GroupWare and Group Decision Support Systems for Wood Procurement Organisation. A Review

Teijo Palander, Mari Toivonen and Sanna Laukkanen

Palander, T., Toivonen, M. & Laukkanen, S. 2002. GroupWare and group decision support systems for wood procurement organisation. Silva Fennica 36(2): 585–600.

Many kinds of decision support systems (DSSs) have been suggested for use of wood procurement organisations, but few meet the real needs of team managers in group decision-making process. Therefore, it has been concluded that the important features of group decision support systems (GDSSs) should be developed for teamwork-based organisations. Electronic meeting systems (EMSs), Computer-aided Visualisations (CAVs) and heuristics as well as other numerical approaches as combined with optimisation seem to be some of the most promising elements of GroupWare, because decisions are made in distributed groups and they deal with human behaviour. Relations between GDSSs and spontaneous decision conferencing (SDC) for modern organisations are also discussed, and suggestions for future research of management approaches are also given.

Keywords teamwork-based organisation, group decision-making, communication, collaboration
Authors' address University of Joensuu, Faculty of Forestry, Box 111, FIN-80101 Joensuu, Finland **E-mail** teijo.palander@forest.joensuu.fi
Received 28 June 2000 **Accepted** 27 May 2002

1 Introduction

Applications of telematical or telemechanical technology have provided organisations advanced information and communication systems. They have been shown to be very helpful electronic systems (GroupWare) in all kind of group work. Recently, attention has focused on the relations between group decision-making and communication in organisations' dispersed structures. When organisations are being streamlined and more focused on advancing logistics, the value of group decision-making will constantly increase. In this respect, domestic research has also reported team managers' needs for education of helpful GroupWare (Leppänen et al. 1999, Toivonen and Palander 2001). Furthermore, the reinforcing effects on individuals of observing other managers succeeding well in co-ordination of responsibilities in teamwork-based organisation using GroupWare are well established in international literature.

The theory of GroupWare approach supporting small group communication and collaboration has been discussed for about ten years, while the technology for conferencing systems has been available for management of organisations for twenty years. Recently, these systems have been developed to support everyday decision-making, which is referred to as Spontaneous Decision Conferencing (SDC) (Hämäläinen and Leikola 1995, Palander 1998c). SDC can be used to manage whole decision-making processes of a group, in which Group Decision Support Systems (GDSSs) can be used to avoid groupthink and Electronic Meeting Systems (EMSs) in turn can especially help to support group dynamics. All of these tools are understood as subsets of GroupWare.

Characteristics of the decision-making situation of Finnish wood procurement organisations have been described as presented in Fig. 1 (Palander 1998b). At all organisational levels team managers' real needs for GroupWare were assumed according to this description list. Actually, it has been found out that group decision-making in teamwork-based organisations requires more communication than traditional decisions made without group in organisations based on functional divisions (Leppänen et al. 1999). This is because the transformation of the organisation to a team structure requires changes to several organisational features, focusing attention on the functionality of the team instead of on the actions of the foreman. These changes are especially extensive for an organisation with its personnel geographically dispersed (Mohrman 1999). Thus, if geographically dispersed team-based organisations are used, in addition to effective communication, the need for possibilities for collaboration is especially high (Cohen and Mankin 1999). However, extensive time is still spent at different meetings and in the travel to these meetings. Since also distances between managers are further extended, more GroupWare for collaboration should be used in decision-making (Toivonen and Palander 2001).

Decision Support Systems (DSSs) are largely used and discussed in literature. Generally, they are interactive computer-based systems, which present decision alternatives (Harstela 1997). With DSS a decision-maker can better understand and learn a decision-making process, and thus make better and perhaps also faster decisions (Scott-Morton 1971, Keen 1981, Turban 1988, Silver 1991). For some time, the definitions of DSSs have included properties like interaction, the ability to solve ad hoc problems, and the use of models (Jelassi 1986, Turban 1993). However, theory behind DSS is quite narrow, because GroupWare technology has developed. Therefore, more comprehensive systems have been developed for groups, which need to use many ways of communication. These systems are called GDSSs, which are in that sense subsets of GroupWare, because GroupWare may provide electronic collaboration facilities needed in GDSS. Originally, Rao and Jarvenpaa (1991) laid out the foundation for future research in the GDSS topic area.

