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20 Planning, appraisal and risk analysis in clonal forestry projects

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Abstract

Clonal forestry, clonal forestry projects and clonal forestry project planning are described as a means for establishing standard and accepted methods for defining resource allocation priorities. Many clonal forestry projects fail to be approved, not because they are not economically efficient, but because they are planned and appraised in a vacuum of the decision maker's preferences. From this analytical framework the approach to the economic appraisal of clonal forestry projects is described and standard methods for the correct valuation of their costs and benefits are introduced.

Among the various elements of project appraisal, profitability criteria used to rank projects are discussed. The rules when evaluating mutually exclusive projects are laid down with special reference to the estimated productive life of an investment.

Having dealt with risk-free cases first, the study then describes the treatment of risk and uncertainty in project appraisal. A distinction is made between the

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treatment of risk, which can be assessed quantitatively by expressing it in terms of the probability of a certain event occurring, and uncertainty, which is essentially indeterminate. Not only is a given event unreliable (uncertain), but its degree of unreliability is also unknown. Traditional methods of dealing with risk include adding a premium to the discount rate, upward – downward revision of prices and costs, and introducing subjective probabilities into the calculation.

More recent and less traditional views on the treatment of risk are also reviewed, including: (a) the need to take into account the decision-maker's attitude toward risk, (b) the use of certainty equivalents in addressing risk premium issues in discount rate computation, (c) the use of scenario techniques in conjunction with multi-attribute utility theory to integrate multiple risks in multi-objective forest planning, (d) discounting risky cash flows using a weighted average cost of capital, (e) connecting the Faustmann's formula for land valuation in forestry (first announced in 1849) with recent attempts to incorporate biological and economic risk into the same problem, etc.

Finally, the rules for the treatment of uncertainty in project appraisal are described and a 5-step practical approach to undertaking risk analysis in forestry investments is provided. The latter includes:

- *Delineating the system*
- *Identifying Potential Hazard Factors*
- *Assessing Hazard Factor Damages and Probabilities*
- *Estimating the Impact of the Hazard Factor Probabilities and Evaluating the Threats*
- *Managing the Risks Identified*

Clonal forestry

Clonal forestry involves the multiplication of individual tree genotypes, and deployment of these clones (i.e. groups of genetically identical individuals) for the purpose of establishing fast growing and more effective plantations. Deployment is generally in blocks of selected individual or mixed clones, to enhance efficiency and quality of growing timber stands, Sometimes a mix of a few selected clones is deployed in an attempt to more closely mimic natural patterns of genetic variation over the landscape.

Clonal projects

From an economic standpoint, clonal forestry projects are no different than other forestry projects. They typically involve the allocation of scarce productive resources, usually forest land, capital (including technology), and forestry labor, for maximum sustainable economic efficiency [1;2;3].

Government-led clonal projects will tend to be located in public lands and focus on a mixture of business, social and environmental goals. The direct business or financial goal will be similar to that of private enterprise i.e., to maximise the market value of assets within a sustainable development framework. Within this context, clonal forestry projects can be reduced to a profitability decision, and to the subsequent implementation and on-going management of the chosen project, usually in perpetuity and for maximum sustained yield.

Project planning

For properly planned clonal forestry projects, one must have a fairly good idea of the goals sought, timeline involved, inputs required (including R & D and technology), and flow of expected benefits and costs throughout the project life. While economic principles should prevail throughout the planning and appraisal process, there are also political and social considerations that are essential. The *sine qua non* political and social condition that must be met, is that projects fit with broader state and regional development plans, and that they are conceptualized, defined and appraised within the context of "a standard and accepted method for establishing priorities" [4;5;1;6].

A frequent handicap in public project planning and selection is the lack of uniformity in criteria between Government ministries (usually representative of economic sectors) and/or regional development agencies (usually responsible for local planning and administration. At times, conflicting criteria may exist between departments of the same ministry or even sections of each department. This lack of uniformity would seem to arise from conflicting present and past political decisions, from preconceived ideas about certain types of investments, or simply from particularly strong personalities among officers and administrators.

Without a standard and accepted method for establishing priorities, the project planner may find itself at odds with the decision maker (DM). Many Government projects fail to be approved, not because they are not economically efficient, but because they are planned and appraised in a vacuum of the DM's preferences.

Project appraisal - Valuing costs & benefits

Profitability criteria

How should investments in clonal forestry be appraised and evaluated? As stated in “Clonal Forestry” above, the answer is no different than for other investments in forestry or, for that matter, in other sectors of the economy.

