for CORINE users and interested parties a general introduction to the technical realisation of the work.

In comparison to the rules of the initial survey CLC1990 the requirements for the update detection are explained. The realisation of the CLC2000 survey for the German lots interpreted by EFTAS GmbH is visualized with the use of the in house software tool **LaCoSurvey 1.7**, which is especially developed for CORINE land cover update.

Additionally several examples and case studies of database adaptations and land cover changes are provided to demonstrate the improvements and quality of the database and the land cover development.

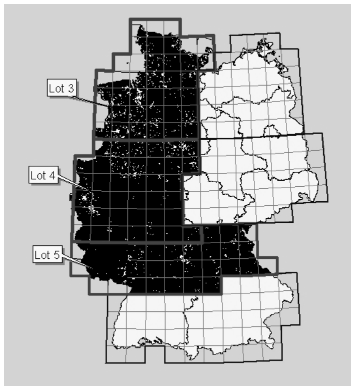

Fig. 1:

Overview of German lots interpreted by EFTAS GmbH.

1 Principles

Focused on the scale 1:100.000 the initial CLC1990 survey was executed with 44 classes on the base of Landsat 5 TM satellite images with 25 m ground resolution. This interpretation was done on hard copies and digitized afterwards in a second step.

The minimum size of polygon areas was 25 ha and a width of 100 m for linear features. Regarding the change detection CLC2000 these main aspects where added with the minimum size of 5 ha for land cover changes and improved by the use of Landsat 7 ETM satellite images with 15 m ground resolution.

The interpretation of the CLC2000 dataset is completely digital and improved by some changes regarding the interpretation rules and nomenclature requirements to eliminate significant weak points of the CLC1990 data base like e.g. underestimation of villages.

2 Execution

As shown in figure 2 the interpretation of CLC2000 is done in three steps.

- At first the CLC1990 dataset has to be checked and cases of incorrect interpretation or necessary adaptation because of the new requirements as well as real land cover changes have to be flagged.
- In the second step the vector data and their related attributes of the marked cases for CLC1990 corrections or adaptations have to be implemented.
- The last step is the mapping of real land cover changes.

All steps deliver different datasets with different information stages (see figure 2). They are documented by a system of additional attributes (see table 1), which are necessary for the analysis of the land cover changes.

Additionally the main three step approach of the interpretation is covered by several quality measurements as GIS based plausibility checks, interpretation controls and field visits. The whole procedure is closely realised in accordance to the ISO 9001:2000 certification of EFTAS GmbH.

Tab. 1: Additional attributes and technical codes for polygon specific documentation.

Additional attributes		Technical codes	
Status of CLC1990 data base (NSK1) (correction and adaptation done in NSK2)	ST-90	0 1 2 3 4 5 6 7 8	▪ default setting ▪ CLC1990 (NSK1) OK ▪ incorrect interpretation because of interferences / clouds ▪ incorrect interpretation because of phenology (with or without area changes) ▪ incorrect interpretation because of wrong identification (with or without area changes) ▪ incorrect interpretation because of wrong deliniation ▪ unmapped in NSK1 because of nomenclature adaptation
Identification of land cover changes (implemented in NSK3)	KON-1	0 1 2 3 4	▪ default setting ▪ without changes ▪ changes surely identified ▪ changes identification unsure (temporarily) ▪ not identifiable / field check required (temporarily)
Used references	CHK	0 1 2 3 4 5	▪ default setting ▪ check with field visit ▪ check with orthophoto ▪ check with topografical map (TK25) ▪ confirmed by public utility ▪ check with additional satellite images
Documentation of none real change areas	NRCH	0 1	▪ default setting ▪ no real changes; area was 1990 < 25 ha

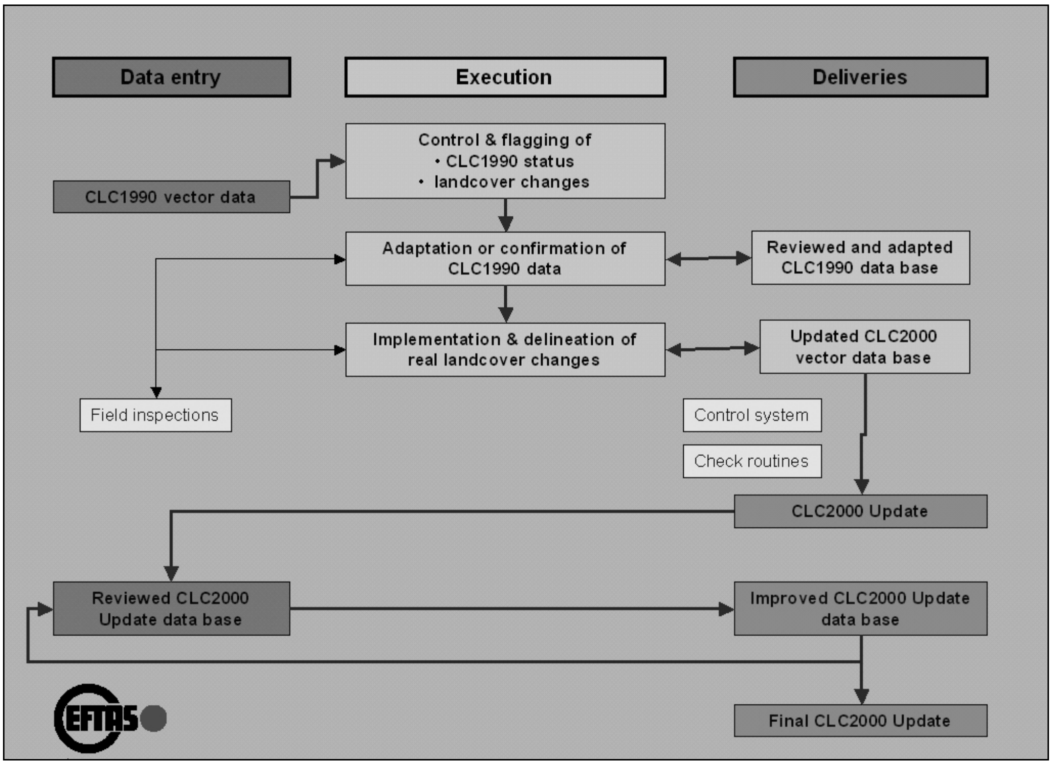

Fig. 2: Three step approach of CLC2000 update workflow.

5 Conclusion

As explained CLC2000 updates are realized with improved methodology, reference material (LANDSAT ETM) and improved interpretation rules and requirements regarding the nomenclature.

The modern concept of onscreen interpretation in a three step approach provides the potential of detailed analysis between corrected errors and real land cover changes.

Finally the system of technical codes and additional attributes together with the use of the efficient land cover interpretation tool LaCoSURVEY developed by EFTAS GmbH for CLC2000 purposes guaranties a successful realisation and a high quality of the CORINE LAND COVER 2000 dataset.

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Vergleich von CORINE Land Cover-Daten mit klassifizierten IRS-1C-Daten und deren Anwendung bei der Umsetzung der EU- Wasserrahmenrichtlinie im Freistaat Sachsen

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Abstract

The assessment of diffuse contamination inputs to groundwater for its initial characterisation, has been carried out for Saxony by a combined emission/ immission approach, using classified cartographic satellite data IRS-1C. As a result, 22 groundwater bodies (of a total of 72 mainly covering Saxon territory bodies) have been detected as potentially at risk. Using the administrative district of Döbeln a sufficient congruence between classified data of IRS-1C 2000/2001, and of CORINE Land Cover 2000 has been established. So, both kinds of data can be used for the purpose of EU- Water Framework Directive, leading to comparable results.

1 Einleitung

Die am 22.12.2000 in Kraft getretene EU-Wasserrahmenrichtlinie legt einen Fahrplan fest, um bis zum Jahr 2015 für alle Gewässer einen guten Zustand zu erreichen. Der erste Schritt zu diesem Ziel ist eine „Bestandsaufnahme“ der Gewässer, die mit dem „Bericht 2005“ an die europäische Kommission endet. Für die Bestandsaufnahme werden zuverlässige Daten zur Landnutzung benötigt. Diese gehen in die Erstbeschreibung Grundwasser, die Prüfung der Auswirkungen menschlicher Tätigkeiten auf das Grundwasser und die Erhebung signifikanter Belastungen von oberirdischen Gewässern ein. Die Flussgebietsgemeinschaft Elbe hat sich im Herbst 2003 auf die Verwendung von CORINE Land Cover 2000-Daten in den fünf deutschen Koordinierungsräumen geeinigt. Der “Bericht 2005“ wird die digitale Karte „Bodennutzungsstruktur nach CORINE Land Cover“ enthalten.

