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The renaissance of National Forest Inventories (NFIs) in the context of the international conventions – a discussion paper on context, background and justification of NFIs

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Abstract - National Forest Inventories (NFI) cover whole countries and strive to put the resource forest and the ecosystem forest into a quantitative framework. While for forest management inventories it is very obvious that they shall support management decisions and contribute to making forest planning, silvicultural interventions, conservation management and timber sales more efficient, the purpose of NFIs is not immediately visible nor "measurable": they are to support national (and sub-national) level policy processes that relate to forests. NFIs have a long history and do experience currently a boom because the availability of a science-based quantification of the forest resource and its changes is among the prerequisites for results-based payments to developing countries when they implement measures that are efficient - and evidenced by verifiable results – in reducing greenhouse gas emissions from forests. While forest monitoring science does currently focus very much on increasing precision and accuracy of forest monitoring, on integration of ever more efficient remote sensing techniques and modelling methods, surprisingly little research is being published on background, strategic justification, institutionalization and impact of NFIs.

O renascimento dos Inventários Florestais Nacionais (IFNs) no âmbito das convenções internacionais – uma discussão envolvendo contexto, antecedentes e justificativas

Resumo - Os Inventários Florestais Nacionais (IFN) cobrem o país todo e são desenhados para análise dos recursos e ecossistemas florestais sob uma ótica quantitativa. Enquanto que para os inventários florestais direcionados ao manejo florestal é óbvio que os mesmos devem dar suporte a decisões relacionadas ao manejo, ao planejamento florestal, às intervenções silviculturais, ao manejo visando à conservação e à venda de madeira mais eficientes, o propósito dos IFNs não é imediatamente visível ou mensurável: eles são desenhados para dar suporte a processos de decisão em nível nacional (e subnacional), envolvendo as florestas. Os IFNs tem uma longa trajetória e estão passando por um processo de aumento de interesse em função da possibilidade de quantificação dos recursos florestais com base científica; tais mudanças estão entre os pré-requisitos para pagamentos a países em desenvolvimento baseados em resultados, quando da implementação de medidas eficientes – e evidenciadas por resultados verificáveis – na redução da emissão dos gases de efeito estufa pelas florestas. Enquanto a ciência do monitoramento florestal atualmente enfoca com destaque o aumento de precisão e a acuracidade do monitoramento florestal, integrando técnicas de sensoriamento remoto e métodos de modelagem cada vez mais eficientes, surpreendentemente poucos resultados de pesquisa tem sido publicados sobre antecedentes, justificativa estratégica e impactos dos IFNs.

Introduction

Forests are and have always been at the same time an ecosystem and a resource and it is these two distinct views onto one and the same vegetation type that drive much of the current discussions about forest related management and forest related policies. The ecosystem view is nature-centered and the resource-view is human-centered. The ecosystem view demands little or no interventions (except for protection) so that the ecosystems can develop and evolve undisturbedly; it sees the forest as a natural system, so-to-say on its own rights. The resource view builds on systematic interventions and steering of forest development and focusses on the environmental and productive functions of forests, however with a long-term and sustainable approach. Both views are firmly integrated into modern forest management and forest policy.

The non-endlessness of the forest resource became already clear several centuries ago when overexploitation lead to severe forest losses and damages in many parts of the world and in particular in Central Europe. It was then the time when silviculture was introduced as a systematic approach to managing forests instead of mere exploitation and when the term "sustainability" had been coined, both in the book Silvicultura Oeconomica by Carl Von Carlowitz (1713).

It is maybe interesting to note in this context, that forests were the first resource where something like "planetary boundaries" became obvious, which have developed to one of the most pressing issues in our days: although the wood-shortage was certainly not a global issue at that time, but rather a localized issue, the resource was not any more available within reasonable reach of the users. Today, with the immense population growth and the ever increasing resource consumption, these boundaries are becoming apparent at global level for practically all resources which had been considered endless for most of the times of human history, including, for example, fresh water, oceans, air and minerals.

Then, given the non-endlessness of the forest resource, its well-known capacity for growth and regeneration, together with the equally well-known and clearly–evidenced multi-functionality of forests regarding their economic, ecological and environmental services, there should be a generic interest by governments to protect and enhance the forest resource to the extent possible which does also imply to conserve forest ecosystems.

