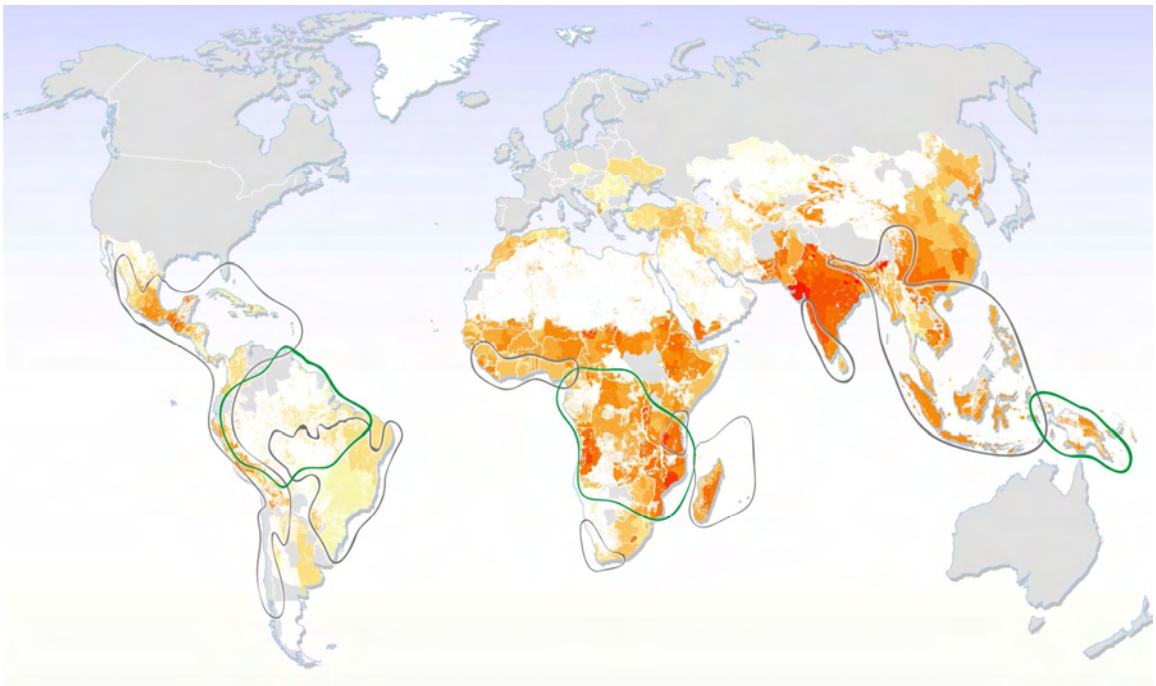
Poverty-Conservation Mapping Applications

IUCN World Conservation Congress
17-25 November 2004



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Poverty-Conservation Mapping Applications

IUCN World Conservation Congress, 17-25 November 2004[1]

*The Congress theme: "**People and Nature - only one world**" is designed to help position conservation as an integral and essential component of sustainable development.*

Abstract

A useful approach to explore linkages between development (*people*) and conservation (*nature*) is through the use of poverty-conservation mapping. Although poverty-environment mapping in biodiversity applications has been limited, there are numerous potential applications that are of use to IUCN and its members. Such applications range from substantiating the key role of biological resources in food security to improving geographic targeting of pro-poor ecosystem management. While poverty-environment mapping offers a suite of tools for improving the analysis between biodiversity and development issues, it must not be seen as a panacea for understanding or solving poverty-conservation problems. Mapping applications need to be used together, not in lieu of, other approaches including multi-level socio-economic assessments, traditional and community-based knowledge, community mapping, and statistical analyses.

1. Introduction

Key goals of the World Conservation Union's (IUCN's) Congress (17-25 November, 2004) is to help maintain the many values and services provided by ecosystems and to discuss new ways to explore the complex relationships between development (*people)* and conservation (*nature*) at regional to global scales (IUCN, 2004a). The IUCN's programme for 2005 – 2008 highlights IUCN's emphasis to evaluate the direct and underlying causes of biodiversity loss and unsustainable practices. The programme recognizes that "wealth, poverty, and inequity" is one of the four major underlying threats to biodiversity and sustainability. Other threats considered are human population dynamics, consumption patterns, and market failures and policy distortions.

[1] This report has been written by Mathilde Snel, a consultant contracted by UNEP/GRID-Arendal (mathildesnel@hotmail.com). It includes some extracts from a recent summary on poverty mapping application in the health sector, written by Anna Ballance. Maps and graphics were prepared by Hugo Ahlenius (hugo.ahlenius@grida.no). The report was reviewed by Hugo Ahlenius (hugo.ahlenius@grida.no), Marianne Fernagut (marianne.fernagut@grida.no), and Otto Simonett (otto.simonett@unep.ch).

The IUCN programme indicates the need for new approaches to evaluate the highly complex relationship between economic growth, poverty, inequities, and environmental degradation: "Tools and methods to support [poverty-focused conservation actions] … need to be developed and constantly improved…" (IUCN, 2004b, p. 34). As indicated in this report, **poverty-conservation mapping offers a valuable tool to help evaluate the complex relationship between poverty and conservation**. More specifically, mapping applications in combination with socio-economic analysis, multi-level evaluations, community-based participation, and other qualitative and quantitative approaches provide a suite of powerful tools with which IUCN and its members can address improved management of protected areas, the equal distribution of natural resources wealth to rural people, and other poverty-conservation concerns.

