Renewable Resources and Value-Based Complex Forest Management

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INTRODUCTION

The human society is an inseparable part of nature and if we perceive it as complex and difficult to describe, this is a result of the capabilities of our consciousness. The needs of the society and the vital resources required for its existence are completely embedded in the aspects of the surrounding reality. The nowadays use of natural resources demands a more complex assessment approach that takes into account factors such as economic efficiency, social impact, environmental impact, etc. The manner in which we conceptualize and utilize these resources depends on the level of the collective and personal individual consciousness and its perfection. Different social groups perceive and use the natural resources with different aspect of intensity and different awareness. This determines the multiple aspects of the production processes in the process of objectives' multiattribute modeling and formation as well as in the control of these processes. Accounting for the social and group interests in the nature utilization processes have been analyzed by various contemporary authors (Farnsworth, 1983; Shukla & Dubey, 1997; Jungmeier, 2003).

In the literature are discussed different decisions making approaches, as the focus is on the different aspects of the group decision making as a response to the multiple aspects of the interests and needs of the various social strata representatives. In the considered approaches and methods it is sought to additionally account for the intensity of the social or group preferences and their combination in common relation. However, it is necessary to emphasize that measurement and comparison of preference intensities are mathematically permissible in the interval scale (Clark, 1990; Keeney & Raiffa, 1999; Jungmeier, 2003).

There are many investigations of the production processes and its modeling (Hotelling, 1931; Swallow, 1994, Clark, 1990). Widely known and discussed are the models for production management proposed and used by Canadian scientists Clark and Munro (Clark & Munro,1975). Both types – the exhaustive and renewable production were considered. Clark's models aiming at optimal resource use have been applied to fishing industry in Canada and mining enterprise, but they can also be applied to other branches of the economy and human activity such as agriculture, mining, logging, ecology, etc (Clark, Clarke & Munro, 1979). As a leading scientist in the theory of non-smooth optimization, Clarke has made a brilliant analysis of the optimal control under such modeling and has determined a strategy for finding this control (Clarke, 1983). However, there remains the question of accounting for and including social, economic and other human factors as an extension to this modeling. In our view this can be achieved by using measurement theory and utility and multiattribute utility theory (Fishburn, 1970; Pfanzagl, 1971; Keeney & Raiffa, 1999).

In the present chapter we will consider value based control of logging process with jointly accounted for complex social, ecological and economic factors in the modeling and control. Cases of renewable natural resources are considered including economic efficiency and social effect for the population.

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The new element is taking into account the social impact on the population, such as pay, ecological effects such as biodiversity and their combination with economic efficiency in logging. This is achieved by constructing a multifactor utility function which under the different control models is used as an objective function or as a part of the differential equation describing the production process. The utility function is constructed based on the preferences of biologist expert and reflects his attitudes with respect to the considered production – in this case logging (Lyubenova et al, 2015). Such utility function can be constructed for every stakeholder: government, business, ecologists, or all of them combined in a single multifactor utility function.

BACKGROUND

In ordinal or ranked scale it is possible to search for a common conforming relation only in the same scale. Under the same, in essence, ranked approach there appears the so called Arrow's paradox (Ekeland, 1983). For this class of problem and on that level of measurement the most appropriate mathematical solution is the Kemeny-Snell's median (Litvak, 1982). However, finding it requires "branch and bound" type algorithms and this makes these algorithms difficult to use in practice. If a higher scale for measurement of the preferences is taken, such as the interval, there still remains the question for the respective mathematical validity and availability of appropriate theory and implemented algorithms.

In our view, the most mathematically founded is the approach of utility theory and multiattribute utility theory (Keeney & Raiffa, 1999; Pavlov & Andreev, 2013). Their proper use permits the most complete inclusion of the mathematical and computational power in the process of multifactor modeling and the control of natural exhaustive or renewable resources. The measurement scale for the utility function is the interval scale which allows for exact assessment and comparisons of the expressed human preferences and their intensity with respect to the production process and different aspects of it (Fishburn, 1970; Pfanzagl, 1971). In fact, the utility function is an analytical representation of the preferences in the temperature or interval scale. From conceptual point of view, when assessing utility it is necessary to account for real processes such as inaccuracy in the expressed preferences, errors, information uncertainty, etc. All of that places higher requirements to the process of assessment and measurement of the preferences and their analytical representation as utility. Due to this reason it has been chosen to use the approach of measurement theory combined with the theory of stochastic programming for the assessment and practical implementation of the utility and preferences in practice (Pavlov, 2005; Pavlov & Andreev, 2013).

FOREST SYSTEM, PREFERENCES AND UTILITY EVALUATION

In preceding years, a multiattribute utility function has been built, taking into account three important factors pertaining to a forest system (Lyubenova et al, 2015). The main objective and structure of the study was formulated by a qualified bio ecologist expert. On the basis of his preferences, the corresponding single-attribute utility functions were evaluated, and using the structure of the problem and the type of independence by utility among the factors, sub-objectives a muliattribute utility was constructed. This multi-attribute utility function could be used in a value based production model as objective function (Keeney, 1988). It is a polynomial approximation of von Neumann's utility and mathematically this polynomial approximation provides the standard for the application of utility in optimal control problems.