In evaluating and comparing investments, analysts often calculate an investor's maximum "willingness to pay" (maximum bid price) for specific assets or financial ventures. In forestry, such ventures might be the acquisition of forests and forest land, wood processing facilities, forestry companies; or, on available land, investments in projects such as afforestation (e.g., with clonal inputs), intensification of forest management, pre-commercial thinning, fertilization, etc. The standard method used to estimate the "willingness to pay" is to calculate the net present value (NPV) of projected costs and revenues for the investment, i.e., the present value of future revenues minus the present value of future costs [7;2;8].

Put another way, when analyzing an investment option, a table can be drawn up showing the receipts and the expenditures to be expected during each year of the project’s lifetime and, thus, the profits it would yield. Hence, all investment becomes an exchange between future receipts and present or forthcoming expenditures.

As shown by Casasempere [1], the choice among a number of investments reduces simply to that between cash flows. The appraisal of these cash flows necessitates a solution that can grade them to a single point in time. The method for adjusting time streams for temporal differences in their present or current value is discounting. By virtue of discounting, costs and revenues are reduced to their present value by a given annual percentage margin (rate of interest). This discount rate represents the opportunity cost to the investor of using his resources in one particular way **rather than in the next best alternative.** It is the rate that reflects the present financial returns that have to be foregone by waiting and the general unwillingness to put off profitability until later.

Three criteria for presenting the discounted flow of expenditures and receipts or **discounted cash flow (DCF)** have long been in use and continue to be applied [1;7].

a) Net Present Value (NPV) is obtained by discounting both costs and revenues at a specified rate (often the market rate of interest), and then subtracting the resulting present value of the cost stream from the present value of the revenue stream. Alternatively, current expenditures can be subtracted from current receipts to give a net revenue for each year. The net revenues are then discounted to the present and added. Ignoring risk (addressed later) it is financially acceptable to make any investment which results in a positive NPV. The mathematical expression of this criterion is:

$$NPV = (Ro - Co) + \frac{(R1 - C1)}{(1 + r)} + \frac{(R2 - C2)}{(1 + r)^2} + \ldots\ldots\ldots \frac{(Rn - Cn)}{(1 + r)^n}$$

$$\text{or } NPV = \sum_{t=0}^{t=n} \frac{Rt - Ct}{(1 + r)^t}$$

Where:
R = gross revenue
C = gross cost
R = discount rate expressed as a decimal
T = time interval
0, 1, 2, 3, n = years of the project's life

The NPV value is an absolute measure of profitability. It can easily produce a high value simply because the investment is very large. This criterion does not measure the relative efficiency with which different size projects use resources.

b) Internal Rate of Return (IRR) is the discount rate which makes the present value of the cost stream equal to the present value of the revenue stream, or as is sometimes defined, the rate which reduces the discounted net profit to zero. To compute the IRR one solves the equation:

$$\sum_{t=0}^{t=n} \frac{Rt - Ct}{(1 + r)^t}$$

In a riskless situation, it pays to invest if the IRR exceeds the rate of interest (or cost) at which capital can be borrowed or secured as equity to execute the project, or exceeds the rate (financial yield) that could be obtained from alternative investment opportunities, whichever of the two is higher.

c) **Revenue/Cost Ratio (R/C)** is obtained by dividing the (discounted) present value of the revenue stream by the present value of the cost stream. A variant of this criterion, the net revenue – cost ratio (NR/C), is obtained by dividing the present value of net revenues by the present value of costs.
According to the revenue/cost ratio, a project is worth undertaking when the ratio is greater than one, the larger by which the ratio is greater than one, the larger the ratio, and the more efficient the project. Based on the net revenue - cost ratio, a project is worthwhile when the ratio is positive.

Both the IRR and the revenue/cost ratio measure the efficiency with which resources are employed irrespective of the size of the investments. When projects are not mutually exclusive, ranking by efficiency will result in the largest overall financial gain. The revenue – cost ratio, however, is technically superior, since the IRR can give an incorrect result in special circumstances, i.e. multiple rates in the presence of a NPV function for which the stream of net revenues becomes negative more than once. The practical advantage of the IRR, and one that should not be ignored, is that (assuming it does give the correct result) it is more familiar to businessmen and administrators. It is in fact the correct way to calculate what is loosely known in financial circles as the “yield”.

