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Handling of Woodland in Natural Resource Accounts

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1. INTRODUCTION

One need not go repeatedly into the importance of land as regards its importance in carrying on our daily socioeconomic activities. Especially in a discussion of forests, the importance of land cannot be disregarded because forests cannot exist without the land.

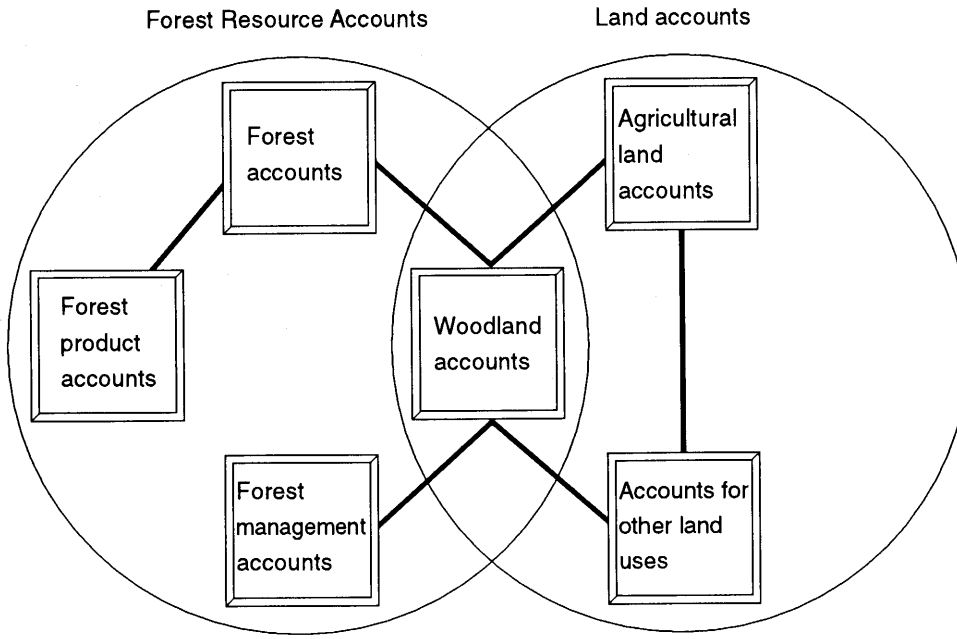
In the developing countries as well, many problems considered environmental, such as deforestation and soil erosion, are closely linked to the land. But the critical lack of statistical information on land is a serious impediment to solving these problems.

In recent years we are seeing attempts at solutions by employing the swiftly-developing remote sensing technologies. This involves using data from satellite imagery and other sources to continuously observe the changes in developing countries' land cover and land use. But it's evident that using only aerial photographs makes it difficult to determine the complex causes of deforestation and other phenomena.

Land use is dependent on the land's natural conditions and the socioeconomic conditions of each geographical region. And land cover is determined under the impacts of land use and based on the land's natural conditions. The state of land in any one region is therefore determined by the combination of its natural and socioeconomic conditions. This shows the great importance of starting by building a statistical system that relates these various kinds of information organically and continues to collect information while maintaining its consistency. In doing so, the concept of accounts is useful.

This paper will, while taking into consideration the research done in other countries, explore how woodland should be entered in natural resource accounts. Its purpose is to then discuss the possibility and significance of applying this in developing countries.

Figure 1 How Forest Woodland Accounts Fit into the Overall Accounting Scheme



Note: Compiled by the author.

2. General Structure of Forest Woodland Accounts

2-1 Significance of Forest Woodland Accounts

Roughly there are two ways to see forests, depending on the point of view. One is to describe everything related to forests by looking down at them from above. The other is to see forests from the ground up, which regards them as one form of land use among others, such as agriculture and residential tracts.

Let's begin by evaluating forest woodland accounts from these two perspectives.

Figure 1 graphically presents the place of forest woodland accounts. As shown in this figure, forest woodland accounts can be seen as accounts that link the two systems of forest resource accounts and land accounts. Here forest resource accounts are, as described previously, the way of seeing forests from above, while land accounts are the method of seeing forests from the ground.

Forest resource accounts comprise the four accounts of (1) forest accounts, (2) woodland accounts, (3) forest product accounts, and (4) forest management accounts.[1]

A brief explanation of accounts other than woodland accounts would be that forest accounts represent the initial stock, period flow, and final stock of trees growing in forests as the tree volume. Just as with the assets of a business, such accounts show the trees in a forest, i.e., assets. Forest product accounts use weight, volume, or other physical units to

describe the process of using the variety of forest resources from raw logs to waste. And forest management accounts use price to show the flow of funds used in managing forests.