2 Beurteilung diffuser Stoffeinträge in das Grundwasser

Mit Beginn der Arbeiten zur Erstbeschreibung Grundwasser im Jahr 2002 waren in Sachsen CORINE Land Cover-Daten nur von 1992 verfügbar. Da die Wasserrahmenrichtlinie eine Bestandsaufnahme für das Jahr 2000 vorsieht, wurden für die Beurteilung diffuser Stoffeinträge in das Grundwasser neuere, im Auftrag des sächsischen Landesamtes für Umwelt und Geologie klassifizierte Satellitenbilddaten IRS-1C 2000/2001 verwendet (LfUG/HUGIN, 2003). Im Folgenden werden unter IRS-1C-Daten die klassifizierten Daten verstanden.

Von der Länderarbeitsgemeinschaft Wasser (LAWA) wurden sechs Methoden zur Beurteilung diffuser Stoffeinträge bei der erstmaligen Beschreibung des Grundwassers vorgeschlagen (LAWA, 2003). In Sachsen wurde der Ansatz 4 (kombinierter Emissions-Immissions-Ansatz) verwendet:
Als potenziell gefährdet durch diffuse Stoffeinträge werden die Grundwasserkörper angesehen, bei denen

- der Anteil der Flächen mit landwirtschaftlicher Nutzung und Nitratkonzentrationen im Grundwasser von größer/gleich 25 mg/l oder
- der Anteil der Siedlungs- und Verkehrsflächen

mehr als 33 % der Gesamtfläche des Grundwasserkörpers beträgt. Folgende Arbeitsschritte wurden durchgeführt:

1. Zusammenstellung von Messwerten von Nitratkonzentrationen im Grundwasser aus dem Jahr 2000 aus der Grundwasserüberwachung des Landesgrundwasserdienstes und von Wasserversorgern
2. Regionalisierung der Messwerte mit dem Regionalisierungsverfahren IDW (Inverse Distance Weighted)
3. Einteilung der regionalisierten Nitratkonzentrationen in die Klassen 1 (Nitratkonzentration kleiner 25 mg/l) und 2 (Nitratkonzentration größer/gleich 25 mg/l)
4. Ermittlung der Landnutzung aus IRS-1C-Daten, Kategorien „Ackerland" und „Dauergrünland"
5. Bildung der gemeinsamen Schnittmenge aus der Fläche der regionalisierten Nitratkonzentrationen Klasse 2 mit den zusammengefassten Kategorien „Ackerland" und „Dauergrünland" der IRS-1C-Daten
6. Ermittlung der Flächen der Kategorien zu Siedlung und Verkehr der IRS-1C-Daten
7. Bewertung: Als möglicherweise gefährdet durch diffuse Stoffeinträge werden die Grundwasserkörper angesehen, bei denen der Anteil der Flächen nach Punkt (5) oder der Anteil der Flächen nach Punkt (6) mehr als 33% der Gesamtfläche des Grundwasserkörpers beträgt.

Nach dieser Methode wurden die sächsischen Grundwasserkörper bzgl. der diffusen Stoffeinträge in das Grundwasser beurteilt. Von den 72 mit ihrer Fläche überwiegend auf sächsischem Gebiet gelegenen Grundwasserkörpern wurden 22 Körper als möglicherweise gefährdet eingestuft. Für diese Grundwasserkörper wird nun in der weitergehenden Beschreibung geprüft, ob für sie das Risiko besteht, die Ziele der Wasserrahmenrichtlinie bis 2015 nicht zu erreichen.

3 Vergleich von CORINE Land Cover-Daten mit IRS-1C-Daten

Seit 2003 liegen für Sachsen die neuen CORINE Land Cover-Daten von 2000 vor (UBA/DFD DLR, 2003). Daher sollte an einem Beispiel geprüft werden, ob die Landnutzung von CORINE Land Cover 2000-Daten und IRS-1C 2000/2001-Daten ähnlich dargestellt wird und ob als Folge davon die Verwendung beider Datenarten bei Arbeiten zur Umsetzung der Wasserrahmenrichtlinie zu vergleichbaren Ergebnissen führt.

Abb. 1 zeigt die Anwendung der in Sachsen umgesetzten Methode zur Beurteilung diffuser Stoffeinträge in das Grundwasser in einem Ausschnitt für den als Beispiel herangezogenen Landkreis Döbeln. Auf Abb. 2 ist die Landnutzung im Landkreis für beide Datenarten gegenübergestellt. Die Auflösung der IRS-1C-Daten ist mit 5 m * 5 m deutlich größer als die der Landsat-Daten mit 30 m * 30 m, die den CORINE Land Cover-Daten zugrunde liegen. Wie auf Abb. 2 zu sehen ist, können die IRS-1C-Daten kleinere Landnutzungsstrukturen wie Bahnlinien, Straßen oder Fließgewässer besser wiedergeben. Trotzdem hat sich gezeigt, dass die höhere Auflösung der IRS-1C-Daten für die Methode zur Beurteilung diffuser Stoffeinträge in das Grundwasser nicht erforderlich gewesen wäre und bei der Datenverarbeitung mit GIS-Systemen zu höheren Rechenzeiten führt, was eher hinderlich ist. Eine verallgemeinernde Schlussfolgerung zur Verwendung kleinerer Auflösungen für alle Arbeiten zur Umsetzung der Wasserrahmenrichtlinie kann aus diesem Anwendungsfall jedoch nicht gezogen werden.

Tab. 1 enthält einen prozentualen Vergleich der Landnutzung im Landkreis Döbeln. Grundlage war der Klassifizierungsschlüssel der IRS-1C-Daten, dem die Landnutzungskategorien der CORINE Land Cover-Daten zugeordnet wurden. Diese Zuordnung ist problematisch, weil einigen Nutzungskategorien unterschiedliche Definitionen zu Grunde liegen. So beinhaltet die Kategorie „Dauergrünland“ der IRS-1C-Daten Flächen, die nach EU-Definition nicht in die Fruchtfolge einbezogen sind und auf denen mindestens fünf Jahre lang Gras erzeugt wurde. Die Kategorie „Grünland“ der CORINE Land Cover-Daten erfasst dagegen „Wiesen und Weiden“ bereits 3 Jahre nach der Umwandlung. Bei einem Vergleich von IRS-1C-Daten und CORINE Land Cover-Daten in den Kategorien „Dauergrünland“ und „Grünland“ sowie „Ackerland“ und „Ackerflächen“ treten daher im Landkreis Döbeln erhebliche Unterschiede von 9,6 % auf.

Tab. 1: Vergleich der Landnutzung im Landkreis Döbeln (Sachsen) anhand von CORINE Land Cover 2000-Daten und IRS-1C 2000/2001-Daten

Landnutzungsklassen **Klassifizierung nach**		**CORINE Land Cover 2000-Daten**	**IRS-1C 2000/2001 - Daten**
IRS-1C	**CORINE Land Cover**	**%**	**%**
Dauergrünland	231	0	6,06
Ackerland	211	81,74	72,17
Laubwald	311	1,2	4,78
Nadelwald	312	0,07	0,19
Mischwald	313	2,21	0,5
Siedlung, Gewerbe, Industrie	111, 112, 121	7,34	13,11
Straßen	122	0	1,55
Bahnlinie	122	0	0,26
Fließgewässer	511	0	1,1
Standgewässer	512	0	0,29
Rohstofffläche	131	0,14	0
Restfläche	alle übrigen	7,29	0

Analysis of water and matter balance using Corine Land Cover data on different spatial scales

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Abstract

For the derivation of input parameters for mesoscale water and matter balance models and assessment procedures such as ABIMO, SWAT and ArcEGMO as well as for the evaluation of erosion risk potential differently aggregated data sets of the Corine Land Cover (CLC) classification had been utilized. The paper discusses the applicability of the CLC data for the approaches on different scales. Moreover, CLC was used to create a web-based GIS for visualization of the results of the flood mapping of the Mulde river 2002 (Haase et al. 2003a).