Monitoring of the forests at national level is one of the prerequisites for such government actions. Only when a resource is known with respect to its major characteristics can a targeted management be put into place; what cannot be measured cannot be managed. And it is National Forest Inventories (NFI) that generate scientific type of information (as opposed to anecdotic information, rumors and speculations) about forests on national level.

NFIs on a statistical basis have a long history, yet about 100 years ago the European Nordic countries with their huge mainly boreal forests implemented the earliest NFIs. At that time, these inventories based on long transects that crossed the provinces; such NFI was, for example, implemented in 1917 in Norway (The taxation…, 1933; Kleinn & Tomter, 1993). There had been earlier larger area forest inventory types of studies like a provincial inventories in Sweden in the 19th century and the teak inventory in Burma in the 1860 (Hesmer, 1975), yet these studies had an empirical descriptive character and statistical sampling had been developed and introduced only by the end of the 19th century. In fact, the early NFIs in the Nordic European countries did contribute to developing statistical sampling at that time (Lindeberg, 1923; Langsaeter, 1926). These early NFIs were exclusively focused on the production function of forests and their starting point was the concern about the long-term availability of the raw material wood; ecological issues were not at stake. And these NFIs were probably the first ever studies to analyze status and changes of a renewable natural resource for larger areas. After World War II, the same motivation made the newly founded UN Food and Agriculture Organization to set up the Global Forest Resources Assessment Program that has produced since then every 10 years an overview report on the State of the World's Forests from a compilation of national level forest information from the individual countries (since 2010 every 5 years).

NFIs have continuously been further developed both in terms of the scientific bases and in terms of efficient implementation. These developments and the implementation experiences in many countries have generated a versatile toolbox that is now available with a multitude of approaches for the planning, implementation and analyses of NFIs as well as for their institutional embedding within the forestry and environmental sector in a country. The technical part of this toolbox is firmly rooted in scientific approaches of sampling, modelling and integration of remote sensing.

Scope and goals of NFIs and its evolution

In general, NFIs are being implemented to generate and make available science-based data and information with the primary goal to guide and support decision processes in forest-related policies. In order to serve this purpose, NFI results need to be defendable and credible which is guaranteed only when the NFIs are firmly rooted on science. Then, results of NFIs may contribute to reduce speculations and guide controversial discussions; this, however, will only happen when all parties accept scientific information as a matter of fact. Beyond policy, results of NFIs serve also to generate scientific hypotheses and to support scientific research.

While the early inventories focused entirely on interests of the forestry sector – namely wood production – the focus and scope has been widened more and more and various other sectors are interested in NFI data and in integrating their variables into the NFI process. NFI data serve to monitor sustainability of forest management and forest policies on national and sub-national level, and they enter into various international reporting processes including the UN-FCCC and UN-CBD. Various NFIs have developed towards general land use inventories where all (or many) land uses including their relevant variables recorded; other NFIs include explicitly also the tree resource outside the forest which constitutes a relevant and more and more recognized tree resource in many regions (Schnell et al., 2015), so that they developed essentially from a "national forest inventory" to a "national tree inventory".

Figure 1 illustrates some characteristics of the development of NFIs over the past century, modifying a graph from FAO (Branthomme, 2010). The topics that had been in the foreground were in the early times and for a relatively long period the provisioning of the resource wood. In the 1970s the term "multipurpose inventory" was coined. The integration of the assessment of biodiversity indicators became an additional focus in about the 1990s as was the monitoring of sustainable forest management; this enhancement of the NFIs went along with the development of the comprehensive framework of Criteria and Indicators for sustainable forest management. A major focus in current NFIs has been for about 10 years now the contribution to the processes that aim at the reduction of carbon emissions from forests: well implemented NFIs are an extremely relevant data source for MRV (Measurement, reporting, verification) and they comply with the quality demands that are defined in the COP decisions to UN-FCCC, in particular regarding "transparency, consistency, completeness".

It is, of course, difficult to predict the future developments regarding the scope. One may state, however, that the NFI technical approaches are well suited to integrate emerging data needs. It is unlikely, that interest in forest conservation and management will decrease in the near future; it is more likely that emerging topics like soil and water protection will gain more relevance as will be the forest utilization.