Mutually exclusive projects and life of the investment

When projects are mutually exclusive so that only one can be chosen for implementation, ranking by relative efficiency criteria, may be incorrect. For example, if adequate funds are available at a fixed rate of interest, it will be usual to seek investment opportunities which produce the maximum NPV. However, if the opportunities for investment are limited – e.g., if there is only a limited area of land that can be afforested, or a limited supply of raw material available for processing – then the project which gives the maximum NPV may not necessarily be the most efficient.

If the investments are repeatable and have different duration, their NPV should be compared over the same length of time to be valid. This is necessary because each investment life may generate a different stream of costs and revenues. In forestry projects of long duration (not an unusual situation) it may be more advisable to use infinite time streams.

A common time period is also necessary with the IRR. Although this criterion employs a NPV of zero, and profits can always be reinvested at the market rate of interest, investments should be considered over the life span of the largest project and explicit consideration should be given to the reinvestment of intermediate returns.

Risk and uncertainty

Traditional treatment of risk

The discussion so far has dealt with riskless cases only. There is no single correct method of allowing for risk. The Organization for Economic Cooperation and Development (OECD) classifies the risks of investment into three categories:

- Risks which can be measured in terms of a probability coefficient related to each possible situation, e.g. economic activities subject to climatic conditions are uncertain, but known in terms of probability.

- Risks relating to a future situation which cannot be measured in terms of probability, but which depend on a single event or limited number of events such as the outcome of political negotiations, scientific discovery, etc. This is what may be more properly called “uncertainty.”
- Risks due to ordinary mistakes in forecasting and planning.

The inherent quality of risk is that it can be assessed quantitatively by expressing it in terms of the probability of a certain event (result) occurring. Uncertainty, on the other hand, is indeterminate. Not only is a certain event unreliable, but also its degree of unreliability is unknown [1].

The theory of choice under uncertainty remains one of the major subjects of controversy in economics, and there is considerable disagreement between economists and statisticians on quite fundamental issues. Therefore, it is difficult to determine the most efficient way of dealing with risk and uncertainty in project appraisal.

There is no unique approach to the treatment of risk and uncertainty in a theoretical context. There are, nonetheless, several popular methods that have been used successfully in project appraisal in the past [1]. They include:

a) Adding a premium to the discount rate

Depending on the degree of risk involved, a premium may be added to the discount rate to reflect the uncertainty of future costs and benefits in present value terms. This is a popular method with the private sector, which is assumed, largely in the face of uninsurable risks, to function under conditions of greater uncertainty than the public sector. While the uniformity of this criterion has advantages in terms of preventing subjective and irrational preferences from biasing the result, there is the corresponding disadvantage that risks do differ between cash flow items and projects and that they can, to some extent, be broken down for separate consideration instead of being lumped together in an overall risk allowance.

b) Upward – downward revision of prices

Under conditions of uncertainty for specific project prices, a popular method to deal with risk is to adjust downward the expected future output prices and/or to adjust upward the expected future input prices.

c) Introducing subjective probability into the calculation

This is a common approach for evaluating investments. The procedure allows for risk and uncertainty by estimating, in addition to the most likely future price of each input and output, both an upper and lower limit. In this manner, a triplet of cost-revenue estimates can be obtained: **a most optimistic, a most likely, and a most pessimistic estimate** of the net revenues in each time period. This method, unfortunately, does not give a good idea as to the likely chance of each estimate occurring.

A more thorough approach to the informed guesses method is possible by attaching to each of the three price outcomes, the most optimistic, the most likely and the most pessimistic, **the conjectured probability of them occurring**. The resulting treatment of risk cannot, of course, be more accurate than the subjective estimates of price probabilities. However, it does bring out the full implications of the estimates.

More recent views on the treatment of risk

Other economists have recently researched the treatment of risk in forestry and have come up with the following ideas:

- According to Pukkala and Kangas [9].

*"**Risk** refers to a situation in which the probabilities of the possible outcomes of a decision alternative are known; if the probabilities are unknown one speaks of **uncertainty**.*

……….The main sources of risk in forest planning include success of regeneration, growth, survival of trees, and economic situation, especially timber prices. A planning approach that corresponds to the real-life situation is stochastic rather than deterministic. By using the distributions of outcomes of decisions, the risk associated with the various alternatives can be dealt with analytically.

