ON THE INCLUSION OF NATURE AND ITS DYNAMICS IN FARMERS'S OBJECTIVE FUNCTIONS FOR ECO-SYSTME SERVICES PROVISION:
A NEW STRATEGY IN BIO-ECONOMIC MODELING

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Abstract

Because objectives influence behavior, there should be thoughtfulness of economists on stating objective functions. In contrast, most farm economists work with the assertion that farmers maximize income. A major question is, are there alternatives? It is the aim of this paper to get a deeper insight into deliberations on objective functions. We go beyond income maximization and show how a probabilistic approach on life-styles provides better insight. We suggest the use of probabilities, humans face if they do not know the status in which they live. Labor intensive and nature providing farming is contrasted with intensive, eco-system service extracting farming and put into a dynamic bio-economic approach. Life-styles occur with probability π and $(1-\pi)$. The occurrence is modeled dynamically making probabilities endogenous. A programming approach is suggested to depict behavioral equations of life-styles. Finally, we discuss how farmers, by the help of an eco-system services planner, learn and change probabilities.

1 Introduction

In positive analyses of farm behavior, there is the current practice of using profit maximization as the predominant objective of farmers; even in bio-economic and landscape modeling (Segerson et al. 2006) profits dominate. But when it comes to normative problems of sustainability, issues on objectives emerge culminating in requests to change farmers' attitudes and objectives (McNeely and Scherr, 2003). Traditionally there was always a distinction between social and private objectives (Cirary-Wantrup, 1985) and it seemed that traditional societies better coped with problems of enforcing rules of sustainability creating intrinsic motivations or modifying objectives. The role of public authorities in promoting commercially and extraction or conservation oriented strategies have become an issue again (Tisdell, 2003). For instance with respect to degrading environments or pursuing sustainability in cases of soil fertility, pest and disease problems, public authorities try to convince farmers to farm more sustainable, already, as part of their objective; but it seems that the profit logic is against that. The term sustainability converts to a catch word. It means conservation does not stay in tune with short-run interests (objective) of farmers. However, in theory and practice, narrowly thinking farm economists, but also academic scholars without contemplation, work with the assertion that farmers maximize profit; or, if more complicated, they use expected utility as the criterion for decision making (see an overview by deJanvry et al, 1991). Major questions at hand are, are there alternatives in formal modeling, which better incorporate farmers' knowledge on dangers to overexploit nature, and how can we justify a departure from the intuition that farmers are pure homo economicus?

Eventually, we may look in the past and ask, what constitutes a farmer nowadays, how is he distinct from past farmers, and what was the objective in the past? Then we will discover the term peasant (Weber, 1993), eventually as someone living closer to nature. At least a review of literature on past behavior of peasant farmers, i.e. before modernization and commercialization of agriculture, provides some hints how peasants under difficult ecological conditions included nature conservation in their objectives (Ellis, 2003). Additionally a literature survey on peasants in today fragile areas can shows how peasant develop strategies of private nature conservation, notably in contrast to commercial farming in fertile areas. This gives hints on strategies and tactics to avoid a collapse of eco-systems (McNeely and Scherr, 2003). One has also to be careful to say that fertile areas are different. Perhaps it is only a matter of time that fertile eco-systems become as well fragile. A threshold issue may emerge where a new objective is needed in restoration of eco-system services. Restoration can be similar to those of a poor peasant working for nature. Such issues seem to be related to objectives of farmers.

Our main departure from a common assignment of commercial strategies (cash, profit, income, or utility maximization), which maybe suitable for fertile situations, has to be seen along the need of finding and assertion of ecologically more sound strategies for fragile situations, notably also if ecologically disastrous and economically bad situations are envisaged. We think there are already dynamics which should impact on current behavior. A major criticism of the income maximization approach, from a system perspective, is that the profit maximization can only work under "good" conditions; in contrast if we enter in a world of thresholds, diminishing eco-system service, need for restoration, rehabilitation, etc., things change? Especially under resource exploitation, a switch in underlying parameters, what enable extraction, can happen (Naevdal, 2003); no longer allowing a self-cure. Eventually, a change of strategies (reconstruction at minimal effort, living within limits, etc.) is 'wiser' than extraction. We must portrait how to frame a typical set of equations taking environmental impacts as part of a description of a 'necessary' environmental decline. The derived equations serve as a representation of behavior under good and bad conditions. This 'rationally' should be an integral part of a forward looking decision making. A new strategy is needed, when a live support system is impeded. Then the question is, how could we more correctly portray the potential views of the decision makers? Importantly, we have to identify alternative objective functions and strategies that suit "bad" conditions. In the context of an anticipated future state of exhausted natural resources and low eco-system services, an exploitative economy using simply discounting becomes obsolete. The very likely event is: we can not continue to pursue our current objectives because thresholds are passed; then we have to learn how to restore or rehabilitate resources. Restoration and rehabilitation are costly and their conduct depends on objectives. Restoration under ecologically bad conditions enforces different, strategically encompassed objectives which are only partly depicted by profit maximization (Naevdal, 2003). Even then, with discounting, we could ask whether agents are rational if they merely exploit and do not look at future efforts to restore or rehabilitate. Notice restoration is a heavy task for humans.

Basically, we may envisage increasingly "bad" conditions, which resurrect the need for the objective of a hard laboring peasant. A renewed interest in peasant objectives and behavior should include efforts to protect nature. Instead of looking merely at "good" starting conditions, which allow commercial exploitation and pure profit maximization, notably as the core for behavior, we distinguish behavior according to the underlying labor economy and eco-system. In a good situation, as we portray it, labor is merely a quantitative measure of input, serving primarily the control of machines. A farmer does not specifically care about personal efforts. Additionally one can assume perfect markets for food and labor which means that it does not matter where to work, rather the availability of money as an exchange for labor determines the availability of food. This is the current situation with energy intensive farming, where substitution prevails. As a result of modernization, farming became an external input concept. After introducing huge amounts of external inputs, farmers are now not used to real manual labor. Manual laboring is characterized by high efforts. Effort is more than just counting hours. With increasing work loads physical efforts are increasing and efforts appear in peasant objectives. As a hypothesis, under peasant conditions, effort minimization matters. Efforts are energy consuming and normally peasant farmers try to minimize physical efforts to obtain food for survival and shelter.

In contrast to commercial farming systems, peasant farming systems are mostly without much external inputs, especially if they face very high input prices, for instance, of energy (Ellis, 2003). A peasant is hard working for food, and physical energy use is escalating with efforts. It means that the use of manual efforts is straightly linked to food production; the aim is then to retrieve an energetic net balance as part of a livelihood strategy. We foresee that this reemerges after an eco-system collapse. Conditions for peasant behavior can either be retrieved from historical information or constructed future scenarios; it implies a retreat to more miserable situations than today. Misery eventually comes with increased energy prices and declining eco-system services. The core issue is that we can predict that eco-system services are depleted and fossil energy is becoming extremely expensive. This miserable situation, as to be anticipated; it could imply a revisit of poverty and insanity in rural lives.