2. Poverty mapping and poverty-environment applications

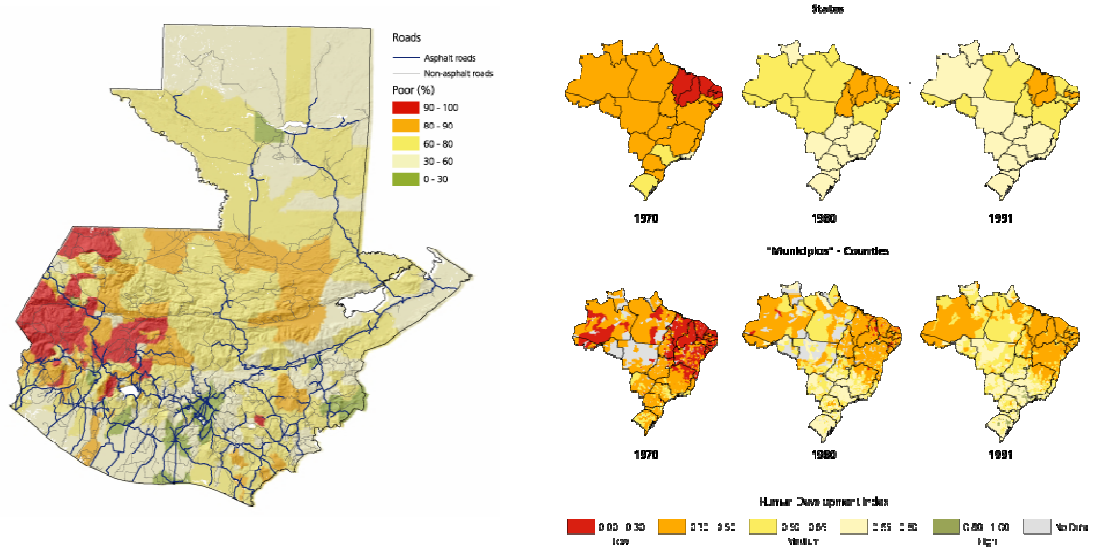

Figure 1. Types of poverty maps: e.g., the use of the small area estimation technique (Guatemala) and Human Development Indicators (Brazil).
Different methods can be used to develop poverty maps ranging from the recent use of the small-area estimation technique (see left map of Guatemala) to the use of composite indicators such as UNDP's Human Development Indicators (HDI) (see right map of Brazil). Although the new small area estimation technique provides high resolution poverty results and is the only poverty mapping method that generates a statistical error estimate, its use is rigorous both in terms of data and technical requirements. Other methods such as the HDI have a longer history of use and are more intuitive and easy to understand, despite providing coarser and less objective poverty results (Henninger and Snel, 2002)

Poverty mapping is increasingly becoming an important tool to evaluate a wide range of social, economic, and environmental problems. As indicated in a review on the use and impact of poverty maps (Henninger and Snel, 2002), poverty maps have been successfully used in an array of applications ranging from improving the geographic targeting of poverty reduction strategies, programs, and development assistance to informing emergency response initiatives, food aid programmes and projects, and state- and local-level decision making. Different methodologies can be used to develop poverty maps and include the use of simple composite indexes (such as the

Human Development Index), sophisticated economic techniques (such as the small area estimation method) and proxies (such as malnutrition or stunting rates) (Figure 1). Appendix 1 includes a more detailed explanation on poverty mapping methodologies.

While **poverty maps** are being used to support various social, economic, and environmental goals, their **use in conjunction with environmental data and in spatial and comparative analyses is limited** (Henninger and Snel, 2002; Snel and Ballance, 2003). Nonetheless there are an increasing number of poverty-environment mapping applications. Such applications include analysis of food insecurity in Cambodia, the identification of the impact of global climate change on poor livestock keepers' livelihoods, the evaluation of poverty-environment linkages in Madagascar; and assessing patterns between land cover change and human migration in Ecuador (Henninger and Snel, 2002; Thornton et al., 2002; WWF Conservation Strategies Unit, 2002).

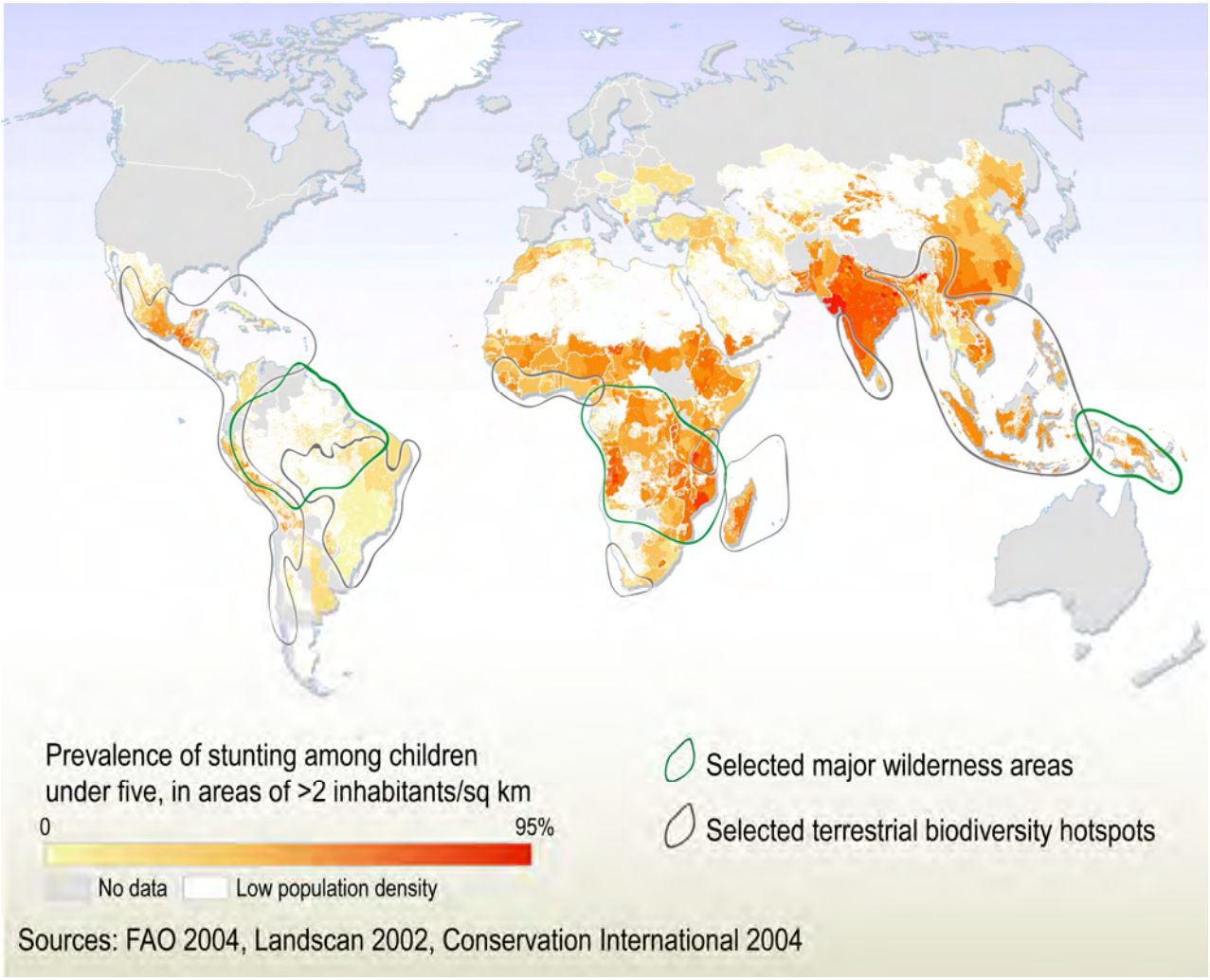

Figure 2. Use of map overlays to identify relationships between biodiversity and poverty.
This map may be used to show areas in which biodiversity is threatened. Areas where high poverty and high population density coincides with high biodiversity may indicate areas in which poor people likely have no other choice than to unsustainably extract resources, in turn threatening biodiversity. The map has been produced from three primary data sources – stunted growth data collected on first level administrative units from FAO (FAO 2004), population density from LandScan (LandScan, 2002), and areas of high biological significance (major tropical wilderness and biodiversity hotspots) from Conservation International (Christ et al., 2003).

