Decision Support Systems in Forest Management: An Integrated Approach

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Abstract: *Decision making process - especially in natural resources management, encounters myriad of challenges to objective decisions, significant decision depends on amount of information and capability of decision makers to handle massive data. In forest management, these challenges such as lack of enough data and cost associated with obtaining insitu spatial data, have been minimised with the use Geospatial Decision Support System (GDSS). GDSS has shown great capability of capturing, storing, analysing, retrieving and manipulating data for aiding spatial decisions. This technology proliferates quickly and as a result decision makers overlook other systems for forest governing. Following this situation, people living adjacent to forests have found it difficult to accessing forest resources - and their livelihoods, which depends on forests have been compromised. The continuing degradation of forest resources despite existence of different management strategies - such as (community based forest management and joint forest management), has made it necessary to assess decisions on forest conservation. Focus Group Discussion (FGD) strategy was applied to capture extent of use of Indigenous and Local Knowledge (ILK) and GDSS in forest management decisions, observation was applied to implicitly relate the narration from FGD and the reality while interview method was applied to forest officials to capture use of ILK in forest decision making. The results revealed that ILK related to forest management; however the uncovered ILK has been insignificantly used together with GDSS in making decision for conservation. This paper establishes the ignorance on ILK as one among other factors behind the continued forest cover depletion despite existence of conventional conservation strategies. The developed framework integrates GDSS and ILK to aid forest decisions which will ensure sustainable forest conservation and serves for forest needs of the communities adjacent.*

Key Words: Decision support systems, indigenous knowledge, decision making and forest management.

INTRODUCTION

The imperative to formulate good regulations for management of forests and enforce them is strongly reflected both in outcomes one and two of the UN conference on environment and development (Rio de Jeneiro, 1992 - the first outcome at balancing social economic dimensions by integrating environment and development into decision making by improving decision making processes. This outcome further called for integration of economic, social and environmental consideration in decision making at all levels. The second outcome aimed for conservation and management of resources for development in ways which includes integrated approaches to planning and management of land resources, combating deforestation, combating desertification and drought also conservation of biological diversity and promoting sustainable agriculture and rural development. The reality is that human ecological footprints are exceeding ecological capacity of the environment and this is the concern that calls for global efforts to forest management. This concern was firstly pointed out in a mission report titled “Limits to Growth” by the Massachusetts Institute of Technology for the Club of Rome (1972, 2004) and in Wackerngel and Rees (1996).

Since then there have been different development strategies in the world which have resulted in today’s status of forest management - in the world, Africa, and particularly in Tanzania. However, in social practice these strategies have been facing challenges in their implementation. A serious challenge is in the area of decision making. Forest managers around the world find the use of geospatial data collection and analysis tools easier to use when making decision. This is because with geospatial tools, data manipulation is made easier hence aiding greatly the process of o decision making. Unfortunately, decision is not only independent to technical spatial data; other information like the socio ecological is also important. However this is hardly incorporated with spatial data when using geospatial tools in decision making process. A challenge arising from this argument is the possibility of making a decision which does not consider community needs from the resource.

To ensure decisions balance user’s needs and conserve for future user’s needs, there is a need of having massive data to accommodate different needs during decision making. Geospatial tools - in this case referred to as Remote Sensing and Geographical Information Systems, have manifested great capability of gathering spatial data, hence aiding forest decisions (Turban et al., 2001; Mc Connell and Burger, 2011). Indigenous knowledge has also - in several occasions, proven the ability to aid forest decisions by providing sociological data (Briggs, 2005, Brossius, 2005, Kajembe, 2009 and Cooper, 2010). Both tools are not self satisfactory in terms of other data. Geospatial data is rich in scientific ecological explanation but is lacking in socio ecological explanations. The vice versa is true for indigenous knowledge. It is therefore the task of forest decision makers and managers to consider both tools to be able to gather multiple data for forest decision making.

Geospatial technologies which are referred in this context as Geospatial Decision Support Systems and ILK are both treated as decision support systems for forest management but in different levels. The challenges have been on the efficiency of the each tool in aiding forests management and whether one is superior to the other. The adoption of GDSS has changed many scientists and other decision makers thinking towards forest management. They have been impressed by the ability of GDSS in aiding forest decisions to the extent of stereotyping other tools like the ILK.