1 Projects

At the Department of Applied Landscape Ecology at the UFZ Corine Land Cover data (1992) have been used in different projects on different spatial scales for

- to estimate parameters of the water balance based on the Bagrov-Glugla-approach (model ABIMO calculating the groundwater recharge) and simulation models ArcEGMO (precipitation – runoff) and SWAT (water and matter balance) to realise a first top-down assessment of conflict areas of nitrate discharge in mesoscale river basins,
- to locate nutrient emissions at the community level based on N- and P balance surplus agricultural farms and enterprises in comparison to the proportion of arable land and grassland,
- to derive runoff regulation parameters such as roughness and discharge coefficient for the evaluation of flood risk at the large mesoscale,
- to classify the erosion risk at the landscape level (1:100.000),
- to formulate conceptual models for the risk assessment of acidic input in surface and groundwater (Haase et al. 2003b),
- last not least, to characterise the flooded areas of the Elbe and Mulde floods in August 2002 in form of a web-GIS *(http://www.mulde.ufz.de).*

The projects in which Corine Land Cover data serves for the above described assessment and modelling procedures are supported by the BMBF „Decision support for the application of the WFD at the example of the Weiße-Elster basin, Central Germany“, FLUMAGIS (Ems) and by the Centre for Environmental Research „Integrated management of river basins in the Saale basin“.

2 Methods and Results

Modelling water and nutrient fluxes requires adequate land use data. Therefore, land use class proportions of CLC were compared with the data sources of the biotope (land use type) and soil mapping (scale 1:10.000 and 1:25.000). Although it is common about the fact, that different scaled data sets deliver different results in proportions of land use classes, a comparison shows the differences more clearly.

Because CLC provides areas larger than 25 ha, the proportion of grassland is underestimated by 80% in comparison the biotope and land use type mapping (BTM). In contrast to arable land the areas of grassland usually are smaller than 25 ha. Areas of waters are underestimated by almost 100%, urban areas by 40%. Forests areas with ca. 15% less proportion of areas are represented adequately to the proportions derived from the other two data sets.

The underestimation of proportion of land use classes remains also apparent in a higher level of aggregation. Figure 1 shows the results of an assessment of potential erosion resistance (PER) based on CLC and BTM for subbasins of Saale basin according to a method for site comparison (VERMOST; Thiere et al. 1984). The CLC based assessment reveals an overestimating of erosion compared to BTM based assessment there, where the proportions of grassland are high. For subbasins with low grassland proportion, CLC is suitable for first mesoscale overview investigations (Fig. 2, 3). Hence, an essential reduction of required input data (Fig. 3 and Tab.1) could be reached. The CLC data set were used as a filter to focussing further detailed land use analysis.

Tab.1: Comparison of CLC and ATKIS data evaluating the proportion of arable land in an intensively used agricultural watershed (Helme-Zorge near the Harz mountains in Central Germany).

Total catchment of the Kelbra dam	**47% arable land (CLC-Daten)**
Sub catchment of the Helme	70% of the total Kelbra area
	(30% belong to the Zorge catchment)
Total catchment of the Helme	**72% arable land (CLC-Daten)**
	60% arable land (ATKIS)
Difference (ΔA)	**12% (39 km^2)**

One essential aspect of the Saale *(http://www.ufz.de/saale)* and the FLUMAGIS projects *(http://www.flumagis.de/)* is to detect areas with high potential of diffuse nutrient and acidic input into river systems (Fig. 4a-d; 5). Following an integrated approach, the assessment of landscape functions is combined (risk of nitrate leaching and critical loads) with the spatial distribution of nutrient balances of arable land and water quality issues. To estimate the water balance coupled with matter fluxes there have been used the land use information of CLC (third level) for the parameterization of land use classes which serve for conceptional and deterministic models. Dedicated parameters are root dept, leaf area index, degree of surface sealing for the infiltration capacity, acidifying potential etc. The simulation of water balance coupled with matter balances with CLC data input permit a first overview of effects of land use to the water cycle (Haase et al. 2003a,b and Haase & Volk 2003).

For the Bulgarian country the mapped forest ecosystems involve 55 EMEP 50x50 km^2 grid cells, of which 26 are covered by brood leaved forests only, but in other 29 cells, the forest is a composite of both brood leaved and coniferous. Sometimes, there are more than 20 species in one grid cell. Values for most of parameters and resulting critical loads, stored in separate records, show a great variability. In this case some of tree species will not be protected by calculated average critical loads when their individual critical loads are lower.

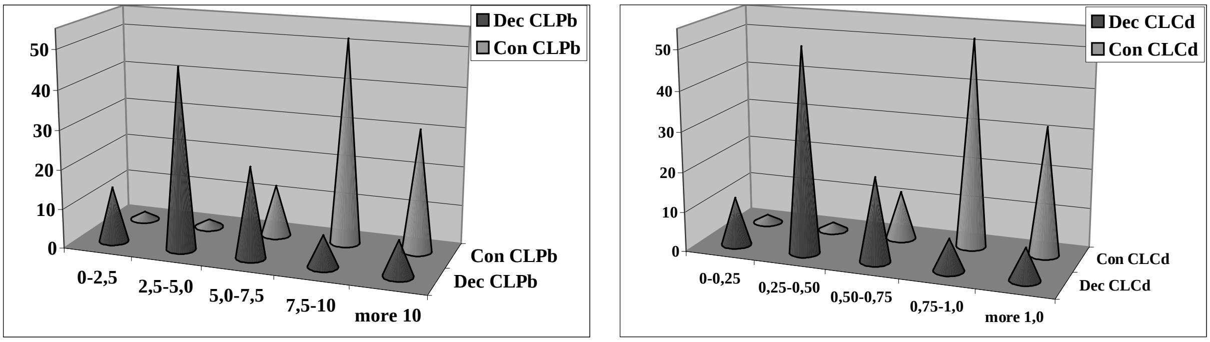

Fig. 3: Distribution of critical loads values of Pb (left) and Cd (right) for brood leaved (red) and coniferous (green) forest ecosystems in Bulgaria, in percent

Concerning the distribution of critical loads of Pb and Cd, for 44 % of the grid cells covered by brood leaved forests, critical loads of Pb were situated between 2,5 and 5,0 gha^{-1}yr^{-1} for Pb and between 0,025 and 0,050 gha^{-1}yr^{-1} for Cd, when the maximum of the grid cells with coniferous forested catchments (50 %) were included in the class of 7,5 – 10,0 gha^{-1}yr^{-1} for Pb and between 0,75 and 1,00 gha^{-1}yr^{-1} (fig. 3). The picture was similar for Cd. This kind of distribution of the critical loads confirms that brood leaved forest ecosystems are more sensitive to the both Cd and Pb deposition than coniferous ones.

4 Conclusion

It could be concluded that using the CORINE Land Cover information the calculated values for acidity and heavy metals give a good initial indication of the spatial variability of ecosystem sensitivity to acidification and heavy metals pollution in Bulgaria. By combining the CORINE Land Cover map with EMEP grid cells network, critical loads of acidifying pollutants for both coniferous and brood leaved forests together with their corresponding areas for every EMEP grid cells could be shown on only one map, which gives the possibility to compare them easily

Although the high buffering capacity of the Bulgarian forested area, brood leaved forests are more sensitive to the acid deposition and heavy metals than the coniferous ones. Taking into consideration that the deciduous forest ecosystems occupy two and a half times more of the area in the country, than the coniferous ones and that the critical loads for the deciduous forests are much lower than those for the coniferous ones, at similar geographical and climatic parameters, the deciduous ecosystems could be used as a biological monitor for atmospheric pollutants concentrations reduction.

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4 Users

The CLC database has been considered in all countries involved to have an important role in supporting various activities in the process of harmonisation and integration with European Union policies. In most cases, the applications serve a range of end users. However, it is evident that their results are of primary importance to decision makers, followed by experts and the general public, in compliance with the original terms of reference for CORINE programs. Figure 3 shows the end-user statistics. Despite these figures, significant numbers of applications are still developed at the scientific/expert level. It is therefore emphasised that experts should also seek other products and presentations to promote and enable wider incorporation of CLC based information in decision making processes at both national and local level, and also addressing the needs and interests of the general public.

