Non-timber **forest** products in **Uganda**

Spatial tools supporting sustainable development

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Preface

Human wellbeing relies on our ability to exploit our diverse and often fragile natural environment sustainably and into the far distant future. If there is no such thing as environmentally neutral economic growth, there is certainly an increasing number of options for sustainable human and social development. Such new approaches are essential to the achievement of the United Nations Millennium Development Goals.

Non-timber forest products (NTFPs) have been a particular focus of development interest in recent years. The hope is that forest-dependent people can gain new income-generating opportunities with minimal environmental costs. Fruit, basketry, honey and medicinal plants are just a few examples of economically and socially valuable products that can be produced from a sustainably managed natural resource base.

To offer a long-term source of income, NTFP production will still require careful planning, management and monitoring. Ideally, NTFP commercialization should raise the standard of living for the poorest communities whilst protecting vulnerable ecosystems and their biodiversity. Spatial analysis can support these dual objectives by informing locational decisions, directing external support to areas with the greatest prospect of success.

This project demonstrates that powerful spatial analysis tools now allow the combination of relevant social, economic and environmental data into a common analytical framework. The results offer a strong indication of the most appropriate sites for the sustainable development of NTFP harvesting and commercialization. Such 'expert systems' can be made accessible to any number of stakeholders, providing a truly participatory and inclusive tool for the sound management of our common natural heritage.

Jon Hutton
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Introduction and scope

The importance of natural resources in supporting rural livelihoods is increasingly being recognized in national and international policy. For example, achievement of all the Millennium Development Goals will depend on maintaining the environmental goods and services that are key to human productivity. Approaches to development are therefore required that enable incomes to be derived from natural resources, while supporting the effective conservation of these resources.

Non-timber forest products (NTFPs) offer an important example of how such goals may be achieved in practice. Many rural livelihoods are based on the collection and sale of products derived from forest resources, including fruits, nuts, fibre and resins. Trade in NTFPs can act as an incentive for forest conservation by providing a source of income from resources that might otherwise appear to have little financial value. In addition, the environmental impact of harvesting NTFPs is generally much lower than typically results from timber harvesting. As a consequence, many rural development initiatives are now supporting the commercialization of NTFP resources.

Rural communities often require external financial and technical support for successful commercialization of NTFP resources. Some national governments, aid agencies and non-governmental organizations are providing such support, to assist with the process of rural development and environmental conservation. However, exploiting NTFP resources may not be an appropriate option for sustainable development in all areas, as some rural communities are located far from potential markets, or do not have access to appropriate forest resources. Tools are therefore needed that could be used to direct external support to those areas with the highest potential for success.

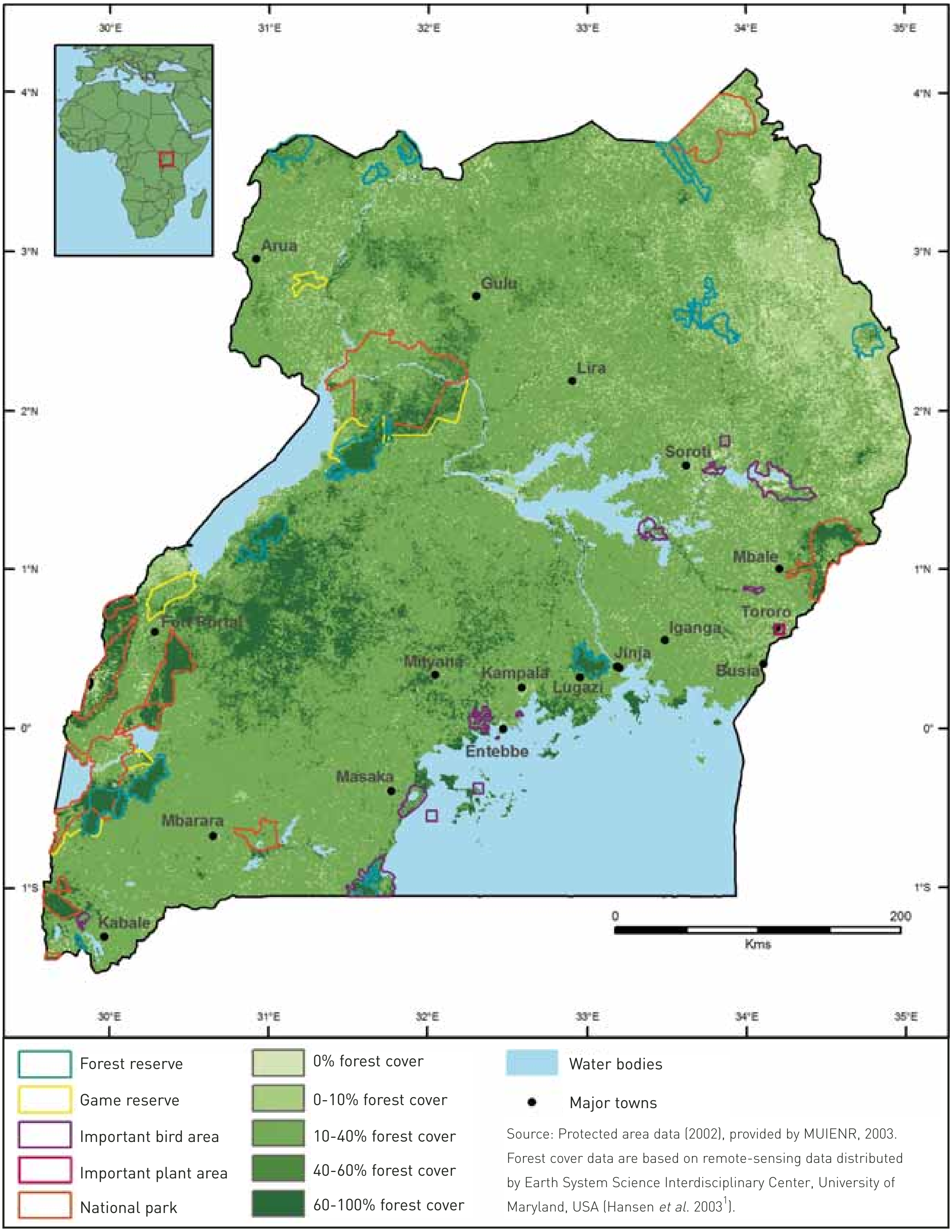
This report describes an approach to define where NTFP resources offer an appropriate option for sustainable development. This is achieved using Uganda as a case study. Uganda's rich natural heritage and its position as one of the most rapidly growing economies in Africa serve to highlight the conflict between national development efforts and the need for a globally responsible approach to natural resource conservation.

The report addresses the following questions:

- How can NTFP commercialization contribute both to rural poverty eradication and forest conservation in Uganda?
- How do spatial factors affect these two goals?
- Based on currently available information, where do specific NTFPs have the highest chances of being successfully developed and commercialized in an economically and environmentally sustainable way?
- How can this spatial analysis be refined in the future to give a more complete picture?

Research into NTFP commercialization is still relatively recent and many of the datasets necessary for a thorough analysis of these questions are still lacking. However, sufficient information was available to build a demonstration model using geographic information systems (GIS), providing a useful preview of the benefits of such an approach.

Figure 1: Forest cover and environmentally vulnerable areas in Uganda



Source: Protected area data (2002), provided by MUIENR, 2003. Forest cover data are based on remote-sensing data distributed by Earth System Science Interdisciplinary Center, University of Maryland, USA (Hansen *et al.* 2003[1]).

Non-timber forest products and sustainable development

Uganda has an exceptionally rich and varied natural resource base and a number of important protected areas hosting extremely high levels of biodiversity (Figure 1). Agricultural productivity is low, and Uganda has one of the highest population growth rates in Africa. In recent decades, political instability, unregulated agricultural expansion and limited institutional capacity have contributed to a depletion of natural resources across the country[2]. Sustainable solutions to Uganda's economic development are urgently required if its natural resource base and biodiversity are to be conserved in the future.

NTFPs, broadly defined as any forest-derived tradable products other than commercial timber, have been widely regarded as a potential meeting point between conservation and rural development priorities[3]. Common examples of NTFPs in Uganda include medicinal plants, handicrafts, musical instruments, honey and light construction material. Their production is usually less destructive than timber harvesting, and offers good opportunities for improving livelihoods as NTFPs are generally easily accessible to the rural poor and little capital investment is needed for collection, processing and marketing[4,5]. Several studies have demonstrated the success of NTFPs in providing this so-called 'win-win' solution to development and conservation[6]. Despite difficulties in assessing the total economic value of this sector, the Forestry Department of Uganda estimates that NTFP commercialization contributes UShs66 billion (approximately US$33 million) per year to national income, worth 17 per cent of the forest sector's contribution to gross domestic product (GDP)[7]. It is therefore suggested that policies geared towards increasing the economic return of NTFPs will lead to an internalization of forest resource values and an increased incentive for conservation through local resource management.

However, this assumption is controversial. Not all NTFPs remain 'environmentally benign' when extracted on a large scale, and not all resources remain accessible to poor, landless producers once their value becomes apparent to more powerful stakeholders[3]. The conservation value of NTFP promotion may be just as scale-dependent as any other form of forest exploitation such as timber harvesting or palm oil production. It may simply be that the relatively low demand for, and low investment in, NTFPs explains their reputation as environmentally sound, people-friendly products[3].

If NTFPs sometimes fail to make a positive contribution to sustainable development then there is a need to analyse the ecological, socio-economic and cultural factors that determine the success of NTFP commercialization[5]. NTFPs can undoubtedly provide many potential benefits to people and the environment, if managed carefully. Programmes such as SAFIRE (Southern Alliance for Indigenous Resources) and CAMPFIRE (Communal Areas Management Programme for Indigenous Resources Project) operating in southern Africa have shown that conservation through use can be a realistic and successful option[8].