*Numerous approaches have been presented for dealing with risk in forestry decision-making. However, the theoretical possibility of dealing with risk is not enough for supporting practical decision-making. If the decision alternative that maximizes utility is sought, **the decision-maker's attitude toward risk has to be taken into account**. A risk-avoiding person does not choose the same plan as a risk-seeking or a risk-neutral person.*

- Klemperer [2] notes that the U.S. Office of Management and Budget (OMB) recommends that government projects and their expected values be appraised with a **10% real risk-adjusted discount rate**. The figure is a reflection of the average before-tax rate of return on private capital in the United States at various risk levels. He warns, however, that not all U.S. agencies follow the OMB guide. For example, the U.S. Forest Service adopts a **4 percent real discount rate**.

The OMB argues for higher discount rates on the basis that Government projects should earn as much as private ones. If that were not to occur, capital would shift from higher rates of return (more efficient use) to lower rates of return (more inefficient use). The problem with the OMB strategy is that the 10 percent real discount rate applies to investments of average risk and average duration, and forestry projects are not average. In general, it would appear that the OMB's high discount rate would tend to be biased against low-risk investments and in favour of high -risk projects.

Klemperer addresses the risk premium question by employing **certainty-equivalents**. He uses a simple algebraic formulation and demonstrates that for any given perceived risk level, the correct risk premium for the discount rate declines with increasing payoff periods. As a result he suggests that the further that revenue from a risky venture is in the future, the lower the correct risk-adjusted discount rate (RADR) should be, given the same degree of risk and risk aversion. Thus, he observes, that "forestry's long production periods may often require lower RADRs than average short-term industrial RADRs".

Finally, Klemperer concludes that there is no such thing as the correct RADR for forestry's expected values. "In reality, a different RADR should be used for each cash flow, depending on its probability distribution, on its time from the present, and on the decision-maker".

Given the difficulties in identifying the appropriate RADR, it seems appropriate that a process of explicitly modeling risk in the cash flows would be worthwhile pursuing.

- Pukkala [6] uses a scenario technique in conjunction with multi-attribute utility theory to integrate multiple risks in multi-objective forest planning. He divides the risk sources into three categories: risks related to inventory data (including growth and yield), risks arising from unknown future states of nature, and risks associated with the decision maker's preferences. Pukkala uses the novel approach of integrating the decision maker's attitude toward risk in planning by means of the distribution of a weighed utility index. The utility index is computed from an additive utility function and optimization is done using a heuristic algorithm. They show that the choice of a forestry plan is not only affected by risk but also by attitude toward risk.
- In a later publication, "Risk Analysis in Forest Management", Klemperer [10] suggests discounting risky cash flows in private projects using a **weighted average cost of capital (WACC)**. When raising funds for investment, a private firm can borrow capital from lenders or issue new shares of stock. In the first instance it will have to pay interest (cost of debt) and in the latter it will be required to pay dividends (cost of equity). Equity is the share of ownership which shareholders have in the firm. Thus, the cost of debt and equity combined is the cost of capital, which, when weighted by the firm's percentages of debt and equity, yields the WACC.
- In his "Focus on the Treatment of Risk in Forest Valuations" in a New Zealand context, Liley [8] sponsors the view that:

"In an NPV environment, there are two broad alternatives for addressing risk: (1) including suitable allowance in the derivation of future cash flows, or (2) incorporating some extra margin in the discount rate.

A number of authors describe the issues involved……….All acknowledge that in calculating the NPV for risk projects, it may be common practice to add a premium to the discount rate. Because decision-makers tend to be risk-averse, penalising more risky investments would appear to be a valid means of adding extra stringency to the investment process. However, the user does need to be aware that this approach can distort the relative magnitude of immediate and future cash flows."

He goes on to summarize the problem by pointing out that:

(a) Use of a risk-adjusted discount rate assumes **risk is compounding over time**.
(b) No specific guidelines are available on how to determine the **appropriate adjustment factor**.

"Plus, frequently, the further into the future that the revenues arise, cash flows become less certain, however:

- *Not all risks increase over time. (In New Zealand plantations, for instance, windthrow risk may be greatest between two years and four years old (toppling), and then after thinning operations which may occur before age 10 years).*

- *Where risks do increase through time, it may not be exponential as with compound interest.*
- *Market uncertainty is not a sufficient reason for discounting, as it may involve outcomes better or worse than expected."*

