SPECIES VULNERABILITY

Potential threats to the bamboo resource

Species' vulnerability is a measure of the increased risk of extinction as a result of unsustainable harvesting or other perturbation(s). A standard definition of sustainable forest management describes it as "the process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment" (ITTO 1992a,b, 1998; see also Mankin 1998; Wijewardana 1998).

While most definitions of sustainability in this context refer to harvesting, other actions (or inaction) can also lower sustainability and raise species' vulnerability. The sustainability of a species implies that the impact of anything that affects its natural condition is so low or minimal that the species is not threatened with extinction. Thus, the low vulnerability of a species indicates that it is probably sustainable – assuming that existing conditions remain in a relatively steady state. For example, if the bamboos of Khaling-Kharungla are considered not to be highly vulnerable to extinction, then they can be harvested indefinitely at current rates and in current conditions (i.e., provided that the harvest rate is adjusted to result in negligible impact on the structure and dynamics of the plant populations being exploited or on the surrounding ecosystem; cf Peters 1994).

[21] On conflict resolution in forestry, see FTPP 1998.

We now ask – Do the current conditions, trends, and practices concerning the exploitation of bamboos from the FMU augur well for the sustainability of the species? Or, is the resource vulnerable to extinction?

Several threats to the sustainability of bamboo became apparent during the fieldwork. In addition to the commercialisation of bamboo, they include the construction of roads, imposition of the government permit cutting system, commercial logging, and livestock grazing. But, because our intuitive conclusions from the field show insufficient rigour to satisfy most scientific management planners, we sought a more analytical (and, if possible, quantitative) approach. To improve the analysis we adapted a vulnerability assessment system from the literature (Wild and Mutebi 1996), modifying it to allow a more quantitative mode of analysis. By this means, we gain a clearer appreciation of the various threats to bamboo, and of their severity. From the analysis that follows, a planner can make relatively more precise predictions and plans to manage and maintain plant resources and surrounding ecosystems sustainably; and can take remedial action where required.

The result of our analysis is summarised in the 'Rapid Plant Vulnerability Assessment Checklist' in Table 5. The checklist is based on a set of categories within which specific threats to a species are discussed and scored (ranked). This system identifies the most important trends.

To begin the vulnerability ranking process, we have defined and discussed thirteen categories of potential threat. Note that there is partial overlap between some categories.

A discussion of factors affecting the sustainability/vulnerability of bamboo

In the following discussion, the bold definitions in quotation marks that introduce ten of the 13 categories (Nos 1 to 7 and 10 to 12) are derived from Wild and Mutebi (1996). For more clarity, some additional descriptions have been paraphrased, with slight modifications from the original. To the original list we have added three new categories (Nos. 8, 9, and 13) that broaden and strengthen the analysis. The definitions that introduce these three new categories are our own. Our ranking of relative vulnerability is shown in parentheses for each category in the discussion, as they appear in Table 5.

Natural conditions and species' life

Life form and provenance

(1) Reproduction and longevity (LOW vulnerability)

> "**Long-lived, slow-reproducing species are more vulnerable than short-lived, fast-reproducing ephemeral species.**" (Life form refers to the ecological characteristics of a species, such as growth rate, reproduction, and longevity.)

Observations: The data indicate that the most likely bamboo life form vulnerability at Khaling-Kharungla may occur in the sexual stage, when the plants flower and die. The most serious problem occurs as seedlings come up and are eaten by cattle. Traditional cutting and harvesting are not as critical as grazing during the seeding stage after flowering (July to September). If a generation of seedlings is eaten, there is no other source for growth and regeneration. Our data indicate that this is not the case to date and that regeneration has been ample.

A further risk may occur if the resources are very heavily harvested, limiting the number of shoots available to bear flowers.

(2) Habitat (NIL)
"Species with very narrow habitat requirements are likely to be rarer and more vulnerable."

