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# FOREST MACHINERY REQUIREMENT ESTIMATION – FROM SPREADSHEET TO SIMPLE DYNAMIC MODEL

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## ABSTRACT

Spreadsheet software are commonly available and used in machinery requirements estimations. There are numerous uses and methods available to spreadsheet software, but there are limitations in their capabilities. Due to these limitations, spreadsheet software were compared with a simple dynamic simulation model. Both methods were validated against values from literature and results showed the same trends, with some differences in the values. The simulation model allows possible future development such as including locations and real transport distances and having realistic harvesting times. Wider usability of simulation models does offer more future development possibilities allowing more thorough research of the subject.

## 1 INTRODUCTION

Spreadsheet software are commonly used in research studies. This is due to their availability and easy use. In the project "Impact of forest sector on regional economy of South Savo –Future vision on 2020 century" (later project) (Karttunen et al. 2017), spreadsheet software was used to estimate the need of forest machinery, but some resources were also allocated for developing simple dynamic simulation software. The purpose of the spreadsheet analysis, and therefore of the model also, were to estimate the number of forest machinery required based on the availability of forest resources.

Forest resource availability is dependent on the forest management and harvesting regimes in addition the market demand. The project aimed to estimate the future need of forest machinery with different forest management options. The number of required machineries depend on how much feedstock have become available, but also on how much biomass was processed by previous machines in the system. The amount of products that the machine in question has to process varies based on the supply chain structure.

The aim of this study was to compare results between spreadsheet software and simple dynamic simulation model that were developed to estimate the future forest machinery need. Advantages of developing dynamic simulation model using queue theory and possibilities for future development are presented. Discussion of the necessity of simulation model and how it expands result set inside the study boundaries were conducted.

## 2 MATERIAL AND METHODS

During the project estimation of the required forest machinery was done with spreadsheet software and simple simulation model, developed with Anylogic™. The Spreadsheet uses machinery productivity and an estimation of annual operation hours to obtain each machine's annual performance. Instead, the

simulation model used queue theory where forest products were moving through elements, that represent different operations. Forest resource available was the entity that described the feedstock batch of one stand. Forest resources were delayed in different elements based on machinery productivity.

Simulation model was kept simple and advanced capabilities such as GIS or inclusion of database were left out for future development in this analysis. This was done to ensure that the core design of the model worked as indented, and to make validation easier. However, this limits the possibility to use road network for real distances or to supply availability distributions from databases.

To validate the models, statistical values of forest removals in Finland in 2010 were used to estimate machinery numbers. The model's machinery numbers were compared to corresponding numbers from literature (Ylitalo 2013).

## 3 RESULTS

The number of estimated machines in Finland in 2010 are presented in Table 1.

Table 1: Estimated number of forest machinery for 2010.

| Machine | Literature | Spreadsheet | Simulation [Min] | Simulation [Mean] | Simulation [Max] |
|---|---|---|---|---|---|
| Harvesters | 1900 | 1297 | 1147 | 1775 | 2828 |
| Forwarders | 1970 | 1631 | 1163 | 1691 | 2875 |
| Trucks | 1330 | 1456 | 994 | 1498 | 2557 |
| Chip trucks | - | 142 | 77 | 138 | 191 |
| Chippers | 190-78* | 97 | 0 | 27 | 113 |

*190 based on estimation and 78 from survey.

## 4 DISCUSSION

Validation shows that spreadsheet gives lower estimations for harvesters and forwarders. This was expected, as the spreadsheet used theoretical productivity hours for the estimations and usually real machines may have more leisure times and variations in the productivities. The simulation model has closer mean values with harvester and forwarder estimations, although they are underestimated. This is understandable, as mean values indicate the work of harvesters and forwarders being close to perfect allocation. Timber transportation machinery were also little overestimated in spreadsheet and simulation models. For energy wood, both spreadsheet and simulation model underestimated the need of chip trucks and chippers and the results were found invalid.

By comparing spreadsheet estimations and simulation mean values we can note both having same trends. The spreadsheet gives lower estimations but as validation showed, this was due to using theoretical values for annual productivity. As simulation mean values were lower in the validation due to temporal variance of removals, it is reasonable to report simulation mean values as the minimum need and realistically expect higher amount of machinery needed.

It can be concluded that simulation model does not give high advantages in comparison to spreadsheet model at its current development state. The possibility to add travel distances using GIS and more realistic harvesting timing with database to the simulation model gives more directions and make optimization possible for future development. On the other hand, it would increase the complexity of the model. The spreadsheet model in this study proved to be sufficient, but simple dynamic simulation model gives more future development directions towards not as simple model with great advantages to the study.

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