Within forest resource accounts, the forest woodland accounts serve to directly link forest accounts with forest management accounts, and provide for their consistency. The arrangement is such that funds and labor for forest management are invested in woodlands or in forests as their output, which yields wood and recreation, as well as the current state of the forests. Forest woodland accounts, which bring about this kind of arrangement, exist in a variety of forms and are highly dependent on the possibilities of data use.

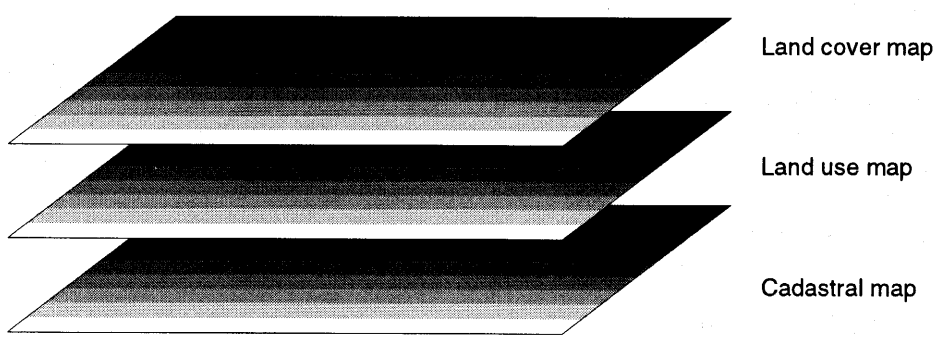
Let us proceed to an explanation of land accounts, which are composed of not only forest woodland accounts, but also agricultural land accounts and account for other land uses (including residential land accounts, accounts for unused land, and other conceivable uses). Each type of land account is meant to describe the state of and changes in land. If the state of land is its stock, and the changes among various states constitute flow, it is possible to put these down in the form of an account. Of the various kinds of land accounts, it is forest woodland accounts that divide off the woodland portion from the land accounts for a number of different uses.

2-2 Data Structure of Forest Woodland Accounts

Because forest woodland accounts use data on the land, which has spatial attributes, the cardinal consideration is how to put geographical information into account form. Technologies called geographical information systems (GIS) or land information systems (LIS) play a vital role in doing so. Attempts at environmental accounting in countries around the world use these in diverse ways; GIS are now used in Australia, France, Germany, and other countries.[2]

Figure 2 is a schematic representation of the geographical information data structure in forest woodland accounts, which have three conceivable types of geographical information: land cover maps, land use maps, and cadastral maps. As the figure shows, these three types overlap so as to cover the same geographical area, but the characteristics of each differ from the others according to its geographical data.

Figure 2 Data Structure of Forest Woodland Accounts



Note: Compiled by the author.

Land cover maps show natural characteristics. Representative types are maps that show surface characteristics known from aerial information such as remote sensing data and aerial photographs, and land maps that classify soil types. Unlike land cover maps, which show natural characteristics, land use maps show the ways that people use the land.

One possible way of explaining the difference between land cover maps and land use maps would be to envision a situation in which a section of land is shown on the land cover map to be all woodland, while in that same area people engage in both forestry and tourism. On the land use map, however, it would be possible to divide that same area into forestry and tourism zones, or primary and tertiary industry zones.

Cadastral maps show the ownership of land where modern land ownership relationships have arisen.[3] In societies where modern land ownership systems have developed, the treatment of land is basically determined through the owners, which means that in woodlands as well, forest management actions such as logging and silviculture are closely associated with owners' actions. What is more, the results of such actions determine the state of forests.

Additionally, even when land is incorporated into some kind of plan under government policy, it is possible to represent it as the attributes for each parcel of land. This means that what we call a cadastral map is by nature also a land planning map.

By using the three types of maps described above, we can express all land characteristics. Specifically, land cover maps describe the natural environmental characteristics of land; land use maps show the socioeconomic aspects of land, and cadastral maps show the legal and institutional aspects of land.

Of course, all three types are not necessarily available in every situation. Most regions of developing countries probably do not have cadastral maps. Especially when it comes to accurate cadastral maps of mountainous areas, which are covered by forest woodland accounts, progress leaves something to be desired even in Japan. Furthermore, people who prepare land use maps must perform on-site surveys and interpret photographs, which is why map preparation costs are very high. For this reason land use maps are, in not a few instances, prepared by a reclassification of land cover map information.