The value of poverty-environment mapping is to highlight spatial correlations and disparities. Figure 2, for example, illustrates a simple map overlay used to identify possible relationships between biodiversity and poverty. The map, based on a simple overlay analysis, highlights areas where biodiversity is potentially threatened by human populations: areas in which poor peoples have no other choice than to extract natural resources unsustainably. More specifically, Figure 2 suggests that biodiversity may be particularly threatened in West and Central Africa, Central America, South-East Asia and other regions where high stunting rates in children (under 5) – a proxy for poverty – coincide with biodiversity hotspots and wilderness areas (dark orange and orange areas in the biodiversity hotspots and wilderness areas)[2].

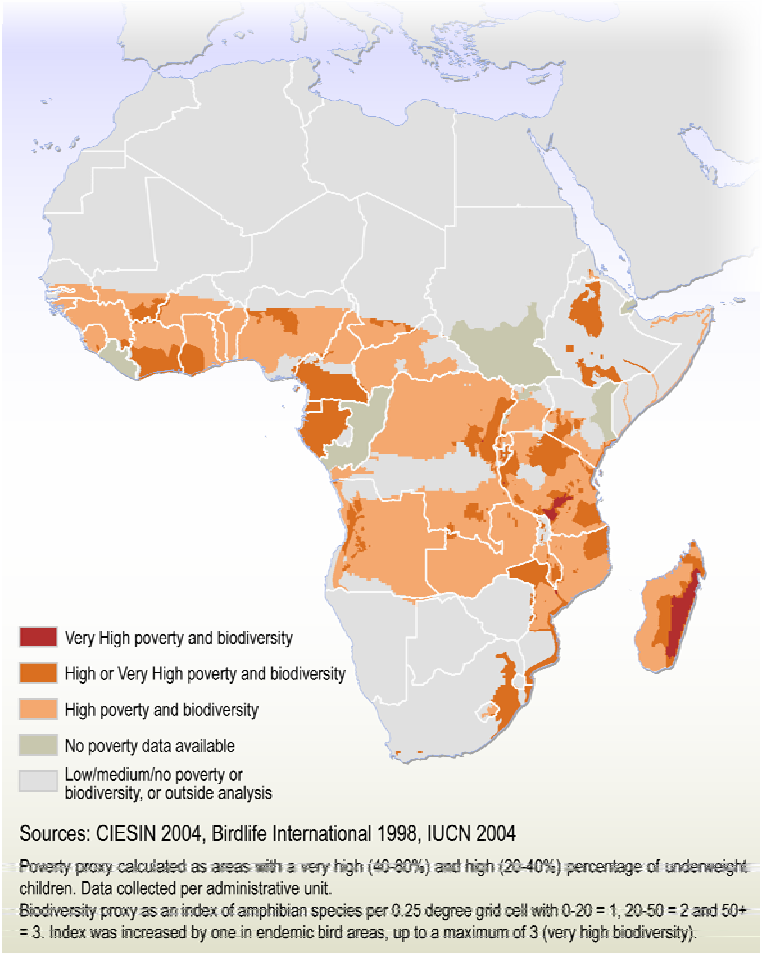

Figure 3. Relationships between biodiversity and poverty in Africa
This map may be used to show areas in which biodiversity is threatened in relation to poverty on a continental scale. Areas where high percentage of underweight children - used as a proxy for poverty - coincide with a high occurrence of amphibian species and endemic bird areas - a proxy for biodiversity - may indicate areas in which poor people likely have no other choice than the unsustainable extraction of resources, in turn threatening biodiversity . The map has been produced from a simple site selection using poverty data (CIESIN, 2004) on a first level administrative boundary level together with endemic bird areas (Stattersfield et al., 1998) and amphibian species (Conservation International, 2004) as a biodiversity proxy.

[2] To highlight areas with highest priorities for poverty alleviation and conservation, data on stunted growth in children (under 5) - at first level sub-national administrative units (FAO, 2004) - was "filtered" to only display stunting in areas with high population density. Population density data was based on the Landscan data model, (Landscan, 2002), while areas of high biological significance - major tropical wilderness and biodiversity hotspots - was based on Conservation International data (Christ et al, 2003). Biodiversity hotspots are defined as "regions that harbour a great diversity of endemic species and, at the same time, have been significantly impacted and altered by human activities". Wildlife areas are "at least 70% intact and are generally under less pressure from encroaching human populations than are the biodiversity hotspots" (Meyers et al., 2000 in Christ et al., 2003, p. 3).

A similar analysis at continental and regional level for Africa - although based on other data and proxies - indicates at a higher resolution the relationship between biodiversity and poverty. Figure 3, for example, indicates that "very high" poverty (based on percentage of underweight children) coincides with biodiversity (based on the presence of endemic bird areas and amphibian species) in eastern Madagascar, south-central Tanzania, and northern Ethiopia (see red areas in Figure 3)[3].

Figure 4 indicates in greater detail for Eastern Africa areas where biodiversity (based on a freshwater biodiversity index) coincides with poverty (based on percentage of children with stunted growth)[4].

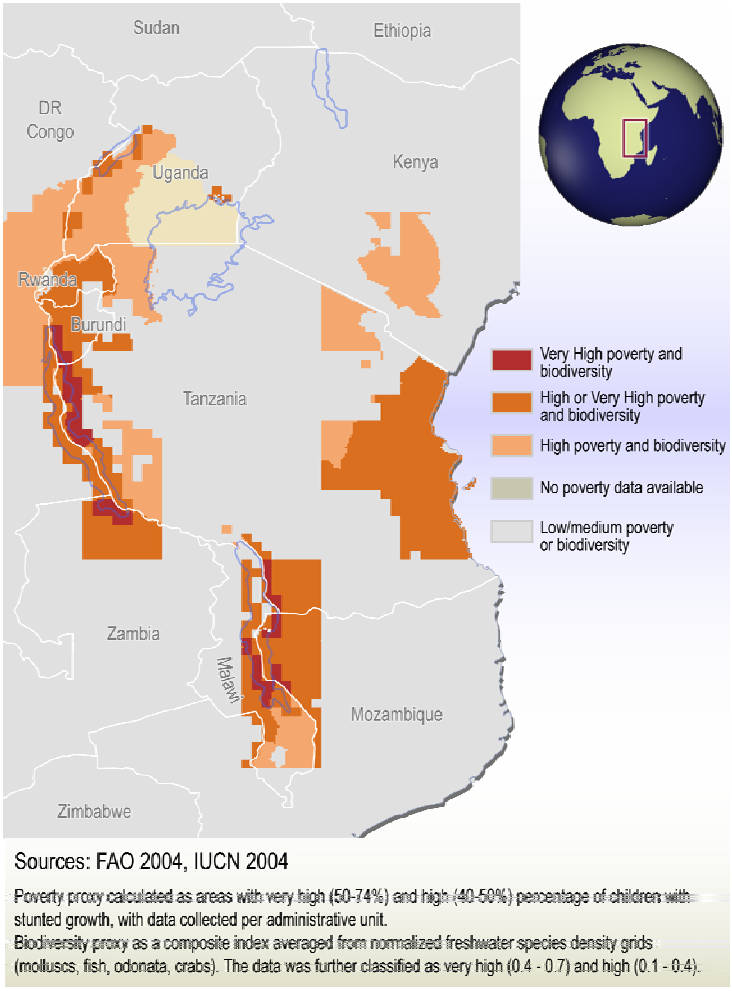

Figure 4. Freshwater biodiversity and poverty in eastern Africa
Red areas where high percentage of children with stunted growth - used as a proxy for poverty - coincide with a high freshwater biodiversity index - a proxy for biodiversity - likely indicate areas in which poor people have no other choice than to unsustainably extract resources, in turn threatening biodiversity.