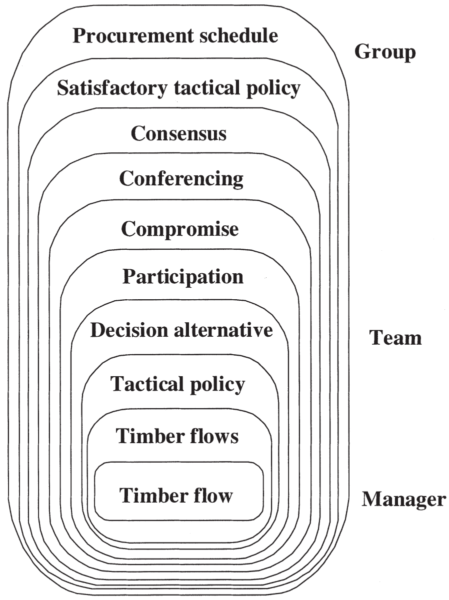

Fig. 1. Characteristics of decision-making situation and respective decision-maker levels.

Theoretical research into group decision-making is recent within the field of wood procurement. Consequently, studying GDSSs and the features adhered to them are also just beginning. However, EMSs, Computer Aided Visualisation (CAV), optimisation and some numerical approaches of GroupWare have been found useful in the formulation of models in the context of GDSSs (Palander 1998b, 1999a). Although most of GDSSs systems are undeveloped, there are expectation values to study them, since big forest industry companies are interested in developing them.

Reviewers of DSS suggest that difficulties in the decision-making processes of wood procurement include the remoteness of planning models from the actual decision making and a lack of heuristic and cognitive components (Robak 1991, Harstela 1997). In the sense of electronic systems, they obviously mean numerical approaches, when they mention heuristic and cognitive components. Following the approach of GDSS research, Toivonen and Palander (2001) suggest that these difficulties should also include so called group aspects. They showed that these difficulties are partly due to the lack of human and social interaction caused by the geographical separation of managers involved in the process, as well as the attitudes of managers towards the new tools. Partly, of course, the difficulties are caused by the general unpredictability of the natural environment, in which wood procurement functions are performed (Palander 1995).

Anson et al. (1995) have reviewed various group researches. They found that structured communication and decision-making procedures have been effective in enhancing social interaction, although the procedures have been used without computer support. In order to find more support for group decision-making, potential computer applications related to GroupWare have also had to be found out. They have been directly reviewed under several well-known subject areas, such as Decision Analysis (Corner and Kirkwood 1990, Spector 1993), Group Decision Processes and Mathematical Programming (Lewis and Butler 1993), Group Meetings (Anson et al. 1995), EMSs (Dennis et al. 1991), and Conferencing (Hiltz et al. 1991). These reviews provide knowledge about the potentials of communication and collaboration tools, which could also effect positively on managers' attitudes.

The emphasis of this review will be on the group decision-making related to the team-based structure of the wood procurement organisation, and its relationships with customers. The contribution of the article is to produce a theoretical understanding for the support of it in the wood procurement process. GroupWare, SDC, GDSSs, EMSs, CAVs, and some other numerical approaches are to be described and defined to accomplish this objective. The necessity of GDSSs is going to show by the over twenty years of development of group decision-making. The aim is to analyse literature related to group decision-making within the context of management science, decision science, psychology, education science, sociology, and forestry in order to synthesise the features, which GDSSs need to be suitable for wood procurement applications.