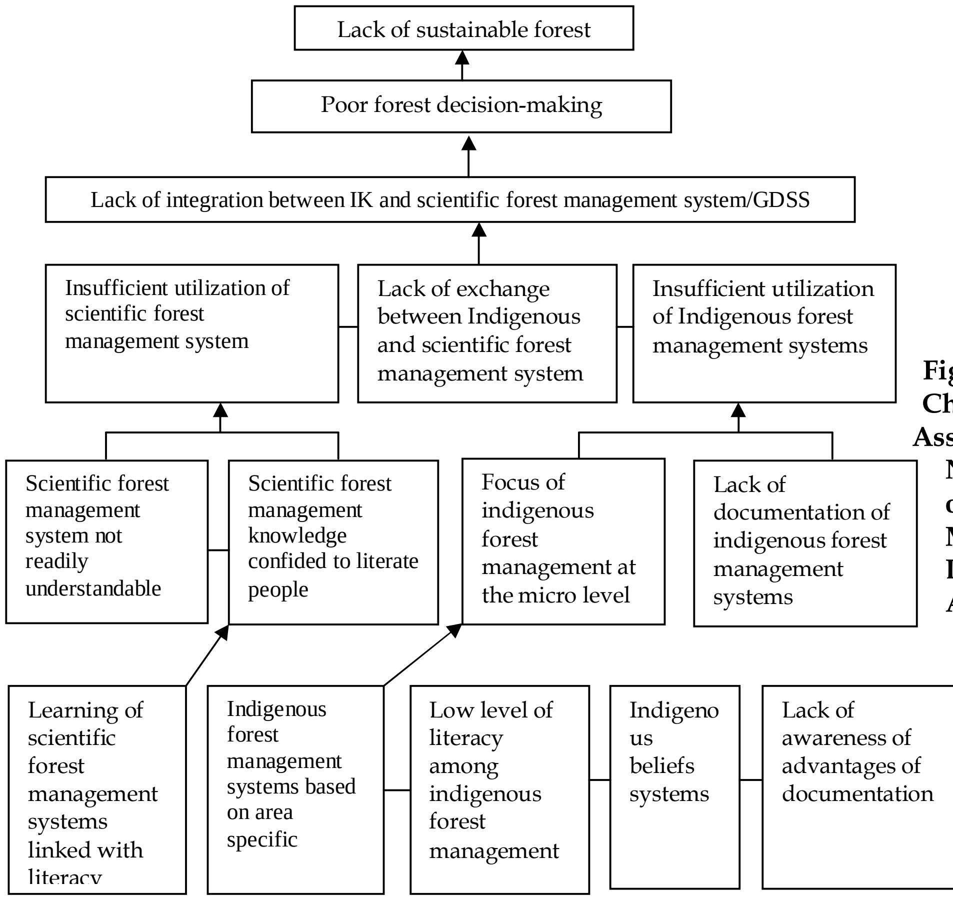

Figure 1: Challenges Associated with Non-Integration of Forest Management Decision Approach

This and the proliferation of forest-related science and technologies have led to erosion of ILK together with its consideration to forest management. Community forest needs are now compromised more than ever and forest sustainability has increasingly become jeopardized. According to McCall and Minang (2005) respect of indigenous knowledge is one of the key aspects of good governance and decision making. Further, it is a positive measure of local community capability, with potential to set community members on an equal status with outsider's experts, and maybe the only resources of which the local group, especially the resources poor, has unhindered ownership. Ignoring ILK in decision making is more of top down management from technological expertise, as the technology leaves much to be desired over the activity in question when it comes to implementation of the made decision. Figure 1 highlights shortfalls of each tool and challenges associated with non integration of IK and GDSS in forest decision making.

As per Figure 1, the use of scientific tools in forest management (RS&GIS) is based on literacy. This means that scientific forest management is confined only to literate people mostly forest experts. Furthermore, the use of scientific tools in forest management is not readily understandable to illiterate people. On the other hand ILK is area specific and confined more on indigenous people with indigenous beliefs. Furthermore, ILK is characterised with lack of documentation and awareness to the importance of documentation. The confinement of ILK to micro level of the community curbs its use in forest decision making. The same impact results on the use of scientific tools such as RS and GIS in forest management as it confined to only literate people. If indigenous and local knowledge does not link with science or vice versa, the result is lack of enough information to forest decision making. The scientific point of view lacks ILK and ILK lacks the technical scientific point of view. This generally results in poor forest decision making and eventually unsustainable forests.