Observations: None of the bamboo species studied has a very narrow habitat; therefore there is no vulnerability in relation to habitat specificity. These are frost-hardy species, and there is plenty of room for them to flourish. Furthermore, the habitat of the most highly-valued species, *B. grossa*, is not seriously affected by logging (which occurs below it in elevation).

(3) Growth Rate (LOW)
"Slower growing species will be more vulnerable to use."

Observations: The growth rate of all three species is fast. They grow approximately two metres per month in their first year. Mature size is achieved in about five months during the first season and growth in height is finished by October. In the second year they grow branches and more of a crown, and they thicken and become more lignified (harder, stiffer). Under ideal circumstances, therefore, growth rate should not be affected.

(4) Abundance and Distribution (LOW)
"Abundant widely distributed species are less vulnerable to overuse."

Observations: These three bamboo species are widely distributed throughout Bhutan (in and out of the study area). In eastern Bhutan they flourish throughout the same elevational ranges and rainfall regime, in the same forest type (cool broadleaf), and also within conifer forests.

Use and demand

(5) Parts Used (MODERATE)
"The part used significantly affects sustainability... If a certain size, age, or quality of a plant is used, the remaining population may ensure the survival of the species. But there is a risk that ecological assessments may indicate a higher availability than the more selective resource user assessment and lead to an overestimate of supply."

Observations: The parts used significantly affect sustainability, based on harvest index (the ratio of useful parts to biomass). In general, the moderate use of fruits, nuts, or leaves of plants has the least impact, while the use of twigs, branches, bark, stems, and roots, in that order, has more impact on longevity and reproduction. Consistent use of the whole plant leads to local extinction.[22]

If care is taken in the pattern of selection and use of the bamboos, by size, age or quality, and by time and season, the remaining population may endure, survive, and procreate. The term 'care' implies reliance on rational management, whether indigenous or scientific (noting that many indigenous management systems are scientifically sound), or some combination.

(6) Demand (MODERATE)

"The level of demand has a major impact on the plant. Demand is made up of two factors – the quality harvested and the frequency of harvest."

Observations: The demand on a resource is also influenced by a number of other factors, some of which may be entirely out of the control of local people or scientific managers. They include human population growth and a consequent change in need and demand, levels of supply (resource quantity and availability), resource access (easy or difficult), seasonality, permit systems, available substitutes, market tactics, and so on. Demand, of course, tends towards selecting the best of the resource, which, if harvested in excess, may influence the quality of future regeneration.

While bamboo mats are in great demand throughout eastern Bhutan, local informants observed that the pressure on the resource (hence its vulnerability) may fall off somewhat with the recent introduction of strong plastic-coated tarpaulin material. It is thought that the placement of tarpaulin sheets with mats repels moisture and fungal infestation, increasing durability and lifespan of the mat for up to three years. If this is the case, demand for bamboo mats should decrease commensurately, assuming that other factors (like population growth) do not interfere. The long-term effect of this substitute on demand, however, has yet to be determined.

Frequency of bamboo harvesting to meet demand is, therefore, not a serious issue, unless it leads to immense over cutting, or to harvesting during the most vulnerable season for young plants (July to September). So far, this appears to be only a moderate threat.

(7) Substitutes (LOW)

"The availability of substitutes affects species' vulnerability by reducing demand."

Observations: The typical eastern Bhutanese house roof is covered by 25 mats. The cost of roofing a typical house at Wamrong or Khaling, including materials, labour,

[22] In the coppicing species of *Daphne*, for example (in the harvesting of which the bark is stripped and used for making traditional paper), it has been determined that removal of bark down into the rootstock increases vulnerability (decreases plant survival), while removal of the bark down to a point a few centimetres above ground level reduces overall vulnerability, allowing regrowth by coppice (Messerschmidt 1988 and personal observation).

and so on, is conservatively estimated to be Nu 2,000.[23] By comparison, a corrugated metal roof on the same house would cost around ten times that amount, or about Nu 20,000. Where a mat roof lasts about three years, a metal roof lasts up to 12 years for the best quality (Table 4).