- Buongiorno [11] works at connecting the Faustmann's formula for land valuation in forestry (first announced in 1849) with recent attempts to incorporate biological and economic risk into the same problem.
- Peltola and Knapp [12] note that, while expected net present value (ENPV) is a commonly used criterion in optimal forest management, it only applies to risk neutrality. If the forest owner has other risk preferences, a utility function needs to be used. Expected utility is the most common way to handle stochasticity (randomness) in an a-temporal framework, but is problematic in in-temporal problems. Given that recursive preferences can overcome a variety of the difficulties associated with expected utility in stochastic control problems, they apply them to forest management. The authors weigh the effects of risk aversion and inter-temporal substitution on optimal forest management.
- Other authors comment that estimates of real risk-free rates of return (historic and anticipated) on U.S. Government bonds, range from 1 - 4 percent before tax, equivalent to the nominal risk-free rate less the inflation rate. Thus, they suggest that a 3 per cent risk-free real rate would be reasonable. The investment analyst would then need to add his own risk premium to come up with the applicable discount rate.

Treatment of uncertainty

In the previous paragraphs, this discussion has assumed that future benefits and costs are known (if not in absolute terms, in probabilistic terms). One may wonder what appropriate provision can be made in project selection for the true uncertainties of the future? Should a state or nation bias its selection against uncertain projects? Or is this a matter of small concern? This matter will be briefly reviewed, first because the entire subject of decision making under uncertainty remains highly controversial and second, because, given the context of our analysis, the recommended approach is in fact quite simple.

This section refers throughout to the usual understanding of uncertainty, i.e. a situation in which the probability distribution of the various outcomes is unknown.

There is a question whether public decision making should at all be concerned with the effects of uncertainty. While the firm typically specializes in a few products and undertakes a small number of projects, nations do quite the opposite. As a result, the overall performance of the firm is highly correlated with the performance of each of its investments, but a nation’s economic performance is not. Failure of one project may spell bankruptcy to the firm but a similar failure in public investment may well be matched by an extraordinary success in another project. In effect, by having a large number of small projects, the government reduces its uncertainty (and risk) considerably. In the view of some economists, it reduces them to a negligible level not worth the trouble of appraising them.

But how could we account for uncertainty if we actually wished to do so? This falls into the category of **decision making under “uncertainty”** and several rules have been used over the years to deal effectively with the problem. The most commonly applied rules are

- The Maximin-Returns Principle. According to neoclassical economists, the decision problem faced by all the rules is identical. A choice needs to be made among a number of alternative courses of action. The practical consequences of adopting any particular course, depends not only on the choice made but also on external factors referred to as **"the states of nature"**, unknown at the time of making the decision. Therefore, the decision can only be based on three types of considerations: some judgement as to the likelihood of nature being in each of its possible states; predictions as to the consequences of each course of action under each state of nature; and assessments of the economic and social desirability of each possible outcome. The maximin-returns principle requires that each alternative be evaluated by the minimal return that it guarantees, and that the one with the highest guaranteed return be adopted. In other words, the procedure is to choose the project that does best in the worst conditions. This method suffers from two defects. It is exceedingly conservative, and it disregards all potentialities of a decision except under the worst possible circumstances.
- The Maximax Returns Rule. In opposition to the above principle, the maximax returns rule seeks to choose the project that provides the highest returns under the best (most optimistic) conditions. This principle suffers from the defects of being extremely optimistic, and of incorporating expectations unlikely to be realized in the real world.
- The Minimax Risk Principle. This method is at times called the minimax regret rule and allows for a decision to be made, taking the fullest possible advantage of all potentialities in a situation. The procedure is to choose the alternative for which the maximum (total) possible risk is as small as possible. This is often referred to as choosing the project that minimizes the maximum level of social regret had any of the alternative actions been undertaken.
- Probabilistic Approach. This method is based on the assumption that it may be possible to express judgements about the likelihood of various states of nature by assigning probabilities to them. These probabilities must be computed using as much statistical evidence and other empirical data as possible. As a result, these probabilities will be relative to the state of information at the time of the decision. Under this rule, the choice among decisions amounts to the choice among the probability distributions of outcomes associated with each decision. Usually, this analysis is reduced to a statistical exercise by which the net benefits of the project at each point in time are weighed by their probabilities. The arithmetic sum of the weighted net returns provides a probabilities weighed present worth which can then be assessed in the normal way.

Many economists have difficulty in accepting the rationale of this method. In their view, there are **serious philosophical implications** connected **with attaching probabilities to a state of nature**. The assumption of a most probable state of nature which is unknown, and cannot be known, would require the existence of a gambling deity of the universe. But as Einstein has said, "God does not play dice." Additional disadvantages, and perhaps as important as the first, are that the concept is hard to implement objectively, is highly sophisticated if used properly, and will not be operational for the average public investment facing a lack of probabilistic back-up data.