Apparently, in the long run there should be a vision or a new way of living in a more labor intensive economy; at least we presume that, due to adverse effects in the eco-system as a result of the current farming practices (not eco-friendly), there will be a likelihood that farmers have to work harder to maintain soil fertility and their natural environment. Eco-system services are endangered and need substitution or restoration. If substitution of eco-system services is becoming too costly, restoration or rehabilitation is an option. This option needs normally laboring harder, i.e. restoration is more like a peasant than a commercial farmer situation. So what has to be depicted is not a black and white contrasting of lifestyles, rather life-styles can be voluntarily chosen. For the decision maker it can be rational (foresight of precarious scenarios, lifestyles and switch of objective functions) to allocate his labor in favor of nature so that a too deep fall into an ecological catastrophe (switch in regime) can be avoided. To anticipate this danger we can, as will be shown, work with probabilities as heuristics to describe the eventual future of farmers. As will be further shown, for the description we use a joint objective function composed of probability oriented partial objective functions and a learning behavior of farmers. Then it is the aim of the paper to show the rational of using a mixed objective function which is composed of a peasant, commercial and transition farming system. Finally, as dynamic constraints we introduce eco-system dynamics including systems a switch between collapse and rehabilitation.

The contribution is organized as follows. 1. We already have given a conceptual outline of the problem. 2. Now the method is outlined and applied to different types of objective functions and decision making. 3 We unify the different objective function components. 4. It will be shown how the unified objective function can be brought into a dynamic modeling concept of eco-system service conservation and public decision making. For this purpose we use a dynamic control approach.

2 Basic Concepts of a Unified Objective

2.1 *Peasant Farming Approach*

A methodological entry to specify an objective for a "new peasant", i.e. a person who works for nature, is to assume simultaneous deliveries of food and of nature. Food is not delivered for the sake of a preference rather for survival. A peasant is then minimizing labor efforts "e" given that a certain set of criteria for minima of food and nature (re)construction are met. In the objective function efforts can be measured by the energy use in particular crop production systems "ς". Next we split the criteria, to be met, into "c" crops (food), "a_n" area for nature, "n_n" nature elements, and "i" income. In this respect similarities to goal programming prevail (Wallace and Moss, 2002). Area for nature is treated distinguished since it requires additional efforts of land preparation for nature; labor relates to land and nature. Energy, as effort related, is minimized. Additionally we see efforts for income generation. Income generation is needed to buy other commodities like medicine, shelter, transport, etc. Income generation is by cash crops that need different efforts than food crops. In case of a linear programming approach the eco-system services can be explicitly modeled as nature elements and area to be provided.

$$\begin{aligned} \text{Min } P_p &= \pi\varsigma\, e + g \qquad (1)\\ A_{11}\, e &> n_n\\ A_{31}\, e &> a_n\\ A_{21}\, e &> c\\ \alpha_{31}\, e &> i\\ e &> \underline{e} \end{aligned}$$

where: e = effort
π= probability to be a peasant (set one)
n = nature provided measured as biodiversity index of eco-system service (for example bees)
a = area released for nature
c = crops produced
i = income generated from cash crops
$\underline{e}$ = effort observed
g = fix minimum effort
A_{ij} = technology matrices

We assume that labor is sufficiently available and efforts count. In principle the effort devotion for nature could be planting of trees, pruning, watering and other maintenance activities. This supported nature has a positive impact on biodiversity, i.e. the eco-system services. The category is n_n, it is counted in efforts needed. Hereby we assume that nature needs a fixed portion of effort. As an alternative we can specify nature as land, dropping one equation and leave it to farmers how to combine factors. Finally to be a peasant occurs with a probability "π" (it can be π =1).

We distinguish private and public goods. Private goods are crops "c". Public goods, "n", are things provided as nature in a community. For this, we presume, in peasant economies and communities, that soil fertility heavily relies on the proper functioning of the eco-system (eco-system service); peasants extract but also support nature. Nature has a caring and an extraction aspect for them. The extraction needs are determined by the need for food. Hence "c" is related to the extraction for food. Food is a bundle of basic needs of different types of foods (grains, potatoes, meat, etc.). It corresponds to a diet, been identified as appropriate to sustain a certain number of humans, within a peasant community. This enables us a specification of crops as constraints containing two crucial elements in the "objective" of peasants: population and diet. Being formulate as constraint it is dual to effort minimization. The same applies in the formulation of a certain amount of income "i" as minimum financial requirement. Eventually we have to further look for less equal constraints with respect to land and eco-system services. And the aspect of an exchange economy can be modeled as a zero budget constraint.

At the moment we want to show the methodological implication: The dual of minimization of efforts, as specified above, is a maximization of "utility" measured in units of cost accounts, efforts; though still being a "utility" from consumption of food and nature provision perspective. "Utility" is energy in food measured by energy used to produce food. This duality shall count for peasants; it allows us to include exchange merely as financial constraint. It is different from income or utility maximization. For instance, the unit of measurement is a "kcal". Note it must be a viable system i.e. energy spent for efforts in cropping, income generation and nature provision must be supported by the calories available. As it is a linear programming problem, by the programming of corner solutions, this problem can flexible. For that we suggest to apply, for a generalization, a maximum entropy approach; Several analytical functions are possible. To get a quadratic exposition see: Howitt and Paris, (1999). With respect to shadow prices we have to calculate a dual of the above problem giving us cost functions:

$$\text{Max} \quad n_n \lambda_1 + \quad c \lambda_2 + \quad i \lambda_3 \tag{2}$$

$$A'_1 \lambda_1 + A'_1 \lambda_2 + A'_3 \lambda_3 < \pi \varsigma$$

where: λ = shadow price

In the dual case the constraints determine a link between shadow prices and the criterion for the objective function. Notify, the criterion in front of labor for effort minimization determines also the criterion in front of the income. Hence we see a straight link in calculation of the shadow price of the constraint and income as well "price". Each constraint of "n" as vector has a "value function".

$$A'_n \lambda_n + \lambda_{0,n} = \pi \varsigma \tag{3}$$

However, under the above conditions of a linear relationship in optimization, notably as linear programming, which gives a pre-determination of functional forms for supply and factor demand functions, a quadratic expression can be obtained (Paris and Howitt, 1999). A simple expression is that shadow prices are calculated as dependent on the constraints and corresponding "utility: N". This corresponding "utility" is a function of a minimization of efforts:

$$N^s(e, \lambda) = e' \psi_{11} + \lambda' \psi_{21} + .5\, e\, \Psi_{11}\, e + e' \Psi_{21} \lambda + 0.5\, \lambda' \Psi_{31} \lambda \tag{4}$$