Along with the widening of the scope and target objectives as illustrated in the round boxes in Figure 1 there has come other changes, that are depicted in the lower part of the graph. First, the users of the NFI and the NFI results have changed from the forest and wood sector to the general environmental policies; secondly, also the geographic scope has changed and the NFIs are not only of interest at national and sub-national level, but are more and more entering into global processes; and thirdly, the group of experts involved has also widened.

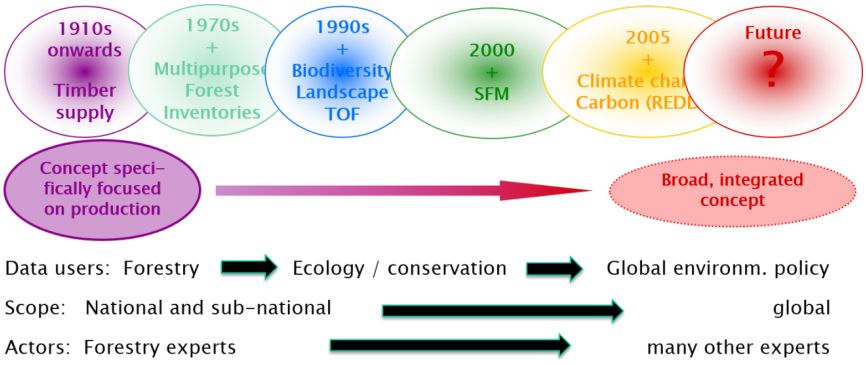

Figure 1. Some characteristics of the development of NFIs over the past about 100 years (modified from Branthomme, 2010): new needs were evolving and flexibly integrated into NFIs.

Obviously, approach and design of NFIs have been such that it was straightforwardly possible to integrate more and more forest-related issues of national interest and to adapt the design to newly emerging demands. In times when environmental and ecological awareness is increasing because of increasing pressures from the growth of population and resource use, NFIs constitute a multiple source of information. How a NFI has developed over the past century along with changing requirements has recently been described in detail in Fridman et al. (2014) for the case of the Swedish NFI.

Observations on the historical development of NFI implementation

One may distinguish three historical periods regarding implementation of NFIs: the first NFIs had been installed in the Nordic European countries directly originating from the recognition that there was an information gap about the state and development of the wood resource forest. These NFIs were national initiatives and were implemented exclusively with national funding. In the 1960s to the 1980s then, the second period, there were many NFIs implemented in developing countries within the framework (and funding) of bilateral or multi-lateral projects of technical cooperation. Tewari & Kleinn (2015) report a number of about 45 of such projects implemented by FAO alone. These NFIs were largely driven by the technical cooperation and the need of development agencies to have good forest data for to support designing forest management policies in these countries. The NFIs were designed as projects of a defined duration and the major goal was the production of the missing one-shot information about the current status of the forest resource. "Forest monitoring" as a long term endeavor with a focus on changes over time was not at stake. The sustainability of these projects was modest – some few exceptions excluded like the Forest Survey of India (Pandey, 2008; Tewari & Kleinn 2015); and in many cases the capacity built was lost soon. In this period, important textbooks related to forest inventory were issued (Prodan, 1968; Husch et al., 1972) and also the technical publications FAO, "Manual of forest inventory" (FAO, 1981) and "Planning a forest inventory" (Husch, 1971); actually, a publication that focuses explicitly on the planning and implementation aspects of NFIs has not been published since then to the best knowledge of this author. The actual "boom" of implementation of NFIs in many countries, which constitutes the third period, has its cause in the incentives that both international processes and bi/multilateral processes offer in the context of the international conventions: countries shall be compensated for example for the long-term reduction of their forest carbon emissions. These "results´ based payments" require evidence that the results have really been achieved as reported – and in this process of measurement, reporting, verification (MRV), NFIs are among the most valuable data sources both for determining the baseline and for determining the actual results. As Figure 2 illustrates, the forest area inventoried has considerably been increased in this phase.