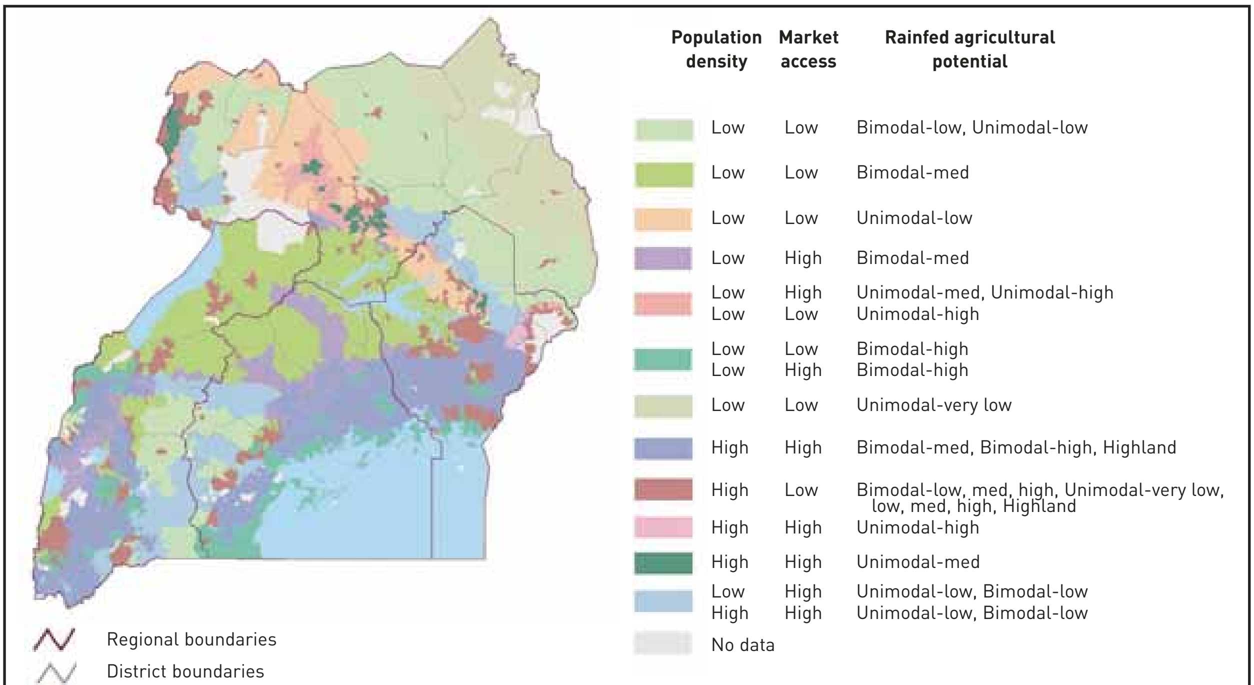
The purpose of this report is to demonstrate how development zones for non-timber forest products may be delineated through spatial analysis, with an explicit focus on environmentally sustainable income-generating opportunities for the poorest sections of Ugandan society. These people, by definition, lack access to financial capital, land and labour, and have limited geographical mobility.

We therefore suggest that the specific NTFPs under consideration should fulfil the following requirements:

1. Be readily accessible to poor rural communities. The resources should be available in forests with communal access rights (therefore usually natural or semi-natural as opposed to plantation forests), and collection points as well as market points should be within manageable distance. While beyond the scope of this project, issues surrounding land tenure and its effect on resource exploitation should be taken into consideration.
2. Harvesting should cause minimal environmental disruption.
3. Production should remain non-exclusive once commercial value has been demonstrated, and populations local to the resource base should retain the benefits of commercialization.

A discussion of the possible policy options to ensure implementation of requirement 3 is beyond the scope of this project (for further information, see studies such as Marshall *et al.* 2006[5]). However, requirements 1 and 2 lend themselves well to spatial analysis. The methods by which this can be achieved constitute the main focus of this report.

Figure 2. Rural development domains in Uganda based on spatial variations in market access, agroclimate and population density



Source: Bolwig *et al.* (2002)[2].

Spatial tools for sustainable development: the 'development domain' concept

Poverty is one of the main concerns of Ugandan policy initiatives today. Development and maintenance of human welfare and capital is a fundamental component of the country's long-term development strategy. The Ugandan Poverty Eradication Action Plan 2000 (PEAP) has set out four main pillars of action[9]:

- **Pillar 1: Economic growth and transformation**
- **Pillar 2: Governance and security**
- **Pillar 3: Ability of the poor to raise incomes**
- **Pillar 4: Quality of life.**

Whilst all four goals are linked, it is towards pillar 3 that research into NTFP development might most directly contribute. More than 80 per cent of Ugandans are employed in agricultural activities and earn less than 50 per cent of the gross national income[9]. There is growing recognition both nationally and within the international donor community of the linkages between economic development and the spatial pattern and quality of the natural resource base.

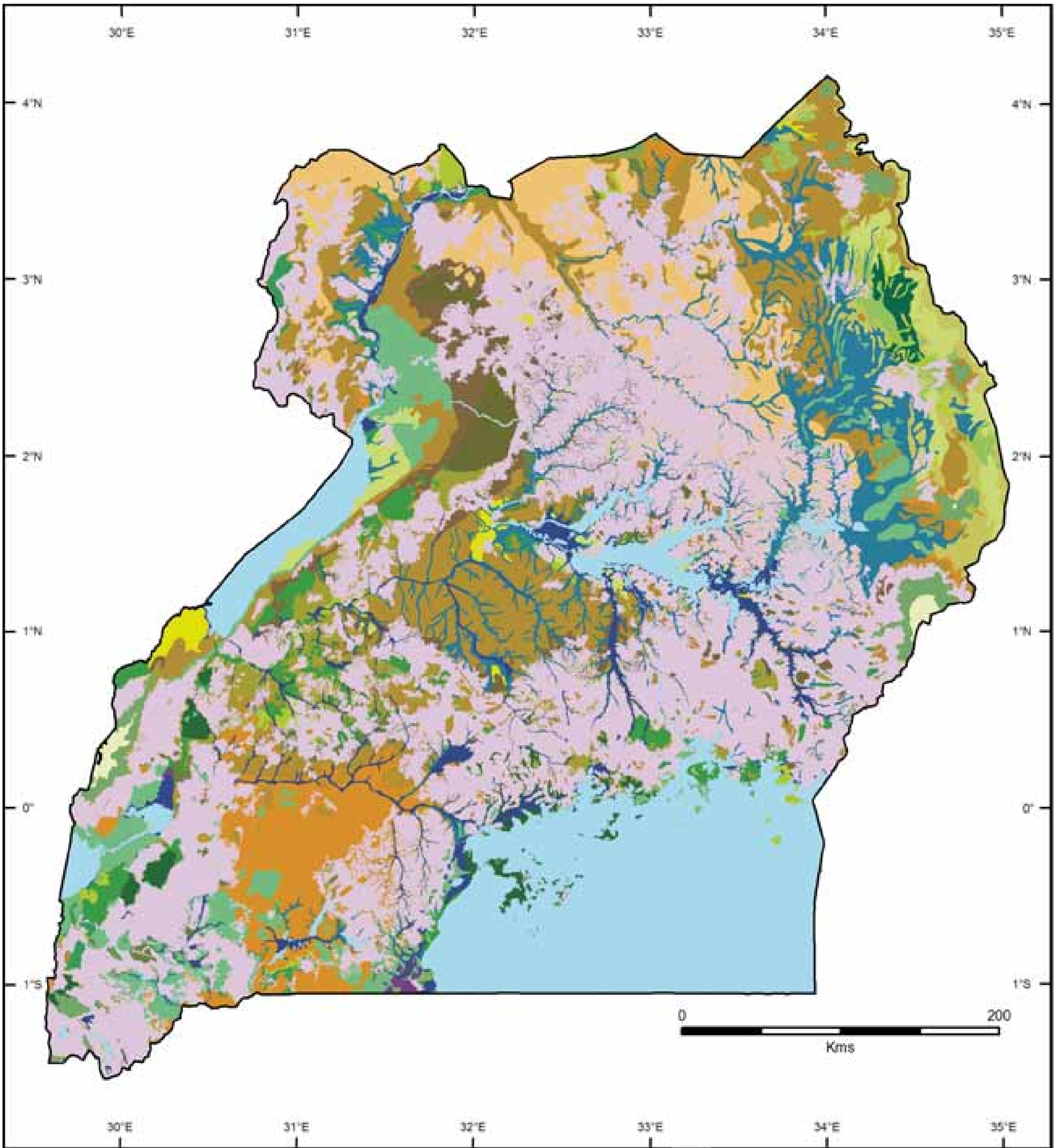
Sustainable land use is essential to economic growth and poverty eradication in rural Uganda, where the vast majority of people depend on natural resources for their livelihoods. In light of this, USAID/Uganda asked the International Food Policy Research Institute (IFPRI) to prepare a planning framework for rural land-use development, entitled Strategic Criteria for Rural Investment in Productivity (SCRIP). It adopts land use as the unifying factor to integrate agricultural growth and rural livelihood needs with responsible environmental management, including biodiversity conservation[2]. Land-use analysis produces location-specific outcomes from environmental variables (soils, landscape, climate, natural plants and animals), their distribution over space and their interaction with socio-economic factors (population density, income distribution and infrastructure).

IFPRI's approach developed previous work by the Center for Development Research (ZEF, Germany) which has been instrumental in implementing the concept of development pathways. Development pathways are defined as common patterns of change in farmers' livelihood strategies, associated with their causal and conditioning factors[10].

Many natural and socio-economic factors may determine development pathways and these depend heavily on the specific location of a particular study. This view is replacing the 'blanket' approach of implementing development policies at a national level irrespective of regional and local heterogeneity. Previous research on agricultural development has indicated that certain natural resource and socio-economic factors are of particular importance. In Africa, the most significant include population density, access to markets and agricultural potential[11]. IFPRI integrated these factors by spatial analysis using GIS to map 'development domains' for the whole area of Uganda (Figure 2).

A development domain is a stratified model of spatial parameters used to identify which development pathway has the highest chance of success in a specific area. Development domains can be used to delineate areas within which a given pathway or, in the case of this project, the development of a given NTFP, may most successfully result in poverty reduction. The range of NTFP definitions in the literature[3], the high number of potential NTFPs found in Uganda and their wide-ranging resource base mean that a generic NTFP development domain would cover almost all of Uganda, making it of little use as a policy-targeting tool. Our approach therefore adopts a product-specific modelling process, rather than computing a set of generic parameter combinations to fit multiple products.