[3] More specifically, Figure 3 is based on percentage of underweight children at first level sub-national administrative units (CIESIN, 2004) and a composite index on the presence of endemic bird areas (Stattersfield et al., 1998) and amphibian species per 0.25 degree grid cells (Conservation International, 2004). "Very high" poverty refers to areas with 40-80% underweight children per administrative unit, while "high" poverty entails 20-40 % underweight children per administrative unit. In future analyses the poverty data could be further enhanced by filtering areas in which high population density occurs (as done for Figure 2).

[4] The biodiversity proxy is a composite index based on freshwater species data (e.g., molluscs, fish, odonata and crabs) in which averaged normalized freshwater species density grids were used. Biodiversity data were further classified as "very high" (0.4 – 0.7) and "high" (0.1 – 0.4) (IUCN Freshwater Biodiversity Assessment Programme, 2004). The poverty proxy calculates very high (50-74%) and high (40-50%) percentage of children with stunted growth.

Spatial models can also be developed to help predict causal relationship between socio economic variables (e.g., poverty) and environmental changes (e.g., biodiversity loss). A recent evaluation by the International Livestock Research Institute (ILRI), for example, uses poverty maps and global climate change scenarios to evaluate the potential effect of global climate and demographic change on poor livestock keepers in developing countries (Thornton et al., 2002) (Figure 5). Similar global change modelling can be used to evaluate how climate change affects biodiversity and poor peoples' livelihoods.

The map overlays and spatial models, as those indicated above, should not be seen as an end in themselves. Verifying and further evaluating relationships with additional data – such as through field socio-economic analysis and cross-referencing with traditional knowledge – is essential. More specifically, participatory approaches can further inform on the underlying causes and drivers of poverty and biodiversity loss. The use of participatory community-based mapping, for example, can help identify and localize types of environmental problems and priorities perceived at the community level; describe local level land tenure, property, and access rights; document existing hazards and safety nets; etc. (personal communication, Coolman, 2004).

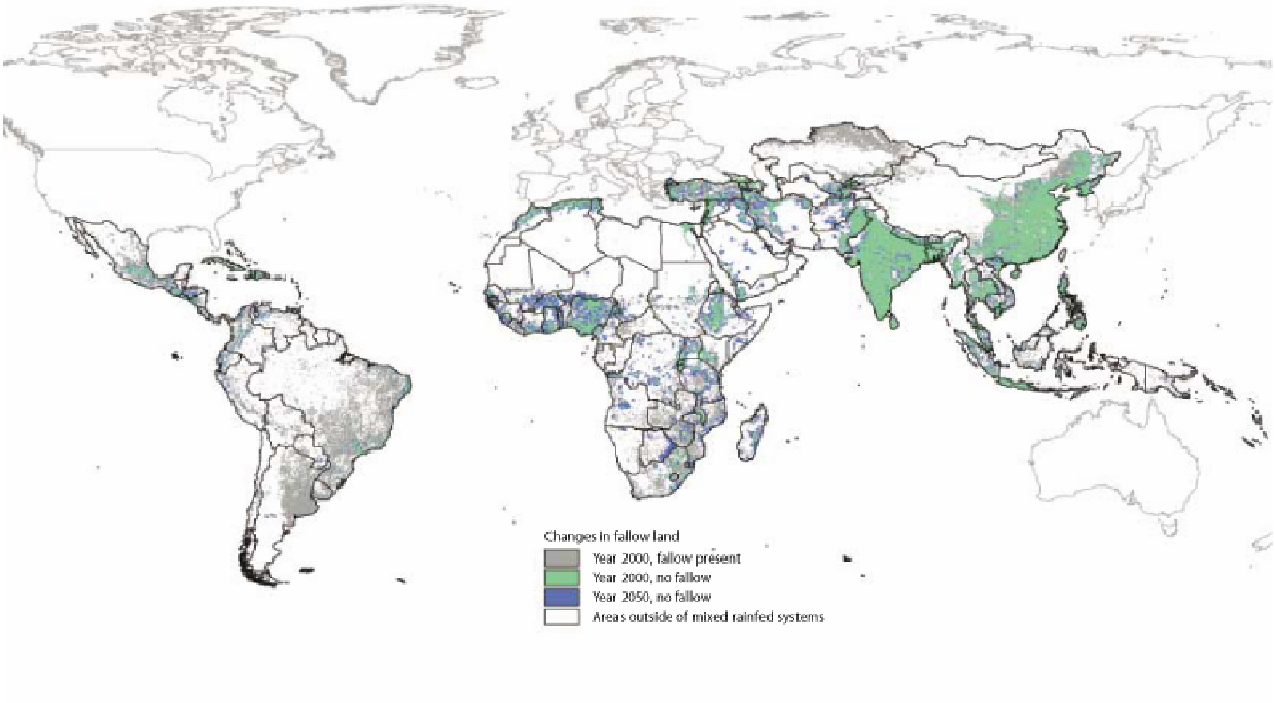

Figure 5. The impact of global climate and demographic change on poor livestock keepers
This map indicates changes from 2000 to 2050 in global fallow land in mixed rain fed production systems in developing countries. As indicated, global climate and demographic changes are anticipated to reduce the range of fallow area available (Thornton, 2002).

3. Potential poverty-conservation applications for IUCN and its members

Various potential and existing poverty-conservation mapping applications that IUCN and its members may consider are subsequently discussed. The following list of potential and existing poverty-conservation mapping applications is not exhaustive. **The noted applications are intended to draw attention to and spark discussion on the complex spatial relationship between poverty and biological resources and on possible poverty-conservation mapping applications of use to IUCN and its member organizations.**

The mapping applications need to be considered in light of the numerous advantages and limitations of maps. While maps are a powerful communication tool to present information and communicate findings, maps are only as good as the data on which they are based. Strengths and weaknesses of maps and mapping applications have been described in detail in Appendix 2.