The coefficients Ψ_{2j} of the representation (4) give the full account of the benefit function; they are part of a calibration; and they can be retrievable from a Maximum Entropy approach (Howitt and Paris, 1999). Maximum Entropy means that one or very few observations, which are the results of programming, can be used to reconstruct quadratic objective functions and linear behavioral equations. Then, the previous expression is a net calculus given by E which is a surplus for the peasant:

$$E_p = N^n(e, \varsigma) - \pi \varsigma e \tag{5}$$

It corresponds to efforts and is measured in effort units; though income and shadow prices are linked.

$$N^n(e, \pi\varsigma) = e' \psi_{11} + [A'_n \pi \varsigma]' \psi_{21} + .5\, e' \Psi_{11}\, e + e' \Psi_{21} A'_n \varsigma\pi + .5\, [A'_n \varsigma\pi]' \Psi_{31} A'_n \varsigma \pi \tag{6}$$

Equation (6) is a description of the benefits of the peasant as objective function. Given this equation, the expression in the formula is equivalent to the problem of minimizing costs minus benefits (5). Behavioral functions can be depicted and we receive linear response functions which are the result of derivatives assuming an analytical optimization. The behavioral equations (7) depict the equilibrium between a determination of efforts and exogenous factors as well as are derived from minimizing efforts for getting the benefits. For instance, taking derivatives we get expressions:

$$\partial E_p / \partial e = \psi_{11} + \Psi_{11}\, e + \Psi_{21} A'_n \varsigma \pi = \varsigma \pi \tag{7a}$$

$$\partial E_p/\partial \pi \varsigma = \psi_{21} + \Psi_{21} e' + \Psi_{31} \lambda = A e = [n_n, a_n, c_1, i] \qquad (7b)$$

The crucial thing is that this depiction of a peasant farmer, which is primarily based on his objective function to "minimize efforts", contains deliveries for nature and a suitable welfare measure. Deliveries can become part of the analysis of the societal objective function. Please further notice that deliveries are introduced as a constraint; i.e. for the farmer they are exogenous, but for a social planner they should be endogenous. The advantage of the approach is the detection of a flexible function, which is calibrated for a given technology (from programming). A crucial question, in this regard, is: what is an eventual incentive for a peasant to provide nature? In the above analysis we received a shadow price. The shadow price could be used to provide the 'payment' or incentive needed. It is expressed in physical terms to compensate efforts. Similar shadow prices are given as marginal improvements in a diet which are expressed as wishes "c". The peasant, for now, is just requested to offer land and efforts for nature. The question is will farmers go for that? Under this condition a crucial issue is how to determine the probability to be poor as well. We have to make it endogenous, which will be done soon.

2. 2 Commercial Farm Approach

For commercial farmers (or the probability to be in a situation of profit maximizing, extractive farmer) we suggest a conventional approach on income maximization

$$\begin{aligned} \text{Max } \; I^n &= (1-\pi)\, p\, c_c \qquad (8)\\ A_{21}\, c_c &< n_u\\ A_{22}\, c_c &< s\\ a_{22}\, c_c &< l_c \end{aligned}$$

where p: gross margin
l = labor availability
s = eco-system service
c = cash crop

The optimization includes an eco-system service and results in a quadratic cost function

$$C^n(c_c,p(1-\pi))=(1-\pi)p' c_c - c_c' \psi_{21} - (1-\pi)\, p' \psi_{22} + .5 c_c' \Psi_{21} c_c - c_c' \Psi_{22} (1-\pi) p + .5(1-\pi)\, p' \; \Psi_{23} (1-\pi)\, p' \qquad (9)$$

And this "costs" correspond to a maximization problem of net income = cash minus costs:

$$I^n = M - C^n(c_c, p(1-\pi)) \qquad (10)$$

Such standard approach, oriented towards welfare and equilibrium for commercial farmers, implies that welfare economic conditions for a joint function in production and consumption are explicitly considered. The core indicator is income received from farming which translates into utility. For comparison in peasant economies consumption needs are given as constraints and efforts are minimized; whereas here simple profit/income maximization is assumed in commercial farm economics. In equation (11) a similar approach on net disutility minimization can be depicted as parallel. In neoclassical economics, if we argue for the market equilibrium, the partial income maximization is still optimal in terms of joint welfare maximization. It can be argued that optimization of profits, either by the delivery of a primal or a dual characterization, is like a joint welfare maximization. Our focus shall be on labor and its costs, which are given by disutility to work in a commercial context. Technically, even operating in a commercial environment, cost minimization is sufficient to correctly depict a welfare problem. For a primal, if it is measured in disutility of labor "D", we would get (11) to be minimized.

$$F^P = D(\ldots) - U(\ldots) \qquad (11)$$

By this function net welfare $F^P(\ldots)$ is optimized. Hereby D(…) is the equivalent of a cost measure which is mirroring the utility derived. A cost equivalent "D" is, for instance, a disutility function for laboring. It corresponds to a normal cost function C(…) which is a monetary measured disutility and which is measured equivalent to constant levels of monetary costs C(.). In the case of a commercial farmer, sales and purchases are balanced and they are just a matter of transaction. No cash is stored; though for the decision making cash matters. For the dual accounting, which is in cash measurements, we can artificially maximize the cash surplus (difference between net income minus expenditure).

Anyhow we get the same behavioral function as we get it in case of utility maximization. It means it is reasonable for the farmer to minimize expenditure and maximize income (F^D) because he gets utility:

$$F^D = M(\ldots) - I(\ldots) + C(\ldots) \quad (12$$

Such monetary objective, by coincidence, results in the same behavioral functions as from (11). It provides the basis for a completely commercial oriented farmer if we put π=0. But now we integrate.

2.3 New Approach

Now we may think of merging the disutility and utility of commercial farms with the "disutility" and "utility" from peasant farming. The aim is to get a strategic decision making combining both. The further idea is that a decision maker looks into the future and assigns probabilities to strategies (life-styles), he can pursue (Mayumi, 2001). He either can pursue the strategy of a commercial farmer or the one of a peasant. This decision maker is guided by probabilities and will partially decide to become either peasant or farmer with respect to life-styles and behavior; in other words he is a hybrid. Apparently from his wish he would like to be a commercial farmer, enjoying low energy prices, low efforts and high eco-system services. But he is cautious and may anticipate a decline in his prosperous current situation. For that reason, in resource allocation, probabilities matter; a hybrid strategy occurs. The problem is either given by the maximization of a joint function of a welfare measurement in the life-styles or by maximization/minimization of cash equivalent. A next step would be towards inclusion of the risk of being a peasant (risk adversity); it even implies to do maximization with a probabilistic approach. However, a joint objective function can be expected as materially measurable surplus S, which is a combination of the farmer's objective (life-style) and the peasant's objective (life-style).