2 Group Decision-making and GroupWare

GroupWare is organisation's software for computer-supported co-operative decision-making (Anson et al. 1995). For GroupWare decision-making models and methods have been adapted to group dynamics so that decision-making groups can actively reach consensus through equal participation. Thus, the decision-making groups' broad needs to aggregate information and to choose among decision alternatives are satisfied in group processes (Hackman and Kaplan 1974).

When group decision-making is used, GroupWare applications of SDC can be used to provide possibilities for the use of EMSs. In studies of this area, conferencing is defined as a subset of the Computer Mediated Conferencing Systems, but actually both of them are taking on more of the features of conferencing methods (Hiltz and Turoff 1985). Therefore, many distinctions between simple electronic messaging systems and group-communication-oriented conferencing systems will become negligible. Then GroupWare would facilitate brainstorming, decision-analytic problem structuring, prioritisation of criteria and analysis of the alternative decisions (Hiltz et al. 1991, Hämäläinen and Leikola 1995, Palander 1998c).

In wood procurement, managers work in geographically separated offices. To support decision making, they could collaborate using GroupWare-like telecommunication in their remote decision-making sessions (Toivonen and Palander 1999). Anson et al. (1995) have suggested that in this kind of session group members could have electronic videoconferencing support, or simply teleconference. In practice, using GroupWare technology, e.g. shared written or visual information, model bases, audio- and videoconferencing, decision-making groups could share ideas, aspirations and preferences, and consequently enhance collaboration.

3 Group Management and Spontaneous Decision Conferencing

In the 1990s, organisations have been under pressure to manage information flows effectively and efficiently in order to be able to respond to the changing aspects of decision-making. Therefore, it is not surprising that use of information continues to be an important element in the management of decision-making processes of teams (Kärhä 1998). For example, for decision making, a supervisor must be concerned about how each of his busy team managers interprets information and interacts in communication. However, at present there is an ideological controversy between the flexibility of teamwork, and the control inherent in the traditional leadership (Hayes and Walsham 2000, Wiesenfeld et al. 1999).

In order to improve the use of information, group collaborations even without GroupWare can be adapted to multiple decision maker situations. For this purpose managers' preferences must be aggregated into a single group or consensus preference (Lewis and Butler 1993). According to Sen (1970), this aggregation requires three distinct and interrelated activities: individual preference measurement, interpersonal preference comparison, and group preference determination. Sen (1970) constructed a utility model providing the aggregation principle to structure human interaction.

However, group meetings are often not as effective as they could be (Shaw 1981). Meetings may lack a clear focus, because making a clear difference between group decision-making and negotiations is very difficult. Often managers may even hold back from participating because they are apprehensive about how their ideas will be received. Particularly, team managers are experts in the field of the decision task, but they are rarely experts in the theories involved with decision making. Therefore, meetings may end without a clear understanding or record of what was discussed.

Despite the difficulties, little computer support is available for group meetings, which is surprising, given the ubiquitous nature of computer support in modern organisations (Meriläinen et al. 1995). According to the group studies, a group in an organisation may use many approaches to adapt a participatory phase of collaboration to a management policy. Often, a method of full-scale conferencing is used. Generally, it is understood as a two-day meeting in which a decision-making group tries to solve a strategic decision problem with the help of a facilitator and a decision analyst. Unfortunately, two-day meetings last too long and strategic decisions are rarely made. Therefore, a method has been developed to support everyday group decision-making, which is referred to as SDC (Hämäläinen and Leikola 1995, Palander 1998c).

Often DSSs as kind of Management Information Systems (MISs) have been recommended without the needs for SDC or GDSSs, because time for meetings is characterised as a critical factor at the top hierarchical level of wood procurement organisation. Similarly, setting a date for the lower level managers' meetings is also difficult. However, decision-making groups of them are characterised as ongoing groups. Thus, spontaneous and ad hoc group meetings are characteristics of their decision-making process. The above mentioned special characteristics encountered in the meetings would suggest that computerised conferencing and the related decision-making approaches should be join with them and especially from the managers point of view (Huber 1991, Palander 1998b). Therefore, they suggest GroupWare-like SDC to manage group collaboration in meetings.