The documented poverty-conservation applications depend on spatial data on biological resources (endangered species, protected areas and recreational sites, and medicinal resources), land cover and use (including vegetative type, vegetative change and condition, agriculture, forestry, and soil type and condition) and socio-economic variables (income and poverty rates). Availability and sources of this information have been indicated in Appendix 3.

The poverty-conservation mapping applications have been discussed about the IUCN World Conservation Congress' four themes:

- Ecosystem management;
- Biodiversity loss and species extinction;
- Health, poverty, and conservation; and
- Markets, businesses, and environment.

3.1. Ecosystem management

The first theme about which IUCN's World Conservation Congress is organized regards the global challenge to balance nature conservation and human needs. An "ecosystem approach" emphasizes the need to manage entire land and seascapes towards securing both conservation and human demands for food, clean water, etc. Poverty-conservation mapping applications can help manage ecosystems as subsequently described.

- **Identification of opportunities for pro-poor ecosystem management:** Key economic sectors such as agriculture, irrigation, and aquaculture are increasingly seen as opportunities to improve food production, while enhancing biodiversity and reducing poverty (IUCN, 2004c). Biodiversity, poverty, and other maps may be used to geographically target areas where eco-agriculture, aquaculture, river basin management, and other sustainable practices may be supported to improve food supplies, biodiversity, and human conditions. The World Resources Institute (WRI) has already used extensively mapping technologies to assess globally the current health of the goods and services

provided by numerous ecosystems ranging from forest to coastal and grassland (Burke et al., 2000; Matthews et al., 2000; Revenga et al., 2000; White et al., 2000; Wood et al, 2000). Similar analyses in conjunction with poverty data can be conducted to identify ecosystems in which pro-poor ecosystem management can be supported.

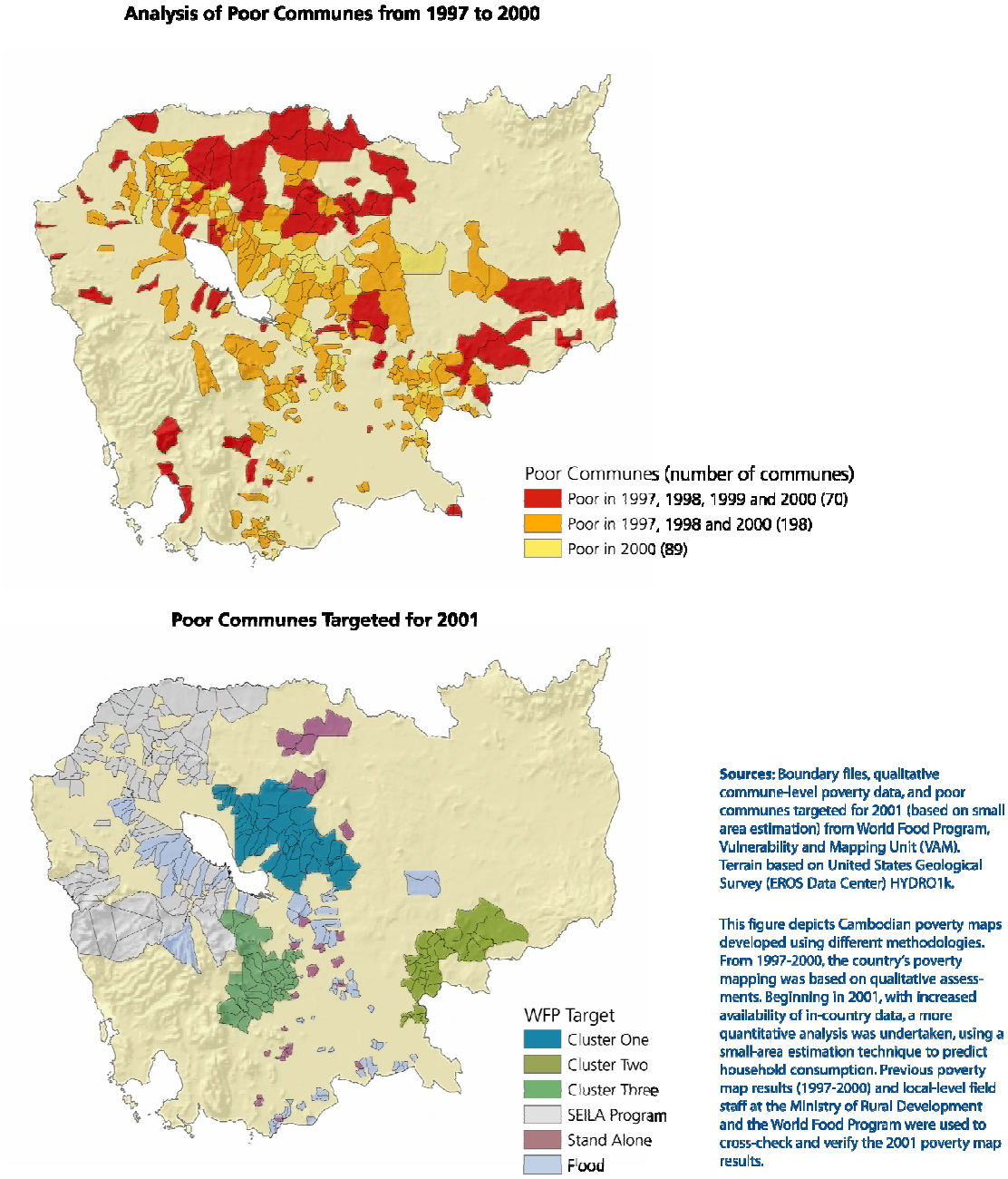

Figure 6. Use of poverty maps and local-level field verification to locate poor communes in need of food aid in Cambodia

WFP has since 1995 used poverty maps in combination with qualitative assessments to identify communes in need of food aid interventions. While during the late 1990s WFP relied on poverty maps based on expert qualitative assessments, in 2001 a poverty map based on the quantitative small-area estimation technique was used. Previous poverty map results (1997-2000) and local-level field visits were used to verify and cross-check the 2001 poverty map results. The use of poverty maps in conjunction with qualitative assessments offers a powerful suite of tools to improve poverty-focused geographic targeting (Henninger and Snel, 2002).

- **Substantiating that biological resources play a key role in food security:** By combining global sub-national spatial indicators of poverty, nutrition, and biodiversity, the important role of biological resources to food security is substantiated. Such visual data on the link between biological resources and food security can help IUCN and its members lobby on the significant importance of maintaining biodiversity wealth to address food security in developing countries. Although poverty maps have not yet been used in conjunction with biodiversity data to address food security, poverty maps have been used as an important tool to locate areas in need of food aid. In Cambodia's "food for work" interventions poverty maps were, for example, used to identify the most food insecure communes in need of World Food Program's (WFP) funding (totalling US$50 million for 2001 – 2003) (see Figure 6) (Henninger and Snel, 2002).