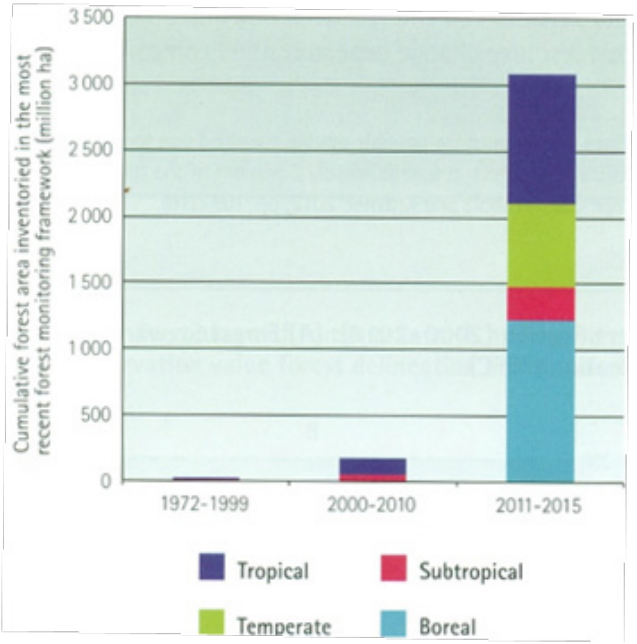

Figure 2. Cumulative forest area under NFIs. Source: FAO (2015).

While this actual implementations of NFIs is – as in the mentioned second period – largely driven by the outside (international initiatives and incentives by multilateral funds and donor countries), there appear to be considerable differences: not one-time inventories are implemented in this current phase, but the COP decisions to the UNFCCC do clearly demand that forest monitoring systems are being implemented that have a longer-term character and allow for the monitoring over time of the forests at national level and its characteristics: Decision 4/CP.15 to the UN-FCCC suggests that "robust and transparent national forest monitoring system (NFMS)" are being implemented that should, among

other points, use "a combination of remote sensing and ground-based forest inventory approaches" and that should provide "estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities" (United Nations Framework Convention on Climate Change, 2009, p. 12).

These COP decisions have a considerable impact on NFIs in several regards (United Nations Framework Convention on Climate Change, 2009):

1. NFIs, as core elements of National Forest Monitoring Systems, are recognized as an important base component of national forest planning and of aligning national forest policies to international commitments;
2. NFIs require a long-term view which implies that it is not one-shot projects any more but rather, NFIs are to be considered elements in monitoring programs (as opposed to monitoring projects) that consist of a series over time of consistently implemented NFIs;
3. As a consequence, this long-term character makes that it is imperative that forest monitoring systems are being institutionalized; that is: a permanent national institution needs to take care of the system and its further development with the side-effect that institutional knowledge is built and maintained;
4. And, again as a consequence of the before said, national capacity needs systematically to be developed – and have a good chance to be maintained and enhanced in institutionalized systems ;
5. NFIs and their framework (the NFMS) are stipulated to be "*transparent, consistent, as far as possible accurate, and reduce uncertainties"* in the COP decisions: the only way to adhere to these expectations is to plan, implement and analyze NFIs according to scientific principles.

This actual third phase is probably the most complex one as compared to the preceding phases both on the technical and the policy level and the lack of clear guidelines or "best practice" suggestions became apparent. Similar to what happened in the second phase as described before, that important publications came up, there are various initiatives to support and give guidance to the implementation of NFIs mainly on technical scientific level (e.g. the Methodological Guidelines Document (MGD) of Global Forest Observations Initiative (GFOI) (2016), but also on overall strategic and organizational level (e.g. the Voluntary Guidelines for National Forest Monitoring of FAO, 2017); many of them consider NFIs as components of the wider endeavors of national forest monitoring systems.

Two reasons may be identified why the current phase of implementation of NFIs is expected to be more sustainable than earlier phases: 1. NFI results make relevant contributions to national reporting to the international conventions that can hardly come from other sources and 2. results based payments in the context of REDD+ and related processes give an extra incentive to generate a data base on forests that can be checked and verified on scientific grounds.