3. Woodland Microdata Sets

3-1 The Character of Woodland Microdata Sets[4]

The use of data in economic analyses until now has not always seen importance in organically relating macro and micro economic data. Efforts are therefore being made to build micro-based data sets for household and business behavior and to bear out various economic analyses in a way that is consistent with a framework for ascertaining macro-economic relationships. An effective, practical concept for this purpose is the microdata set, described below.[5]

GIS or LIS as described in the section on data structure in Section 2 can be regarded as, by nature, microdata set concepts in the sense that they build organic relations between micro-based land information and macro-based forest resource accounts.

If one follows Sato[6] in the characterization of GIS/LIS as woodland microdata sets, the following interpretation is perhaps possible:

(1) Flexibility and detail are the rules when performing analyses, and it is necessary to have something on the order of individual records corresponding to the land parcels in cadastral maps.
(2) They are seen as intermediate accounts coming between the micro and the macro, and they are accounts that link managing entity accounts and forest resource accounts (i.e., an adjustment account that conforms to conditions of the land).
(3) When the body of data comes from a sampling survey, "missing entries" will result in an insufficient amount of data, and in bias among "data hierarchies," which necessitates computational adjustments to maintain consistency.

Let us consider these in detail.

(1) This means that when building a woodland microdata base the major underlying assumption is that cadastral maps can be used. This is related to the matter of to what we equate the individual records in territorial statistics such as a woodland microdata base.

When the circumscribed areas (for example, clearly defined forested areas or forestry zones) in land cover maps and land use maps are made into individual records, their map borders are unstable and it is difficult to systematically assign IDs. By contrast, the property boundaries in cadastral maps are stable as borders in individual records, and systematic IDs are readily generated. From this we can see that land parcels in cadastral maps are the most suited for the individual records in woodland microdata bases, and that is the same as the individual records in microdata bases for economic activities based on the finances of companies and households.

(2) This means it is appropriate that the state of a forest's management history, land cover, and land use be made into a data base using the records described in (1) as the foundation. This corresponds precisely to the appropriateness of having the subjects' histories recorded on their individual records when working with personal statistics.

And when we consider the role of woodland and forest accounts as natural resource accounts, it is possible to discern a more constructive significance: Because environmental problems are often associated with the land, it is most appropriate to organize and integrate environment statistics as land statistics.

(3) This is a matter pertaining to microdata bases in general. For reasons of cost among others, it is impossible to conduct censuses on all information, and that goes for land surveys as well. As in the Norwegian example I shall present in the following section, sampling surveys are the rule. In such instances it is the vital role of microdata bases to make sure of consistency among computations.

As this shows, regarding GIS/LIS for woodland zones as woodland microdata bases and using them as forest woodland accounts is the most flexible approach because it subsumes both forest resource accounts and land accounts, and systematizes them. And while microdata bases for economic activities involve serious problems with regard to observing the privacy of business and household finance information, this method is effective because "with regard to land it has practicality owing also to the idea that it is public, and as a rule land registration records and the like are already open to the public."[7] However, cadastral maps are needed to build woodland microdata bases, and that puts the biggest limitation on the use of this method.

3-2 Land in Norway's Resource Accounting System

Norway and France have since the 1970s been working on the development of resource accounts, and in the process of that development they have also put effort into developing land statistics to serve as resource and environment statistics. Norway's land account is oriented toward developing a microdata base as a comprehensive land survey system. In France, land is seen as part of the Territory or Space Accounts[8] that make up the French Natural Patrimony Accounts. This section will deal with the Norwegian example, a pioneering achievement in accounting systems using microdata bases for land.

In developing its environmental accounts, Norway faced anew the need for a solid statistical base. One thing it had to do was create a register capable of arranging statistics in account form, and another was to standardize categories and measurements.

Registers are a form of statistical survey widely used in northern European countries.[9] It involves managing as registered files many kinds of administrative records including personal, company, and land information, and using this as a statistical system. It is microdata bases that are used for management.