According to Hiltz and Turoff (1985), an organisational solution to constrict the flow of information and communication is not without its costs. On the other hand, meeting outcomes are contingent on the balance of an electronic meeting's gains and losses (Connolly et al. 1990). Accordingly, group-collaboration characteristics, e.g. group features, organisation's infrastructure and the Decentralised Information Processing Technique, could establish an initial balance of decision consciousness, which the decision-making group may alter by using EMSs and SDC (Dennis et al. 1991, Palander 1998a). Therefore, Ancona's (1987) research on boundary management (i.e. the management of a decision-making group's performance with situations and individuals external to the decision-making group) raises an interesting theoretical point with respect to management. Ancona (1987) found that teams equally matching the characteristics could be differentiated based on boundary management.

4 Group Dynamics and Electronic Meeting Systems

Generally, the advantages of EMSs compared to an ordinary face-to-face meeting include: reducing the impact of social obstacles (passivity, domination, etc.), more careful preparation for a meeting, and a better structured meeting process (Fish et al. 1993, Nunamaker et al. 1991, 1995, Tan et al. 1998). Research into the processes of group collaboration has also shown that there is no difference between the outcomes of technically sound videoconferences and face-to-face meetings, but without video, electronic meetings produce significantly worse results. This conclusion bases on the fact that the difference between the impact of video conferencing compared with that without video mainly relates to communication, which is apparent in the long run.

In group collaborations, managers can use EMSs for advancing group dynamics. It is possible due to a built-in provision to allow anonymous suggestions and to applications of heuristic decision practices (Beck and Lin 1983). These features act to eliminate some managers' dominating behaviour and produce a more innovative atmosphere (Ellis et al. 1991, Nunamaker et al. 1991, Stefik et al. 1987). Using advancing features of EMSs a group may be efficient in decision making. As a result, a significant portion of research on GDSSs is related to EMSs that primarily support the communication process between decision-makers, e.g. teleconferencing, electronic mail, and different networks.

A large amount of research into group dynamics comes from the fields of social psychology and human behaviour in organisation (Williams 1978, Shaw 1981, Finholt 1997). In order for a group to be efficient and to meet its goals, the support of communication between the group members is needed. In general it is known that communication is effective within an efficient group. If it is not, it can be improved, e.g., with non-verbal communication by means of visual cues like gestures and facial expressions. Furthermore, in an efficient group, consensus must exist on the division of participation and management among the members; appropriate decision-making methods for specific situations should be applied in a flexible way; the leadership should be equal or acceptable to the group as a whole. For these features developing of EMSs is ongoing.

5 Groupthink and Group Decision Support Systems

In the recent DSS research, criticism has been directed toward the lack of interaction between the cognitive and psychological aspects of human problem solving and decision support (e.g. Carlsson 1991, Vanharanta et al. 1997). Therefore, a special form of DSSs, active decision support system, was studied, in which the DSS played an active role in dealing with ambiguous and complex problems (Manheim 1989, Carlsson and Walden 1995). The active decision support system does not follow specific orders, but has the ability to respond to non-standard requests and commands. However, real applications dealing with immaterial investments are still waiting for future innovations (Keskiäijö et al. 1996).

Among other social issues, DSSs have failed to provide features for addressing problems of groupthink (Palander 1988b). In particular, it may be associated with the following: incomplete generation of decision alternatives, incomplete understanding of goals, failure to examine the risk of preferred choices, poor quality of search for information, bias in the interpretation of information, failure to appraise alternatives. To avoid these problems, the features of decision support need to have not only the features of DSSs, but also hardware, software, and models necessary to reveal the negative aspects of groupthink. GDSSs represents this technology (Anson et al. 1995, DeSanctis and Gallupe 1987, Sauter 1997). They suggest structured decision-making processes with numerical approaches, which would support the aim of reaching satisfactory decisions instead of rational decisions following the principles first described by Simon (1955).