There is a need, therefore, of integrating ILK with spatial data to aid in cross cutting decision making in favour of both community and the forest ecosystem. The two arguments uncover the pressing need to improve and regulate management of forests particularly on higher level of decision making. These also serve for appreciating the two decision making aiding tools (ILK and GDSS) by integrating them in order to mitigate the cost of forests decision making basing on one of the tools only. In case of GDSS tool, is more of top down orientation, while ILK is missing scientific analysed facts to improve and balance the management decision on forests. This paper was prepared to respond to the need for provisioning of possibilities of integrating GDSS and ILK in forest decision making process to enhance forest sustainability using Zigi river catchment in East Usambara Mountains as a case. The attention is mainly on improving forest management decisions which do not compromise community needs and livelihoods while maintaining sustainable forest services.

Study area

The study was conducted in Zigi river catchment area which is located within the Eastern Usambara Mountains. The area has coverage of about 1050km^2 (Mwasha, 1989,in Mwanyoka, 2005). Recent study by Hepelwa (2010) shows the size the area being 1,100 km^2, located between 4°48'S and 5° 13' S, and 38°32' to 38°48' E in Muheza, Mkinga and Korogwe districts, Tanga region. It has an elevation of 1,265m and the mean elevation of about 355.44m. The area has a bi–modal rainfall pattern.The long rain period is from March – May and the short rain period is October – December. Monthly average rainfall stood between 30mm and 174 mm for the period between 1995 and 2005, On the other hand, the maximum temperature ranges between 28^{o}C and 35^{o}C and the minimum temperature between 17^{o}C and 23^{o}C. Apart from settlement, the area is characterized by six other land use cover and about 15 forest reserves (Figures 2 and 3).