$$S = (1-\pi)\,[D - U] + \pi\,[E - N] \quad (13)$$

Here N is nutrition and E effort as energy. D is disutility and U is utility. The approach can be alternatively expressed in monetary terms if we use the mirrored M expenditures and I income in the objective function of farmers as well as still thinking in physical efforts E for labor and nutrition N.

$$S = (1-\pi)\,\lambda\,[I - M \geq P] + \pi\,[N - E] \quad \text{or} \quad S = [I - M \geq P] + \pi^*\,[N - E] \quad (14)$$

Equation (14) enables a revelation of π if the behavioral assumptions are correct. The function can be considered a net generalized benefit-cost approach and it has to be amended for the net surplus. As done before we can use linear programming and the theory of positive mathematical programming to first establish the partial net benefits in functional forms, but then second integrate them. The crucial thing is that we need to model a synthetic objective function and the corresponding behavior, as derived from that function. It means part of the behavior is motivated by interest in extraction and part by the need to preserve. A decision maker following that strategy offers, by his programming, similar functional outlines as if he pursues selected life-styles, but by the probabilities he also offers a joint strategy. The regulatory mechanism is the probability. Probabilities have to be linked to what is expected and what can be done. Variables, on which decisions are made, are basically the allocation of labor and land, but also the purchase of input and nature provision and use of eco-system service.

Technically we have to constrain the availability of land and labor to close the model. A further closure is needed for the exchange opportunities of a "new-peasant"; this has to be clarified and the resource constraints to be specified. Basically cash constraints are prevalent in both of life-styles, peasant and commercial. As in the introductory session notified, for instance the utility oriented farmer uses a market to maximize independently utility and income. This no longer holds. Now objectives include the probability of future states based on environmentally oriented behavior in the past. The basic aim is the utility from food. Only, thanks to a fully established exchange system (see the limitation in de Janvry et al., 1991) for farm operation, farmers could reduce the problem to income maximization; but we think, they should not do that because eco-system services and work for service have to be integrated. In contrast the "new" peasant is confronted with a limited exchange system which is strongly characterized by a divergence of sales and purchase as well as prices, and he recognizes the probability of a shift in the system. Exchange and the goal of eventual cash maximization is part of the constraint not a goal for its own sake. The cash constraint receives a shadow price. In converse, the maximization of utility and income is characterized by a shadow price for the nutrient constraint and a prevalence of nature which is for future eco-system service. Similar things will appear in jointly synthesized objective functions. Knowing the functional conditions after optimization, shadow prices can be equated.

3 Concept and need for transitional behavior of peasants

So far, basic categories of strategic decisions, such as traditional peasant and commercial farmer, are presented and a first outlook for integration has been given. Now, we will further explain how the new approach can be established in a time frame. For simplicity and introductory purpose the concept presented until now has worked with two strategies or states, within which distinct objectives could be pursued. It was further argued that probabilities help to merge the initially disparate concepts into a joint approach where farmers become alert to end up as peasants if the eco-system looses its function to provide services. We called the distinct categories peasant farming and commercial farming. Though we introduced probabilities, we did not elaborate on the determination of probabilities, its dynamics and insight gaining for farmer. A next step is to integrate changing probabilities into dynamics of behavior and explain the heuristics of probabilities in more detail. For that purpose we introduce a dynamic concept of changing life-styles, of learning, etc.; and show how to integrate transitional behavior. For this: 1. we touch on a broader concept including transitional situations and probabilities. 2. Then we reckon arguments to consistently describe transition and states of life-style.

Basically we argue that we have to anticipate the dynamics to find the needed recognition of a decline or improvement in eco-system conditions. This recognition has to be realizable in farmers' opinion, and include his options for the future. In this respect, as a crucial thing, observation, or as a matter of contemplation, we should not forget that the past development from a peasant to a commercial farmer was primarily enabled by a decline in energy prices (Weber, 1979). In many areas of the world that dynamic was enabled by a comparatively resilient eco-system, at least for several decades; but now weaknesses appear. A continuation of an ideal pathway of commercialization is not self-evident. It is likely that it will not continue, rather the opposite will happen. It means a rise of energy prices and reduced service is a threat. If we assume increasing energy prices, a different type of transition can emerge, and as we further assume eco-system service decline (Hassan et al., 2005), restoration is a likely transition type. Restoration will be effort consuming and, under energy scarcity, it is a peasant task.

Our concept for a future transition which is meant to increased eco-service recognition can be best and easily understood if we think about a likely development from an initially good situation, with a lot of eco-system services, to an increasingly bad situation, of today and in the future. Notably over time, if farmers do not care about eco-systems, it probably happens that damages occur. In an ecologically good situation, at the beginning of commercialization, farmers have enjoined a nearly maximum of eco-system services, partly inherited from hard working peasants; but this is gone now, though commercialization was built on it. Also we could presume that the commercial situation was initially good and remained good until now. By the word 'commercial situation' we especially refer to cheap external energy. Both situations, ecological and economic, have to be combined to get a better outlook.

To get the full dynamics of events and their probabilities, for an outlook, we suggest a new set of combined probabilities. For the probability (heuristic of availability) of eco-system services we state a variable ε and define "best" situation as close to 1. At the same time, as was observable whilst the period of commercialization, the variable β shall indicate the prevailing fortune of having a good commercial environment (low energy prices). As a tendency β is defined as probability of a suitable condition for a commercial life-style (esp. low energy prices for inputs, machinery, transport, etc.). Note, the scope for both, the commercial and ecological outlook, were considerable good as commercialization started; but by now we postulate a declining environment. If, especially the commercial outlook had been bad and a strong eco-system recognition needed, things would have been different, recognizable as life-style. As a comment: Under the conditions of the past decades it made sense to follow a strategy of income maximization since the conditions $\varepsilon=1$ and $\beta=1$where nearly fulfilled.

If the probabilities change, counter probabilities tell (told) farmers to be cautious. For the following it is assumed that there is a certain counter probability that conditions for a commercial life-style "will" not prevail for ever. Different life-styles and probabilities are to be outlined. Before going into detail, let us think: We may have to anticipate a future of deprived eco-system services and commercial decline. Apparently, that would be a life in misery, especially from a point of view of current farmers who eventually are scared of hard laboring. Assuming that probabilities for such scenario are the opposite $(1-\varepsilon)$ and $(1-\beta)$, which means low ε and β, rural dwellers can foresee a choice of life-style that corresponds to nearly pure survival. For the actions taken, a shift in life-style may improve the eco-system services before that; in a temporary framework, there is a new probability that the situation improves. The scope is to behave well today so ε is maintained at a reasonable scale.