Figure 3: Vegetation types and areas under cultivation



High altitude moorland and heath	Moist *Acacia* savannah	Grass steppe
High altitude forest	Moist *Combretum* savannah	Bushland
Medium altitude moist evergreen forest	*Butyrospermum* savannah	Moist thickets
Medium altitude moist semi-deciduous forest	Palm savannah	Dry thickets
Woodland	Dry *Combretum* savannah	Post-cultivation communities
Forest/savannah mosaic	Dry *Acacia* savannah	Communities on sites with impeded drainage
Tree and shrub steppe	Grass savannah	Swamp forest
Swamp	Water bodies	Areas under cultivation (NBS)

Source: Vegetation types derived from Langdale-Brown *et al.* (1964)[13]. Areas under cultivation derived from the National Biomass Study (1996)[14]. Data provided by MUIENR.

Development domains for NTFPs in Uganda – Methodology

Development domains are derived from the intersection of spatially distributed parameters within a GIS. In its SCRIP analysis of agricultural development domains for Uganda, IFPRI used parameters identified as critically important to agricultural development in East Africa[2, 11]. These were agricultural potential, access to markets and population density. Together these represent a mix of absolute and comparative advantages in production found in different geographic areas. In the context of NTFPs, agricultural potential is replaced by the potential occurrence of species used in NTFP production. Market access is used as a comparative advantage indicator in a similar approach to that of the SCRIP model. However, data regarding the effect of population density on the comparative advantage of producing specific NTFPs, rather than alternative products, are not yet available. Two additional factors were included here in estimating appropriate areas for NTFP production. These were poverty distribution and areas of importance for biodiversity. The following sections review these various datasets and their integration to derive development domains for NTFPs.

DISTRIBUTION OF THE NTFP RESOURCE BASE

The base layer of an NTFP development domain is the spatial distribution of habitat classes associated with the occurrence of species required for the NTFP's production. This can be understood as the maximum potential distribution of its resource base: locations where the necessary species may be found in the wild, or where ecological factors would favour their cultivation. Products were related to a spatial distribution of their resource base by integrating the results of two contributory studies to the development of IFPRI's SCRIP framework.

As part of SCRIP, an analysis was undertaken of a representative selection of commercially valuable NTFPs along with their associated species, and the environmental impact of harvesting was estimated[8]. Fifty-five species were selected that displayed high potential for commercial NTFP development as well as minimal environmental impact in exploitation. The term NTFP was defined in a broad sense and includes products derived from trees which may occur in fragmented woodlands as opposed to forests *per se*.

A second report produced as part of SCRIP by the Makerere University Institute of Environment and Natural Resources (MUIENR) aimed to characterize the major remaining natural and semi-natural ecosystems of Uganda[12]. It identified those which are most threatened, and where they are located, and considered how people might receive greater benefits from the remaining natural resources.

MUIENR's analysis is based on the 22-class Langdale-Brown (L-B) vegetation map of Uganda produced in 1964[13]. There is no evidence of any major change in the classification of these ecosystems since the 1960s, besides those identified as land currently under cultivation by the National Biomass Study of 1996 (NBS)[14]. So the L-B classification can be seen as a map of potential vegetation over much of the country[12]. In order to highlight only those natural and semi-natural areas that may be accessible to the landless poor, NBS agricultural areas were subtracted from the L-B cover (Figure 3).

MUIENR researchers related the results of their analysis to the 55 sample species by tabulating the likely occurrence of these within each L-B ecosystem class. A broad overview of which natural resources are to be expected where, and whether they are likely to be sufficiently common or extensive to justify any recommendations for further use, is provided.

On the basis of these data, it was then possible to generate a database relating NTFPs to L-B classes via their shared species. This database was in turn linked to the GIS model described here, effectively providing an interactive mapping facility for the maximum potential resource base of selected NTFPs (Figure 4).

PROTECTED AREAS

If NTFPs are to promote sustainable management and conservation of natural resources, their development should be appropriate to the protection level and conservation value of affected ecosystems. Debate continues about the relative merits of exclusionary conservation practices and the more inclusive and participatory 'conservation through management' approach. We assume here that some areas do require absolute protection, but that in many areas properly managed NTFP harvesting might be appropriate.

In its study, MUIENR ranked protected area (PA) sites according to their conservation importance and vulnerability. This value was derived by combining several parameters such as areal extent, occurrence of IUCN-listed Red Data species, and current level of protection and management by either the Forest Authority or the Uganda Wildlife Authority.

Figure 4: Relational database structure for determining the resource base of selected NTFPs in Uganda

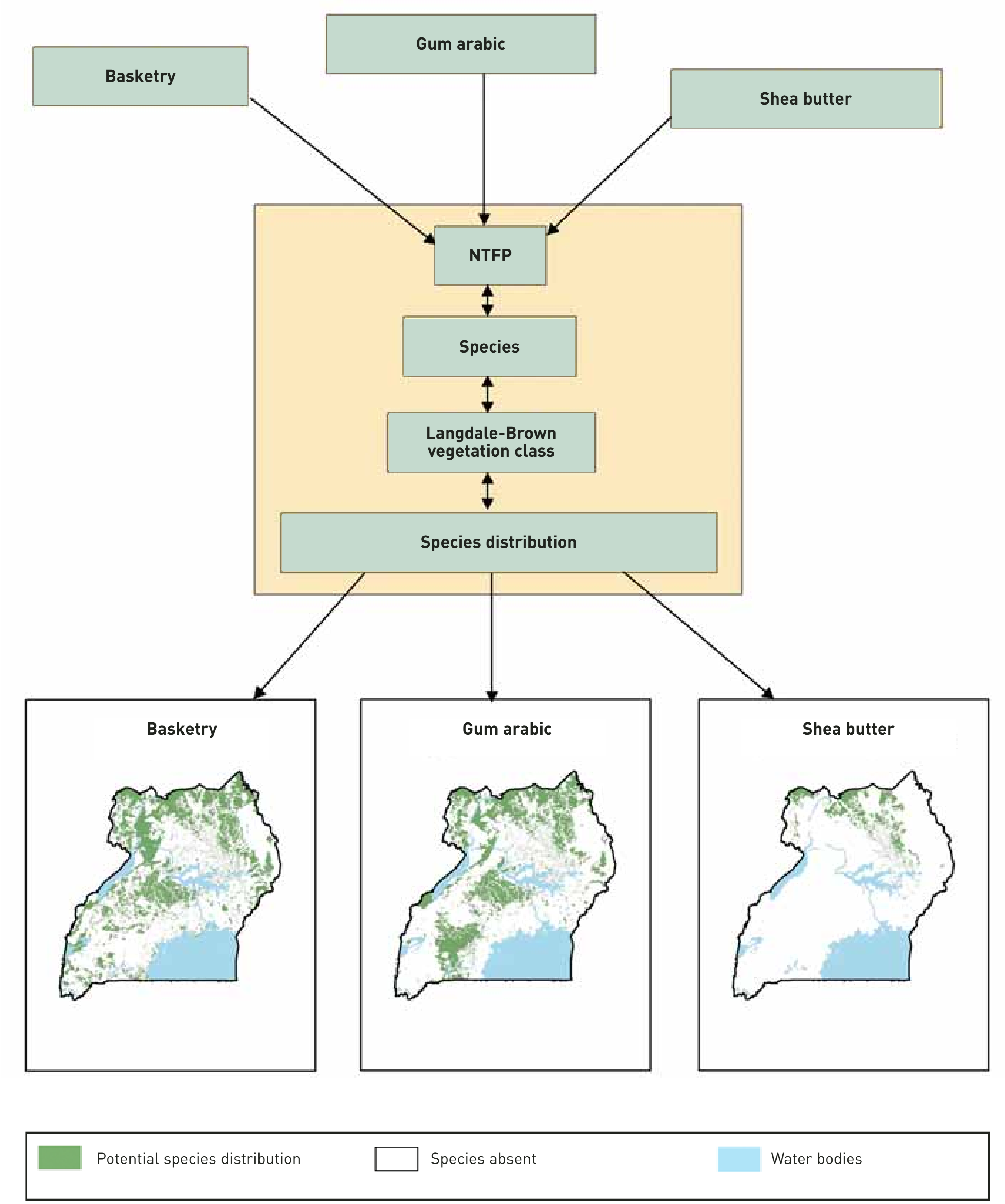
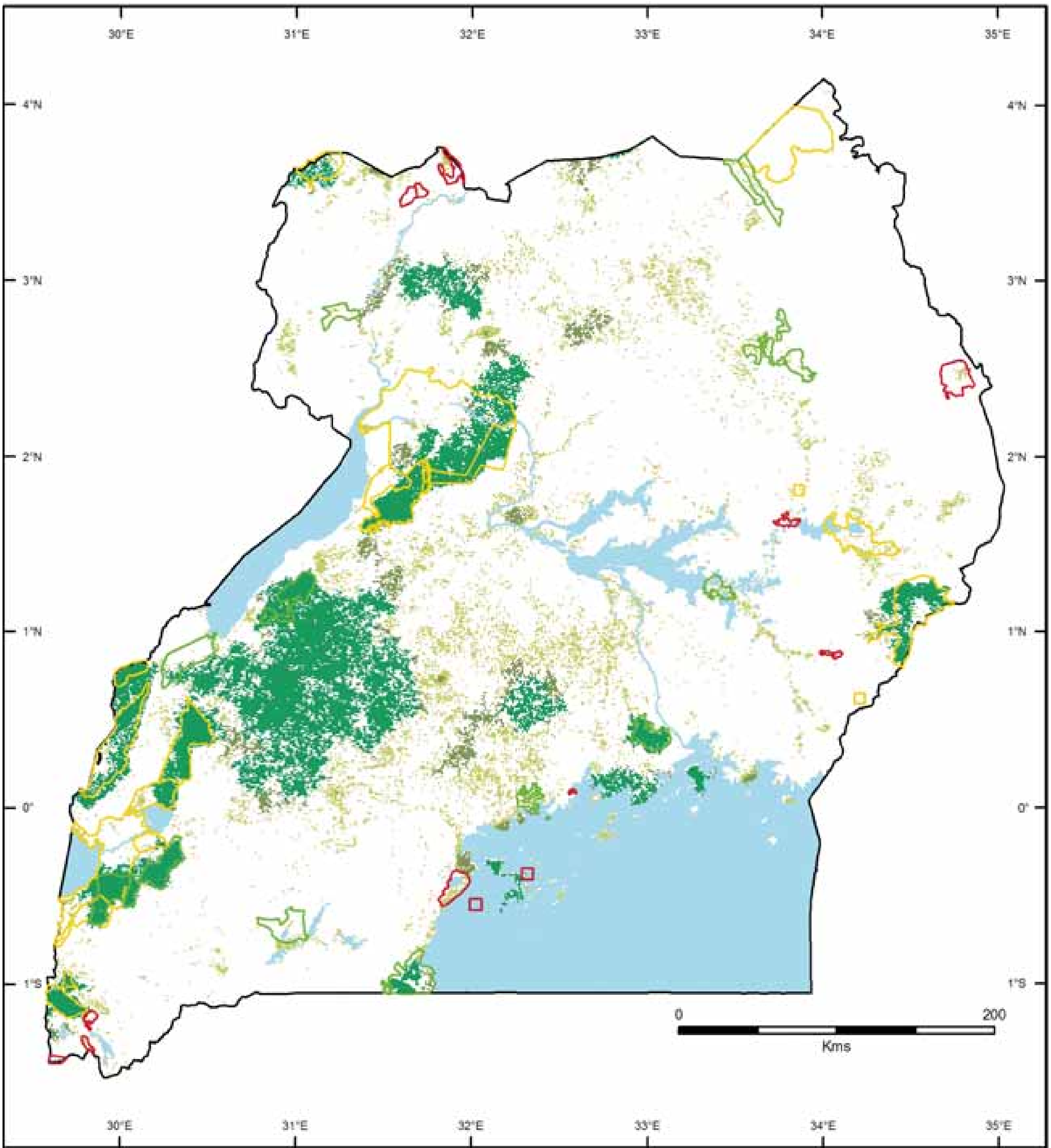