Table 4: **Comparative prices for house roofing in communities near Khaling-Kharungla FMU**

Roofing material	Approximate cost*	Duration
Bamboo mats	Nu 2,000	3 years
Corrugated metal	Nu 20,000	7 to 12 years (varies by quality)
Other	n/a	4 years (softwood)
(e.g., wooden shingles or shakes – though not locally available)		12 years (hardwood)

*Given an average size house, the costs in column 2 include the roofing materials plus labourers' wages, meals and refreshment.
Source: Field notes

Thus, in the short run, the difference in immediate cost of mats over corrugated metal roofing provides an important economic incentive to favour continued use of bamboo mats. For the majority of local people, mat roofing is the only option, as metal roofing materials are prohibitively expensive since enough cash or savings to purchase them is not easily acquired. Local people say that because bamboo mats are easily accessible and relatively inexpensive, bamboo is their first choice among the options. There are also aesthetic and cultural considerations which favour bamboo mats over metal roofing materials (although these are not often voiced).

As noted earlier, commercially available plastic-coated tarpaulin sheets have come into use recently in association with bamboo mats, potentially lengthening the period of use of the mats. We have no firm data, however, on the incidence of tarpaulin usage, nor of the actual increased lifespan of mats.

Similarly, but to a much smaller extent, corrugated metal roofs may also reduce the need for matting. So far, however, the number of metal roofs in the area is low, although an increase in their use has recently been noted at Khaling town.

Social, cultural and economic effects on a species

Basis of management

(8) Traditional management – presence: low, absence: high (HIGH)
"Traditional management, if based on indigenous knowledge of a resource (and has sound scientific utility; often it does), reduces resource vulnerability."

Observations: In many communities of users, there are individuals ('local experts') who have intrinsic knowledge about species' reproduction, longevity, and seasonality, and of the parts and products used. This knowledge exists at Khaling-Kharungla where,

[23] This figure of Nu 2,000 is derived from the following calculation: 25 mats x Nu 50 each + salary for 7 days' labour @ Nu 50/day + 3 meals and refreshments. The house owner typically hires six or seven labourers, and together they usually accomplish the task in one long day

in the past, it has been used to inform traditional management decisions, particularly resource protection (under ridam), harvesting practices, product design, supernatural sanction, and other sociocultural and economic aspects of the species, its use, and its environment.

Indigenous knowledge tends to be holistic, and although it may not be expressed (by the locals) in scientific terms, the richer or greater (robust, long-lasting) it is, the more likely it is to have real scientific management value (see DeWalt 1994; Duffield et al. 1998; Grenier 1998; Ortiz 1999; Warren et al. 1995). Traditional management often promotes species' protection over silvicultural management. At Khaling-Kharungla the indigenous ridam system was used to restrict access and use of the species on a seasonal basis, backed up by belief in supernatural sanction. Such systems tend to enhance species'sustainability and reduce vulnerability.

However, when commercial pressures or other outside influences impinge, and harvesting demands on a traditionally protected resource increase, indigenous knowledge and traditional management systems tend to break down. Outside pressures often undermine their utility, respectability,and efficacy, whereupon local tradition is lost (and it, like the resource it was meant to protect, also becomes vulnerable).

During the field research, local bamboo harvesters and mat-makers were engaged in focus group discussions and expert interviews, but precisely how much they know and the quality of their knowledge (i.e., depth of understanding) is still uncertain and needs further study. Some knowledgeable people expressed the belief that the bamboo has been over cut and its accessibility diminished (they must go further into the forest to find it, compared to the past). They now feel that some areas should be periodically closed to harvesting combined with reinstatement of the indigenous ridam system of protection.