Four side-observations on NFIs

A number of "side observations" may be due here in the context of planning and implementing NFIs, that need to be addressed as they sometimes appear to be nor properly observed nor appreciated:

1. National forest inventories have always a technical and a strategic-political dimension. It is not sufficient to look at NFIs as technical studies only that need to be optimized in terms of statistics, remote sensing and modelling. In all planning stages it must be kept in mind that – while an NFI may have many elements of a scientific study - it is definitively not a purely technical study, but it serves well defined purposes. And it is commonly not the inventory planners who define the overall purposes and goals of a NFI. Adherence to sometimes fuzzily formulated policy goals requires willingness and skills in communication on both the policy side and the NFI technical planners´ side.
2. In a follow-up to the first point, it is mistaken to generally assume that more precise information will automatically lead to better decisions. No one will argue that this may be the case when using the information in a proper and rational manner. The point here is, however, that the information and its precision and accuracy must optimally meet the needs of the information users (usually those involved in policy decision processes) – and that policy processes follow different dynamics than processes in natural sciences; rationality not always being a core element. It is interesting

to note that practically all publications about forest inventory design aim at improving the quality of the results in absolute terms, and not as related to the stipulated information needs of the policy processes into which the NFIs are embedded. This has likely to do with the fact that most inventory statisticians – including this author - are lesser experienced in the field of social and political sciences than in natural sciences. Frequently it is simply assumed and believed that better information leads to better decisions. And on the other side, those involved in the policy processes are usually not able to specifically guide the inventory planning: it has been a common situation that they do not have deep knowledge about NFIs and their potential value and are not capable or willing to clearly express their information needs so that inventory planners can translate them unambiguously into inventory variables to be recorded.

3. Likewise in research on national forest inventories: most publications start out with the statement that good information is needed for good decisions. The research reported then is strictly limited to increasing precision and accuracy, reducing biases, and increasing cost-efficiency. Impressive progresses have been made over the past decade in this field, in particular in the field of statistical modelling and remote sensing integration. However, this author has not found publications that equally comprehensively evaluate the second component of the above statement: that the improvement of data / information quality has actually led to an improvement of decisions; commonly the scientific articles end with the finding that information quality has been improved. There appears to be considerable scope for research in this context.
4. Another field that appears to be under-researched is the systematic evaluation of the impact of NFIs. We all do believe that the data and information produced by NFIs are being used in a reasonable and straightforward manner and make a difference. However, there are only few studies that systematically analyze the use of NFI data in the framework of different policy processes. This is somehow surprising as an analysis of the impact would be an excellent base for the improvement of follow-up inventories. There appears to be considerable scope for research also in this context.

These four side-observations can nicely be integrated into the NFI design process where NFIs are seen as elements within decision processes; this is elaborated in the following section.

Decision processes and the role of NFIs

NFIs - and all other forest inventories as well – need to be considered elements of decision processes. In forest management inventories, this refers to management decision processes; and in NFIS this refers largely to policy decision processes. A NFIs is never its own end, but serves well defined goals, where the definition of these goals comes – in the best case – from a real information need of responsible decision makers. The role and position of NFIs within such decision processes is illustrated in Figure 3. In a first step, information needs (and thus the goals of the NFI) need to be identified and defined. This is entirely independent from the inventory and the inventory experts and is being formulated by the policy decision makers; inventory experts may advise and illustrate options by making reference to inventory reports, for example, of neighboring countries; however, inventory experts should refrain here by taking influence and define goals and scope for the decision makers; it is not unusual that such advices are expected from the inventory experts. An important and sometimes difficult task for the inventory experts is then to "translate" the information needs into measurable indicator variables that can be recorded in an inventory with reasonable efforts. This "translation" process needs to take place in close coordination with the decision makers because it is likely that many detail questions need to be addressed and clarified. For many variables, it is straightforward to identify measureable variables and well proven approaches are readily there (e.g. growing stock and its changes). For others, there need to be definitional clarifications first (e.g. species composition in mixed forests: should it be reported in terms of basal area or number of stems or crown cover – and for which sociological class of trees [all or only the dominant]?). And for others again, some sort of indicator model needs to be established first - and agreed (e.g. "biodiversity" or "naturalness / intactness").

With the finalized set of variables – to be observed both from field observations and from remote sensing

– the inventory design can be crafted, manuals written and training organized. Data collection will then be organized and carried out, data quality control measures enacted and eventually the data analyzed, assessed and reported.

In a next step, these reports are evaluated by the target decision makers who may base the development of options and scenarios on this scientific base of information. These decisions may then be implemented – be it within policy processes, management processes or in research. In the best case, then, the role of NFI data and information in these decision processes is systematically evaluated and the impact of such decision support identified; this will be an extremely instructive input to the planning of the next NFI phase within the National Forest Monitoring System.