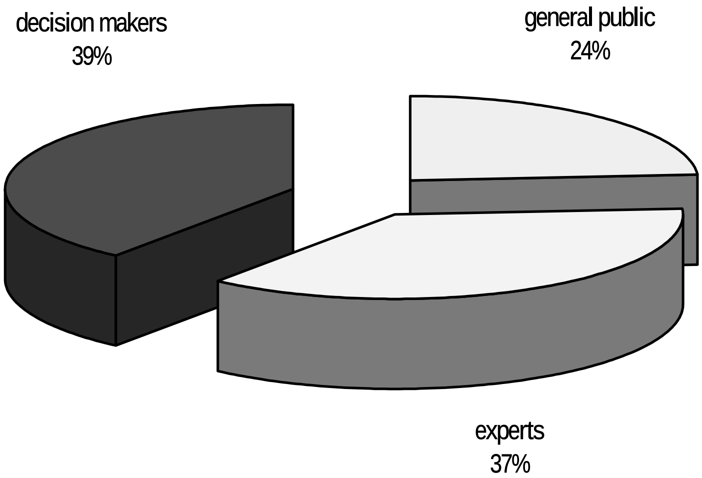

Fig. 3: End-User Breakdown of CLC Applications

5 Conclusion

In the context of ongoing I&CLC2000 project, the European Topic Centre Terrestrial Environment (ETC TE) continues in this effort. It currently run another survey on use of CLC information, the new survey will bring updated overview on CLC applications in both the EU member states and candidate countries. More information can be found on http://terrestrial.eionet.eu.int

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Spatial and Temporal Analyses of the *Echinococcus multilocularis* and *Trichinella spiralis* Occurence in the Slovak Republic

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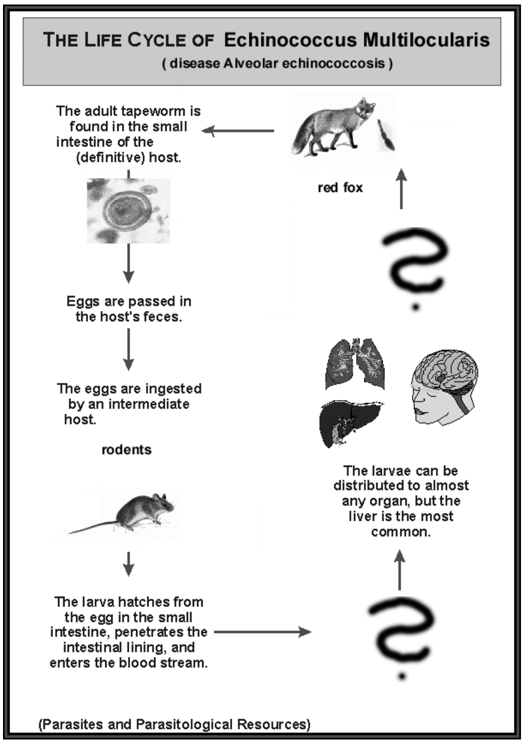
Abstract

A total of 2130 red foxes (*Vulpes vulpes*) were captured and examined for intestinal infection with *Echinococcus multilocularis* and *Trichinella Spiralis* in period 2000-2002, across the whole territory of the Slovak Republic. No significant differences in prevalence were observed between foxes captured in different seasons (spring and autumn/winter). Also the sex of red foxes had no effect on prevalence of the monitored parasites according to basic statistic analyses. Spatial and multitemporal GIS analyses were done and relations with land cover, hypsography, hydrology and land cover diversity were examined. Strong relations were found with altitude levels and some land cover classes on one hand, but no relations with land cover diversity or hydrology on the other hand. The highest prevalence of infected red foxes was recorded at 200 – 400 meters above sea level and in areas with high proportion of CORINE land cover classes 311, 211, 243, 312, 313, 11, 231, 324. Finally spatial model of the potential risk occurrence of both parasites helped to create potential risk map that is available also in animation mode at Internet site http://www.sazp.sk/parazity Influence of various potential factors to spread of this zoonosis is discussed. Monitoring of these parasites continues and further analyses and modelling based on the new CLC2000 is necessary.

1 Introduction

Parasitic zoonoses – parasitic diseases transmitted from animals to humans are recognised as an important public health problem. Alveolar echinococcosis, caused by the larval stage of *Echinococcus multilocularis* (*Cestoda*: Cyclophylida: *Taeniidae*), is considered as one of the most serious. From January 1982 to December 2000, nine European countries reported 559 patients with alveolar echinococcosis (Kern et al., 2003). In Central Europe, the life cycle of *E. multilocularis* included mainly red fox (*Vulpes vulpes*) as a definitive host and rodents as intermediate hosts (Rausch and Schiller, 1951). Although the mechanisms of the parasite transmission to humans are not well-known yet, and the susceptibility of the people to the infection is probably limited), countermeasures relevant to human prevention are very important, and this is supported also with fact, that treatment of alveolar echinococcosis is very difficult and expensive.



Reports about finding *E. multilocularis* tapeworm, or its larval stage in surrounding countries earlier considered as free of the parasite and rapid increasing of the prevalence rates in endemic region supported the investigation of the *E. multilocularis* occurrence in red foxes also in our country. In the Slovak Republic, infection of red foxes with *E. multilocularis* was for the first time described in 1999 (Dubinský et al., 1999). In the following year, more extensive epidemiological survey was initiated in the whole territory of the Slovak Republic. We discuss factors presumably influencing existence and spread of this parasitic zoonosis.

Fig. 1: The Life Cycle of Ehinococcis Multilocularis

Unlike many parasites that demonstrate a high degree of host specificity, Trichinella spiralis, the trichina worm, can be found in many species of carnivores and omnivores. Animals are infected with T. spiralis when they ingest infective larvae (juveniles) in raw or undercooked meat. The larvae mature into adults in the host's small intestine in a few weeks, and the female worms give birth to larvae. (The males die after fertilizing the females, and the females die after producing larvae.) The larvae enter the blood stream of the host and, eventually, end up in the host's muscles. Here the larvae mature into infective larvae, and the next host is infected when it eats these larvae. In the muscles the larvae cause a severe host reaction that results in soreness and tenderness of the muscles (view diagram of the life cycle). Although this parasite probably only rarely causes fatalities in humans, it can cause extreme discomfort. Trichinosis is probably best known as a parasite that humans contract from eating raw or undercooked pork. Through an aggressive program of meat inspection, the incidence of trichinosis in pigs in the United States has been lowered to less than 1%, so it is unlikely (but not impossible) that pork products purchased in your local supermarket will contain Trichinella larvae. Most recent outbreaks of trichinosis in the United States have been traced to pork products from pigs that have not been inspected and that have been slaughtered privately. Because of its low host-specificity, almost any "wild" meat should be considered suspect, and hunters should be careful when preparing meat from their kills. In particular, a number of infections have been traced to contaminated bear meat.

2 Spatial Analyses

The capture site of red foxes was located according to cadastral units and with help of basic residential units. For each cadastre with infected red foxes the percentage proportion of individual land cover categories was calculated using the CORINE Land Cover CLC1990 data. The dependence analyses of *E. multilocularis* occurrence and *Trichinella Spiralis* on the

CORINE class were done by modelling of the regions. Occurrence polygons from over the last three years and selected CORINE land cover categories were integrated into one region layer suitable for time sequence analysis. The modelling proceeded in Unix ArcInfo environment.

Dependence analyses of relevant parasites occurrence on land cover class were done. The auxiliary parameter was created – weighted occurrence:

WOC (k,p) = SO (p) . KAT area / LOCarea

WOC – weighted occurrence for the given CORINE category
k – *given CORINE category* p – *parasite*
SO – *sum of all positive occurrences in the sampling locality*
KATarea – *area of CORINE category within the sampling locality*
LOCarea – *area of the locality*

Similarly, the dependence analyses of relevant parasites occurrence on altitude level were performed. For weighted occurrence it is valid:

WOH (i,p) = SO (p) . ALTarea / LOCarea

WOH – weighted occurrence for the given ALTITUDE level
i – given ALTITUDE level p – parasite
SO – sum of all positive occurrences in the sampling locality
ALTarea – area of ALTITUDE level within the sampling locality
LOCarea – area of the locality).

Resultant weighted occurrences entered into frequency analysis, both parameters were weighted again and consequently maps of potential risk were created.

RISK (p) = k .w (k) + i . w (i)

RISK – potential risk on the scale from 1 to 5
p – parasite k – category CORINE Land Cover i – ALTITUDE level
w (k) – weight attributed to land cover category
w (i) – weight attributed to altitude level)

GIS and image processing systems were used for analysis and modelling (Unix ArcInfo, PC ArcView, ESRI, EASI Pace, PCI Int), graphs and statistic (Microsoft Excel).