Certainly there is a rather little change that an ideal situation of probability $\varepsilon=1$ and $\beta=1$ will emerge for ever in future. Especially, we will consider β to be an exogenous variable, and a plausible future will be a decline of commercial scope, especially with respect to low energy prices. With respect to the eco-system service we see things differently. We foresee a positive contribution to nature (by working peasant) who improves eco-system services and this will change the probability. Peasant/farmers, in their assertion, will hopefully reckon a life-style that increases eco-system services, though it is hard working. For the welfare-effort-issue, this life-style is not favored. So rural people have to build scenarios, of what they want. It means that scenarios and probabilities can emerge where the eco-system service improves or declines; to maintain services means hard laboring for nature. Laboring for nature is laboring for a better future or avoiding collapse; a future is expressed as probability, notably to be reachable at a reasonable level of eco-system services. Probabilities are considered driving forces in a mechanism to accomplish behavioral change. As will be suggested we aim at a depiction of the consequences of a decline in the scope of commercial farming and transfer this anticipation to an recognition in the objective function. Transferring it into an objective function means to depict likely future well-beings of rural people in light of an anticipated decline of the scope of commercial farming life-style: It may appear, rural people assert it better to be a peasant (in the sense of: be prepared!) and farmer. After a reversion of the secular trend of cheap energy for agriculture, new challenges are emerging and these challenges we want to analyze. For clarification, to combine challenges with increased requests for eco-system services is the focus. Our approach integrates eco-system services in probability analyses. Hereby we assume that a new request for eco-system service exists and that the service is a proportional factor to a profit or surplus function statement for different styles and activities.

For the reason of transition, we categorize behavior in four sections (Diagram 1). These sections work along distinct categories. Categories are constructed according to the logic of a combination of effects of eco-system state, services and life-style as well as commercial scope. If we assume that two categories/lifestyles for commercially good and two for ecologically sound farming exist, we assign these categories joint probabilities; combinations of probabilities result in four new categories which come into existence. For each category, probabilities are given as: β is a probability that a favorable economic situation occurs and ε is a probability that a favorable ecological situation exists. The probabilities substitute previous "π's", whereas π is now a combination such as $\pi = \varepsilon\cdot\beta$.

Diagram 1: Overview on transitional state

	Probabilities:		Categories:	
Com.	β	$1-\beta$	commercial	peasant/eco
ε eco	$\varepsilon\cdot\beta$	$\varepsilon(1-\beta)$	semi-commercial (overall good)	no longer commercial but eco (ecological sound but poor)
$1-\varepsilon$ no-eco	$(1-\varepsilon)\cdot\beta$	$(1-\varepsilon)\cdot(1-\beta)$	no longer eco but commercial (ecologically bad, still good comm.)	neither commercial nor eco (disaster)

To understand the logic behind the probabilities and life-styles in Diagram 1 we need to know what scenarios are anticipated and how they are categorized and interact. Remember that we assumed, so far, that either a probability β of a good commercial or a good ecological ε situation is being decisive for a commercial objective function and vice versa. This is not operational. Now we combine simple

categories into an ecological prospect and commercialization prospect, for instance π= ε (1- β) which will be explained soon. Evidently, to make concepts more operational, a combined probability is used.
To proceed, firstly, even from the logic of survival under adverse conditions and also from the point of view of creating scope to solve problems we should start with the most adverse condition. This is characterized by being neither ecologically nor commercially conducive for farming. Adverse conditions are threats to peasants and characterized by resource availability only for survival. Because we categorize this situation as negative for farming, for instance, migration is eventually the only option and we could take income from migration as a reference income; but we also see laboring for a better environment as the core and could assume effort minimization with a strong component of nature provision. For a later unified objective this gives absolute low benefits and it should serve merely as benchmark. A scenario of no reasonable eco-system services and no commercially favorable situation will force decision makers to recognize disaster. In such cases net gains are almost zero in the short run, but give pay-offs in the long run. So we take it as reference value and threat with a certain probability.
Secondly, let us continue with a description of the better categories. For instance, as a further scenario we use the state of "commercial with no need of eco-system service". It is mostly appealing for profit seekers and strongly prevailing in developed countries' agricultural sectors, which have been modernized and are based on chemical inputs. Looking at "(1-ε)·β" it implies that the commercial category dominates. It equivalently means ε converges to zero and β converges to one. It is operating without the need to have eco-system services, such as natural pest control and pollination. The opposite is given by (1-β)·ε. In this case a low probability for commercial imposes a strong need for a full development of eco-system services; by ε=1 the eco-system completely dominates. For life-style it says: peasants with effort minimization. We will assign corresponding objective functions to the categories.
A special case is given by ε·β. In this case a peasant's objective with a commercial background shall prevail. It is called the transition case. This transition case is especially necessary for a description of a transition from a past peasant to a commercial farmer. But, it can also serve as the background for modeling a farmers' fear to become a poor peasant having a similar objective, if a declined eco-system is imminent. Because of an expected probability of low commercial prospects the transition should encourage peasant to behave such a way that they support the building up of eco-system services. This building up of eco-system services is understood as nature provision at minimal efforts (peasant behavior) for ecosystem service. Note, we distinguish nature provision and eco-system service. Nature provision is a pre-caution activity; it contributes, though does not directly deliver. A dynamic approach is needed. We work soon with the concept of Naevdal (2003) that the eco-system service is linked to thresholds of nature prevalence. Thresholds are given by ecological knowledge. Before we enter into this arena let us first go into a deeper understanding of the transition peasant's knowledge modeling.

4 Dynamics of probabilities and ecological transition

For the elaboration of, first, the ecological background, second, corresponding probabilities and, third, their perception by farmers as well as for, fourth, a consensus with ecologist and, fifth, forecasting, we further have to clarify on the emergence of our endogenous probabilities. The idea is that farmers become receptive to future eco-system services by learning changes in probabilities, linked directly to prevailing services. It means farmers work with up- or downwards moving probabilities and they learn from observation; i.e. we assume a farmer in this respect is adaptively rational (Pashigan, 1970). Probabilities shall adjust within few years. In this context, we, for the first time, need to involve a predictor or eventually planner of system behavior. A basic question for both, farmers and predictor, is how nature appears. Like in Naevdal (2003) we assume that the objective function of a benevolent eco-system manager or planer is `benefit-cost´ maximization of an objective function of the agricultural sector. This function includes the partial life-styles and probabilities (see below). The objective function is now composed of variables which are individually optimized by farmers and the joint system variables according to an assertion of future lifestyle probabilities. The planner seeks to forecast the dynamics in probabilities and conveys them to cultivators as been directed by the eco-system behavior. Forecasts and dynamics must coincide to assure the rationality in learning and adaptation. It