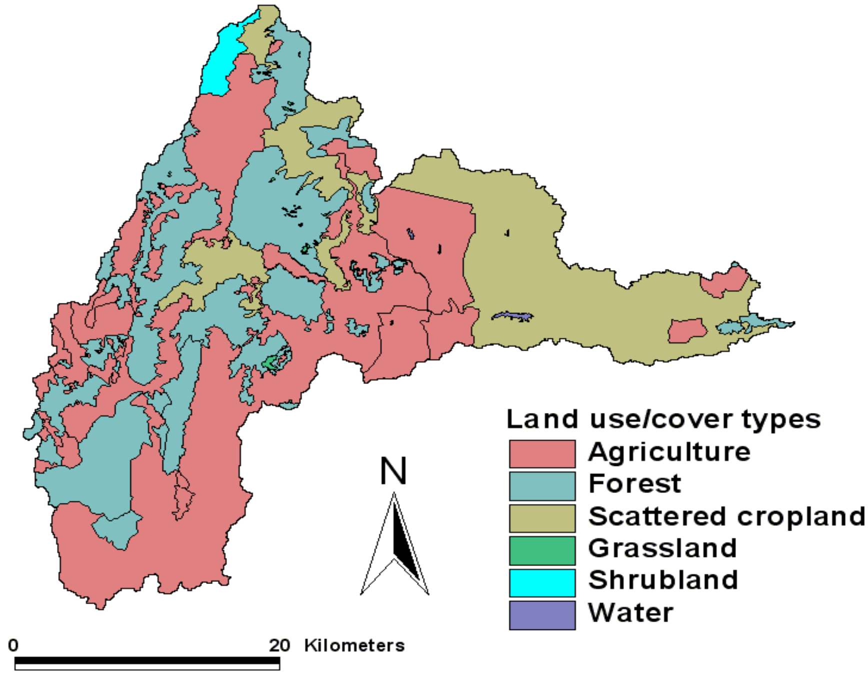

Figure 2: Zigi Land Cover

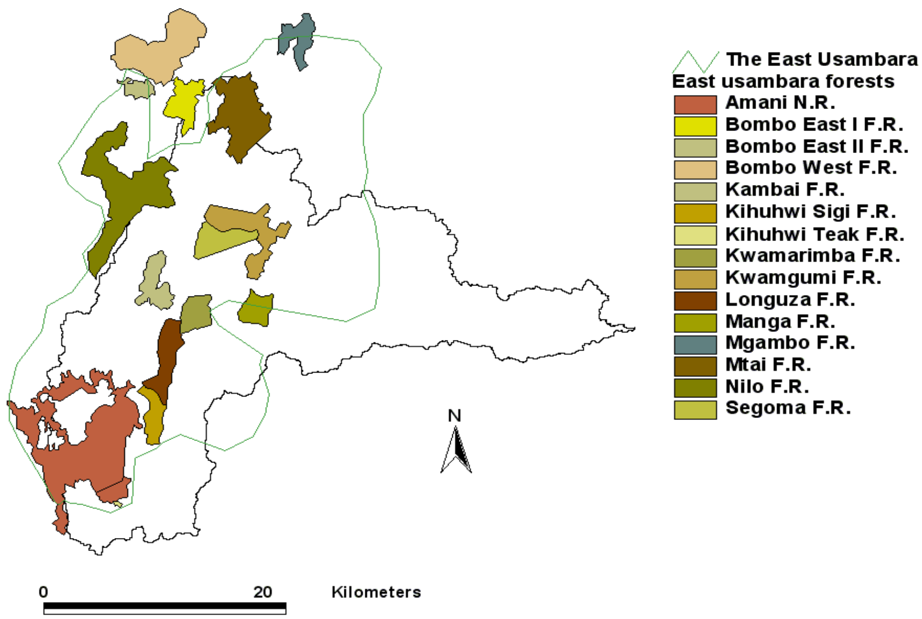

Figure 3: Forest Reserves in Zigi

The estimated population in the catchment area was about 204,461 in 2012, with 100,843 males and 103,618 females (NBS, 2012). Household size of 4.3 and a population density of 77 inhabitants/km^2 (NBS, 2012). About 41% and 5.6% of the people are aged below 15 years and above 64 years respectively (NBS, 2012). The population growth rate is estimated to be 2.2% per annum (NBS, 2012).

METHODOLOGY

Focus Group Discussions (FGDs) was used to assess the level of consideration of ILK in forest decisions in relation to the current conventional conservation strategies in place. Ten FGDS were conducted in ten villages with a group size of 8 to 10 participants. The groups comprised of men and women randomly selected from the villages. Discussion touched on issues of forest resources, use, and management at local levels using their non-conventional knowledge. The discussions also focused on the extent of the use IK in forests decisions. Face to face interviews were conducted with forest official at district, regional and national levels to assess the use of GDSS and ILK in forest decision. Forest officials at these three levels were purposively chosen basing on their nature of duties. The interviews further focused on the use of both ILK and GDSS in facilitating forests decisions. Content analysis and literature survey was used to asses ILK as systems that can aid decision on forest management. GDSS as secondary data was assessed in its capability to aid spatial decisions on forest management. Researcher's observation on implicit link of forests and narrated ILK was used to establish a link between ILK and forest management.

RESULTS AND DISCUSSION

Integrations of GDSS and ILK in Forest Management

GDSS and ILK are both decision making aiding tools, the former being the most popular at present and used to aid decision making in several management sectors. On the other hand, ILK is considered informal and unpopular decision making aiding tool which have impacted or supported decision of various sectors including rural community forests. Concerning the forest management decisions which have for long been compromised with lack of enough information, the challenge is now solved with the use of GDSS. This is because GDSS has shown to have the ability to gather much data and information needed for forest management than ever before. The challenge is now on the capability by decision makers to organize the information so as to result into objective decision over forest management.

This challenge is also associated with erosion of other decision aiding tools like the ILK. The use of GDSS has relied more on data and information - Remote Sensing (RS) and Geographical Information (GIS) and forgot to consider non-GDSS tools in aiding forest decision making Process. ILK has for long - even before the use of GDSS, used by local communities in various areas to govern forests, local community's knowledge of interaction with forest had a great impact on the sustainability of forest and livelihoods. Many GDSS are resource or site specific similar to ILK, because each resource has kind of data to be used in a developing a decision support system. The same it is with ILK as each particular community has a different interaction type and level with resources they are living with and therefore different indigenous and local management knowledge (Pattison et al., 2004, ORAP. 2013). There are GDSS for marine resources, wildlife, agriculture, landscape, and forests - to mention only a few. In Lake Manyara, RS and GIS have been successfully used to asses water balance and provided significant information for decision makers. In this regard, RS/GIS are used as decision support tools for water resources management (Deus &Gloaguen, 2013). By this means, it is possible to provide timely and up to date water resources information to managers and operational decisions for sustainable conservation.

Mc Connell and Burger (2011) have also shown the use of GDSS in supporting conservation of agricultural land - by not only helping farmers creating buffers and overlaying different soil layers, but also by aiding farmers to make informed decisions regarding tradeoffs between production and conservation enrollment. Furthermore, GDSS aids farmers in comparing profitability of crop production with conservation in a spatially explicit context by using profitability tool in Mississippi (Mc Connell and Burger, 2011). In additional to that with GDSS farmer conserve and produce while allowing them to identify more profitable field regions with compared to other field regions.