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Utilization of CORINE land use data and other datasets for the simulation of N-trace-gas emissions from soils in Germany

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Abstract

Two biogeochemical models (DNDC, PnET-N-DNDC) were used to estimate national and regional N-trace-gas emissions for Germany. Due to the complex nature of these process-oriented models, large amounts of datasets had to be integrated into a Geographic Information System (GIS). An important part of this database is the CORINE land use dataset, which was used to define areas of agricultural and silvicultural use. Differences between the areal extent of the CORINE dataset polygons and official statistics (Statistik regional, Destatis) implied new methods for correcting these discrepancies.

1 Introduction

With regard to global climate change, soils are of significant importance as sources of atmospheric trace gases such as N_2O and NO. The impact of N_2O on the total human-induced greenhouse warming is estimated to be 5% of the total anthropogenic warming, but a long atmospheric live-time and a high heating potential raise concerns about possible consequences caused by a steady increase of this trace-gas in the atmosphere. The quantification of the regional source strength (including emissions from soils), which is unavoidable for the signatory states to the United Nations Framework of Climate Change (UNFCC) is presently implemented by emissions factors (IPCC-approach), which specify the fraction of N_2O emitted to the atmosphere where N-fertilizers are applied to soils. These factors possess large uncertainties since the emission release is governed by a complex system of interacting environmental and anthropogenic forces.

Previous studies have shown that process-oriented models are able to simulate the complex interactions between biosphere, atmosphere, hydrosphere and pedosphere (e.g. LI et al., 1996; LI, 2000; LI et al., 2000). The utilization of those models on a regional scale was also demonstrated (e.g. BUTTERBACH-BAHL et al., 2001, 2002; BROWN et al., 2002), but complex data processing and integration procedures have to be applied to provide the necessary input variables for heterogeneous regions like Germany.

2 Methodology and general processing steps involved in this study

As shown in Figure 1, the dataflow and processing scheme can be split into five main tasks. In the first step (basic data fusion), basic spatial datasets were integrated to define areas of unique environmental phenomena: land use (e.g. agricultural), administrative registration (e.g. located in the county "Main-Spessart"), soil conditions (e.g. soil type haplic luvisol) and climatic conditions (e.g. reference station No. 27221). To determine agricultural and forest areas the CORINE land use dataset was used (marked as (*1) in Figure 1).

In the following step ancillary data was integrated to incorporate detailed information about crops and forest stands on individual polygons. Non-spatial parameters (e.g. farming practice), data generalizations, and input drivers for the biogeochemical models used in the study were created afterwards. The resulting files were then used as input datasets for the process-oriented models DNDC (agricultural soils) and PnET-N-DNDC (forest soils). In the final step, national emission inventories for the N-trace-gas species N_2O and NO were derived. Additionally, regional and temporal emissions were visualized by animations of daily emissions and a range of map products were assembled.

3 Utilization of CORINE Land Cover data

As described above, the CORINE Land Cover data played an important role in discriminating areas of agri- or silvicultural use. However, significant discrepancies were discovered when the areal extent of land use classes was matched with the official statistics of the German administration. As shown in Figure 2, these discrepancies were not evenly distributed over the entire study area and the extent of agricultural areas seems to be overestimated by the CORINE dataset, whereas the data of forest areas shows less variations.

Since the simulation effort depends on a wide range of input factors, all data was calibrated to match the areas registered by the official statistics. As a primary measure, the CORINE land cover subclasses (e.g. grassland) were combined to form a more general classification, reducing severe differences between grassland and arable land distribution in the GIS and the statistics. Furthermore, a regionalized area-correction-factor was applied to match the areal extent of the statistics (market as (*2) in Figure 1). This factor was also used to correct small differences introduced by generalization efforts.

4 Discussion

4.1 What may have caused the differences between CORINE and statistical data?

The observed differences can be attributed to a range of possible factors. The most likely reason for the observed overestimation of agricultural land is the use of a relatively coarse 25 ha generalization threshold. Since the land use pattern of Germany is very complex this threshold is likely to increase agricultural areas, since those typically large units are sharing boundaries with small-scale scattered land use patches and therefore grow at the expense of those heterogeneous features. Furthermore, the time of data acquisition of the two datasets does not match. The statistical data was assembled by 1995/1996, whereas the CORINE land use dataset was integrated from a range of aerial image products (often ac-

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Utilisation of CLC 90 & 2000 data for monitoring the impact of CAP developments on the rural landscape

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Abstract

This paper describes the utilisation of CLC90 & 2000 data to assess the impact of developments in the Common Agricultural Policy (CAP) on the EU's rural landscape. Three indices are used: a simple agricultural diversity index, the Shannon index and the perimeter area ratio index. All three are computed in a grid of 3 x 3 km² and then summed up or regrouped at regional level. Preliminary results for Ireland, the Netherlands and Luxembourg show for most of the regions higher values for the indices computed with CLC2000 compared to CLC90.

1 Introduction

Changing conditions in the sector, new challenges and a steady learning process are reflected in the different reforms of the Common Agricultural Policy. Thus, CAP reform can be seen as a continuous process. The CAP has undergone considerable changes since the early years, when the focus was on a short-term-oriented counteracting of economic and social pressures, to the direct income payments, rural development and agri-environment measures applied today.

One other important point to mention is the request made by the European Councils at the end of the '90s for a series of agri-environmental indicators (AEI) which would serve to monitor the constantly evolving interaction between European agriculture and the environment. Landscape, land cover and land use were identified as important components of the 35 agri-environmental indicators listed in the Commission's Communication to the European Parliament and the Council COM (2001)144 "Statistical Information needed for Indicators to monitor the Integration of Environmental concerns into the Common Agricultural Policy".

2 AE landscape indicators

At the end of the '90s an informal working group on AE landscape indicators was set up to explore the tools available to monitor and assess agricultural landscapes and their development over time. The original members of the group were different Commission Services, DG AGRI, EUROSTAT/F & GISCO, JRC & EEA; DG ENV joined later and DG RTD more recently.

The different teams publish the results of their work together in joint publications and these publications are recognised to be extremely valuable by international organisations such as the OECD.

The first of the 3 joint publications resulting from the collaboration mainly assessed the use of the "1990" land cover component of the CORINE inventory. While interesting, the first results provided only static analysis, whereas our main interest is in temporal developments. Today, with the availability of preliminary data from the CLC2000 update, we will be able to compare both inventories.

3 Methodology

The 44 different CORINE land cover classes are regrouped in 22 classes, as our aim is to shed light on the relationship between agriculture and the rural landscape. For that reason, level 1 of the nomenclature is used for artificial features, level 2 for water, wetlands and forestry, with the exception of scrubland, for which level 3 is used, as for agriculture.

Three indices are computed. The agricultural diversity index simply counts the different cover classes in a unit area - the more classes there are the more diverse or rich the area is. The Shannon index quantifies the diversity based on two components, the number of different patch types and the proportional area distribution among patch types. Thirdly, the Perimeter/Area ratio index equals the length of all borders between different classes in a unit area divided by the total area of the reference unit.

All 3 indices are computed in 2 steps: the base unit is a grid cell of 3 x 3 km² in which the indices are calculated, the results are summed up or regrouped at regional level (NUTS 2 or 3) and the median is used as the best estimator at regional level. We have received preliminary figures for CLC2000 and revised CLC90 figures for several countries. In this abstract, we show only results for Luxembourg, Ireland, the Netherlands and part of the Czech Republic which were the first countries we received data for (see Table 1 and Figure 1).

4 Preliminary results

At MS level: for the 3 MS, all indices are higher in 2000 than in 90. Increases rank from 1% for the perimeter/area ratio index in NL to 15% for the same index in Luxembourg.

At regional level: in IRL, all regions have higher indices in 2000 vs 90. In NL, some regions have a lower diversity index and perimeter/area ratio in 2000; this is not the case for the Shannon index. In the Czech Rep., the results are more contrasted.