Since 1997, a simple rotational system has been imposed by local leaders at Khaling-Kharungla. For example, at the time of our study the bamboo resources in Khaling Block (near Brekha and Bephu villages) were closed to cutting. After a few years, we were told, the ban would be switched over to Lumang Block (near Wamrong town). Local leaders also expressed a desire to see both the rotational access scheme and the indigenous ridam system incorporated into an amended FMU Operational Plan.

It is questionable, however, if rotation will make any difference. The resource in the reserved area will not be used; hence, an increasing proportion of culms will become old. The only perceivable advantage would be that, if flowering occurred in the reserved area during a closed year, there would be a full flowering, compared with limited flowering on residual shoots in areas where cutting was allowed. (Reservation does not affect total supply, only its age.) Apart from that, the only effect would be to limit supply to that available from the unreserved area; but this, in turn, may lead to over-cutting in the open areas. (A better solution might be to allow cutting within both areas, i.e., over the whole resource, in a more controlled manner; or, possibly, to time closures to correspond with the species' years of sexual reproduction).

Finally, it is interesting to note that the ridam-imposed seasonality fits neatly with the biology of the plant. The most naturally vulnerable time for young shoots is the summer season which was traditionally closed to harvesting.

(9) Scientific management – presence, low; absence: high (HIGH)
"Where reasonable policy is in place and sound scientific management is practised, based on objective and in-depth scientific knowledge, the vulnerability of a species should decrease."

Observations: This dictum assumes that good management policies exist, that scientifically-informed guidelines are followed, and both policy and management are based upon in-depth understanding of a species under various conditions of use or abuse (and that no contradictory socioeconomic or political tradeoffs are imposed). Where neither scientific management nor traditional management exist (the current situation in regard to the bamboos of Khaling-Kharungla), vulnerability increases dramatically.

Commercial effects and other outside influences on a species

Harvesting and commerce

A number of outside conditions and demands tend to affect the vulnerability of a species in terms of reproduction and longevity, parts and products used, and the decisions and tradeoffs that go into policy and management decisions. They include the following (Nos 10-13).

(10) Seasonality – as related to use and demand (HIGH)
"Demand may be reduced if harvesting is restricted to seasons."

Observations: Some species are highly vulnerable if critical seasonality is ignored. Care must be taken with species like bamboo not to harvest them during the flowering or seeding seasons. Traditional and scientific management practices usually take seasonality into account, restricting human access accordingly.

Bamboo harvesting is conducted during the dry winter season when agricultural field work is at a minimum, access to the forest is easier, there are no leeches (which inhibit human access), new seedlings are at least risk, the weather is dry, and the mats can be made under dry conditions (limiting fungal infection).

Vulnerability based on seasonal harvesting can be more complicated than this, however. If the issue is expanded to all seasonal perturbations which impact on bamboo life form vulnerability, then there is cause for concern. In the past, no access to the forest was allowed during the season of highest life form vulnerability, July to September; while, today, human access to the forest is uncontrolled and cattle grazing is unregulated.

(11) Response to harvesting – as related to life form (MODERATE)
"The ability of a species to regrow or increase its growth rate as a response to harvesting affects its vulnerability."

Observations: Over-harvesting, under commercial pressure or in the absence of good knowledge of a species' life form, can have devastating effects and may lead to local extinction. Thus, ability of a species to regrow or increase its growth rate as a response to harvesting directly affects its vulnerability.

In the study area, all bamboo species reshoot vigorously and grow well after cutting. For next year's harvest, young shoots are preserved with little harvesting.

Local people mostly harvest second year shoots, and take some care not to damage younger ones. But, our informants also said that some cattle grazers allow their animals to browse freely and cut the tender shoots for fodder (though illegal). Nonetheless, the remaining population of bamboos should ensure survival of the species.