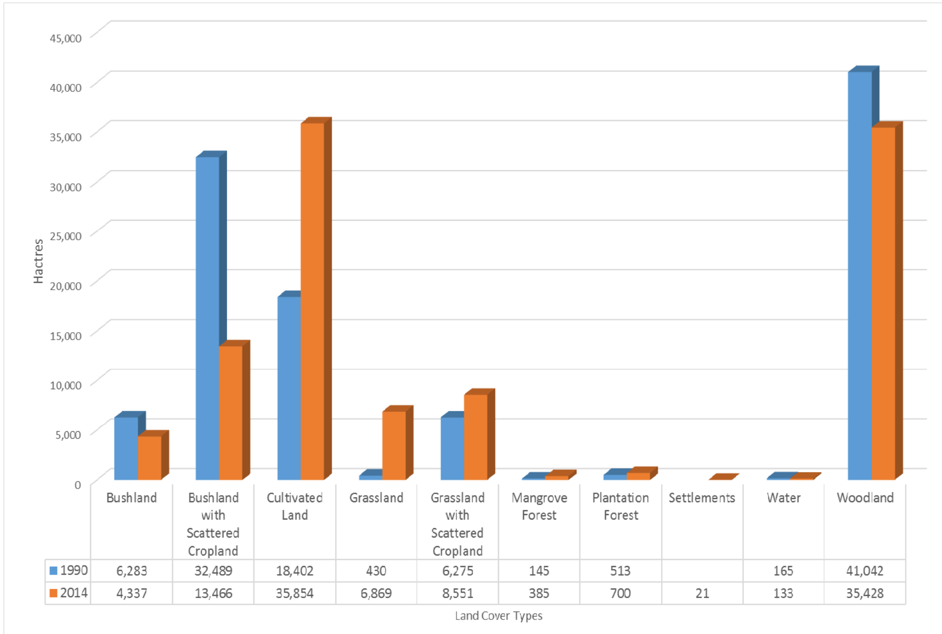

Figure 4: Zigi Land use Change by Hectares

Like in agriculture and in water resources management, GDSS have also aided forest management decisions in various ways inclusive the extent of encroachments, species distribution and disturbance for instance in the satellite analysis provided in Figure 4 showing a 1.8-18% decrease of bush land, 5.3% decrease of woodland, plantations and cultivation land increasing by 0.2 and 16.5% respectively. The land use cover change is provided in an average of twenty years' difference. The results are useful information to decision makers, because they can assess achievement or failures in conservation programs set for a decade or more. Unfortunately these results like any spatial results do not feature IK practices available in the community. Indigenous and Local Knowledge has for centuries been used to regulate community interaction with forests. In India, tribal populations of Andhra Pradesh are well known for their well-organized ILK in managing natural resources (Rao and Ramana, 2007), and Nimachow, *et al.* (2010). In line with this, a report by Africa Adapt (2011) has highlighted different areas that have used ILK in conservation and forest management in Africa. A number of authors (Catherine and Hoppers, 2002; Kweka, 2004; Meshack, 2004; William *et al*. 2012; Rantalla, 2013) have documented ILK and its uses in natural resources management. A paper by Woodcock (1995) - more than two decades ago, have specifically highlighted the use of ILK in forests by people of the eastern Usambara. Woodcock acknowledged a highly manifested indigenous adaptive capacity to the changing environment that manages to sustain their livelihoods and forests management, by changing their reliance from forest derived foods to farms and bush land derived foods when access to forest resources is prohibited.

Although ILK may change with time, it is still important to recognize the wealth embedded in ILK on forest management. Consider these eminent roles of ILK in the community of Zaka in Zimbabwe which for years have been used to conserve environmental resources by regulating use of forests (Tanyanyiwa and Chikwanha, 2011). In this community some forests are set as sacred; harvesting of edible fruits is limited by defined days per week to access forest resources, clans are responsible for ensuring that they don't miss or go short of rainwater and other water supplies. With this responsibility, clans act like policemen to protect forest resources. In Zaka community, mixed farming has been practiced to conserve soils. Sacred wells have remained unpolluted and ensuring supply of clean water (Tanyanyiwa and Chikwanha, 2011; Risiro. *et al*, 2013). A lot of ILK and forest management skills have been documented to show the importance of ILK in aiding forests decisions hence management (Jackson, 2004, Stevenson, 2005, Kwame, 2007, Sharma *et al*., 2009, and Parrota, 2012).