Research into groupthink has revealed an interesting phenomenon. Conflicts caused by controversial ideas and different opinions should be encouraged, because they increase the quality and creativity, as well as the commitment to decisions. The drawbacks to conflict within group decision-making include the excessive impact of dominant personalities on outcomes and erroneous consensus. In the latter situation, decisions are not criticised in order to avoid conflict, thus maintaining a good atmosphere. These disadvantages should be controlled during the decision-making process (Johnson and Johnson 1987, Hogg and Abrams 1988, Baron 1992, Couger et al. 1993, Hogg and Vaughan 1995, Sosik and Avolio 1998).

According to the literature, several comprehensive theories for group decision-making have already been applied in DSS research. Most of them, e.g. multiple attribute utility theory, social judgement theory, and social choice theory, are usable in GDSS research. In fact, GDSS as the concept adopted for research, when the development of elements of GroupWare started for decision making. These elements resembled computer supported collaborative work systems. They included work patterns, as well as tools for the specific organisation's co-ordination, control, and norms. When the elements are deeply embedded into the social practices of an organisation, they strengthen the organisational social constructs.

GDSSs are especially convenient for situations with several nearly equal alternatives (Piippo et al. 1999). Recently, it has been stated that at the local level of wood procurement organisations, decision making may be a tactical choice between alternatives that have been calculated to be equal (Palander and Toivonen 1999). According to them, further knowledge of different situational conditions influencing decision making is therefore needed. In addition, procurement plans and decisions may need to be modified, sometimes rapidly, during their implementation due to changes in timber requirements or the natural environment. Under these circumstances, GDSSs supporting interaction and communication of managers are better able to manage the groupthink in the logistic management problems (Palander 1996, 1998b, 2000b).

Kärhä (1998) proposed use of DSSs for timber buyers' work. The aspect of timber buying is based on customer satisfaction (satisfaction of a seller), the monitoring of which is usually included as a part in a whole quality management system. Palander (1998c, 1999a) has proposed using GDSSs for all kind of managers' work. Particularly, he developed an adaptable system model for the determination of balanced stocks in the logistics flows. The model was applied according to the theory of Simon (1955). Thus a decision-making group can determine bounded rational sizes for the buffer stock. The model could also be used as a business process model, because for supply chain management both material and monetary flows of the model were depending on satisfaction of mill customers. Testing broader GDSS applications that could support actual decision-making and a whole environmental quality management is just beginning.

6 Co-operative Groups and Computer-aided Visualisation

Current, major challenges for managers of wood procurement include: changes in the forest owner population (Ripatti and Reunala 1989, Sikanen 1999, Leinonen 1998), a hectic pace of working (Klen 1998), forest owner satisfaction (Kärhä 1998), mill satisfaction (Palander 1998c), all-inclusive service (Kärhä 1999), and socio-economic logistics (Palander 1999a, 2000b). To respond to these challenges, CAVs have been understood as a potential feature of GDSSs to provide more efficient support for managers to cooperate with forest owners and public. A search for new more appropriate CAV models has therefore started. It also seems that new innovations and development in communication and information technology can, at least partly, meet the needs for efforts that CAV models require in wood procurement.

In decision making of wood procurement, CAVs mean any visual way to give information to decision-makers, in which e.g. figures, images and photos have been used to compress information before the knowledge has been formed. In the first place, CAVs have been suggested for forest industry companies, because decision making about logistic decision alternatives could be made easier, if group managers could also be motivated with participatory and interactive planning (Palander 1996, 1997, 1998b). Particularly for mill satisfaction, which is the main responsibility of wood procurement organisation, CAVs could support managers dealing with abundance of information. Palander (1997) has also stated that Geographical Information Systems (GISs) with its internal CAV will probably be a part of these kind of decision-making and planning systems.