Figure 5: Protected area vulnerability and forest integrity index



Protected area vulnerability

- High
- Medium
- Low

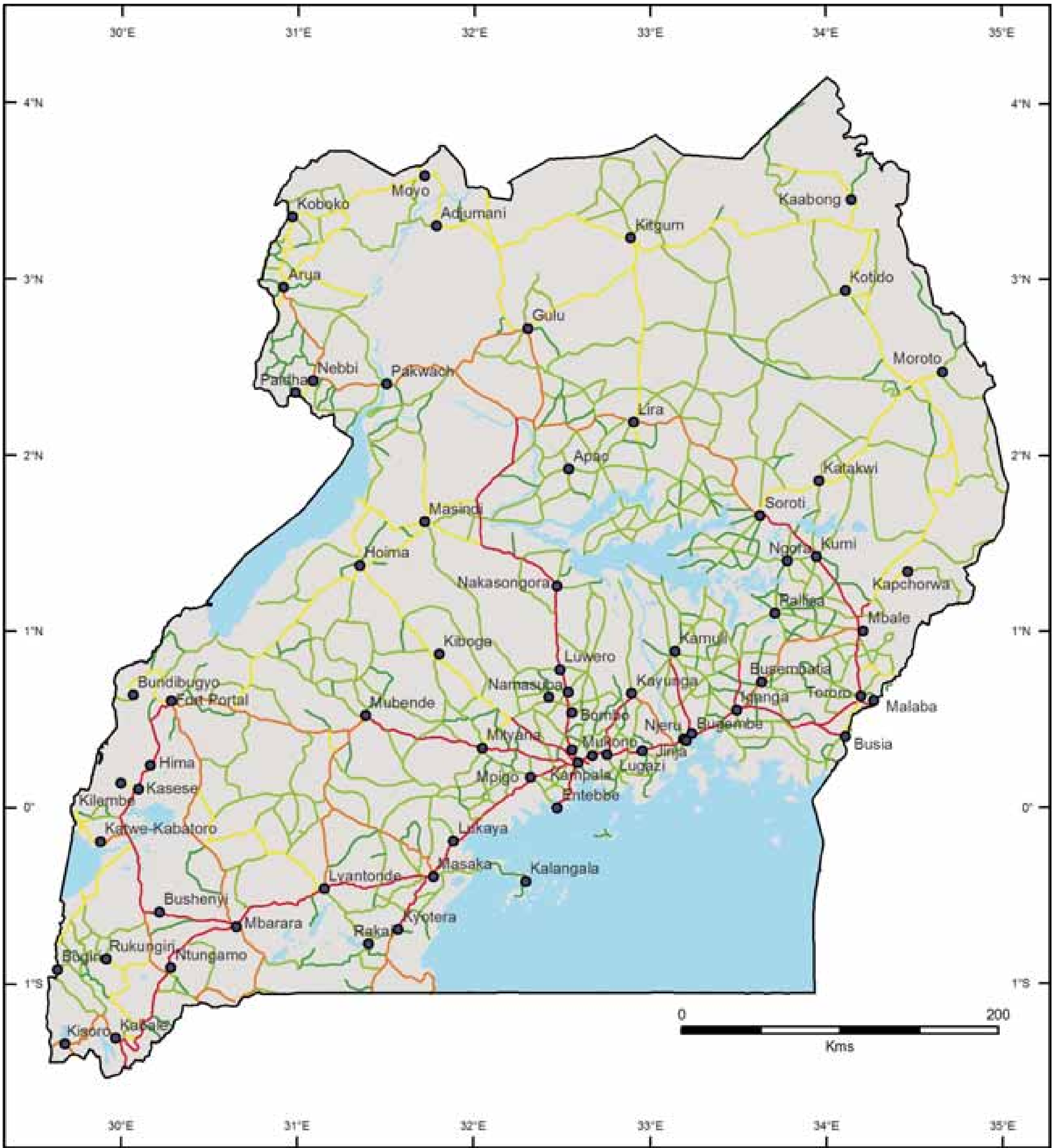
Forest integrity index

- High
- Medium
- Low

- Forest cover <40%
- Water bodies

Source: Protected area vulnerability derived from MUIENR (2002)[12]. Forest integrity derived from Kapos *et al.* (2000)[15].

Figure 6: Market towns and road network



Road class	Estimated road speed (kms/hr)
1	70
2	50
3	40
4	30
5	20

Water bodies

Market towns

Source: Road network classification by Bolwig *et al.* (2002)[2].

Road network and market data (2002), provided by IFPRI.

The highest-ranked PAs are least suitable for extractive use. They are small, already being exploited, or unprotected, despite having high conservation importance[12]. We used this ranking to exclude unsuitable areas from NTFP development domains. PAs with a high (H) ranking were excluded from consideration. It is assumed that in the remaining PAs appropriate multiple-use zones can be implemented. In some instances these may already be in place.

In addition to MUIENR's ranking of protected areas, we used a backdrop layer of forest integrity. These data were derived from MODIS satellite imagery to give an indication of forest fragmentation in areas selected for NTFP production[15] (Figure 5).

MARKET ACCESS

The Uganda Participatory Poverty Assessment[16] states that distance to markets is seen as one of the most important causes of rural poverty after poor health and disease:

"...people living in rural areas, especially those communities distant from a major town, complained of lack of proximal, frequent markets ... Local people cited long distances, impassable roads, and lack of affordable transport, especially in the rainy season, as barriers to accessing markets. Women complained of time wasted walking long distances, while men mentioned the transport problems associated with reaching general markets in the town. While in other sites, local people said distance and lack of road access restricted the frequency of market attendance, led to goods being damaged in motorized transit, and theft of profits on return from markets..."

This concern is echoed in Uganda's Plan for Modernization of Agriculture (PMA)[17], which defines rural infrastructure and market access as two of its seven priority action areas.

As an input to NTFP development domain identification, a map was generated to estimate travel times from any point in Uganda to its nearest marketplace. The surface was generated using road and urban settlement data (Figure 6). Roads were differentiated into five classes and an approximate average travel speed allocated to each class as shown in the legend to Figure 6.

For the computation, points not associated with roads were assumed to be accessible only on foot and the associated speed of travel was set at an average of 1 kilometre per hour to account for difficult terrain and product load. These figures are based on best available estimates and travel experience in Uganda, but should be subjected to more rigorous survey in future work. Additionally, the Poverty Eradication Action Plan (PEAP) recommends the promotion of affordable, alternative means of transport such as ox carts and bicycles for the rural poor. This suggests substantial variation in speeds on a particular class of road as the means of transport may vary widely from one NTFP trader to the next. The text on page 19 reviews a way of coping with this sort of uncertainty.

Additionally, no distinction is made here between products that are processed on site and products sent to processing facilities. We are making the broad assumption that from the point of view of the NTFP resource collector there is no difference between constraints faced when selling to the end-user (market) and those faced when selling to secondary processors. What is more, a number of NTFPs, such as honey and charcoal, are sold at the nearest roadside as opposed to town markets[18]. For these products, a more accurate description of travel times would therefore be based on distance to busy roads. These finer points require data on the processing and marketing methods of specific NTFPs, information that could be acquired in future surveys.

The resulting travel-time surface is illustrated in Figure 7. Although the results should be seen as estimates at this stage, preliminary checks against actual travel time between various towns show that they are within the correct order of magnitude. They suggest that the average travel time from any point in the country to the nearest market town is around six and a half hours.

This surface can be integrated into the development domain identification procedure to exclude areas too far from possible markets for NTFP production to be economically worthwhile or feasible. The exclusion mask can be varied according to travel-time threshold values appropriate for the product in question. A thorough survey of appropriate threshold values was beyond the scope of this project, and so they were arbitrarily allocated according to the estimated market potential of the products under study. Products sold in local markets were given a five-hour travel time threshold whereas products sold on international markets (via Kampala) were given a higher threshold of ten hours.

POVERTY

Most Ugandans are self-employed, mainly in agriculture, where over 80 per cent of the population earns less than half the national income. If NTFP development is to benefit the poorest sections of society then attention should be focused in those areas with the highest rates of poverty. At the time of the present analysis, several poverty mapping projects were underway at global and national scales. Further details can be found on http://povertymap.net. Here we use IFPRI's district-level data, where poverty incidence is defined as the share of households that fall under a given expenditure-based poverty line[19]. The data are illustrated in Figure 8 and show wide variations in poverty levels throughout the country, with the highest incidences occurring mainly in the north and east.