is necessary that a planner maximizes the sum of likely benefit streams over a given period. The constraints in maximization are expressed in services and probabilities. We follow the below introduced dynamics on likely environmental situations farmers faces, i.e. the planner has knowledge on the eco-system prevailing and the commercial prospects as well as translates them into probabilities.
For the purpose of interaction, we have to model future probabilities as dynamics of ε and β, first, and second see actions for their integration into objective functions. Hereby the probabilities can be treated as if the problem for the predictor/planner is a semi-deterministic approach. Note we are not talking about a stochastic approach in its traditional sense; rather probabilities serve as an indicator system or heuristics. Because stochastic dynamic optimization requires a very profound mathematical formulation of stochastic processes and objective functions, we omit that; rather in this contribution, we merely modulate a dynamic optimization given quasi probabilities. For practical purpose to gain "optimal" probabilities as parameters this is sufficient; so probabilities can be recognized by farmers. The idea is to depict the increasing likelihood that farmers loose eco-system services: though they need them more than today. Foresighted shifts in probabilities shall alarm farmers to switch to appropriate technologies and life-styles (which, most likely will show more peasant than commercial farm behavior in future). At this point of discussion we have to introduce the issue of notifying changes in probabilities. Admittedly, there is a lot of literature on detection of probabilities (Kahneman and Tversky, 2000). We merely make reference to it, in so far, as we admit learning and avoiding crashes. Things are complex; but we have to be reduced them for modeling and see them as cognitive process.
Our foremost problem in objective function description is that we do not see a dynamic optimization of farmers, because we think that peasants (Ellis, 2003) are not capable to calculate all implications of dynamic system behavior, rather they (1) are working with probabilities (heuristics), (2) apply rules of thumb, (3) learn changes in the environment, (4) adapt and (5) seek new strategies. But we still (6) want to model the needed adaptive process by which the eco-system service recognition becomes involved and (7) show how an eventually diminishing commercialization scope can be depicted. Furthermore the design of objective functions and discussion of adaptive processes must be part of a social cost-benefit analysis. Because of that, in a simplistic, though we think realistic, analysis system dynamics are condensed to probabilities. In this environment it makes sense to introduce a learning possibility for the probabilities. Then we presume that a planer on behalf of farmers signals them the current probability and hence one finds optimal pathway for probabilities of eco-system services ε. A purpose of the "ansatz" is to influence probabilities and this starts with a learning of the dynamics.

4.1 General outline of eco-system service

For the purpose of probability injection in decision making it may be sufficient that farmers work with expected probabilities and learn them, as well as the planer/predictor provides the probabilities. By including probabilities in foresight a consistent pathway for eco-system services emerges. A consecutive question is, do we have other tools, for instance, enforcing learning and can we expand the list of instruments? As been usually proposed fiscal instrument may open a venue. In such case a planner is additionally capable to direct farmer/peasant behavior through fining of undesirable activities and paying of desirable activities. Normally this procedure requires a modeling of the objective function as a deviation from an "optimal path", i.e. as if there is a divergence between private and public objectives and behavior. Then, since the coordination of the eco-system service is assigned to a public planner/predictor, this planner has to think, what is the objective function of a farmer/peasant under changing conditions? Also he has to think about a divergence between the social optimum and a private behavior under different behavioral assumptions on learning. In the given case, for a starting, we see the planner (eco-system service coordinator) as a social planner who seeks the optimum first and then secondly thinks about the instruments. Because, this paper is primarily about the design of the objective function and delineation of a plan on eco-system development, we limit our scope to that. The consecutive issue is a depiction of the effective eco-system dynamics as been viewed from the ecologists' point of view. We assume two regimes of eco-system service (Neavdal, 2001) with different steady states, and see them as a dynamic process with a threshold:

$$\varepsilon'(t) = [1 - \Phi_{21}]\, \varepsilon(t) + \alpha \qquad (15)$$

with: (1): $\alpha = 0$, if $N(t) <= N^0$ or (2) $\alpha = \alpha_1$, if $N(t) > N^0$

where: ε^o = is an index ($0<\varepsilon<1$)

N^o = is a threshold

Two cases are to be distinguished: a deteriorated or collapsing system as compared to that of a functioning as well as resilient system. In case one the eco-system service fails in future; though a current service is available. Because the steady state is $\alpha = 0$ the dynamics move towards a disaster or extinction of services. In case two, $\alpha = \alpha_1$, a steady state equilibrium can be reached (Naevdal, 2001); this happens because nature exceeds a threshold. Hereby we assume that the eco-system service is exposed to a self-regulating system which is characterized by thresholds and adjustment Φ. Note further the status of nature is not considered as coincident with the eco-system service. For example, if we look at the pollination by bees, bees need a decent environment (nature) and the survival dependents on the opportunities to feed on nature elements. Hence, a landscape with hedges, small ponds and forest elements will a good guarantee in its provision (Wossink et al. 1998). This is what we mean by nature as a provided entity by peasants. If one wants to re-establish a certain eco-system, farmers have to rebuild nature, at least, up to a threshold. (Labor)costs for nature rehabilitation are part of the above specified problem of peasants and probabilities. The second equation of eco-system services (also in 18b) and its dependency on nature is additionally crucial for our type of decision making, envisaged. In a fourth equation (dynamic constraint: 18d) the probable eco-system conditions for the pertinence of services in future are described by a growth or dynamic nature prevalence concept. As usually applied in resource economics, nature follows its own growth path or dynamics; though it can be augmented by influx n(t). It is difficult to measure nature as stock variable N(t). We can either use area or work with key species. For example the size of tree, heath, or moors cover would make sense. It measures available area for flowering meadows and organic matter to indicate the food sources for bees.

4.2 Commercial prospects

The commercial prospect can be depicted by modifying known models of ad-hoc learning of probabilities, like those given for price formation, for example, in time series analysis. Learning can be linked to rational expectation (Muth, see Pashigian, 1970). For our purpose we assume that a farmer/peasant uses a common learning model or “strategy” for a development of the commercial scope like

$$\beta^e_t = \beta^e_{t-1} + \Phi_1[\beta^e_{t-1} - \beta_{t-1}] \qquad (16a)$$

which can be written in continuous presentation using differential equations such as

$$\beta^{e}{}'(t) = [1-\Phi_1]\, \beta^e(t) + \Phi_2\, \beta(t) \qquad (16b)$$

where: β^e = expected probability of commercial scope

$\beta^{e}{}'$ = change in expected probability of commercial scope

β = observed probability of commercial scope

A clarification on the observation and forecast method is needed. We do not simply assume that the farmer learns from the past. Rather under certain conditions (Pashigian, 1970) it is rational for a farmer to build expectation along the above concept of adaptive learning, especially if a trend can be verified which we assume. Then, we have to explain how $\beta(t)$ is observed. We can introduced the probability β as a relative measure, i.e. a benchmark for a perfect commercial environment is needed. For example, prices for inputs as index become a relative measure between 0 and 1. Additionally two major aspects are involved: 1. the difference between sales and purchase price will most likely increase due to increased transport costs (deJanvry and Sadoulet, 1991) and 2. the price level of other energy dependent inputs also increases. If there is a use of an index, reflecting a cost composition or importance of the two aspects, a reasonable projection helps to depict likely anticipation of farmers.