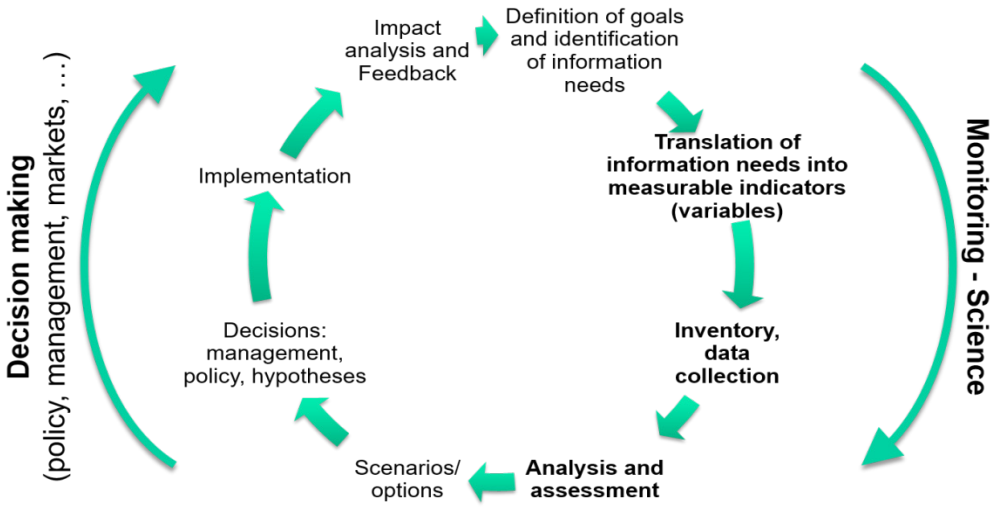

Figure 3. NFIs as components of National Forest Monitoring Systems and as elements of decision processes in forest policy. The bold printed steps are the technical steps which are usually considered making up a NFI. The position of NFIs at the science-policy interface is clearly illustrated where the more technical steps are on the right hand side ("monitoring – science") and the more strategically oriented steps on the left hand side ("decision making").

When looking at this cycle as depicted in Figure 3, one may distinguish two domains: the "monitoring science domain" and the "decision making domain"; which is reflecting the technical and strategic dimensions that were mentioned yet in the preceding section. Forest inventory experts are often focusing very much – frequently exclusively – on the monitoring science domain and impressive advances have been achieved over the past decades in terms of remote sensing integration, modelling and enhancement of precision. It is, however, unclear whether all these developments have really responded to the explicitly formulated needs of decision makers and whether the decision processes have been optimally improved. Commonly, it appears that inventory experts are not sufficiently looking at the decision making domain – and decision makers are not sufficiently looking at the monitoring science domain.

It will need to be one of the core future research fields on NFIs to understand the role of scientific information as provided by NFIs in policy decision processes, and to realistically understand the impact of NFI data and reports. It is a matter of fact – even though a scientific proof is not known to this author – that policy decision are not only (perhaps not even mainly) driven by scientific information, but that other factors like interests and values, academic background, personal experiences, the public opinion and rumors, advises from colleagues and friends are playing a considerable role. An interesting study in this context – even though not from NFI but from community forestry - is Banjade et al. (2006), where the authors found that the weight of scientific information in community forest decision processes was in the order of magnitude of 10% as compared to other factors as mentioned before. Similar studies for NFIs are not known to this author. For most NFIs there appears not to be a systematic follow-up on the use (and possible also misinterpretations and/ or methodological criticisms) of NFIs and their results.

This is certainly another worthwhile field of research when it comes to justify, optimize and streamline NFIs.

The role of academia and scientific research in NFIs

It has been stressed before that expectations towards NFIs and their products (including transparency, completeness, consistency and precision) are typical expectations also to empirical scientific studies. Also, a serious verification of all data generation steps as demanded in the MRV processes, is hardly possible if the NFI had not strictly adhered to commonly accepted scientific principles.

NFIs, therefore, exhibit many characteristics of empirical scientific studies – and that means that scientific expertise is not only important but rather decisive during all steps of optimizing the design, planning the data collection, implementation and reporting. As with scientific studies, there are a number of basic technical principles that need to be observed in order to generate defendable and credible information. An important fact here is that NFI designs are relatively complex by nature and cannot be arbitrarily simplified. Unfortunately, however, a common expectation by those who commission forest inventories is: make it as low-cost as possible. Of course, this is always the goal of project planning, but the side-conditions need also to be stated: that the NFI shall produce the expected products at the expected precision; and that scientific principles are adhered to. At the end, it holds the statement ascribed to Einstein: "Make things as easy and simple as possible – but not simpler". And there are clear limits so as to make NFIs more and more low-cost and simple.