The switch to using registers for environment statistics signified switches in the philosophy and methods of Norway's data-gathering system. This happened because the initially developed point sampling method demanded too much in both time and cost.[10]

For its natural accounts Norway created land registers and water basin registers. The land registers comprise three different registers: Rural villages, cities, and plans.[11]

The purpose of the first two registers is to investigate changes in land use and qualitative changes in land, and their basic technology is spatial sampling that employs existing use maps and aerial photographs. The third register marks regional plans on maps with scales of 5,000:1 or 10,000:1, which form the basis for land use planning statistics. Plan registers are updated annually and used in regional planning.[12]

Employing registers makes it possible to link natural characteristics and land use with other administrative data, and by connecting this with cadastral systems it is possible to cross-total all surveyed items.[13]

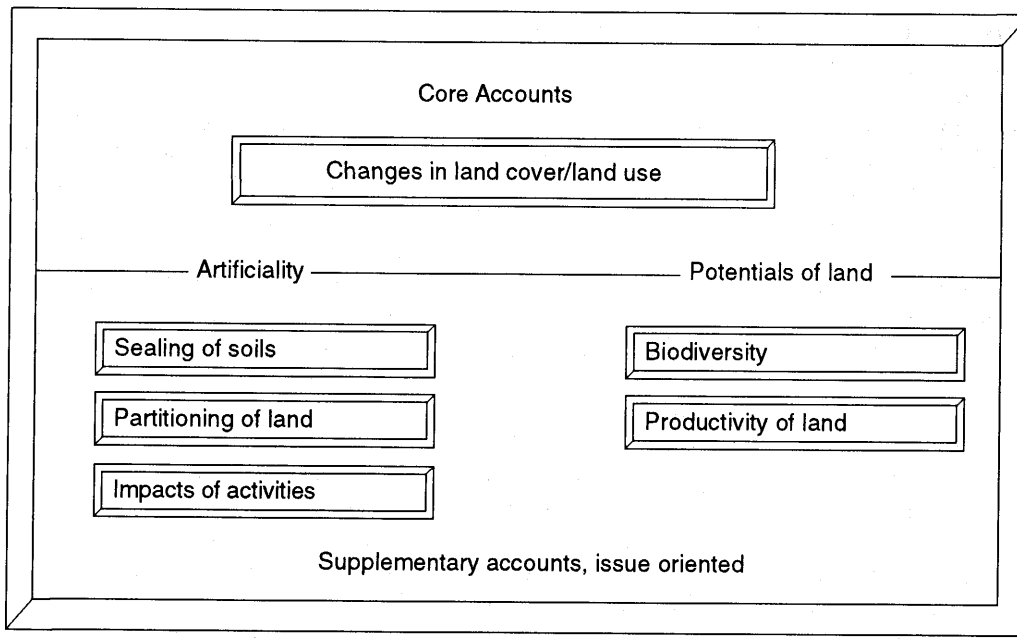
It appears that research on Norway's land accounts had stopped for a while owing to cost restrictions and changes in social needs. But recently research on land use statistics started again, though they have not arrived at an accounting framework.[14] It will be interesting to see what happens in the future.

4. Land Cover and Land Use Accounts

4-1 Land Cover and Land Use Accounts

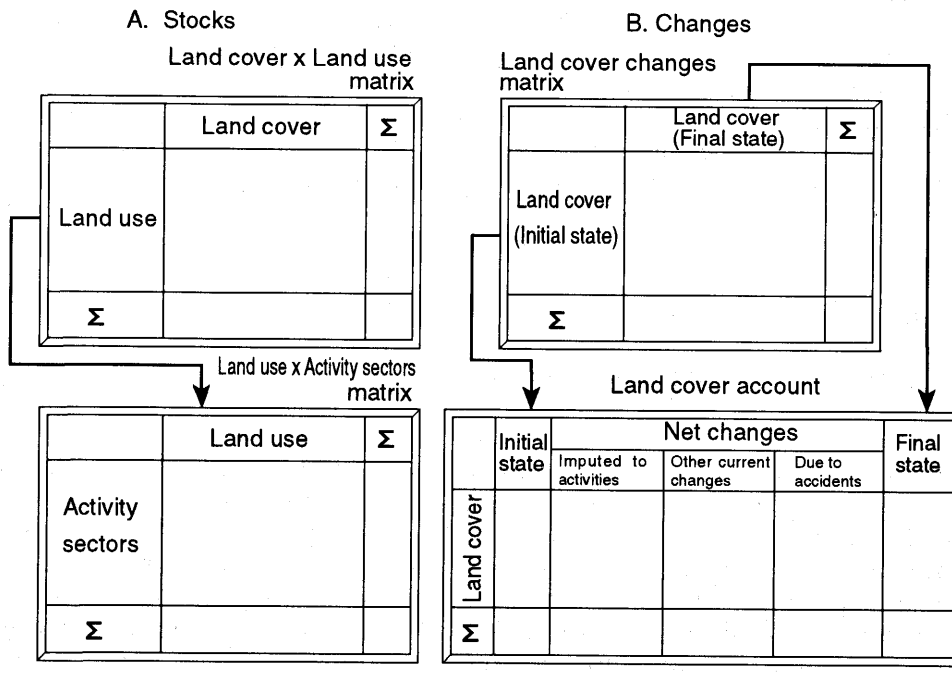
Research on land cover and land use accounts was initially under a special UN/ECE committee of experts, and passed on to Eurostat.[15] The fact that France led the UN/ECE (United Nations Economic Committee for Europe) project clearly suggests that the project's origin was the Natural Patrimony Accounts. Territory accounts are based on the idea that it is possible from the perspective of land use to describe the developmental process of natural patrimony apart from other things. Linkage with socioeconomic accounts is achieved through Comptes Satellites.[16] As natural patrimony accounts for land, there have been attempts at soil accounts meant for the advance of agriculture in sub-Saharan Africa.[17]