CAV of forestry means making descriptive information about a forest (e.g. tree and terrain information) visible. So far, in forestry functions of forest industry companies, CAV of forestry has been used for forest management planning and observing the progress of forest damage. Some descriptive studies on CAV of forestry are: Orland (1988, 1991), Pukkala and Kellomäki (1988), Cox (1990), Orland et al. (1990, 1991, 1992, 1993), Nousiainen and Pukkala (1992), Tyrväinen and Tahvanainen (1999), Nousiainen et al. (1998) and McCarter et al. (1998).

In addition to managers' viewpoint, the need for CAVs may arise from the following reasons: increased interest in social environmental issues, increased public calls for environmentally friendly forest operations, decreased knowledge about forestry among forest owners, and education of communication, computer, and information technology. These are mainly the viewpoints of forest owners and public. Karppinen (2000) has classified forest owners onto four types: recreationists, self-employed, multiobjective, and investors. According to him, the share of recreationists and investors will grow in the future. Recreationists differ from the other groups due to their greater concern for the protection of the landscape values, which relate to outdoor activities. Ripatti and Reunala (1989) have suggested that forest owners are mainly concerned about the visual effects of logging operations planned for their holdings. By the same way public evaluate operations by the visual impacts they cause (Schauman 1988). According to Kilvert and Griffith (1996), perceptions of environmental quality are also primarily visual.

When considering forestry knowledge, a forest owner, public, and managers are unequal in their meetings. With CAV of forestry novices (forest owners or public) and professionals (managers) could cooperate in the proposed forest operations interactively in a way all involved could understand (Orland 1988, 1992, 1994, Cox 1990). It seems that decision making could be easier when impacts of different operations on the landscape were presented as pictures beforehand. Also Johnson et al. (1994), Pukkala et al. (1995) and Nalli et al. (1996) have stated that CAV of forestry could be useful for solving forest management problems. According to Pykäläinen and Kangas (1996) and Pykäläinen (1999) participatory and interactive planning could then be used in decision-making.

During timber and pulpwood trading, there are two major problems: first to find enough stands suitable for sale and then to complete a purchasing transaction. To support the first problem, GISs have already been developed, in which satellite pictures, maps, boundaries of forest stands, and information on ownership are connected. When these features of CAVs have been combined with modern marketing skills of managers, they have proven to be useful ways to locate and buy forest stands (Bergström 1998, Sikanen and Oikarinen 1998). In these systems features of GDSSs for purchasing transactions is still undeveloped. Companies currently use only registers of forest owners with some kind of satisfaction measurements made for specific situations.

In Leinonen's (1998) analysis of future wood procurement, 69% of the respondents estimated that by the year 2030 trading will be accomplished through telecommunications, with no face-to-face meetings between managers and forest owners. Therefore, the innovation of forest owner satisfaction by Kärhä (1998) would presume more applicable systems than registers and GISs can provide for monitoring it in practice. Fortunately, Toivonen and Palander (1999) have developed managers' EMSs using GroupWare-like telecommunications. According to them, the features of CAVs could be integrated into this kind of GroupWare.

7 Group Consensus and Numerical Approaches

When a satisfactory compromise is not forthcoming using only EMSs or face-to-face decision making without GDSSs, numerical problem restructuring, i.e. redefining the group decision and negotiation task presentation, is a key approach (Chatterjee et al. 1991). This can also be conceived from alternative theories of the literature of management science. Accordingly, numerical approaches are fundamental in structuring group interaction and communication processes with computers. Chatterjee et al. (1991) focus indirectly on such approaches that use i) cognitive process theory and game-theory models, ii) group decision theory and negotiation support systems, and iii) management theory and artificial intelligence. These categories have been studied over the last ten years. Although they all have been represented via DSSs, or more specifically, via GDSSs (Anson et al. 1995), here the approach of management science are omitted.