The role of research in practically all steps of NFIs is a primary one. Probably it can even be stated that all sustainable NFIs are "carried" and accompanied by intensive research and involvement of academia. And the lack of integration of research and development may contribute explaining the sustainability-failure of many NFI in the 1960s to 1980s, where the NFIs were implemented as rather stand-alone projects of limited "life-time", frequently by external experts, and without having a simultaneous focus on institutions in the country that care for methods development, research and capacity maintenance.

The relationship between NFIs and academia is a mutual one: NFI design development depends on systematic research to fill gaps that commonly exist regarding methodological details and to adjust the design to the specific national circumstances and expectations; and academia benefits from NFIs not only by means of the definition of relevant research topics in design optimization, but also from the fact that NFIs generate unique national level data sets for scientific analyses and that NFIs offer an excellent domain for capacity development for young scientists. There are hardly more instructive internships for young scientists in many fields of forestry than being integrated for several months into a NFI field team: the permanent exposure to the different forest conditions, the permanent need to quantify observations on forest structure and participation in discussions with forest users do certainly deepen and sharpen the observation and understanding of both the ecosystem and the resource forest in a manner that can hardly be achieved by other types of internships. Also, young scientists who were involved in NFI field work may develop an enthusiasm for the topic that will otherwise hardly grow. For this author, it was one of the most impressive features of the Fourth Brazilian National Symposium on Forest Inventory, where this paper was presented, to see so many young researchers presenting enthusiastically their research topics in the context of the Brazilian NFI.

Best practice guidelines for NFIs

National Forest Inventories are complex undertakings and National Forest Monitoring Systems are long-term programs at the science-policy interface. All NFIs and NFMSs need to be tailored to the very specific national conditions in terms of biophysical conditions (forest types and topography), infrastructure, institutions, traditions in forest management and forest inventory, capacity etc. As a consequence, it is virtually impossible to make specific technical recommendations for best practices, and it is well understandable, that, for example, the COP decisions refrain from making very specific technical recommendations for best practices and remain rather quite vague when it is demanded that national forest monitoring systems be "transparent" (Decision 11/CP.19) and combine "sample based field observations and remote sensing" (Decision 4/CP.15) (United Nations Framework Convention on Climate Change, 2009a, 2009b).

However, some guidance is certainly helpful and required to guide the development of NFIs and NFMSs,

in particular in increasing number of regions where there is no tradition in NFIs and where NFIs need to newly be established.

Regarding the technical elements, adherence to scientific principles, as mentioned before, provides basic and most relevant guidance. With a focus on carbon estimation in the REDD context, such guidance is elaborated in much detail, for example, in the Methodological Guidance Document of GFOI (Global Forest Observations Initiative, 2016).

FAO published voluntary guidelines on national forest monitoring and assessment, in which basic principles of NFI planning and analyses are elaborated. This document has been endorsed by the 23rd Commission on Forestry in 2016 and provides detail guidance not only on technical features of NFIs but in particular also on the context in terms of institutionalization and sustainability.

However, it is misleading to expect that such guidance documents alone will guarantee a proper designing and implementation of NFIs. Rather, a team of experts with technical knowledge and some experience is required to translate such guidance into specific design elements for the particular national circumstances.

Given the challenge to define best practices in terms of technical details when there are so many factors that co-determine the specific design, this author has been advocating for quite a while to compile a guide of "bad practices to be avoided". Such "negative guide" would most likely be very instructive and a model for this is what Sutherland (2006) formulated as "The twenty commonest censusing sins". While such guide has not materialized yet for national forest monitoring, the list of "bad practices" may include points like:

- Look at NFIs as a mere technical exercise not appreciating their policy dimension.
- Look at NFIs as mere administrative study not appreciating their scientific character.
- Be driven by technologies rather than by the definition of and adherence to the objectives.
- Look at remote sensing (or field observations) as the only source of information, not appreciating the merits of integrated systems.
- Planning the definition of inventory variables and inventory data acquisition without considering in detail the subsequent analyses.
- Not using the NFI as a platform for capacity development in particular for young researchers.
- Believing in the results (rather than critically trying to understand them) – which is actually one of "The twenty commonest censusing sins" as formulated by Sutherland (2006).