4.3 Eco-system service probability learning

Now we have to move to the expectation of eco-system-services, i.e. learning of the farmer/peasant. Eco-service expectations are equally qualified and modeled as learning, firstly. Secondly, the real system behavior is depicted and we join it soon. For the moment let us start with the learning process:

$\varepsilon^{e}{}'(t) = [1-\Phi_{21}]\, \varepsilon^{e}(t) + \Phi_{22}\, \varepsilon(t) + \Phi_{23}\, N^{p}(t)$ (17

where: ε^{e} = expected probability of eco-system service

$\varepsilon^{e}{}'$ = change in expected probability of eco-system service

β = observed probability of eco-system service

In this depiction for the eco-service recognition and learning, in (17) notified as an index, we included nature prevalence in terms of $N^{p}(t)$. Nature, for instance, can be an ecological main structure as explained. The structure comprises hedge, grass strips, etc.; for sure the farmers will see correlation with nature and eco-service prevalence. The planer controls the eco-system and asks for contributions n(t) of peasants. Note the contribution n(t) includes efforts; we established already the economics of working and benefiting from nature. The economics for contributing reconsiders nature as exogenous, though strongly determining the well-being indicator of peasants: ε. For clarification, nature appears as a constraint in peasant‘s objective function or it serves as a prerequisite of eco-system services augmenting the production capacities of peasants; jointly with a commercial outlook. The peasant knows the current probability as well as the central planner. Both interact with assertions of life-styles. However, a planner, using objective functions of the rural decision makers and the knowledge on eco-system dynamics as well as commercial scope, develops the optimal path for future probabilities.

4.3 Constraints

Combing the dynamics of the eco-system and learning, gives the system dynamics. Nature has its own dynamics N(t) but by n(t) human contributions are necessary, for example by new stonewalls, hedges, and labor, nature can improve. Expectations are driven by learning and own contributions of peasant lifestyle, and a notification of the status of the eco-system gives:

$\beta^{e}{}'(t) = [1-\Phi_{1}]\, \beta^{e}(t) + \Phi_{2}\, \beta(t)$ (18a)

$\varepsilon^{e}{}'(t) = [1-\Phi_{2}]\, \varepsilon^{e}(t) + \Phi_{2}\, \varepsilon(t) + \Phi_{3}\, N(t)$ (18b)

$\varepsilon'(t) = \Phi_{31}\, \varepsilon(t) + z$ (18c)

$N'(t) = \Phi_{31}\, N(t) + \Phi_{32}\, n(t)$ (18d)

In equation (18) the system dynamics are described. Nature can be directed by annual contributions of humans n(t). In principle equations (18) provide us a recursive scheme of differential equations including dynamic of learning. The instrument variable is n(t) in equation (18d).

5 Setting up the objective function, influencing probabilities and the role of the planer

The so far elaborated knowledge gaining process and eco-system development becomes now part of a further analysis and optimization. As said the knowledge of the farmer is dependent on his situational assertion; it is repetitive and does not go beyond a specific forecasting. The task of the planner is to assure a translation of the eco-system development into the objective of farmers, knowing that probabilities are learned. On the side of the planner this means that the future of the eco-system service has to be put into an anticipation of likely life-styles as well as initiation of the learning process. The instrument is n(t) to assure the prevalence of eco-system services as land set aside and labor. Resource devotions by humans, given in farm plans (notified in n(t) or fees/subsidies), are crucial. Interfering in objective functions means that instrument variables have to be explicitly modeled and that they impose a reduction in the short term benefits. Since they infer in the “optimal” allocation from a private calculus, farmers will feel a decline in their short run personal benefits; but if they will work harder probabilities tell better future. The “well-being” and hence “interest” of peasant/farmers is “manipulable” for future scope. The task of the planner is to use the instrument n(t) such ways that farmers themselves are responding according to the inclusion of the probable outcomes, which are learnt.

For this purpose, we suggest a link between framing practices on the eco-system services side and scopes for adjustment on the objective function side. However, for a further delineation and real anticipation of plans for land use change, it is important to specify the particular instrument in more detail. For the moment we draw on the general outline of an ecological main structure, EMS. In the case of a direct planning for the size of EMS, for instance, a land zoning approach seem to be a most practical implementation principle (Wossink et al. 1998). However, these are suggestions that require a rather complicated exposition of real world concepts by complementary activities of landscape modeling; at least, since it would involve a sizable set of instruments and variables simultaneously, more detailed planning is needed in communities. For the time being, we use one instrument for the dynamics, and it can be also an index and shall be sufficient. Note there are several alternatives to specify instrument or control variables of a planner. Our choice merely has demonstrative purpose.

5.1 Planer's objective function

Having clarified things on the number of variables in the dynamic constraint setup, the objective function needs some further comments. As been highlighted already, the expected value or probability of the eco-system service, conducive for a lifestyle, is a state variable for the planner of the system. Given types of farmer and peasant life-styles and behaviors the predictor/planner summarizes and assures that probabilities add to one. Additionally the expected eco-system service is an element in the particular objective functions. We can presume that, as an example, that the number of bee colonies (size of services) has positive impacts on the yields of the farmer/peasants; in practice the impact of the size of service is different according to decision making styles. To maintain, a mathematically feasible structure we could just take a linear dependency of the absolute volume of eco-system service in the specific objective functions of the decision making styles. An alternative is to take a Taylor approximation on behavior which is structurally conducive to a quadratic outline of probability and volumetric effects. This enables a recombination of probabilities with the volume of eco-system services ε, finally determining the expected profitability of profits or utility functions dependent on the system dynamics. The unit of measurement for eco-system-service remains ε. In principle if we assign probabilities to the predetermined sections and we would get a joint function:

$$W(\varepsilon,N,n,t) = \varepsilon\cdot\beta\ A_{11}(\varepsilon,N,n) + \varepsilon\cdot(1-\beta)\ A_{12}(\varepsilon,N,n) + (1-\varepsilon)\cdot\beta\ A_{13}(N,n) + (1-\varepsilon)\cdot(1-\beta)\ A_{14}(n) \quad (19)$$

where: $A_{11}(\ldots)$ = benefits transition peasant segment
$A_{12}(\ldots)$ = benefit peasant segment
$A_{13}(\ldots)$ = welfare commercial farmer segment
$A_{14}(\ldots)$ = objective disaster segment