- **Indicating the role of small-scale farmers in preserving biological diversity:** The IUCN increasingly recognizes that farmers are a critical ally towards conserving biodiversity (IUCN, 2004c). The use of agroforestry, integrated pest management, aquaculture, and other eco-agricultural techniques – often practiced by poor small-scale farmers - helps preserve biodiversity (vs. the use of monocultures, chemical fertilizers, etc). By combining poverty maps with data on agricultural practices, the contribution of small-scale farmers towards conserving biodiversity may be substantiated. Such analysis helps IUCN and its member organizations indicate the importance of supporting small scale farming and eco-agriculture in developing countries.

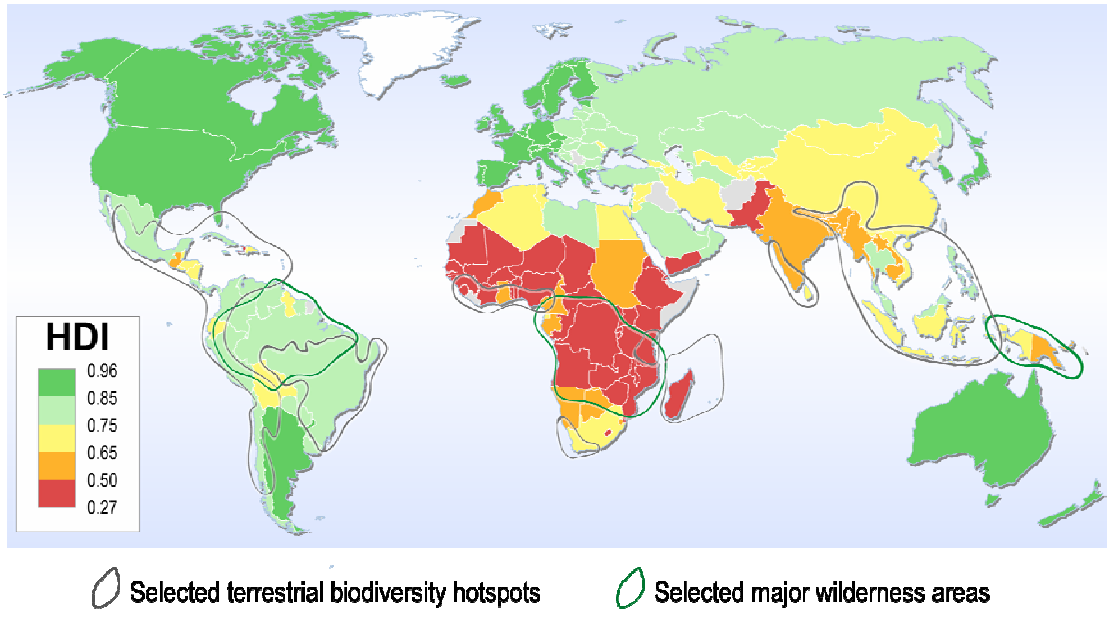

Figure 7. Developing countries and areas of high ecological significance
An overview of the development status of developing countries and areas of high ecological significance show that some of the World's least developed countries are located in the tropical hotspots and wilderness areas, especially in Africa, the Caribbean, and South Asia. Note that the HDI (Human Development Index) is a composite index based on education, health, and economy.

- **Substantiating that biologically rich areas are in developing countries:** Global sub-national maps on well-being (e.g., income) in combination with data on ecosystems, biodiversity, and species can be used to indicate that biologically rich areas are often found in developing countries. Such information is useful to IUCN and its members to lobby for increased conservation funding to developing countries. An examination of the Human Development Index (HDI) shows that some of the World's least developed countries are located in the tropical hotspots and wilderness areas, especially in Africa, the Caribbean, and South Asia (Figure 7).

- **Integrating poverty-conservation maps in poverty reduction strategies:** Mainstreaming ecosystem and conservation maps in high-level poverty reduction strategies and linking these to poverty maps is essential towards promoting pro-poor ecosystem management in national-level planning and programming. Integrating poverty-conservation maps in poverty alleviation strategies helps indicate *where* poor people significantly depend on biodiversity assets, *where* poor communities will benefit from ecosystem management, etc. Such information can be used to improve the geographic targeting of poverty reduction and conservation plans, programs, and other initiatives. Although conservation-poverty data have seldom been integrated, poverty maps have been used in national poverty reduction strategies, in some instances affecting substantial sums of money. In Vietnam, for example, poverty maps were used to geographically target Vietnam's World Bank-funded poverty reduction initiatives amounting to US$240 million, while in Nicaragua poverty maps influenced the allocation of US$1.1 billion in Nicaragua's Strengthened Growth and Poverty Reduction Strategy (Henninger and Snel, 2002).

3.2. Biodiversity loss and species extinction

Another theme about which the World Conservation Forum is organized explores how growing human populations and in particular global change – including global climate change and globalisation – affects biodiversity loss.

- **Identifying biodiversity threats due to environmental changes and shocks:** Droughts, floods, earthquakes, conflicts and other environmental and anthropogenic pressures affect large numbers of people - often in the poorest segments of society - and place significant pressure on terrestrial and marine biodiversity. Spatial analysis and modelling – that combines biophysical and socio-economic data – can be used to evaluate existing and potential biodiversity threats due to environmental changes. These models in conjunction with poverty scenarios can indicate how anticipated changes or shocks affect poor peoples' livelihoods that significantly depend on natural resources wealth – e.g., through declined agricultural productivity, decreasing fish stocks, damaged reefs, displacement, etc. These analyses have the potential to promote a shift from disaster relief to hazard preparedness by identifying regions and peoples at risk to shocks and disasters. Global climate change scenarios – over the next 30 to 50 years – have already been used in conjunction with poverty maps to evaluate the potential effect of global climate and demographic change on poor livestock keepers in developing countries (Thornton et al., 2002) (refer back to Figure 5). Furthermore, land cover change mapping has been commonly used to identify

biodiversity loss and areas in need of reforestation: in Thailand, for example, land cover change mapping indicated that between 1970 and 1990 the area covered by primary and secondary forest declined by more than a half (see Figure 8).

Figure 8. Use of maps to detect changes over time
From 1970 to 1990 there was significant deforestation of both primary and secondary forests in Thailand. During this thirty year period, the area covered by primary and secondary forest declined by more than half. Many other regions of the world are affected by deforestation: namely in South America (Brazil), Central Africa (Congo), Southeast Asia (Indonesia), and Eastern Europe (UNEP and ISRIC, 1997).

- **Evaluating the impacts of biological invasive alien species:** As acknowledged by the IUCN, biological invasion by alien species constitutes the greatest threat to biodiversity after habitat loss. Poverty maps in conjunction with locations of the invasive alien species, changes in agricultural crop, and other relevant data (if available) can be used to evaluate the environmental and livelihood impacts of the invasive alien species. Possible impacts include reduced crop and stock yields, depleted freshwater and/or marine fish stocks, and degraded ecosystems and livelihoods. The International Centre for Tropical Agriculture (CIAT) used maps of poverty, disease resistance, and agricultural production to evaluate *ex post* the impacts of the introduction of disease resistant bean varieties on agriculture (Johnson and Klass, 1999).