Figure 3 The General Model of Land Cover/Land Use Accounting



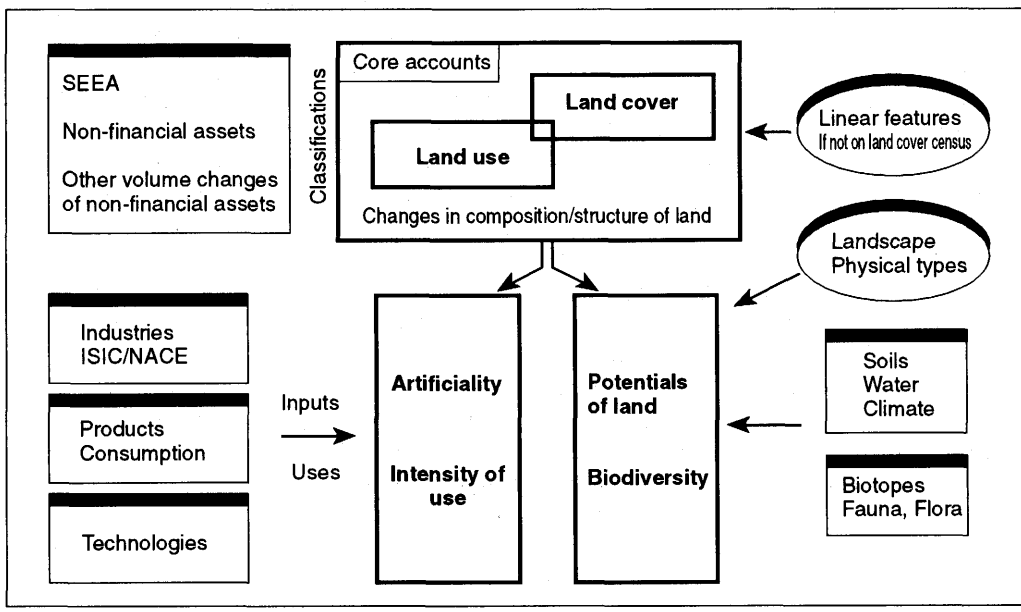
Source: Conference of European Statisticians, *Physical Environmental Accounting: Land Use/Land Cover, Nutrients and the Environment*, 1995, p.5.

Figure 4 Structure of the Core Set of Land Cover/Land Use Accounts



Source: Same as for Figure 3, p. 6.

Figure 5 A General Framework for Land Cover/Land Use Accounting



Source: Jonathan Parker, Anton Steurer, Ronan Uhel and Jean-Louis Weber, *A General Model for Land Cover and Land Use Accounting*, International Association for Research in Income and Wealth Special Conference, 1996, p.24.

Figure 3 shows the general structure of land cover and land use accounts. Accounts comprise core accounts that represent changes in land cover and use, as well as supplementary accounts meant for certain purposes. The two main elements of supplementary accounts are changes in human actions and the natural potential of the land. These are ultimately connected through core accounts. Figure 4 shows land cover and land use accounting, and its relationship with space or socioeconomic data.

Core accounts provide basic information on the structure of and changes in land cover and land use. This information is brought together by land observation techniques such as remote sensing like satellite imagery and aerial photography. Other data sources are necessary to give a detailed account of actual land use affecting land cover. Figure 5 is a conceptual model of a core account, which is described by the stock account showing the state of land cover, and the flow account showing the changes in land cover. Fundamentally, accounts use data collected from either directly observed values (by remote sensing and the like) or sample plots (land use maps and the like) by extrapolating them onto larger geographical areas.