In this function each segment has received a weight by a probability. The probabilities are assigned according to life-styles and vary with future learning, which has been explained above. In the concepts we us partially defined behavioral equation; these behavioral equations were linked to the empirical assignment of being peasants or farmers. Now they are aggregated. The advantage of this procedure of empirical foundation of behavioral segments and the empirical foundation by observation and partial planning is that we can use observable probabilities and connect them with the optimization in linear programming of lifestyles (on functional forms see the above outline). The formulation is best given by a quadratic outline. Then, instead of the initial framing as a combination of a given probability with a deterministic accounting of costs and benefits in each lifestyle, the overall picture appears as function of flexible probabilities: Eco-system services become involved in objective functions. In fact, all partial elements and their aggregation deliver a final quadratic exposition for the planner as given in:

$$\begin{aligned}W_t=&\varepsilon\cdot\beta A^*_{11}\beta\cdot\varepsilon+\varepsilon\cdot(1-\beta)A^*_{12}(1-\beta)\cdot\varepsilon+(1-\varepsilon)\cdot\beta A^*_{13}\beta\cdot(1-\varepsilon)+(1-\varepsilon)\cdot(1-\beta)A^*_{14}(1-\beta)\cdot(1-\varepsilon)+\varepsilon\cdot\beta A^*_{21}\\&[N+B^*_{21}n]+\varepsilon(1-\beta)A^*_{22}[N+B^*_{22}n]+(1-\varepsilon)\cdot\beta A^*_{23}[N+B^*_{23}n]+(1-\varepsilon)\cdot(1-\beta)A^*_{24}[N+B^*_{44}n] \quad (20)\end{aligned}$$

where: A^*_{ij} and B^*_{ij} : modified coefficients for variables representing the farming system and lifestyle

Notice, here β is already determined following a secular trend; i.e. it is exogenous (explained soon). Then a technical issue is now, to determine what are state variables and what are control variables: for us the eco-system service "ε" and nature "N" are state variables; "n" is the control variable.

5.2 Planer's deliberations on commercial prospects

As said, the open question is how the expectation of the commercial "decline" can be modeled. A first logical assumption would be that the decline is independent of the ecological pathway. In such a case a link between ecology and commercial prospects does not exist. We consider commercial prospects independent; otherwise modeling can be quite complicated. One can postulate a rapid decline of prospects noticed and learned by farmers/peasants; the solution is then a differential equation (21a):

$$\beta^{e\prime}(t) = [1-\Phi_2]\, \beta^{e}(t) + \Phi_2\, \beta(t) \tag{21a}$$

$$\beta^{e}(t) = \beta^{e}(0) \exp\{[1-\Phi_2]^{-1}\, t \} + \int \exp\{[1-\Phi_2]^{-1}\, t\}]\, \Phi_2\, \beta(t)\; d\tau \tag{21b}$$

With such an exponential decline of the economic prospect we can simplify the issue to

$$\beta^{e}(t) = \beta^{e}(0) \exp\{[1-\Phi_2]^{-1}\, t\} + \Phi_{20}{}^{*} \exp\, \{\Phi_{21}{}^{*}\, t\} \tag{21c}$$

This element can directly substitute the probability in the objective functions and it can be become easily linked to discounting. If commercial prospects play a role, scenarios are possible on different speed of decline. That demonstrates the importance of eco-services. Assuming the central planner has foresight and takes expectations for the farm community, it contributes to residual discounting:

$$\beta^{e}(t) = \beta(0) \exp\{\Phi_{21}{}^{*} \cdot t\} \tag{21d}$$

5.3 Planer's deliberations for operational choices

For a further depiction and analysis the commercial prospect can now be used as information within the usual discounting $\exp\{-\iota \cdot t\}$, simply by multiplication. For residual, since we expect the development of the commercial component takes an exponential form, the discounting is also exponential. Then we can set up a new control problem (Naevdal, 2001 and 2003) where we us probabilities as arguments in the objective function (22) for the predictor/planner:

$$\int \exp\{-\iota\, t\} \beta(0) \exp\{\Phi_{21}{}^{*}\, t\}\;\; W(\varepsilon, N, n, t)\, dt \tag{22}$$

It emerges as an inter-temporal objective function. In (23) as a generic representation of farmers

$$\int \beta(0) \exp\{(-\iota + \Phi_{21})t\} W(\varepsilon, N, n, t)\, dt \tag{23}$$

The approach of Naevdal is given is a new outline. By this approach the expected eco-service "ε" remains a state variable. Another state variable is nature N. State variables are variables changing over time. They are supplemented by control variables (Seierstad and Sydsaeter, 1987).

For the moment the model does not provide incentive mechanisms to encourage peasants. It just calculates the needed periodical nature provision. As been indicated above amendments allow a more explicit recognition of incentive instruments. Here we outline the necessary path for an engagement of peasants in nature provision and its implication for the eco-system service. For the purpose of optimization of pathways to avoid eco-system service declines, i.e. correctly calculate costs of restoration, we can proceed with a quadratic objective function of the planner (24). Function (24) is a condensed version of (20). For those who are interested in optimization we refer to Naevdal. Our structural outline of the problem demonstrates the need of aggregation of objective functions as a probabilistic approach, and we see possibility to influence the recognition of the eco-system via a eco-system service:

$$\begin{aligned} &\int \iota_0 \exp\{-\, \iota_1 t\}[\, \varepsilon' a_{10} + N' a_{20} + n' a_{30} + .5\, \varepsilon'\, A_{11}\, \varepsilon + \varepsilon' A_{12}\, N + \varepsilon' A_{12} n + .5\, N' A_{13} N] + .5\, n' A_{14} N]\, dt \\ \text{s.t.}\quad & \varepsilon' = A_{21}\, \varepsilon' + z \\ & N' = A_{31}\, N + A_{32}\, n \\ & z = z_o \;\text{ if }\; y(\tau) > y_{thres}(\tau) \\ & z = 0 \;\text{ if }\; y(\tau) < y_{thres}(\tau) \end{aligned} \tag{24}$$

For the optimization we can specify a corresponding Hamilton function (Neavdal, 2001), in which a switching of regimes is included and N and ε are states which have a shadow prices.

$$\begin{aligned} H(t,\varepsilon,N,n) = {} & \iota_0 \exp\{-\, \iota_1 t\}[\, \varepsilon' a_{10} + N' a_{20} + .5\, \varepsilon'\, A_{11}\, \varepsilon + \varepsilon' A_{12}\, N + .5\, N' A_{13} N] \\ & + \lambda_1[\varepsilon' - A_{21}\, \varepsilon' + z] + \lambda_2[N' - A_{31}\, N + A_{32}\, n\,] \end{aligned} \tag{25}$$

One receives optimality conditions similar to Naevdal (2001) and Naevdal (2003). A strong similarity is established with these papers, but the expectations are now part of the process.

6 Conclusions

Our peasant/farmer, who is considered to be conservative and risk averse, will avoid climbing over the edge. He will make plausible judgments on his life-style, based on declines (improvements) of both, commercial opportunities and the eco-system services. Hereby he may feel sometimes trapped as peasant, but for the benefit of a future which avoids climbing over the edge, eco-system services will count. Hopefully, disasters can be mitigated.

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