Tab.1: Results for Ireland, the Czech Republic and the Netherlands

IRL MEDIAN DIVERSITY INDEX					MEDIAN PERIMETER/RATIO INDEX				MEDIAN SHANNON INDEX			
	1990	2000	difference	diff in %	1990	2000	difference	diff in %	1990	2000	difference	diff in %
IRL	3,27	3,53	0,26	8,1	0,0015	0,0016	0,00	11,2	0,75	0,82	0,07	9,6
IE011	3,34	3,78	0,44	13,1	0,0014	0,0016	0,00	13,8	0,77	0,85	0,08	10,0
IE012	3,60	3,70	0,10	2,7	0,0015	0,0015	0,00	4,7	0,74	0,77	0,03	4,6
IE013	3,26	3,69	0,43	13,3	0,0014	0,0017	0,00	15,2	0,78	0,87	0,10	12,3
IE021	2,69	2,69	0,00	0,0	0,0018	0,0019	0,00	5,0	0,72	0,75	0,03	3,6
IE022	3,19	3,29	0,10	3,0	0,0017	0,0018	0,00	7,3	0,71	0,77	0,06	9,0
IE023	3,32	3,66	0,34	10,2	0,0013	0,0015	0,00	16,2	0,69	0,79	0,10	14,5
IE024	3,17	3,23	0,05	1,7	0,0018	0,0019	0,00	5,4	0,74	0,79	0,05	6,8
IE025	3,30	3,49	0,19	5,6	0,0016	0,0017	0,00	8,8	0,78	0,86	0,07	9,4
		MINIMUM		0,04		MINIMUM		4,74		MINIMUM		3,58
		MAXIMUM		13,26		MAXIMUM		16,24		MAXIMUM		14,54

CZECH REP	MEDIAN DIVERSITY INDEX				MEDIAN PERIMETER/AREA RATIO				MEDIAN SHANNON INDEX			
	1990	2000	difference	diff in %	1990	2000	difference	diff in %	1990	2000	difference	diff in %
CZ01	3,43	3,57	0,14	4,0	0,001683	0,001739	0,00006	3,4	0,812	0,831	0,019	2,3
CZ021	3,84	3,88	0,05	1,3	0,002198	0,002138	-0,00006	-2,7	0,935	0,933	-0,003	-0,3
CZ031	4,45	4,17	-0,28	-6,3	0,002710	0,002499	-0,00021	-7,8	1,054	1,013	-0,041	-3,9
CZ051	4,36	4,40	0,04	1,0	0,002932	0,002910	-0,00002	-0,8	1,128	1,180	0,052	4,6
CZ052	4,21	4,24	0,03	0,8	0,002331	0,002306	-0,00002	-1,1	1,010	1,016	0,006	0,6
CZ053	3,97	4,02	0,04	1,1	0,002221	0,002206	-0,00001	-0,7	0,949	0,950	0,001	0,1
CZ061	4,21	3,96	-0,25	-6,0	0,002638	0,002530	-0,00011	-4,1	1,009	0,987	-0,022	-2,2
CZ062	3,85	3,88	0,03	0,7	0,001667	0,001632	-0,00004	-2,1	0,862	0,856	-0,006	-0,7
		MINIMUM		-6,3		MINIMUM		-7,8		MINIMUM		-3,9
		MAXIMUM		1,3		MAXIMUM		3,4		MAXIMUM		4,6

NL	MEDIAN DIVERSITY INDEX				MEDIAN PERIMETER/AREA RATIO				MEDIAN SHANNON INDEX			
	1990	2000	difference	diff in %	1990	2000	difference	diff in %	1990	2000	difference	diff in %
NL	2,85	2,92	0,07	2,45	0,00105	0,00106	0,00001	1,15	0,693	0,719	0,026	3,74
NL11	1,98	2,06	0,08	3,90	0,000713	0,000725	0,00001	1,68	0,479	0,489	0,010	2,04
NL12	1,90	2,03	0,14	7,23	0,000612	0,000660	0,00005	7,84	0,409	0,436	0,026	6,44
NL13	3,13	3,28	0,16	4,99	0,000996	0,001066	0,00007	7,03	0,739	0,769	0,029	3,97
NL21	3,23	3,30	0,08	2,35	0,001128	0,001138	0,00001	0,89	0,810	0,847	0,037	4,56
NL22	3,47	3,49	0,02	0,62	0,001323	0,001342	0,00002	1,44	0,892	0,903	0,011	1,20
NL23	2,41	2,44	0,03	1,26	0,000731	0,000762	0,00003	4,24	0,588	0,622	0,034	5,78
NL31	2,96	3,03	0,07	2,41	0,001126	0,001172	0,00005	4,09	0,717	0,757	0,040	5,53
NL32	2,64	2,66	0,02	0,74	0,001026	0,000980	-0,00005	-4,48	0,674	0,687	0,013	1,97
NL33	2,76	2,85	0,09	3,22	0,001026	0,001013	-0,00001	-1,32	0,679	0,687	0,009	1,27
NL34	2,71	2,77	0,06	2,17	0,000824	0,000829	0,00000	0,55	0,623	0,644	0,021	3,35
NL41	3,30	3,31	0,02	0,51	0,001326	0,001313	-0,00001	-0,98	0,828	0,845	0,017	2,04
NL42	3,81	3,75	-0,06	-1,69	0,001508	0,001495	-0,00001	-0,90	0,969	0,980	0,011	1,17
		MINIMUM		-1,69		MINIMUM		-4,48		MINIMUM		1,17
		MAXIMUM		7,23		MAXIMUM		7,84		MAXIMUM		6,44

2 Methodology

The methodology is based on a hybrid approach, which consists of

– an object oriented image analysis and classification, and

– visual interpretation, which is supported by the results of the classification.

The image analysis is performed on the basis of an object oriented approach using the software eCognition 2.1 which is based on the Fractal Net Evolution concept developed by Definiens Imaging (Baatz & Schäpe, 1999; Blaschke, 2000; Hofman, 2001). This concept is based on two steps:

– the segmentation and object generation, and

– the rule-based classification of the objects.

In the segmentation and object generation step, the segments are generated on several scale-levels to form a hierarchical network of image objects. The segmentation is determined by the parameters colour and shape which are used to define the degree of homogeneity within the segments. The specific settings are defined interactively and are adapted to the different levels in the hierarchical network.

In the next step the knowledge base is created. The rules can be based on spectral and textural characteristics of the objects, the hierarchical context of the segments, and the interaction between neighbouring objects. Based on these rules the image is analysed and classified according to a fuzzy logic or a nearest neighbour algorithm.

Figure 1 shows the structure of the hybrid approach to derive CORINE Land Cover classes of urban areas. Starting with the segmentation of the image, which is based on spectral and textural parameters, several hierarchical segmentation levels are generated. The number of hierarchical levels has to be adapted to the spatial characteristics of the land use patterns. At next the knowledge base is developed. This classification scheme includes an initial ***land cover*** analysis. The category "built-up areas" is classified on the basis of spectral and textural parameters as well as contextual (neighbouring) and hierarchical (relation between segmentation levels) characteristics. Moreover, for the urban areas the degree of sealed surface within each segment is determined by a calculation of the scene-dependant,

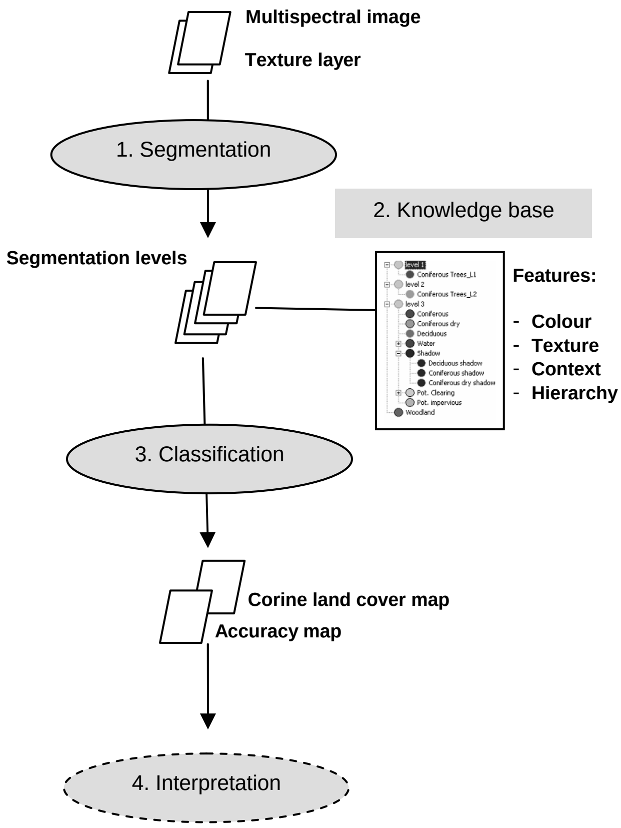

Fig. 1: Flow chart of the semi-automated approach

linear relationship between the degree of surface sealing and the value of the *Normalized Difference Vegetation Index* (NDVI). This technique represents a slightly modified implementation of the basic approach presented by Netzband (1998) and is described more detailed in Esch et al. (2003). Subsequently, the ***land use*** is classified on the basis of both, the land cover analysis and the mapping of the degree of sealing. Additional rules are applied to take into account supplementary contextual and class-hierarchical characteristics as well as the degree of sealing to derive land use classes from the land cover categories.