4-2 Data Needed for Land Cover and Land Use Accounting

Data needed for land cover and land use accounting are divided into three types: Background data, land survey data, and special survey data.

Background data provide permanent landscape types such as land elevation, geology, soil types, and average climate, as well as administrative divisions. Under the classification in Section 2 they correspond to land cover maps.

Land survey data provide land cover data and land use data obtained through remote sensing and sample plot surveys. By means of more detailed field surveys they also provide more accurate land use and biotope information. Under the classification in Part 2 they embrace both the land cover and land use maps.

Special survey data must be added for economic activity and sector accounts. These data pertain to things such as production, intermediate consumption, road crowding, pollutant emissions, and waste dumping. Economic activities are categorized according to ISIC. When special survey data are given greater detail with regard to geographical information they result in the cadastral maps explained in Section 2, but this project does not include that much information.

The possibility of using land survey data in land cover and land use accounts has great importance in determining the accuracy of accounts overall. It is the CORINE Land Cover Inventory (CLC) that provides such a framework.[18]

CLC is a project carried out by the EU for its members and for middle and eastern European countries, and its purpose is to assure the consistency of land cover accounts in the future. It uses satellite imagery to divide land cover into 44 categories at a scale of 10,000:1, and it creates land cover maps whose smallest units are 25 hectares.

But the CLC method cannot draw many linear landscape features such as natural features (rivers, etc.), semi-natural features (trees, etc.), or artificial features (roads, etc.). This is because taking linear features into consideration requires large-scale maps (25,000:1, for example). Currently CLC uses aerial photographs.

A more important matter is that remote sensing does not provide adequate information on land use and biotopes. It can distinguish between agricultural crops and natural vegetation types, but there are limitations to its observation techniques.

First, detailed surveys by remote sensing are costly, which makes it hard to prepared a comprehensive inventory for any one country. Second, when gathering data on land use it is difficult to divide them into categories. For instance, forest uses for timber production, recreation, and soil preservation are all classified as simply forests on land cover maps.

Thus, adding more detailed information on land use and flora and fauna requires gathering data in field surveys relying chiefly on sampling surveys. In this project as well, there are efforts to increase account accuracy by means of, in France, the Ter-Uti Survey, in England the Countryside Survey 1990 (CS90) and the 1978 and 1984 field surveys, and in Germany STABIS25, which uses aerial photographs of a larger scale.

5. Significance and Possibilities of Preparing Forest Woodland Accounts in the Developing Countries

5-1 The State of Land Statistics in the Developing Countries

Environmental problems in the developing countries become increasingly serious with each passing year. And as mentioned at the beginning, many of them are closely connected with the land. We must consider the land, too, if we are to speak of deforestation, soil erosion, and farmland salinization.

Land is also a crucial element when considering resource issues. This is because the forest products, minerals, and other primary products that are a vital economic resource of developing countries cannot even be discussed separate from the problem of land ownership.[19]

The examples of forest woodland accounts discussed so far in the paper are all from the developed countries. In consideration of the serious lack of statistical information on land, it seems extremely difficult to prepare forest woodland accounts in the developing countries, in contrast to the seriousness of the problem.

However, in recent years we have at last begun to see a way to surmount these difficulties through recent developments in remote sensing technologies. As with the United Nations Environment Programme's (UNEP) Global Resource Information Database (GRID) project[20] and the International Geosphere-Biosphere Programme and the Human Dimensions of Global Environment Change Programme's (IGBP-HDP) Land-Use and Land-Cover Change (LUCC) project,[21] people are using satellite imagery and other remote sensing data to continuously observe changes in the developing countries' land cover and land use. By making use mainly of comparatively inexpensive satellite imagery these activities can, in the developing countries as well, continuously monitor changes in the land and environment, which was formerly impossible because of cost. In this sense, it is highly praiseworthy.

But it is also clear that finding the causes of complex phenomena such as forest loss is difficult using only aerial photographs. Land use depends on both the land natural conditions and a regional socioeconomic conditions. And land cover is determined under the impacts of land use while it is at the same time based on the land's natural conditions.

In this way natural and socioeconomic conditions combine to determine the state of land in any one region. It is therefore of the greatest importance to begin by building a statistical system that organically relates various kinds of information and amasses it while maintaining consistency. The application of forest woodland accounting to developing countries can be conceived in this context.