Unfortunately, none of the individual approaches described above stand out as the most satisfactory in all conditions. It is, therefore, up to the analyst to choose a method that best suits his needs. He may even choose not to be concerned with uncertainty in the first place, and depending on the specific nature of the planning problem this may prove to be as valid as choosing any of the recommended approaches. In this light, one is compelled to agree with R. Dorfman when he wrote some years ago that, the issue of uncertainty remains clouded with uncertainty.

Some thoughts on risk analysis in forestry - A practical approach

Gadow [13] notes that a general concept that could be useful in risk analysis is, to remember that forest management is an activity that tends to be strongly affected by exogenous hazards that cannot be controlled. *"Thus a practical approach which can be used in forest risk analysis is to estimate age-dependent cumulative survival (result or outcome) rates for a given set of hazardous factors"*. This is a highly complex methodology that is new to the author, so the reader should not have undue expectations of what follows. But before moving further into this slippery slope of risk analysis, it could be valuable to agree on some terms:

According to Gadow, **damage** is loss expressed in monetary terms. The **damage potential** includes all the potential threats within a given **hazard domain. Risk** has been defined in different ways but one way of viewing it is as the expected loss due to a particular hazard for a given area (or activity) and reference period. An **expected loss** is the product of the damage and its probability.

- Based on the above definitions we could define **risk assessment** as a formal procedure for quantifying risk with regard to the damage potential, including all the possible threats within a given hazard domain.
- It follows that **risk evaluation** would be a formal procedure to evaluate (or appraise) potential threats and benefits. The DCF method described in "Project Appraisal - Valuing Costs and Benefits" is proposed (see above).
- Finally, **risk management** would refer to strategies and actions the forestry planner can take to reduce risk.

(I hope I have not unnecessarily confused the reader with these definitions, since they are difficult to conceptualize given that they are matter of considerable debate among economists and not always agreed upon).

Applications of risk analysis in forestry planning are very rare, as Gadow points out. Thus there is not an established methodology to follow. However, some general principles and guidelines for entering the art and science of risk analysis can be noted.

For example, it would appear valuable to attempt the following exercise:

1) Delineate the system

Study the overall situation and delineate (define) a nomenclature to systematically go about listing all the valuable objects, activities and assets, now and in the future, whether they be inputs or outputs, liable to be affected by risk.

2) Identify potential hazard factors

This is simply a procedure to identify as many of the potential hazard factors liable to affect the system or list in (1) above. This is a highly subjective process but some degree of objectivity can be brought to bear by developing and using check lists that produce a list of potential hazards and critical system elements using specific terms that define deviations from the normal state. Note that the dangerous process is **identified without considering the extent of the possible damage**.

3) Assess hazard factor damages and probabilities

This is more tricky, but one must attempt, as best possible, to assess (or estimate) the hazard factor damages and probabilities (as listed for hazard factors in (2), above). A potential hazard presents a risk if it occurs with a probability greater than zero, and its occurrence will cause a discernible damage to the inputs and outputs listed in (1), above. Gadow suggests that the probability of occurrence of a given hazard factor may be defined by a probability distribution depicting the frequency of certain damaging events on the basis of past observation. (Not a simple or easy thing to do given that past experience may not have focused sufficiently on the dynamics of risk and related damage to assess a correlation). Regardless of how one does the estimating, **the probabilities must sum up to 1 or 100 percent for a complete distribution** [2].

4) Estimate impact of the hazard factor probabilities and evaluate threats

This step is meant to estimate the economic impact (or value) of the major hazard factor probabilities as may apply to discrete (say yearly) events or activities. The approach would be to simply calculate the expected loss by multiplying the damage by its probability (i.e., as identified in 3, above). Given that we have a comprehensive project appraisal methodology at hand in 4., above, we shall dispense here with Gadow's alternative physical evaluation that would estimate the age dependent cumulative survival rates for a given set of hazard factors affecting the system.

5) Manage the risks identified

Finally, based on the results of the risk evaluation, define a management system for the effective reduction and control of risk in the system. The planner must basically ensure that the measures to be taken are cost effective and in balance with the magnitude of the damages that are being reduced. As in any management system, a definition of clear objectives, approach and budget, and assigned program authority, responsibility and accountability would be required as a condition for the implementation of an effective risk management system.

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