ILK has proved its importance in systems in managing forests in various communities in Africa and outside Africa. It has managed to identify ways to minimize negative socio ecological cost in communities adjacent to forests. There is a need – therefore, to strengthen and recognize ILK to improve our forest. According to Woodwork (1995), in identifying ways to minimize negative social cost in conservation whilst maintaining and strengthening local people's entitlements, there is a need to understand the decisions made by local people in respect to their daily subsistence. Local people have a wealth of ILK which they utilize on a daily basis. They are also highly adaptive in many ways to their changing environments. Woodwork (ibid) was calling for not only recognition of IK but also for strong consideration of ILK in decisions that are influenced by other systems.

Currently there is a great use of Geospatial decision support systems tools in aiding forest conservation decisions. However, the use of these systems like - RS and GIS and other western superimposed forests conservation systems, have been in conflict as regards use and priority of use. ILK have been considered primitive and unfit to manage natural resources in favor of western systems. The argument against ILK is put in its spatial difference from one location to another and therefore bringing challenges to conservation. ILK systems are considered subjective and as being needs specific than goal oriented. Briggs (2005), argued that it is not a big step to imagine that conservation can only emerge from the application of western knowledge and that of ILK has less to offer. Forest management has relied exclusively on one knowledge system, namely, modern western system (GDSS). Hence, the dominance of this knowledge system has dictated the marginalization and disqualification of IK.

This difference in perspectives on the ILK systems and GDSS (Western systems) use in forest management can therefore be put together to aid forest decisions because both - in different location and perspective, have shown great ability in forest management. Disregard to both systems superiority, both can be integrated and harmonized to get an integrated approach or framework for aiding forest decisions. This will eventually lead to attainment of sustainable forest management. This does not mean that the two systems have never been used together in aiding forest management decisions. Sustainable forest management planning with the aboriginal people in Australia included the ILK in decision making (Stevenson, 2005).

GIS and ILK was integrated in the micro level of forest management in India (Kuriakose and Pughazendi, 2005). These were few attempts to integrate the two systems in forest management decision making. In all of these attempts the results were in favor of both people's needs from forest and forest needs from people. The integration created a sense of ownership to local people in protection of their own resource rather than government owned resource.

Either of the decision-making systems (GDSS and ILK) would consider other decision-making factors such as political, economical and socio cultural factors in deriving a decision on forest management. Of course the latter have taken much more attention of the decision makers. Here the emphasis is on the use of the two systems in a complimenting fashion while considering other decision-making factors, (Figure 5, 6, 7 and 8).

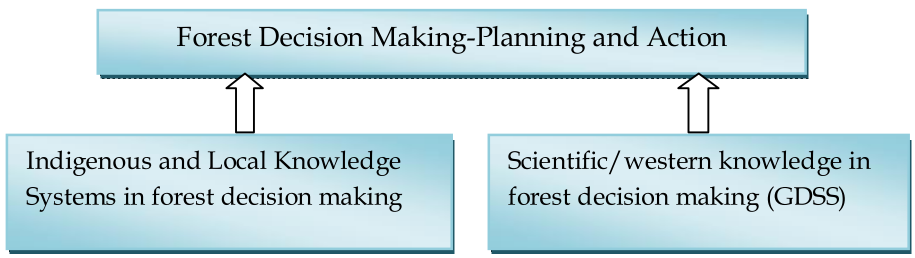

Figure 5: Forest Decision Making Model using Two Separate Approaches/Tools

In the above model (Figure 5), ILK is not merged with GDSS but both approaches are used in a separate way aiming at managing forest resources. The model presents the two approaches as non-antagonistic approaches and more complimenting one. However, this is not enough; there should also be a learning process from one another, or decision makers should learn from both of the approaches so as to gain much more decision factors and bases because learning will facilitate knowledge sharing. The process of learning from one another should start at the beginning of decision making process and build from there in order to facilitate discussions at the planning and decision making stages, (Figures 6, 7 and 8).