Concluding observations

National forest monitoring does currently attract much and increasing attention on global level and experiences new intensities both regarding implementation and regarding research.

It is assumed that national governments require high quality national level information on the forests in order to be able to make high quality decisions regarding the development of the forests on national level both considering them as ecosystems and as a resource. National forest monitoring, therefore, may be considered a default government activity just like national governments do carry out manifold other data-collections to support their policies; such activities include population censuses, inquiries about the economic status of enterprises, and of course also the intelligence that is provided by secret services. Governments are usually investing a lot of resources into these data and information gathering activities, and the same might be expected to hold for national forest monitoring systems that inform about an important national asset, the forests.

As has been illustrated in Figure 1, NFIs have undergone and are undergoing a dynamic development from merely wood-production oriented inventories towards comprehensive landscape oriented assessments that take explicitly into account the multifunctional role that forests have in ecological and social systems. Still, NFIs appear to be the most comprehensive and farthest developed assessment systems of a natural resource on national level, and various other sectors become more and more interested in the data gathered and the information produced. In many countries, the multiuse character of NFIs has explicitly been formulated in the forest law, for example in Germany, where in the update of the national forest act it is explicitly stipulated, that the NFI shall also generate information relevant for nature conservation. It is likely that this multi-sectoral character of NFIs will further develop.

Of course, in order to be sustainable and successful, national forest monitoring systems must not be seen just

as a technical exercise, but the policy dimension needs to be equally emphasized from the outset. Communication and coordination between the technical inventory experts and the policy decision makers is essential in this context; and do appear not in all cases optimal. Also, it appears that the academic curricula cover national forest monitoring virtually merely as a technical exercise of sampling statistics, modelling and remote sensing, and do not adequately address the policy / decision making components. Also, most - if not virtually all - forest monitoring publications focus on improving the statistical efficiency of estimation only; while this is definitively extremely relevant in absolute terms, it should ideally be seen in the context of the explicitly formulated information needs. There are actually not many publications in the forest monitoring context that explicitly address and elaborate this position of NFIs at the science-policy interface; an example is Arnold et al. (2014).

In context of the degree of achievement of the pre-defined goals, another interesting observation can be made which refers to the "impact analyses and feedback" component of the decision process cycle depicted in Figure 3: actually, not much has been published about a systematic analysis of the direct and indirect impact of NFIs and their results. Of course, one may assume that - where NFIs are installed and continued on a permanent basis - the NFI results are useful and valuable for those who cover the cost for these studies; otherwise one may assume that they would be just discontinued. One of the actual uses of NFIs is more than obvious: evidence for the development of the forests towards reducing emissions from deforestation and forest degradation, which may yield in results´ based payments. However, a full-blown analysis of the use and utilization of NFI data and results and an analysis of the fields / sectors where these data are being used and for what, does not appear to be a standard component in national forest monitoring systems. Rather, reporting and internal analysis of the NFI process appears to be commonly the end-point of an NFI cycle. Such impact analysis, however, may be very instructive for optimization and further development of NFI design and implementation and may generate ideas about, for example, the refinement of definitions, the integration of further target variables, the involvement of additional stakeholders / interested parties, the optimization of scope and form of reporting, etc.

Altogether, in the framework of the currently increasing global interest in forests both from an ecological and from a resource perspective, the demand for science-based forest information is also increasing. The results´ based payments make it that NFIs and their results may have an immediate monetary value; this is probably the first time in the long history of NFIs that such a direct monetary value of NFI products is visible. Step by step it appears that governments are looking at NFIs as normal processes of gathering information on a relevant national asset so that NFIs are not any more an exotic undertaking by few concerned parties but rather a "default action in government business". The technical development towards increasing precision and accuracy of estimations and optimal integration of diverse data sources is fast and appears to be speeded up by the globally increasing interest in NFIs. More attention, however, may be worthwhile to be paid – both in research and in practice – to the explicit formulation of the NFI goals and the ex-post analysis of the degree to which these goals have been achieved.

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