3.3. Health, poverty, and conservation

A third key theme about which the World Conservation Congress is organized concerns exploring the linkages of sustainable management and human health, as well as determining how natural resources can be positively employed to help poor people.

- **Identifying areas that are vulnerable to infectious disease outbreaks:** Exposure and cross-transmission of diseases between humans and animals continues to threaten human health and wildlife. Map overlays indicating where dense poor populations live in close contact with numerous species and domestic animals (if data is available) may be used to geographically target areas that are vulnerable to infectious disease outbreaks, such as to SARS and the avian influenza. Such geographic targeting helps inform IUCN on minimizing infectious

disease outbreaks (*ex ante*) or on assessing what triggered the outbreak in the first place and its impact on human communities and animal populations (*ex post*).

- **Substantiating that biological resources are a critical substitute for health care services in rural areas:** By combining global sub-national poverty indicators with data on health services, biodiversity and species, populations may be identified that significantly rely on biological resources as a substitute of health care. Poor populations residing close to biodiversity hotpots in which formal health services are limited (or not existent) are more likely to rely on traditional medicines and plant- and animal-based products for their primary health care. Socio-economic and community-based analyses may subsequently be conducted in the targeted areas to further explain the community's dependence on biological resources for health care. Although poverty maps have not yet specifically been used in poverty-conservation-health application, poverty maps have been used in a variety of health applications, including locating health clinics, developing nutrition indicators, and tracking disease outbreaks (Henninger and Snel, 2002; Snel and Ballance, 2003) (see Figure 9).

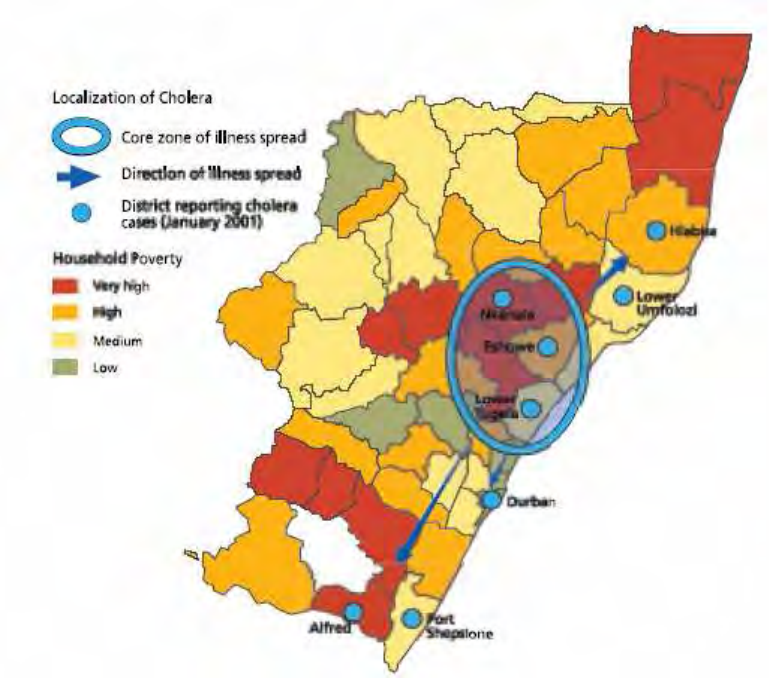

Figure 9. Tracking a cholera outbreak in the KwaZulu Natal province, South Africa
This map depicts an overlay of poverty mapping data with information concerning an outbreak of cholera in the KwaZulu Natal province of South Africa in early 2001. It shows that the disease outbreak originated in areas of very high and high poverty and spread through and towards other poor areas. The map was produced through the cooperation of several government agencies, including Statistics-SA (developer of the national poverty map), the Department of Health (provided disease data), and the Department of Water Affairs (provided information on safe water supplies). It served as the basis for a disease control strategy and helped to target health education messages in affected and high-risk communities. Using this map, the outbreak was effectively contained within three months, with a resulting fatality rate of (0.22%) among the lowest ever observed (Henninger and Snel, 2002).

3.4. Markets, businesses, and environment

The fourth theme about which the World Conservation Forum is organized explores how markets, businesses, and especially the private sector can become more socially and environmentally engaged. Poverty-conservation mapping can help identify and expand green opportunities.

- **Identifying municipalities, districts, etc. for pro-poor conservation royalties:** Poverty-conservation maps can be used to geographically target the allocation of pro-poor conservation royalties. In Panama value added tax was, for example, distributed as conservation royalties to municipalities that protected and expanded their conservation areas: the use of the conservation royalties is thought to have helped increase the percentage of protected area in Panama to 165% (IUCN 2004d). An additional criterion to distribute the conservation royalties is involvement of poor communities in the conservation initiatives. Poverty maps in conjunction with socio-economic analysis can help identify poor communities that will benefit from involvement in such poverty-focused conservation campaigns.

4. Synergies with IUCN's current databases

Although IUCN's databases currently emphasize biodiversity data, given IUCN's current emphasis on poverty-conservation linkages, **strengthening the inclusion of data on poverty and other socio-economic variables will add significant value to existing IUCN datasets**. Furthermore, given that IUCN's "core business… is managing knowledge for biodiversity conservation and the sustainable use of natural resources" (IUCN, 2004b, p. 25), **IUCN and its members can play an invaluable role in promoting the use of poverty-conservation mapping applications**.

It is strongly urged that synergies are sought with IUCN's existing databases in developing poverty-conservation databases, including with IUCN's:

- Green web: IUCN launched a virtual Green web of conservation knowledge;
- Red List of Threatened Species: The 2004 Red List – an updated version of the 2000 Red List – is the most complete data on species collected by 8,000 experts worldwide. The 2004 Red List will be disseminated shortly before the 2004 World Conservation Congress (IUCN, 2004d);
- Protected Areas Learning Network (PALNet); and
- ECOLEX (IUCN, 2004b).

In addition to seeking synergies with existing IUCN databases, synergies with other conservation database efforts are important, including with:

- BirdLife International's Important Bird Areas (IBAs) database;
- The Ramsar Convention's list of Wetlands of International Importance; and
- The World Wide Fund for Nature's "Global 200" priority conservation areas (Christ et al., 2003).

5. Concluding remarks and next steps

As highlighted throughout this report **there are numerous potential poverty-conservation mapping applications of interest to IUCN and its member**. Such applications include substantiating biodiversity's role in food security to geographically targeting areas for pro-poor conservation management. **Although maps and mapping applications offer an important tool to improve understanding of the relationship between poverty and conservation, their use is not a panacea for solving poverty-conservation problems.** Mapping applications need to be used together, not in lieu of, other approaches: such as with multi-level socio-economic assessments, traditional and community-based knowledge, statistical analyses, etc.