The classification result is then given to the interpreter along with additional information on the classification accuracy for each object: Based on this information the interpreter can control and revise critical class assignments or classify those categories manually that can not be identified automatically.

3 Practical results

The approach has been applied to a study area, which is part of the Rhine-Neckar region in Germany, using a Landsat 7 ETM+ scene recorded at 15th August 2001. The object oriented classification approach was used to derive the “Artificial Surfaces” classes of CORINE Land Cover shown in Fig. 2.

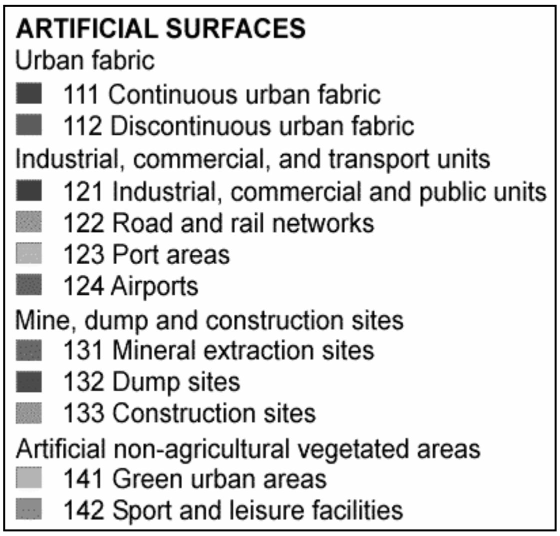

Fig. 2: CLC classes “Artificial Surfaces”

The land cover analysis yields an accuracy of 90 % for the build-up areas. Problems mainly occurred in the context of confusions between highly textured agricultural fields situated along the exterior contour line of the settlements (see Fig. 3). These difficulties are mainly due to spectral and textural ambiguities.

The degree of sealing has been classified with an average deviation of 8% and a maximum deviation of 17% respectively (see Fig. 4). This accuracy is calculated by a comparison with interpretation from aerial photographs.

The overall accuracy of the CORINE Level 1 category “Artificial areas” is about 90%. Regarding CORINE level 2 the categories “Urban fabric”, “Industrial, commercial, and transport units” and the “Artificial vegetated areas” are mapped satisfactorily. Only the detection of “Roads and rail networks” involves significant difficulties due to their small sizes in relation to the spatial resolution of the Landsat data. The classification of “Mine, dump, and construction sites” is limited to the Level 3 subdivision “Construction sites” and even these can only be detected properly within built-up areas. With respect to CORINE Level 3 the degree of surface sealing provides very valuable information. By using this information the differentiation of the “Urban fabric” into “Continuous urban fabric” and “Discontinuous urban fabric” is possible. However, difficulties occur in the discrimination between spectrally similar city centres and commercial sites (see Fig. 5). “Industrial, commercial and public units” can be addressed satisfactorily as their textural and spectral characteristics are quite specific. The identification of “Road and rail networks” is problematical due to the spatial resolution and consequently the results are rather poor. The classifi-

Server based Interactive Classification of Remotely Sensed Data

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Abstract

The Potsdam based company Delphi IMM has developed a semi-automatic interactive system for the classification of remotely sensed images. This system aims at facilitating the classification process following three aspects: distributing the evaluation tasks, the operational integration of expert knowledge and the implementation of a sophisticated software framework. The usage of the Internet as a communications platform is one of the systems major characteristics.

Currently existing evaluation approaches for remotely sensed data are most often characterized by the fact that the tasks of data pre-processing, segmentation (if applicable), classification and quality assessment are conducted solely by one group of experts. A major drawback of this approach is that existing resources, which are potentially more qualified or accessible for specific tasks, cannot be integrated efficiently. Instead, the expert group has to acquire this knowledge first, or in the worst case, accept uncertainties leading to mistakes.

The server based interactive classification system developed by Delphi IMM is an approach to integrate distributed resources in an operational manner.

1 Introduction

1.1 Operationalisation – Distribution - Interaction

A crucial problem in the context of remotely sensed image classification is the lack of running operational methods. However, a classification approach consisting of automatic, standardised (sub-) processes would lead to several advantages over the manual evaluation:

- Efficiency of the evaluation process,
- Comparability of different results by using standardised methods,
- Transferability of the results between different scenarios,
- Quality Assessment.

One important problem of an operational approach is the fact, that the knowledge about the question, which has to be solved in the context of a remote sensing project, is distributed among multiple instances. Hereby knowledge refers to the technical side of using appropriate software tools and setting up the overall classification environment as well as to the professional side of "knowing" how to interpret remotely sensed data, how to process them etc., but also to the knowledge of the ground truth in the region which is the matter of interest.

Most established approaches consider this distribution inadequately. Instead, much time and effort is invested into the compilation of reference and test data even though in most cases local knowledge repositories are present. Thus, a concept to integrate this distributed knowledge has been established and evaluated in several scenarios by the company Delphi IMM.

From the technical point of view, a distribution of the processing tasks makes sense as well. Compute bound services like image-processing tasks (segmentation etc.) can be swapped out to high-performance servers while the control over single tasks and the overall process chain can remain on thin clients. Using an arbitrary network as the communications infrastructure and considering open standards from the OGC no limits are given in distributing the chain.

2 System Concepts

2.1 Operationalisation of the process chain

One important concept of this approach is the integration of the distributed local knowledge into the process chain. So-called local experts have to interact with the system. At specific processing stages these people are able to assess the quality of intermediate results, adjust errors and overcome uncertainties. Although the automatic execution of the processing chain will be interrupted at certain points, this approach can lead to a much faster evaluation and higher quality. By establishing evaluation standards, comparability and transferability are assured. In the following, the process chain is depicted more precisely. Figure 1 gives an overview of the major elements in the chain.

The integration of the local experts is realised in three major steps. First, the experts are given a facility to “tell” the system what the classes of the nomenclature look like in their very own working area, i.e. to provide training data for the system. This step is quite important for the overall result since all further processing steps (segmentation, set-up of the rule network) rely on the compiled statistical data on each of the classes. On the basis of a web application (see 2.2), the local expert can work on the system anywhere in the world with a Java-enabled Browser.

In the next step, the training data objects are compiled and evaluated in terms of shape and class properties. The result of this task together with the knowledge about the characteristics of a certain segmentation algorithm (provided by the knowledge base) makes an efficient calibration of the segmentation software possible. Random samples of the results of the segmentation can then be evaluated – again by the local experts using the web application and additionally by an automatic tool, which compares the segmentation result directly with the given training data (see 2.2).

The third step is the classification itself. In order to set up the rule network, the information given by the local experts can now be directly integrated. The information on class membership of the training data samples have been evaluated and can thus be statistically analysed. Another software tool performs the task of compiling the optimum rule network based on the given training data. Again, the local experts can assess the results and intervene in the case that the result is not sufficient in their minds.

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Development and evaluation of methods for automated land use / land cover classification

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Abstract

Many departments in administration, planning or science need high resolution Land Cover / Land Use information for different purposes. Remote sensing acquires up-to-date imagery of large areas, but up to today there are no existing operational classification techniques for the derivation of complex LC / LU maps. This proposed approach is capable to produce these maps by combining new data mining techniques with databases in a multi-information-level framework.

1 Introduction

1.1 Land cover / Land use information

There is still an increasing demand for accurate Land Cover / Land Use (LC/LU) information in several institutions and administrations for planning und science. Frequently lacking these spatial data, they are forced to use statistical data summarized to administrative levels for monitoring and modelling. In many instances even the statistical data does not provide all information needed, e.g. knowledge about impervious areas (Statistisches Bundesamt, 2003). Therefore accurate, detailed and spatially derived data is crucial to visualize and analyse changes in LC/LU. Remote sensing is the only alternative to acquire spatially contiguous and homogeneous data in various geometric, spectral and temporal resolutions. However, the effort of LC/LU classification by visual image interpretation is too high. Therefore it is far too expensive to produce large scale land use maps from remotely sensed data. Alternatively, operational classification can convert continuous image data into thematic information, producing LC/LU classes to its best level of detail. This initial classification assists human interpreters by producing pre-classified LC/LU maps. Experts are able to focus upon more complex topics.