A risk does occur, however, in the year before flowering and seeding. That is, if everything is cut down including second and third year culms, the plant cannot flower or seed. If management ensures that some culms are left, vulnerability is minimised. So far, this is uncertain, but it looks as if harvesters take some care in the matter, knowing that future resource availability depends, in part, on their watchfulness and constraint.

(12) Commercialisation – as it affects intensity of use and demand (HIGH)
"The ability of a species to regrow or increase its growth rate as a response to harvesting affects its vulnerability."

Observations: As a resource comes under the pressure of commercialisation, expanding away from subsistence use, unsustainable demand (hence, vulnerability) increases. Rational management (whether on traditional or scientific principles, or a combination of both) can ameliorate this pressure, increase a species' sustainability, and reduce its vulnerability.

The commercialisation of bamboo products in the study area is a relatively recent phenomenon. From 1979 onwards, the contract permit system rapidly opened up the resource to market-driven commercialisation. Currently, many of the dealers who contract locals to extract bamboo come from outside the local area.

As noted earlier, the overall production and sale of local bamboo products is measured in 'truckloads' of 150 mats each. Villagers estimate that the equivalent of 20 truckloads of finished mats are for local consumption, against nine for commercial use. At first glance, this may not seem like a great increase or serious threat. Based on a dramatic recent rise in commercial output since the permit system was introduced, however, we now calculate an increase of nearly 50% commercial truckloads over local consumption. The increase is, in fact, even higher because some local non-contract cutters sell mats independently to commercial buyers.

Currently available data show that between 1991 and 1997, 684,660 culms were extracted under commercial permits (Table 3). The average annual cut during this period was 97,809 culms. Since 1994, however, commercial demand increased to an average cut of

124,123 culms per year. Thus, the annual commercial cut more than doubled from 1991 to 1997 (a 105% increase). This, in turn, indicates a considerable threat, hence high vulnerability of the species from this factor.

(13) Other factors – as they relate to access and intensity of use (HIGH overall)
"In each circumstance in which a vulnerability assessment takes place, other interactions may occur to affect species vulnerability."

Observations: Some examples are **road access** which may increase product off-take, as well as **grazing, logging, mining, burning,** and **recreational activities**, that may expose a species to other threats which endanger the remaining growing stock. Each such factor should be carefully examined, although assessing their individual effects is largely a judgment call on the part of the observer. Different perturbations may be identified in relation to other species. Resource vulnerability may be potentially high in relation to some or all of them.

Roads (HIGH)
"Roads increase access, hence vulnerability."

Observations: Local roads include the National Eastern Highway (open since 1962) and the forest access road (started in 1997). Road access has increased bamboo vulnerability from commercialisation, attracting contractors and opening up markets where none existed before.

Road access coupled with the implementation of a commercial contract permit system since 1979 and local population growth has raised demand, with a consequent decline in resource availability. Informants are quick to point out that prior to the road there was less demand and more abundance of bamboo. As demand increases, vulnerability is increased.

Grazing (HIGH)
"Uncontrolled grazing increases vulnerability."

Observations: The key variable is the presence or absence of effective control over herders and livestock. Herders often cut leafy branches for fodder and allow their cattle free range to browse in the bamboo areas. Herds of sheep also graze in parts of the FMU area during the winter. How much sheep grazing affects the vulnerability of the species, or even if they graze the bamboo thickets, is not known.

Grazing of established vegetatively reproducing bamboo clumps seems to have little impact on survival of bamboos. The vulnerability of bamboo to grazing comes when the seedling production cycle takes place. Since the vegetative generation dies off following seedset, the survival of the bamboo relies solely on successful germination and growth of the seedlings. If these are all eaten by cattle or sheep, the bamboo will quickly disappear and will probably be replaced by aromatic broadleaved weeds and unpalatable trees like *Symplocos* spp.

Grazing of young culms, while not killing the clump, will mean that those culms will not be available for harvest in the following year.

Logging (MODERATE)
"Logging, to the degree that it impinges on the resource in question, increases species' vulnerability."