5-2 Toward the Preparation of Forest Woodland Accounts in the Developing Countries

When our purpose is to apply this to the developing countries, it is perhaps best to consider that the data at our disposal will at the present stage be, of the three kinds shown in Figure 2, only land cover maps, which can be newly produced. It is most common to make land use maps by reclassifying land cover data. Trying to skip directly to making a woodland microdatabase as described in Section 3 would not be a sound course of action at this point because the production of cadastral maps, or of land management maps that show what parcels of land are managed by whom, is too costly now.

In that respect, the accounts for land cover and land use described in Section 4 are quite possible to do because they can be prepared even if one has only land cover data to use as the accounting data. The currently gathered land cover data that was discussed in the previous section can be used as is, and in that respect as well such accounting is efficient. While there will nevertheless still be problems with accuracy in the accounts overall, the only thing one can do is improve accuracy by gradually collecting more usable data, as with land use maps, and with cadastral and land management maps. And by doing so, it will eventually be possible to come up with a woodland microdatabase.

In connection with landscape ecology,[22] the geographer Takeuchi says, "Using aerial photographs and satellite imagery as not merely a means to interpret the characteristics of a certain element, but rather to see the appearance of the overall landscape and natural envi-

ronment will perhaps occasion a return to getting the big picture in the environmental sciences, which have been divided into so many small specialties."[23] This way of seeing things in their totality is highly effective for the practical concept of accounts when organically relating a variety of phenomena. Surely in the developing countries the first step should now be taken toward preparing forest woodland accounts.

Notes

1. Furuido, Hiromichi, Forest Resources and a Framework for Ascertaining Their Use: Trends in Research on Forest Resource Accounting, *Ringyo Gijutsu*, 1995.12, pp. 11-14.
2. Fuji Research Institute, Report of Basic Study on the Preparation of Environmental Resource Accounts, 1995, 114 pp. See pp. 55-60.
3. Concerning cadastral surveys in Japan, see: Cadastral Survey Research Society, *1991 Cadastral Survey Handbook*, Chikyusha, 1991, 474 pp. and Tsukada, Toshikazu, *Research on Land Tax Revision and Cadastral Surveys*, Ochanomizu Shobo, 1986, 286 pp.
4. This section is a revised and expanded form of pp. 47-52 of: Yamamoto, Nobuyuki, *Using GIS as a Microdata Set in Preparing Forest Resource Accounts, Report of Comprehensive Research on Environmental Problems in Developing Countries — Environmental Resource Accounts (I)*, Institute of Developing Economies, 1994, 274 pp.
5. There is a detailed discussion of the formation and developmental process of microdata sets in Chapter 8, "Composing and Integrating Microdatabases" of: Kurabayashi, Yoshimasa, *Formation and Development of the SNA*, Iwanami Shoten, 1989, 270 pp.
6. See p. 81 of: Sato, Setsuko, "Development and Problems of Microdata sets," *Kikan Kokumin Keizai Keisan*, no. 99, 1993, pp. 81-134.
7. See p. 337 of Koike, Koichiro, "Current State of Environment Statistics — Concerning Mainly the Resource and Accounting Systems for Forests," *Zoen Zasshi*, vol. 55-4, 1992, pp. 81-134.
8. See p. 421 of: Weber, J. L., "The French Natural Patrimony Accounts," in *Statistical Journal of the United Nations ECE*, vol. 1, 1983, pp. 419-444. See also pp. 279-302 of: Weber, J. L, "Environment Statistics and Natural Resource (Patrimony) Accounting," in *National Accounts and the Environment Papers and Proceedings from a Conference*, 1994, 507 pp.
9. Concerning the register system in northern European countries, there are examples for Denmark, Sweden, and Norway in pp. 869-870 of: Takeuchi, Kei, ed, *Tokeigaku Jiten*, Toyo Keizai Shimposha, 1989, 1185 pp. There is also a detailed description of a recent Swedish example given in: Kobayashi, Nobuyoshi, "Statistical Activities in Sweden," in *Tokei*, 1995.12, pp. 41-44.
10. See p. 21 of: United Nations Economic and Social Council, CES/700, 1991, 44 pp.
11. On the description of land registers, see: "The Norwegian System of Resource Accounts," *Statistical Journal of the United Nations ECE*, vol. 1, 1983, pp. 445-461, p. 460; Alfsen, Knut H., Torsetein Bye and Lorents Lorentsen, "Natural Resource Accounting and Analysis: The Norwegian Experience," Central Bureau of Statistics of Norway, 1987, 71 pp., pp. 25-26; see pp. 101-123 of: Kahnert, Andreas, "Basic Methodological Problems in the Use of Monitoring and Sampling for Purposes of Environment Statistics," *Statistical Journal of the United Nations ECE*, vol. 7, 1990. Also, on p. 62 of Koike, Koichiro, "A Forest and Forestry Assessment Method," *Rinsei Soken Repoto*, no. 30, 1986, there is an abridged translation of: OECD, "A system of Resource Accounts: The Norwegian Experiences," 1980, and there is a detailed discussion of how to design sample survey methods.