Figure 7: Travel time to markets within Uganda

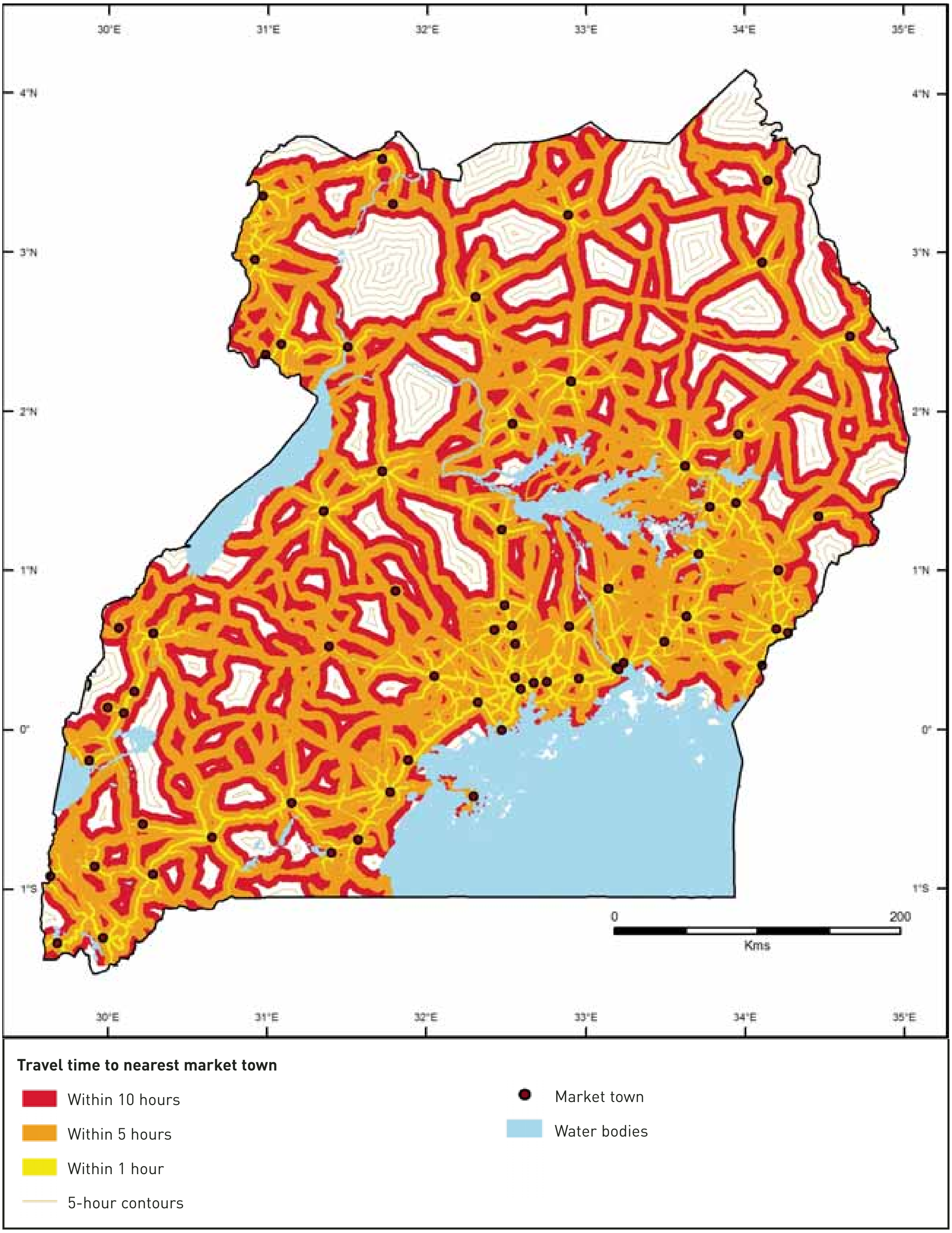
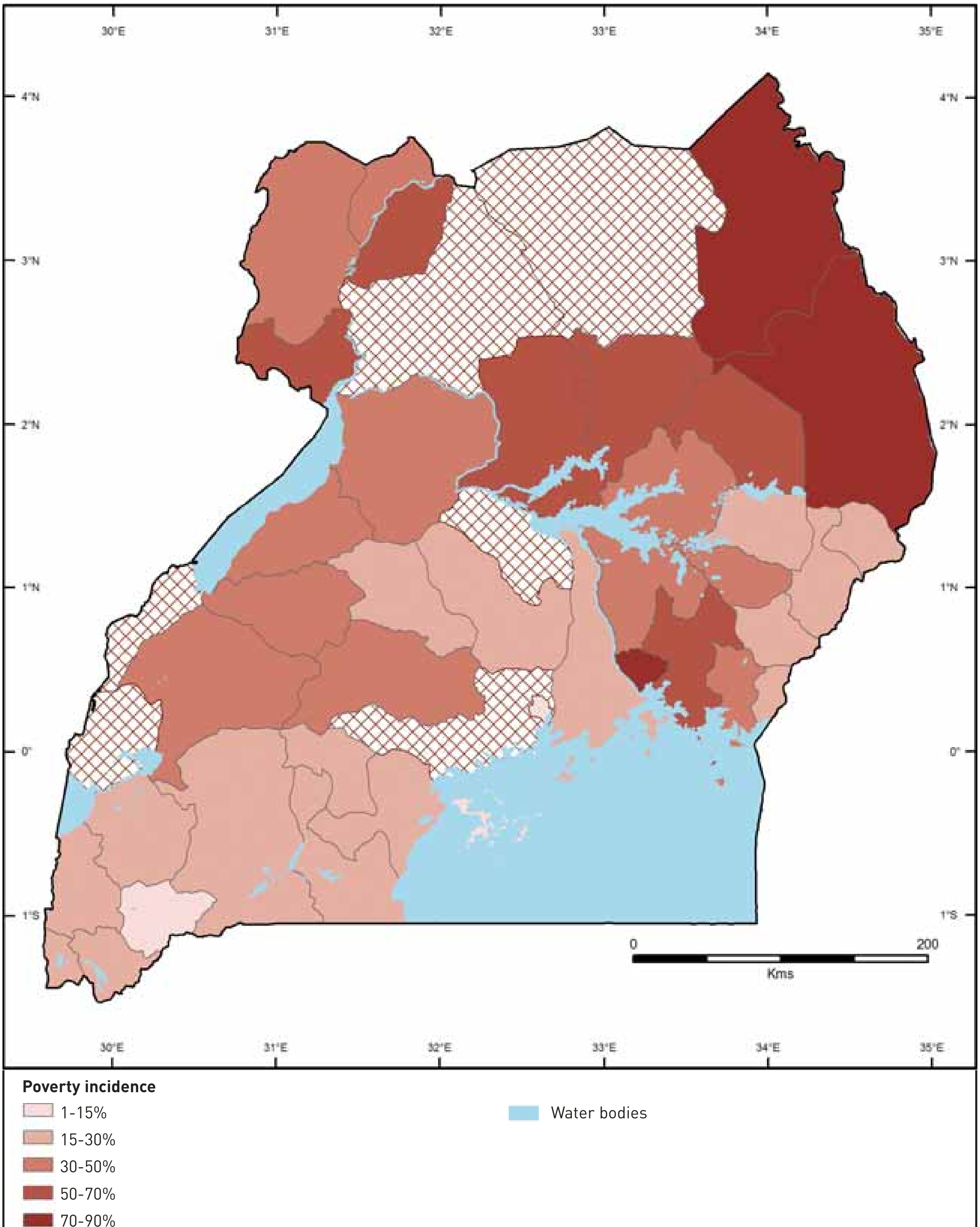
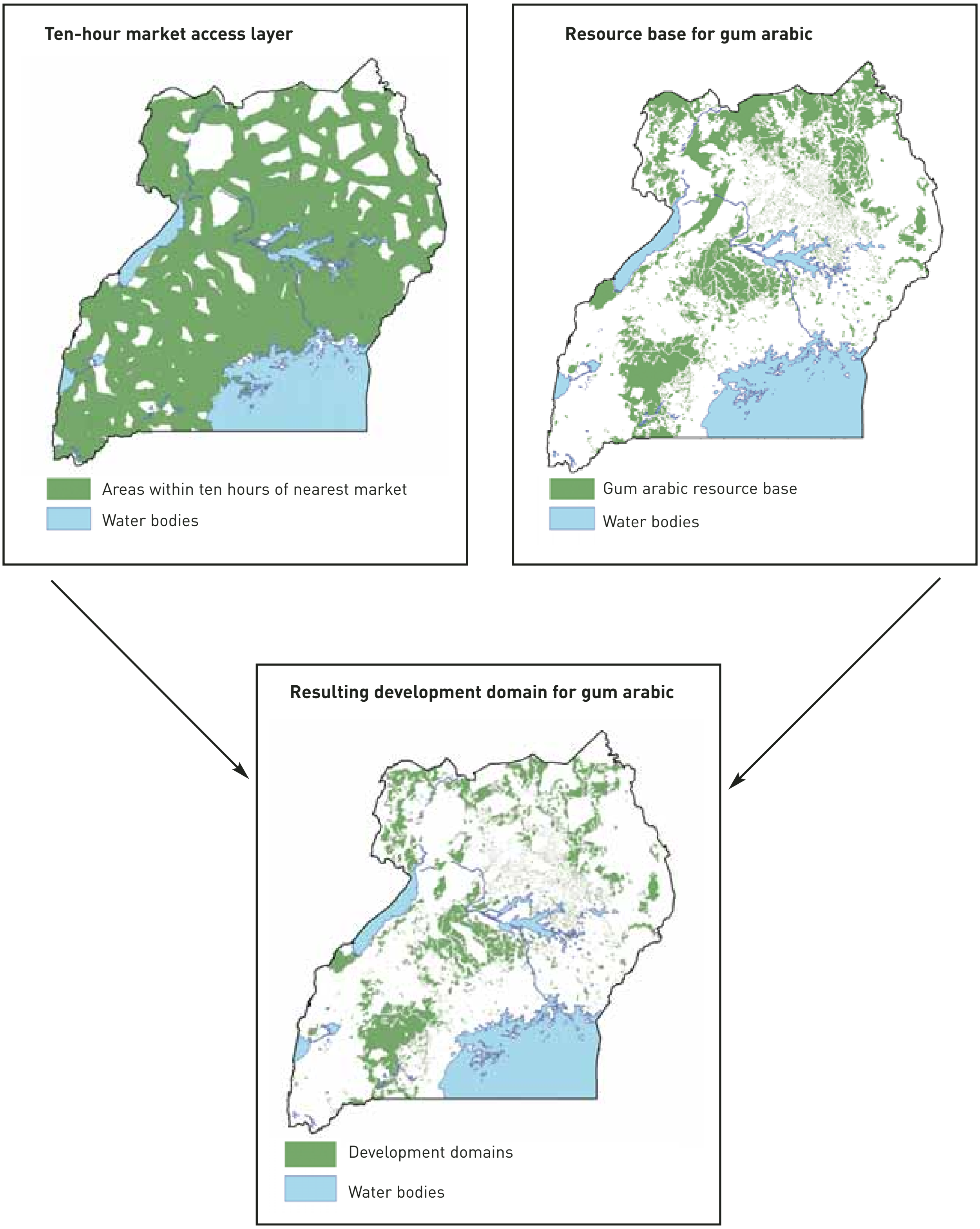


Figure 8: Poverty incidence



Source: Bolwig *et al.* (2002)[2].