Observations: Logging impact in the study area is limited by the fact that the most important bamboo species, *B. grossa*, grows at altitudes above the existing and potential logging cable lines. (The first two skylines are largely in bamboo but it is the little used species of *C. callosa* that is present. The next three skylines reach the lower side but do not extend up into the more useful *B. grossa*. Cable lines planned for installation past the first five are not yet open and fall outside the study area.

Our basic conclusion is that logging should not be a problem in a direct sense, and only indirectly given that the forest road is opening up the area to easier access. The FMU Operational Plan should be amended to be sure that *B. grossa* is not adversely disturbed in any cable lines; there is little timber of any commercial value associated with it. The least important species, *C. callosa*, may be induced to grow down into the cleared logging areas, thus with no obvious vulnerability. (The presence of *C. callosa* in harvested cable lines, however, will make it very difficult to successfully plant and maintain broadleaved tree seedlings as prescribed in the FMU Management Plan.)

Other potential threats (NIL)
"Other vulnerabilties must be examined on a case by case basis."

Observations: Other potential threats in the study area may include alternative land-use practices such as slash-and-burn agriculture ('tseri'), the permanent conversion of forest areas into agricultural production, the uncontrolled harvesting of associated species other than timber, as well as hunting, burning (forest fire), mining, and recreational activities. We detected no threatening activities among these options.

Based on the above discussion, we can rank the thirteen categories on the 'Rapid Plant Vulnerability Assessment Checklist' (Table 5). The ranking proceeds as follows.

1. Potential threats are ranked categorically by placing a check mark in the appropriate column. (In column A, nil or no vulnerability, the rank is 0. In B, low vulnerability, the rank is 1. In C, moderate vulnerability, the rank is 2 and, in D, high vulnerability, the rank is 3). Note that there are no 'killer' categories; in extreme cases of threat check column D.
2. Count the checkmarks in each column and multiply by the value indicated for each column. Enter these totals where indicated.
3. Add together the total values from each column to produce an overall score.

Table 5: Rapid Plant Vulnerability Assessment Checklist

For each category, rate species' vulnerability by marking with a check '✔' in the appropriate column, then sum up the columns for the overall score.

Column	A	B	C	D
Category	NIL 0	LOW 1	MODERATE 2	HIGH 3
Natural conditions and life effects on a species				
Life Form and Provenance				
(1) Reproduction & Longevity		✔		
(2) Habitat	✔			
(3) Growth Rate		✔		
(4) Abundance & Distribution		✔		
Use and Demand				
(5) Parts Used			✔	
(6) Demand			✔	
(7) Substitutes		✔		
Sociocultural and economic effects on a species				
Basis of management				
(8) Traditional Management				✔
(9) Scientific Management				✔
Commercial effects and other outside influences on a species				
Harvesting and commerce				
(10) Seasonality				✔
(11) Response to Harvesting			✔	
(12) Commercialisation				✔
(13) Other Factors				✔
Column Totals:	0	4	6	15
GRAND TOTAL (Sum of columns A,B,C,D)				25

less than 13:	**low vulnerability**
14 to 26:	**moderate vulnerability**
more than 27:	**high vulnerability**

Overall assessment of bamboo vulnerability in the Khaling-Kharungla Forest Management Unit, eastern Bhutan: MODERATE TO HIGH ✔

Adapted with modifications from Wild and Mutebi 1996

A score of 0 to 13 implies low vulnerability and is no cause for alarm. A score of 14 to 26 indicates moderate vulnerability and remedial actions to reverse the trend may be necessary. A score of 27 to 39 reveals high overall vulnerability and a high probability of extinction unless immediate action is taken to halt or reverse the trend.

Using this ranking system, we assess the vulnerability of bamboo species of Khaling-Kharungla FMU in eastern Bhutan at an overall rank of 25: **moderate to high**.