The poverty-conservation mapping applications noted in this report are intended to spark discussion on the complex correlation between biological resources and income and on new methods that may be used to address this relationship. In light of this report's proposed poverty-conservation applications, the following key questions are posed to further stimulate discussion:

- Is poverty-conservation mapping a useful tool to IUCN and its member organizations?
- Are the proposed poverty-conservation mapping applications in line with IUCN interests? Are there other potential applications?
- Provided interest, how can poverty-conservation mapping be institutionalised in IUCN? Similarly, how can IUCN play a leading role in promoting poverty-conservation mapping applications among its member organizations? Consideration must be made to balance the promotion of mapping applications with other qualitative and quantitative approaches.
- What role can IUCN play in overcoming institutional and human mapping and analysis capacity deficiencies, particularly in developing countries where most of the world's natural wealth is found?
- What are other important issues regarding the adoption and promotion of poverty-conservation mapping applications that need addressing?
- What are proposed next steps to support poverty-conservation mapping in IUCN?

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Appendix 1: Poverty mapping methodologies

Two key poverty mapping methodologies have been described in detail below: small area estimation technique and composite indicators.

Small area estimation technique: Poverty maps based on the small area estimation technique use sophisticated econometric techniques to combine a set of identical variables in both the census (national coverage) and surveys (a representative sample of the population). In doing so, this method takes advantage of the universal coverage of the census and the wealth of detail in the household survey. More specifically household characteristics that are found in *both* the household survey and the census are identified, regression models are subsequently used on the detailed household survey data to predict the relationship between poverty (the dependent variable) and other variables (independent variables), and lastly the regression parameters are applied to the census data to predict poverty measure at national level. The poverty measure is usually an expenditure-based indicator of welfare, such as the proportion of households that are below a specified expenditure level. While the small area estimation technique is more accurate – it is the only poverty mapping method that generates an estimate of statistical error – the technical and data requirements are rigorous. This method works best in countries where comprehensive household surveys and national censuses are regularly collected (Henninger and Snel, 2002; Benson, 2003).

Composite indicators: This technique relies on combining various variables to capture the multidimensional nature of human well-being. Variables are initially selected, subsequently standardized (e.g., between a range of 0 and 1), weighted, and combined. Examples of composite indexes include United National Development Programmes' (UNDP's) Human Development Index (HDI) and various basic needs measures. While composite indexes are more intuitive, require less advanced statistical expertise, better capture the multidimensional nature of well-being, and have a longer history of use the selection and weighting of the variables can be subjective, arbitrary, and theoretically unsound (Henninger and Snel, 2002).

Appendix 2: Strengths and weaknesses of maps and mapping applications

Strengths of maps and mapping applications

- **Maps are effective in presenting information and communicating** findings**:** The advantages of displaying information in a spatial format are largely related to the visual impact and effective communication of issues. **Maps can be extremely powerful communication tools** and convey information and findings that are difficult to express verbally. They can deliver a message without pages of text and are in turn ideal for busy people who need succinct strategic views of issues. They can be used to indicate areas of concern, show the extent of a problem, and demonstrate relationships in a way that is more striking – e.g., by showing the intensity of a problem in one area relative to another area or by showing clear linkages between two or more variables.
- **Maps can be used to identify and investigate spatial patterns:** Maps have an inherent advantage in that they draw attention to the spatial dimension of issues and can visually indicate trends over time, so long as variables are collected using the same methodology and over the same time intervals.
- **Maps are an effective means of recording and storing information:** Governments, the private sector, development agencies and civil society groups store large quantities of information about the environment and the location of natural resources, populations, demographic trends, etc. Maps help organize, record, and store spatial information.

Weaknesses of maps and mapping applications

- **Most maps represent only a snapshot of the** situation: Since the environment is dynamic and conditions are constantly changing, **maps can quickly become out-dated**. In some instances data can be recorded in real time or near-real time, however such data are minimally available and costly.

- **Gaining access to spatially referenced information is often difficul**t: Data may not be available for a particular variable, may only be available for a portion of a required area, or may be available for an entire area but where different sampling methodologies, scales, and accuracy levels have been used. Where inconsistent data sets are combined data inaccuracies and error - including mismatched boundaries – are compiled.

- **Not all people readily relate to information in a two-dimensional spatial format:** This is particular evident where **different cultures place different importance or meaning on symbols and colours**. In western culture, the colour red may be used to symbolise danger, whereas in China its use may symbolise luck or a favourable area. Understanding maps may be particularly difficult where maps are of an unfamiliar area or in an unusual projection.

- **High cost and rapidly changing technologies:** Rapidly changing and advancing technology requires costly updating and training and the periodic purchase of expensive specialized hardware. Such high cost limits the adoption of mapping technologies in especially developing country.

Appendix 3: Commonly used environmental spatial information relevant to conservation

Biodiversity: These are usually based on forest cover or protected areas, although specific species or habitat atlases also exist.

> Common sources: National Departments of Environment, UNEP, UNEP-WCMC, IUCN, World Resources Institute

Land cover & use: These maps are informative in modelling environmental change and impacts on biodiversity and human well-being. Land cover change could signify an increase in agricultural activity and forest encroachment, or it could signify changes in the spread of new diseases.

> Common sources: National Departments of Agriculture, Forestry, Environment; UN FAO, UNEP, ESRI's Digital Chart of the World, NOAA, National Departments of Defence, World Resources Institute

Soils: These can be useful to help locate areas of food insecurity or low agricultural potential.

> Common sources: National departments of Agriculture, FAO, UNEP

Water resources: Maps of both surface and groundwater resources exist, in some cases water quality is indicated. These maps may be useful to access water quality impact on biodiversity loss of e.g., freshwater and marine species.

> Common sources: National Departments of Water, UNEP, WMO, GIWA, NOAA, National Rivers Authorities, State of the Rivers Report (South Africa), Pollution Control Authorities, UNEP's Global Programme of Assessment, World Resources Institute, weather bureaus, and meteorological offices.

Poverty: Maps of indicators of well-being ranging from income per capita to nutritional status, to educational level or life expectancy can be very useful in combination with maps of environmental conditions. They are most commonly used by planning and development agencies to target specific areas with specific needs.

> Common sources of poverty or poverty-environment maps are www.povertymap.net, the World Bank, CIESIN, FAO Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS), World Resources Institute

Settlements & infrastructure: Although not strictly environmental, these types of maps are useful in predicting or depicting environmental change as a result of human activity.

> Common sources are national Departments of Surveys and Mapping, and local authorities.

Environmental laws and management: Although not commonly presented in spatial format, a global mapping project initiated by CIESIN at Columbia University relates remotely sensed data (e.g., on land cover change and land degradation) to environmental treaties. Available on www.ciesin.columbia.edu.