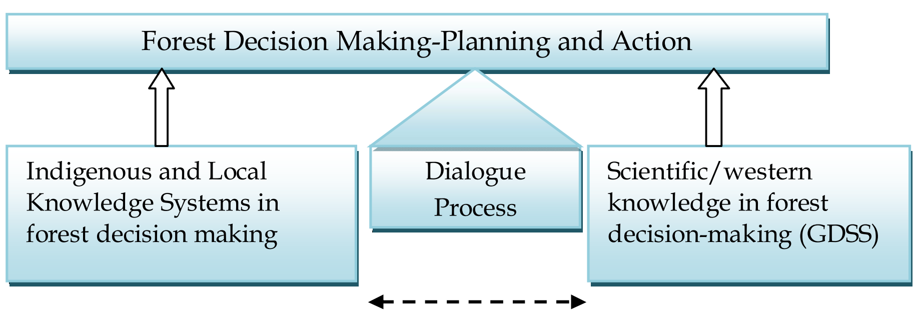

Figure 6: Dialogue process in decision-making

In this stage a dialogue process serves to take information from both ILK and GDSS for the sake of considering their integration. None of the two approaches operate independently; in reality however, decisions affecting the use of forest resources are rarely made in the absence of political and economic considerations. Indeed some would argue that, to date, the latter have enjoyed a much bigger role than "science" in forests decision making. The fact is that, in order to achieve sustainable forests management - which includes (ecological integrity, political certainty, social stability and economic viability) in forest management, serious consideration should not just be on the forest ecology, but to political, economic, social and other factors, all of which are interrelated in figure 7. Following this understanding, therefore, both ILK and GDSS either together or in isolation, consider the ecological, economical, political as well as social cultural information as of essence in forest decision-making. In the attempt to integrate ILK and GDSS in forest decision-making this paper has provided an integrated approach to forest management which is provided in figure 8.

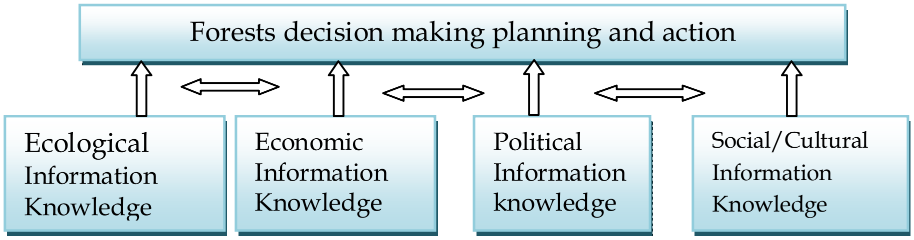

Figure 7: Factors for Forests Decision Making

The integrated approach shows

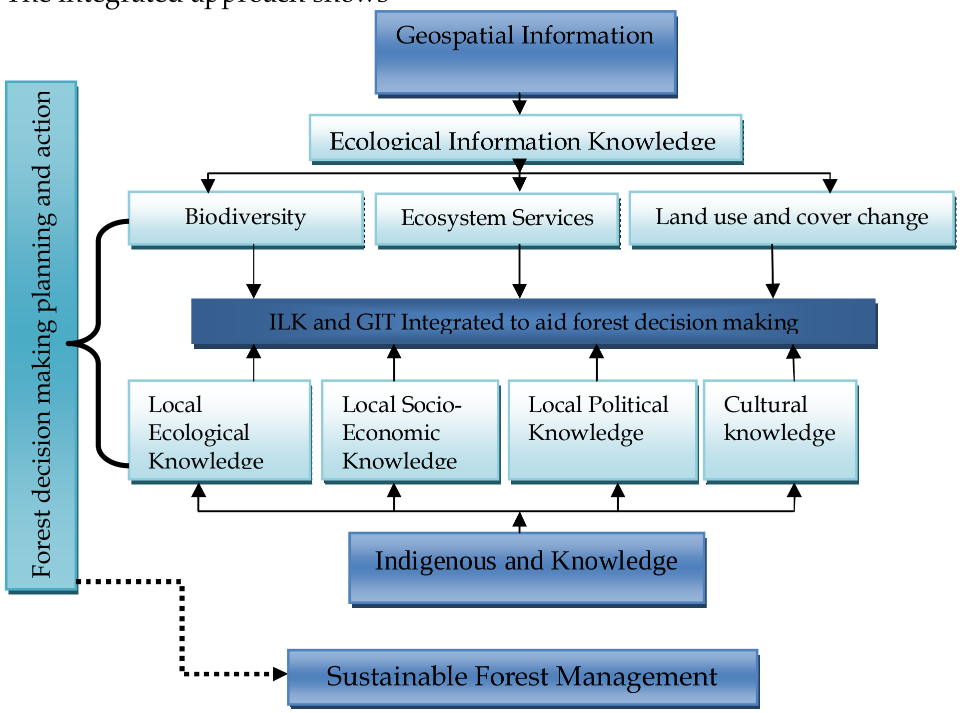

Figure 8: Framework for Integration of ILK and GDSS for Forest Decision-Making

Geospatial information technologies in this paper referred as GDSS collects data on biodiversity, ecosystem and land use cover and change. As opposed to GDSS, ILK can collect local ecological, economic, and political and socio cultural information of forest. The integration of the two therefore, makes an integrated forest decision making planning and action. The assumption made in this framework is that all ILK and GDSS are both utilised to their full capacities and both contribute data to forest decision making. Eventually this integration makes an integrated approach and lead to sustainable forest management - Figure 8.