1.2 The CORINE LC/LU classification

The CORINE Land Cover (CLC) project develops a pan-european land cover database based on remote sensing data. Its hierarchical structure contains 44 different but harmonized land cover classes grouped into five major categories. The first data acquisition was in the mid 90ies. Currently the CLC2000 update is in progress. The information is derived manually by GIS-aided visual image interpretation with tremendous financial and human effort. Its scheduled update interval is ten years.

The hierarchical structure of the CORINE classes allows logical class aggregation, hence abstract mapping. The classification system is extendible by adding classes to level four and five. The pan-european CLC project requires partial operationalisation of the classification process. This operational classification chain enables faster and more frequent update as well as improved class information. The proposed classification system builds upon two different datasets (CLC90 and CLC2000) for training and validation purposes.

2 Automated classification of land cover / land use information

2.1 Classification techniques

Lillesand and Kiefer (2000) distinguish three types of image information, including spectral, spatial and temporal patterns. The analysis of spectral patterns is widely implemented in commercial software packages such as Erdas Imagine™ or ENVI™. Its classification algorithms use statistical clustering, assigning pixels to classes according to its spectral information (per-pixel classification). However, the relation of pixels to its neighbours, utilizing various measurements such as texture or entropy, is often an important characteristic for class assignment and incorporates the spatial pattern into image classification process. If multitemporal data is available the temporal patterns, e.g. phenology and anticipated changes, can be used to aid feature identification.

Common automated classification approaches such as unsupervised classification categorize spectral data into distinct clusters statistically. Afterwards the human interpreter assigns these clusters to thematic land cover classes. Another approach is supervised image classification, which employs representative sample sites of known land cover classes as training areas. Although these training sites refer to real land cover classes additional information such as background knowledge or topographic maps is helpful for accurate class assignment. Due to the process that every pixel must be considered, pixels of unknown land cover are categorized to their most likely land cover class. The pixel-based classification approaches do not allow to determine land use classes, because the satellite cannot observe anthropogenic functions of an area. A solution to this problem of detecting land use classes is either the comprehension of more information extracted from the data source or auxiliary information. Mixed pixels, due to the geometrical resolution of the image, cause further problems, because only objects larger than the geometrical resolution provide spectrally “pure” pixels.

A rather new approach is the object-based classification, integrating spatial and spectral patterns. The image is spatially segmented into homogeneous areas, called image objects, prior to the actual classification step (*Pedley and Curran*. 1991). This procedure generates additional information about the object, e.g. shape, size, and neighbourhood, which can also be integrated into image classification. The commercial software eCognition™ uses this per-parcel approach. Utilizing objects instead of pixels allows the determination of certain land use classes based on object size and neighbourhood relationships.

Several problems arise when applying pixel- or object-based software packages to automated classification of remote sensing data. One of the main difficulties is the missing spatial portability of the classification scheme, because “low level” information like spectral data has a wide range of variability due to phenology or different atmospheric conditions. An analogy to text understanding is the limitation to characters and phonemes during the classification procedure. This information has neither content nor semantics. Considering content, like words and phrases in our analogy, and its relationship within the sentence, presuming some background knowledge, admits to understand the sentence and its meaning itself. The different information layers in images are shown in Table 1.

Another reason for insufficient usage of exiting software is the absence of machine learning capabilities. For common approaches the decision tree is built for one single data set which results in spatial and temporal limitations. Machine learning techniques enable better generalisation and the storage of knowledge in a database for future classifications.

Tab. 1: Information levels in images

	Level	***extracted of ...***	***Information type***
Image Level	**pixel level**	spectral pixel data	tone brightness, saturation texture (kernel size)
	segment level	spectral pixel data shape	texture (adapted) size (absolute) compactness, ...
Semantic Level	**object level**	shape	size (relative) compactness, ...
	class level	segments objects	pattern of segments pattern of objects spatial distribution neighbourhood connectivity
	landscape level	classes, objects	spatial distribution diversity

The available software provides a variety of tools to analyse and classify satellite imagery, but lacking several “intelligent” functions such as database access for a wider range of training data, practical automated object building, or supply / use of “high level” information. All these significant limitations require the development of an appropriate LC / LU classification approach for optical satellite data.

2.2 Development of automated land cover / land use classifications

The development of an automated classification system for LC / LU implies the modular representation of the different information levels mentioned above. A possible structure would be the following:

- **Generation of objects**
    - **Segmentation**
    - **Classification**

A top-down segmentation approach generates homogeneous and contiguous pixel groups called image objects (*de Kok,* 2001). In contrast to homogeneity criteria, which are used in the bottom-up segmentation technique of eCognition™, the difference of colour / texture parameters dependent on image scale is used to produce stable image objects. Instead of decreasing spectral features (eCognition™), all pixel data is used for classification. A spectral database provides information for identifying training samples in the image. A new data mining technique, called Support Vector Machines (SVM), is used for supervised classification. It is a machine-learning based approach developed for classification problems and regression analysis (*Vapnik* 1995; *Schölkopf and Smola* 2002). Contrary to maximum likelihood classification (MLC) the SVM method is non-parametric and produces higher-generalized results.

- **Determination of objects**
  - **generation of features**
  - **hierarchical object building**
  - **content verification**

Up to this step there are only image objects containing the spatial and spectral information of the individual pixels. Further useful knowledge can be calculated, e.g. information about shape, size, or texture parameters. The integration of this additional knowledge allows the construction of complex objects by aggregating the simple image objects.

Class level

Image Object level

Pixel level

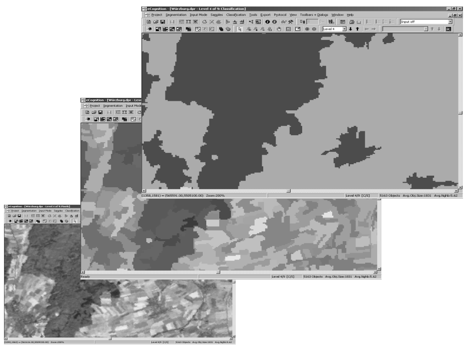

Fig. 1: Object aggregation in different Information Levels

Rules support the aggregation of sub-objects to super-objects and eventually to classes, depending on thematic (land cover fractions and hierarchical status) and spatial (size and shape) generalization. The object aggregation is performed using an iterative exclusion process, because some LC / LU classes are easier to determine than others, e.g. forest / water *versus* settlement / mixed classes.

- **Coding to CORINE classes**
  - **thematic conversation**
  - **geometrical adjustment**

The thematic classes are adapted to optical multispectral and monotemporal satellite data. Therefore some classes cannot be identified with sufficient certainty. The classification can be enhanced with additional information and multitemporal data. Eventually the process terminates, yielding only LC/LU classes. The estimation of some CORINE classes claims a separate object / class conversation, e.g. the combination of impervious cover, meadows, buildings and a certain object shape defines an airport area. Additionally the CORINE classification requires a well defined and harmonized geometry. Certain objects will be aggregated to dominant CORINE objects, e.g. urban parks and cemeteries smaller than 25 hectares will be merged to the urban settlement class.

2.3 Detection and verification of CORINE classes

It is very practical to incorporate the existing CORINE data into the classification system. The supervised classification approach for the image objects requires training samples. These samples must be extracted from the image objects and, and previous CORINE datasets can help to assign thematic knowledge to this training data without manual interaction. For CORINE purpose it is also necessary to use the same geometry for comparison and change detection. Employing CORINE geometry, there are three possibilities of temporal variation. Due to temporal reason, the (1) geometry changed because of processes such as urbanization and / or (2) the thematic content has been altered, e.g. afforestation. However, the most likely assumption for many CORINE objects is (3) no change.

3 Conclusion

It is possible to design and implement a (semi-)automated system for LC/LU classification but several items have to be considered. The system extracts and uses "high" level information because of best spatial portability. Certain classes, mostly vegetation and rough land cover, are determined automatically. For further classes the previous CORINE datasets assist the identification. A human expert makes the last decision, when there are occasions of doubt.

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