12. It appears that the number of survey points has been changed several times. For example, according to p. 115 of Andreas Kahnert (note 11) there is a total of 300,000 survey points.
13. See Koike, 1992, p. 338.
14. See p. 2, Rypdal, Kristin, "Construction and Applications of Emission Accounts," International Association for Research in Income and Wealth Special Conference, 1996, 17 pp. On recent trends in environmental accounts in Norway, see pp. 39-54 of Alfsen, Knut H., "Natural Resource Accounting and Analysis in Norway," *National Accounts and the Environment Papers and Proceedings from a Conference, 1994*, 507 pp., and Alfsen, Knut H., "Environment Accounting: Some Comments Based on Experiences from Norway," International Association for Research in Income and Wealth Special Conference, 1996, 17 pp.
15. For descriptions of land cover and land use accounts, see: Conference of European Statisticians, *Physical Environmental Accounting: Land Use/Land Cover, Nutrients and the Environment*, 1995, 211 pp.; Parker, Jonathan, Anton Steurer, Ronan Uhel, and Jean-Louis Weber, "A General Model for Land Cover and Land Use Accounting," International Association for Research in Income and Wealth Special Conference, 1996, 25 pp.; United Nations Economic and Social Council, CES/717, 1991, 4 pp., CES/717, 1992, 6 pp., and CES/803, 1994, 4 pp. On case studies according to country, see, for Germany: Radermacher, Walter, "Land Use Accounting — Pressure Indicators for Economic Activities," International Association for Research in Income and Wealth Special Conference, 1996, 28 pp., and for England, Scott, Andrew and Roy Haines-Young, "Linking Land Cover, Intensity of Use and Botanical Diversity in an Accounting Framework in the UK," International Association for Research in Income and Wealth Special Conference, 1996, 20 pp.
16. See pp. 437-438 of J. L. Weber, 1983.
17. Davie, A., "Attempting a Patrimony Account for Land in Ivory Coast: Information System and Agriculture Development," *Statistical Journal of the United Nations ECE*, vol. 6, 1989, pp. 27-50.
18. On CLC, see "CORINE Land Cover," 1992 European Conference of the International Space Year, 1992, 24 pp.
19. Lange, Glenn-Marie, "Building Physical Resource Accounts for Namibia: Depletion of Water, Minerals, and Fish Stocks and Loss of Biodiversity," International Association for Research in Income and Wealth Special Conference, 1996, p. 29, relates an attempt in Namibia to build a livestock account on the basis of land.
20. Concerning UNEP's GRID Project, see: Witt, Ronald G. and Hy Dao, "Project Proposal for Improved Human Population Data, Database Management and Guidelines for Spatial Modeling for the CGIAR and UNEP/EAD/GRID," EAD/GRID-Geneve, 1995, 7 pp.
21. Concerning IGDP-HDP/LUCC, see "Proceedings of Land Use for Global Environmental Conservation (LU-GEC) — Global Environment Tsukuba '94," Center for Global Environmental Research, 1995, 121 pp. Also, Because the subject has no direct bearing on the subject at hand I did not take it up, but in connection with this matter there is a discussion of land statistics in natural resource accounting in Lee, A. M., "Land Use Statistics in Natural Resource Accounting Systems," on pp. 463-483 of Brouwer, F. M., A. J. Thomas, and M. J. Chadwick, ed., *Land Use Changes in Europe*, Kluwer Academic Publishers, 1991, 528 pp.
22. On landscape ecology, see: Takeuchi, Kazuhiko, *Chiiki no Seitaigaku*, Asakura Shobo, 1991, 254 pp., and Yokoyama, Shuji, *Keikan Seitaigaku*, Kokon Shoin, 1995, 207 pp.
23. See p. 6 of: Takeuchi, Kazuhiko, "Identifying Landscape Units in Aerial Photographs," *Shinrin Kosoku*, vol. 65, 1991, pp. 1-6.