To implement the framework, decision makers should follow the steps that may eventually allows the integration of GDSS and ILK into decision making.

(i) Gather all the indigenous knowledge related to forest resource use of the community adjacent to forest in questions. That is, to consult with Indigenous people about traditional forest use and critical habitats within their respective management areas in an effort to incorporate indigenous knowledge into forest plans and decision making. This is suggested to be the first thing forest managers should consider when in the process of deciding for forest conservation

(ii) Gather geospatial data of the forest in question using remote sensing and geographical information systems

(iii) Create a GIS database which includes spatial information of the forest in question and their associated Meta data including IK data

(iv) Map all of the significant ILK with spatial reference to spatial reference of the forest or even specific spot in the forest (e.g. Sacred/spiritual places, taboo tree species, preferred tree species for construction and other uses, wild edible fruits, medicinal plants etc)

(v) Incorporate ILK about forest variations and anthropogenic changes in a forest ecosystem to develop an alternative forest resource use and management practice

(vi) Analyse spatial forest data to get forest status information (e.g. forest cover, species content and dominance, extent of disturbance, land use etc) in association with the indigenous practice on forests

(vii) Apply ILK to forest management decision making process. However without involving the indigenous in planning and decision making process, these steps may cause problems for both parties relating to the ownership and use of the intellectual property and the forests. Unless, all these have well been pro-defined

(viii) Include the indigenous people into forest planning and the monitoring of valued forest ecosystem components and valued ecosystem would go a long way towards mitigating forest use associated problems

(ix) Incorporate indigenous people into the decision-making processes, commensurate with their needs, rights and interests. All these steps should consider the four decision making factors as stipulated in Figure 8.

The framework shows the importance of both approaches in aiding decision over forest management. However, the two approaches when used separately results into unsustainable forest management practice. Although not in all occasions the results may be worse but because IK have proven to be an important tool to manage forests it is high time now the two approaches (GDSS and IK) works in harmony. ILK has its advantages and disadvantages and so it is with GDSS. Combining them - as shown in Figure 8 above, is more advantageous than using the approaches in isolation. This is because ILK lacks technical scientific inputs to forest decision making and GDSS lacks indigenous technical knowledge to forest decision making.

Scientific approaches in forest decision making are confined to only literate people while indigenous systems are area specific so they cannot cross cut in all forest management. Because scientific approaches are confined to literate people it becomes harder to penetrate to majority local illiterate people thus leading to poor forest decision making - hence unsustainable forest management decisions. In isolation, both approaches/tools have some setbacks and if not integrated the results are unsustainable forest management.

CONCLUSION AND RECOMMENDATIONS

The extent of GDSS use in forest governance manifests itself at the central government level and with NGO's. Regions and districts face great challenges in applying the technology due to high financial costs associated with the technology and lack of enough and competent expertise. The financial challenge and lack of expertise is a national challenge hence making the use of GDSS in forest governance limited in all the forests of the country. However the little use that exists is also limited to some meta data such as ILK. There are several indigenous practices (rituals, tree species selection, and cultivation of spices) related to forest management, but these ILK's have a limited room in influencing forest management. The existing ILK needs to be verified, assessed and documented and eventually coupled with other data from GDSS on forests to aid decisions which will ensure sustainable forest management and livelihoods. The framework provided in Figures 5, 6, 7 and 8 suggests steps to be followed to integrate ILK into GDSS in forest decision making-planning and action.

Despite the challenges to integration of these two approaches (GDSS and ILK) to forest decisions, still the imperativeness remains significant so as to attain sustainable forest management decisions. This is in line with the use of diverse information and participation of local stakeholders, minimising resource use conflicts and eventually boosting economic development. There should be a serious concern in studying ILK in resource use and document it from time to time. Efforts should be put forward to having enough GDSS expertise to ensure reliable spatial data availability and use. When the two approaches complement each other - instead of overlapping, decisions on forests will be environmentally and socially sound as well as economically viable.

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