Figure 9: Intersection of ten-hour access layer with resource base layer to compute development domains for gum arabic



Development domains – Results and discussion

Three NTFPs were selected for this demonstration: basketry products, gum arabic and shea butter. Figure 9 illustrates the intersection procedure used to define their development domains. The following sections review the results for each product along with summary information regarding related species, distribution, market potential and environmental impact. This information is derived from Baldascini's report to IFPRI (2002)[8].

BASKETRY

Basketry products are one of the main handicrafts produced in Uganda. The main forest or woodland species used include raffia (*Raphia farinifera* (Gaertn.) Hylander), sisal (*Agave sisalana* Perr.) and bamboo (*Arundinaria alpina* K. Schum.). Products include baskets (UShs2 500-6 000), mats (UShs10 000-20 000), table mat sets (UShs4 000-20 000), hats (UShs4 000-7 000), chairs (UShs35 000), tables (UShs40 000) and lampshades (UShs5 000-10 000) (there are approximately UShs2 000 to one US dollar). The products are sold locally as well as more widely to tourists. A five-hour travel time threshold value was allocated for development domain computation (Figure 10).

GUM ARABIC

The main source of gum arabic is three-thorned acacia (*Acacia senegal* (L.) Willd.) although gum arabic can also be extracted from white-galled acacia (*Acacia seyal* Del.), woman's tongue tree (*Albizia lebbeck* (L.) Benth.) and saman tree (*Albizia saman* F. Muell.). It is obtained by tapping or exudation, a process with minimal environmental impact if properly managed. Gum arabic is used in confectionery, soft and alcoholic drinks, pharmaceuticals, and in the printing, ceramics and textile industries. It is also used locally as an adhesive or as an ingredient of traditional medicines. It has an established international market, fetching up to US$5 000 per tonne. A travel-time threshold of ten hours was used for development domain computation.

In addition, *Acacia* is an excellent plant for afforestation of arid tracts and soil reclamation, and so planting gum arabic trees could serve the dual purposes of environmental restoration and income generation. By superimposing development domains for gum arabic on a surface of forest integrity, it is possible to identify areas that might benefit from afforestation while offering income opportunities for the local population (Figure 11).

SHEA BUTTER

Shea butter is derived from the nuts of the shea tree (*Vitellaria paradoxa* C.F. Gaertn.), found in the savannah of eastern and northern Uganda.

It is used in Europe, Japan and Russia primarily in cosmetics as a basis for soaps, creams, moisturizers, hair conditioners and shampoos, and also as an ingredient in chocolate products. Due to its extensive international market a ten-hour travel-time threshold was used to identify its development domains (Figure 12).

DEALING WITH UNCERTAINTY

Research into NTFP development and commercialization is still in its early stages. However, it is already apparent that strict rules as to NTFP land suitability are difficult to define because of the large number of potential NTFPs, the many methods of processing and commercialization, and the number of stakeholders involved in, and affected by, forestry decisions. What attributes should be taken into consideration? Whose interests should be represented, and by what parameter values? As different segments of society (small-scale producers, owners of large farms, national authorities, non-governmental organizations) often differ on what is acceptable, it seems desirable to identify and account for several sets of acceptable conditions, representing the views of these different groups. We suggest that explicitly accounting for this uncertainty offers a realistic, if not a deterministic, approach to spatial analysis. Geographic error and uncertainty should be seen as an integral part of human knowledge and understanding concerning reality. Ideally, information should include well-informed assessments of uncertainty[20] rather than being presented at face value. A potential method of achieving this goal, based on concepts such as fuzzy logic and Bayesian inference, is briefly introduced here. It is suggested that further work be carried out to evaluate empirically the usefulness of such an approach in identifying NTFP development domains.

Fuzzy logic can be applied to the development of environmental indices to resolve many of the problems addressed above, such as incompatible observations and implicit value judgements[21]. It can bridge the gap between

Figure 10: Development domains for basketry products within five hours of closest market

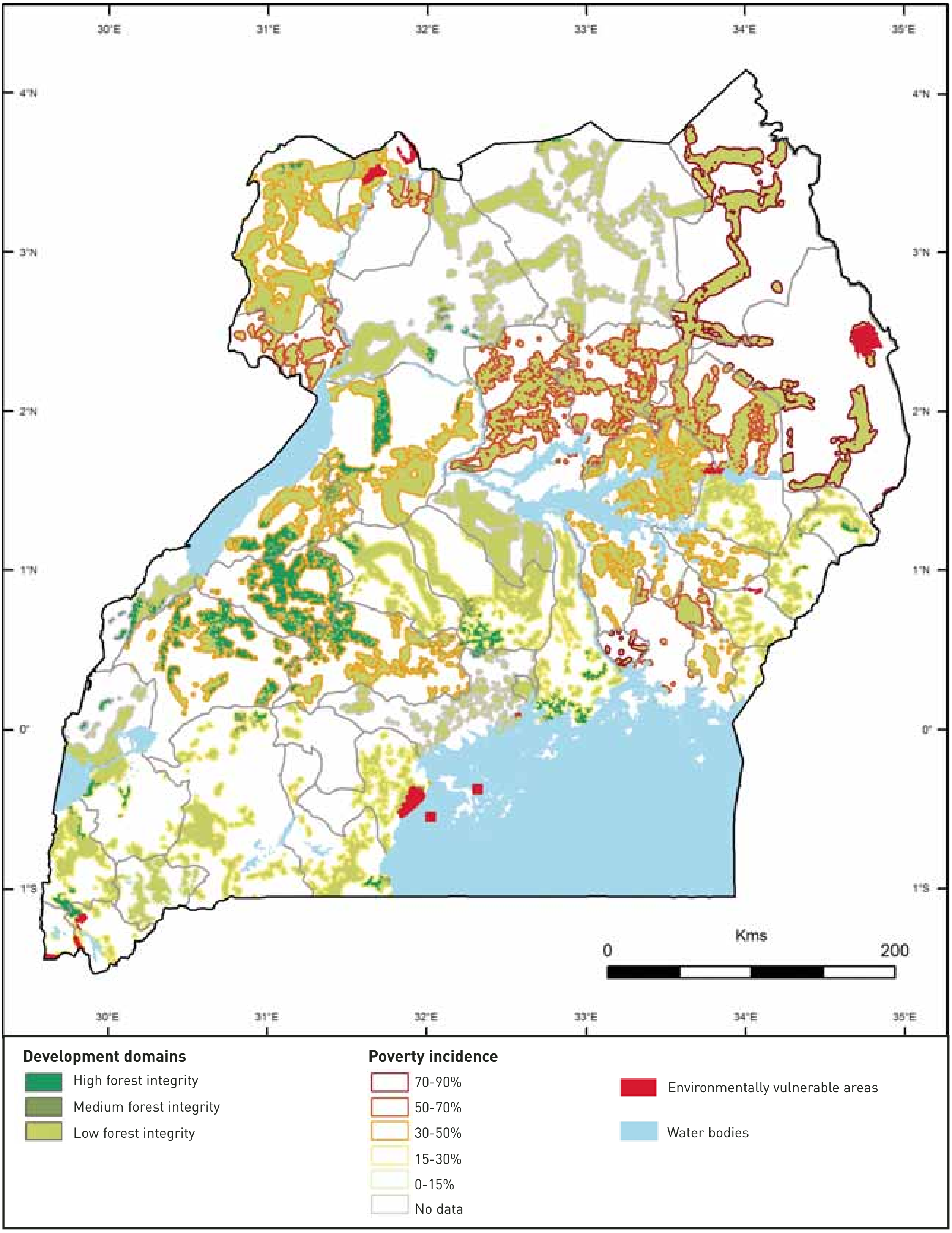


Figure 11: Development domains for gum arabic within ten hours of closest market

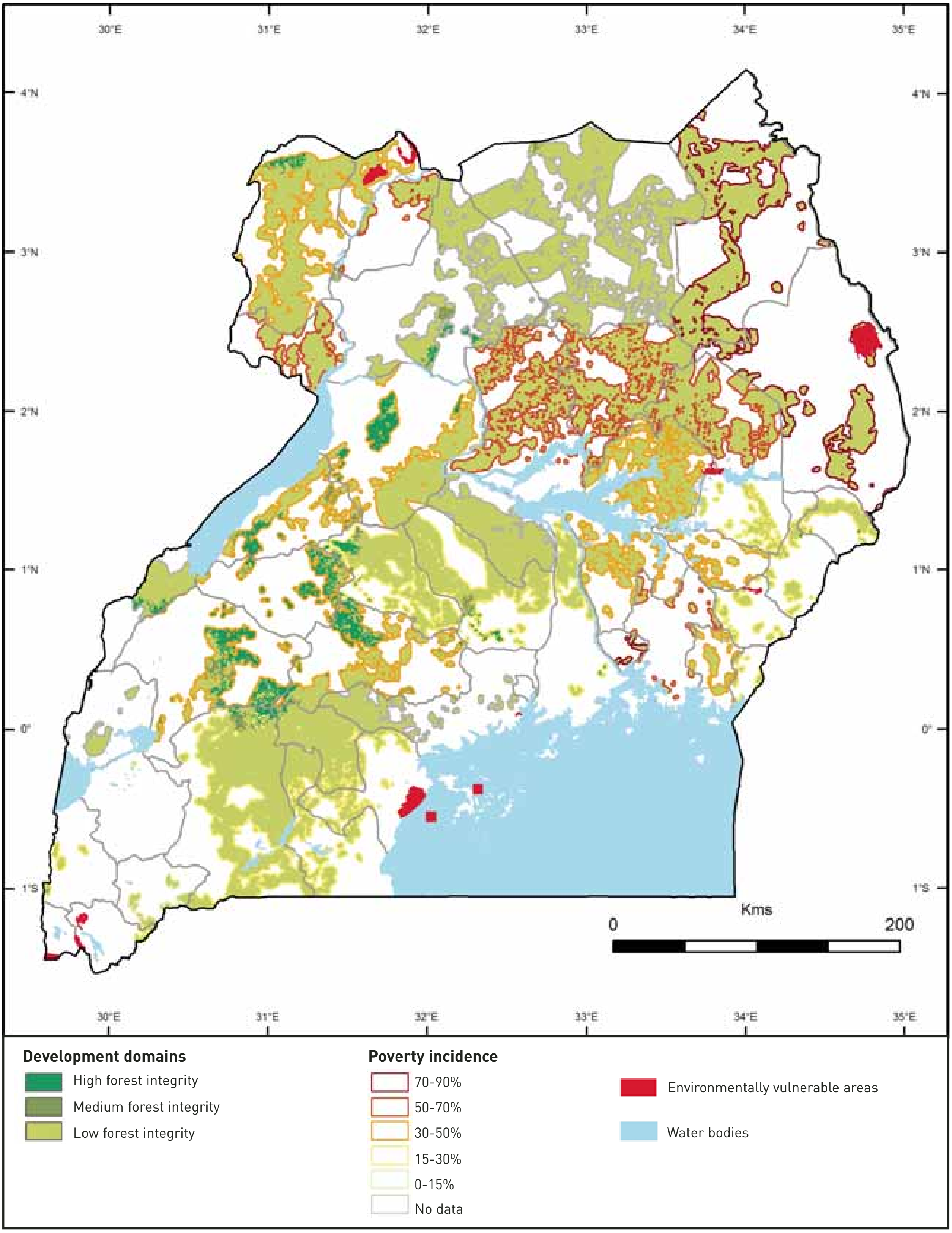
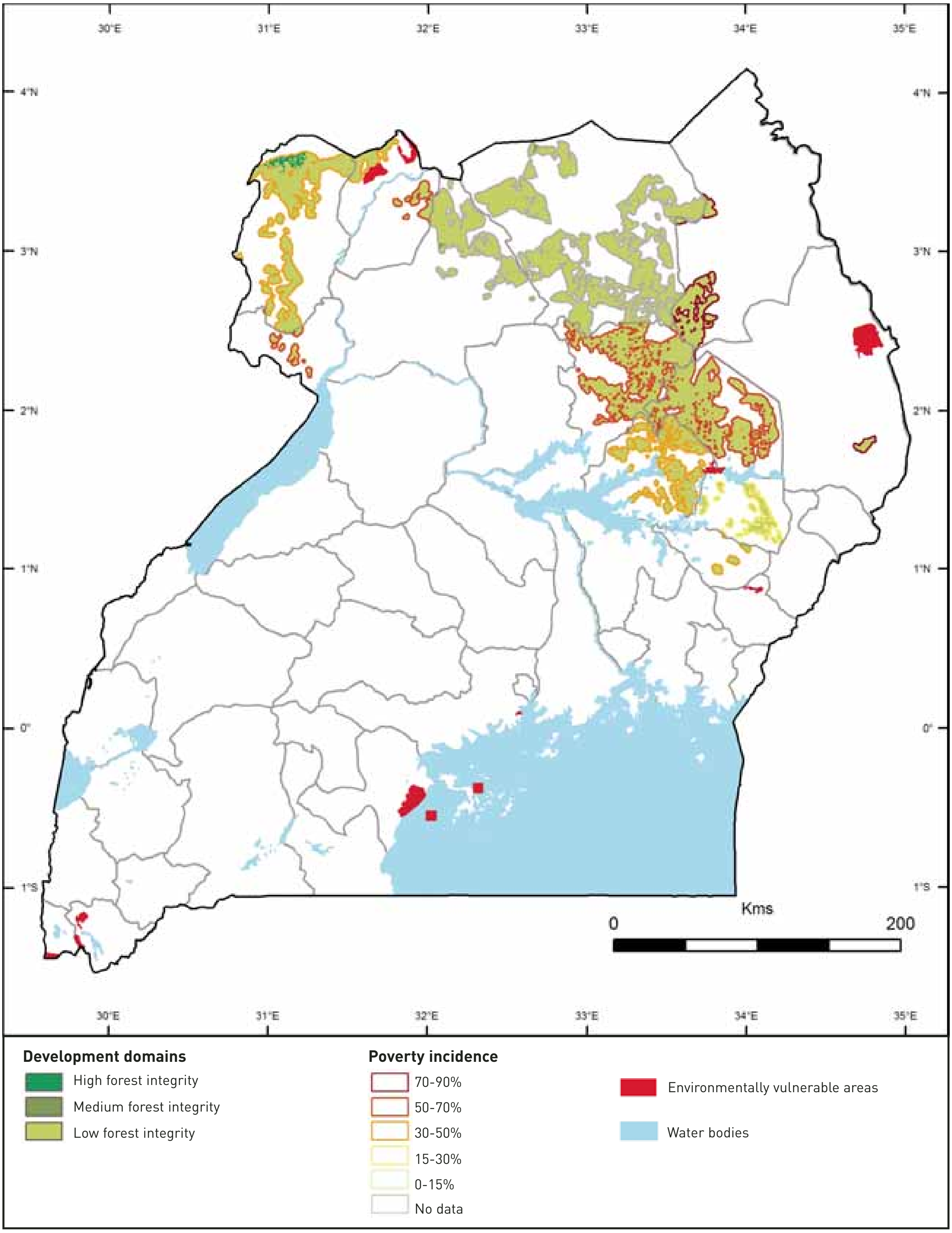


Figure 12: Development domains for shea butter within ten hours of closest market



scientific measurement and the fulfilment of social objectives and provide a way to translate a wide variety of information – objective data, qualitative information, subjective opinions and social needs – into a common language for characterizing environmental effects. In addition, the process of acquiring the necessary information to set up such a system is participatory by nature and contributes to a much more transparent decision-making process.

Fuzzy logic is based on the premise that a statement, instead of necessarily being either true or false, may have a degree of truth. Computationally, this translates into setting the level of truth of a value at a number between 0 and 1. Traditional 'crisp' logic only allows for values to be either 0 (false) or 1 (true). In the case of NTFP development domain parameters, for example, stating that a certain species occurs within a given L-B vegetation type requires some sort of subjective judgement as to the statement's truth. Typically, if there are insufficient empirical data to compute probabilities, this will be resolved by expert opinion with a '0 or 1' type answer and any uncertainty involved in attaining this solution is lost in subsequent stages of analysis. Similarly, the threshold distance for feasible market access may be assessed completely differently by an economist using a financial cost-benefit analysis and by a producer balancing other priorities such as alternative income-generating activities and family obligations. Both opinions have merit and deserve to be reflected appropriately in the final analysis. One way of achieving this is to use the distribution of stakeholder opinion. Databases can readily be developed that provide non-experts with an interface allowing them to input their opinions.

When this approach is applied to the various layers of a development domain GIS model, each representing one parameter, the result can be visualized as a density gradient representing the level of truth or belief in the suitability of a location to the development of a given NTFP. There exist a number of fuzzy and Bayesian algorithms for combining these parameters[22], the simplest of which is a straightforward multiplicative method as illustrated in Figure 13. Such a tool would help land management authorities to appreciate and take account of the variety of opinions and standpoints that resulted in the planning map.

An alternative method of exploring uncertain data is provided by Bayesian belief networks (BBNs). A BBN is a network of linked nodes, each of which is associated with a probability function. The nodes represent either variables with a defined number of states, or variables with a continuous distribution. The relationships between the nodes are represented by the links.

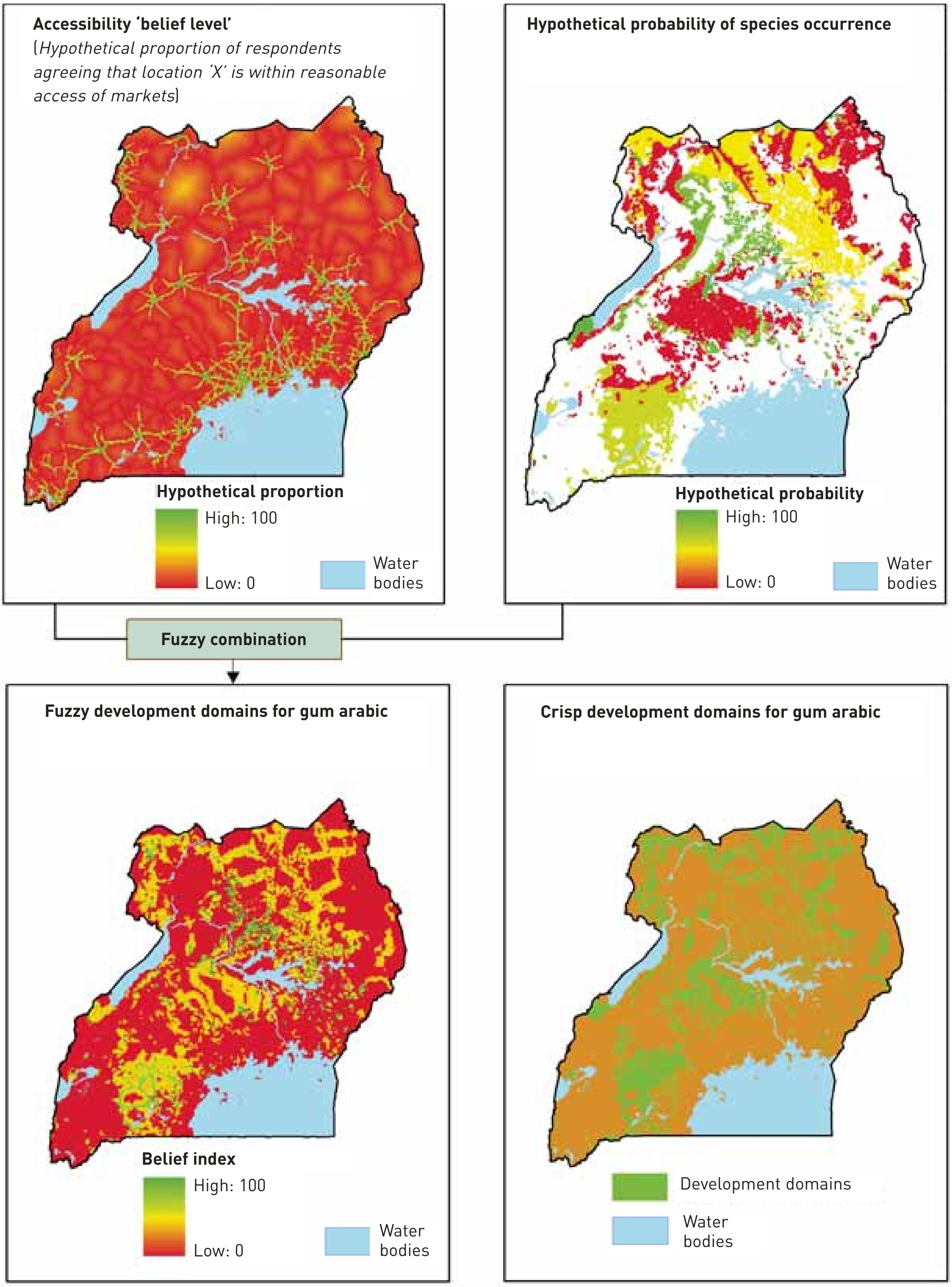
BBNs offer a means of analysing probabilistic data, through the use of Bayes' theorem. In particular, they provide a tool for inferring the probability of the state of a given variable, given evidence about other variables. In this way, they provide a valuable tool for exploring uncertain data. With respect to development domains, many of the issues discussed above in relation to fuzzy logic could similarly be addressed using BBNs. Different forms of information, such as quantitative data, qualitative information and subjective opinions, can readily be integrated and analysed using BBNs, by expressing them as probabilities associated with different states of categorical variables. One of the main applications of BBNs to date has been in the development of 'expert systems', or decision-support tools incorporating expert knowledge, much of which may be subjective in nature.

With respect to NTFP development domain parameters, the occurrence of a certain species within a given L-B vegetation type could be accorded a probability, with an associated degree of error or uncertainty, based on available quantitative or qualitative data, or even expert opinion. Similarly, contrasting assessments of the threshold distance for feasible market access from different stakeholders could be explicitly analysed, for example by representing the probability distribution of stakeholder opinion. As with fuzzy logic approaches, interfaces can readily be developed that provide non-experts with user-friendly access to the tool.

BBNs have been applied to assess the factors influencing success of NTFP commercialization, and the impact of such commercialization on rural livelihoods, in a research project funded by the DFID Forestry Research Programme. The project has developed a decision-support tool to enable those NTFPs with high potential for successful commercialization to be identified. Further details of the project, entitled CEPFOR, are available from the following website: http://www.unep-wcmc.org/forest/NTFP/.

One of the key advantages of an approach that focuses on addressing trade-offs is that it seeks long-term solutions that explicitly reflect (rather than minimize or ignore) the diversity of views among the various community, agency and technical participants[23]. The relatively recent concept of NTFP development domains and the wide variety of stakeholders potentially affected by NTFP issues provide a welcome opportunity to develop decision-support tools that are truly grounded in stakeholder values and maintain transparency in the analysis process. It is hoped that this pilot project might serve to demonstrate this need and generate new research initiatives in this direction.

Figure 13: Comparison of 'fuzzy' and 'crisp' development domains



Conclusions

Geographic information systems (GIS) provide a tool by which seemingly disparate data can be integrated to show their spatial relationship and reveal new information to support land management decision-making. This report has outlined a theoretical GIS-based method to derive development domains for non-timber forest products. Development domains are intended to guide development efforts by mapping areas of comparative advantage in the commercialization of a given product based on four major parameters: occurrence of necessary species (the resource base), access to markets, poverty and environmental vulnerability. At present, the model reveals the potential resource base within an acceptable distance of the market for selected NTFPs. It eliminates highly vulnerable protected areas and signposts domains that coincide with high poverty incidence. It is argued that the successful commercialization of such NTFPs may help provide income-generation opportunities to the poorest sections of Ugandan society while providing incentives for the long-term management and preservation of environmental resources. Although only three representative products were selected for this demonstration, the method should be applicable to any NTFP under study.

However, only a broad and preliminary methodology is presented here. The accuracy of the development domains is dependent mainly on the accuracy or reliability of the available data. Meanwhile, their precision is a function of how many aspects of the problem we can represent spatially – the more aspects we can integrate into the GIS model, the more focused are the resulting development domains. To refine the picture requires several additional datasets that are not available in this phase of the project but are suggested in the following sub-sections as the focus of future lines of research. Additionally, it is argued that an integrated GIS tool could be developed for use by land managers and decision-makers that readily accounts for differing value judgements by various stakeholder groups. Such a tool would allow for participatory and transparent decision-making by explicitly recognizing the uncertainty and subjectivity inherent in land management choices.

RESOURCE BASE AND ACCESS RIGHTS

The model in this project uses data on the potential resource base of NTFP species rather than recorded distributions. The data were derived from a MUIENR analysis of the potential occurrence of species within L-B vegetation classes. This would be a valid basis on which to construct the development domain model, if one allowed for possible domestication of NTFP species in plantation forests or on agricultural land. However, this highlights the issue of resource access rights – the poorest sections of society are dependent on communally accessed land with very little guarantee of tenure. Long-term investment in tree plantations or forest restoration as a method of NTFP domestication may be seen as too risky in comparison with alternative means of income such as agricultural labour. Hence, as a prerequisite for understanding the potential contribution to poverty alleviation, we need to answer the question: 'What guarantee does current land tenure legislation provide to landless populations who wish to invest in planting on common-access land?'

The assumption that people will be in a position to take advantage of NTFP-related opportunities touches on issues beyond the scope of GIS models, such as gender relations and the role of local elites and hierarchical social structures. However, combining the answer to the above question with spatial data on land tenure would allow the GIS model to highlight those areas within the currently selected development domains that also provide sufficient security of access for investment in NTFP domestication.

A related point concerns how best to safeguard natural resources from unregulated access leading to overexploitation. Excessive harvesting of NTFP primary products may be just as damaging to the environment as other forms of harvesting such as timber. Sustainable yields have yet to be estimated for many NTFPs, but resource management usually requires regulations or other agreements on access. A development domain GIS model might contribute to the planning of these regulations by comparing the environmental impact of NTFP production with ecosystem vulnerability. The question that follows from this, and that requires further research, is: 'What environmental impacts result from the production of specific NTFPs?'

INCOME-GENERATING POTENTIAL AND MARKETS

The available quantitative data on the income-generating potential of specific NTFPs are limited. The theoretical framework for research on this issue is largely in development and is complicated by the wide variety of products and services which could be defined as NTFPs, as well as by the various levels of processing that they require. This makes cost-benefit analyses difficult to apply at this stage.

In this project, we based our market access analysis on a set of hypothetical travel-time thresholds as well as estimated travel time by road category. Actual data would allow us to account for stakeholder opinions and could be readily available through surveys and observation. However, the analysis would also benefit from a more quantitative computation of travel costs versus income potential. This should include factors such as quantity-to-weight and quantity-to-bulk ratios as well as market selling price. Such travel-cost data can be integrated into the GIS model in much the same way as travel time, and could additionally account for the nature of the target market. A product attracting an international market and high prices can be derived from a resource base further afield than products attracting national or local demand. GIS is ideally suited to represent such logical rules and can be used to adapt the development domain of a product to its market potential. This analysis requires information such as NTFP market prices, and the quantity-to-weight and quantity-to-bulk ratios of an NTFP during transport.

To conclude, this report briefly reviewed the merit in accounting for subjectivity and uncertainty in spatial analysis. NTFP market analysis is in its early stages and offers an opportunity to incorporate this novel approach. Interactive tools which allow for the input of various stakeholder opinions on all the questions addressed above and retain an indication of the resulting uncertainty throughout the analytical process can now readily be built. Such tools could use only that information which is relevant to a given stakeholder's decision process or combine various stakeholder opinions; their output can display a development domain for a single NTFP or can show those areas with greatest development potential taking all selected NTFPs into consideration. More importantly, they can bring the functionality of expert systems within the reach and influence of non-experts thereby providing participatory and transparent decision-support tools.

Abbreviations

BBN	Bayesian belief network
CAMPFIRE	Communal Areas Management Programme for Indigenous Resources Project
DFID FRP	Department for International Development Forestry Research Programme (UK)
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
GIS	Geographic information systems
IFPRI	International Food Policy Research Institute
IUCN	IUCN–The World Conservation Union
L-B	Langdale-Brown vegetation classification
MODIS	Moderate resolution imaging spectroradiometer
MUIENR	Makerere University Institute of Environment and Natural Resources
NBS	National Biomass Study
NTFP	Non-timber forest product
PA	Protected area
PEAP	Poverty Eradication Action Plan
SAFIRE	Southern Alliance for Indigenous Resources
SCRIP	Strategic Criteria for Rural Investment in Productivity
UNEP	United Nations Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
USAID	United States Agency for International Development
UShs	Ugandan shillings
US$	United States dollar

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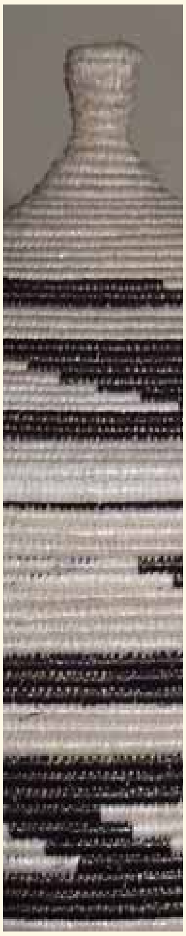

Non-timber **forest** products in **Uganda**

Spatial tools supporting sustainable development

One path to sustainable development for forest-dependent populations is the commercialization of non-timber forest products (NTFPs). Fruit, baskets, honey and medicinal plants are just a few examples of everyday products that can be harvested from a sustainably managed natural resource base.

This report describes a new map-based approach to defining areas best suited for NTFP commercialization. Uganda is used as a case study. As one of the most rapidly growing economies in Africa, its rich natural heritage highlights the conflict between national development efforts and the need for a globally responsible approach to biodiversity conservation. The report addresses the following questions:

- How can NTFP commercialization contribute both to rural poverty eradication and forest conservation in Uganda?
- How do spatial factors affect these two goals?
- Where do specific NTFPs have the highest chances of being successfully developed and commercialized?
- How can this analysis be refined in the future to give a more complete picture?

This project demonstrates that powerful spatial analysis tools now facilitate the integration of social, economic and environmental data, in support of better decision-making. Such 'expert system' tools could be made accessible to any number of stakeholders, providing a truly participatory and inclusive model for the sound management of our common natural heritage.

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