Game theory provides various approaches for obtaining compromise solutions in group decision-making (Cramton 1991, Tolvanen-Sikanen et al. 1995). Recently, these non-co-operative game-theory models have come in for criticism for two reasons: i) they are not robust enough to withstand even small changes in the assumptions, and ii) co-operative models have been found to support negotiations of group decision-making better. Furthermore, combining social choice and game theory to multi-objective mathematical programming situations, a consensus can be obtained only under powerfully controlled conditions (McKelvey and Wendell 1978, Wendell 1980). However, in some situations, non-co-operative models can convey some rich strategic flavour of real-life (Chatterjee et al. 1991).

The decision-making approaches of group studies often focus on mathematical programming. It is used as an integrated part of GDSSs or alone via optimisation. In optimisation made alone, three standard multiple-objective mathematical programming methods for compromising the decision problem are i) generating efficient points (e.g. Yu and Zeleny 1975, Wendell and Lee 1978, Dauer and Liu 1990, Dauer and Saleh 1990), ii) goal programming (e.g. Dyer 1977, Harrald et al. 1978), and iii) parametric right-hand side optimisation (e.g. Hadley 1962, Cohon and Marks 1975). These methods can also include an interface for iv) interactive optimisation (e.g. Benayoun et al. 1971, Dyer 1972, Geoffrion and Hogan 1972, Geoffrion et al. 1972, Benson 1975, Zionts and Wallenius 1976, 1983, Steuer and Choo 1983, Nakayama and Sawaragi 1984, Reeves and Franz 1985, Wierzbicki 1986).

The standard methods are also used as integrated GDSSs. According to Jelassi (1986) and Lewis and Butler (1993), interaction in optimisation methods can be implemented as standalone models with no support for communication and information exchange, i.e. as DSSs. Furthermore, most of the previous methods either used direct exploitation of a decision maker's utility function (e.g. Zionts and Wallenius 1976) or setting of aspiration levels (e.g. Benson 1975). Therefore, Siskos and Despotis (1989) developed a DSS for compromise programming of multiple-objective linear programming problems. Actually, the idea of embedding multiple-criteria decision-making models in DSSs was suggested earlier by Zeleny (1982), Korhonen and Laakso (1986) and Keen (1987). Recently, other integrated systems have been developed to improve the participation of a decision-maker in the methods' interactive procedures (Lewandowski and Wierzbicki 1989, Steuer et al. 1993, Vetschera 1994).

The main drawback of compromise programming remains the same as is in the preceding non-co-operative approaches, namely that the compromise obtained in a group meeting is not a case of a group consensus. It should be agreed through a structured group decision-making task (e.g. Kersten 1987, Iz and Jelassi 1990). Then, due to decision-makers' criteria, the consensus can be the result of two-way communication and participatory democracy supported by using an interactive decision system (Blahna and Yonts-Shephard 1989, Knopp and Caldbeck 1990, Creighton 1993). To facilitate this, according to Watabe et al. (1992) and Iz (1992), GDSSs uses a coordinator or some interactive model to aggregate participants' preferences. Furthermore, the participation of managers during decision making could be properly addressed by both approaches. Thus, the interaction and communication, common to most decision-making tasks of decentralised (distributed) organisations (Hoffman and Maier 1959, Iz 1992), could be most easily included in decision-making using these approaches.

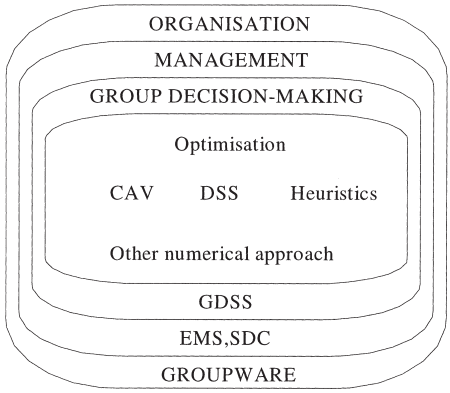

Fig. 2. Features that computerised support systems need to meet in wood procurement; Abbreviations: decision support system (DSS), group decision support system (GDSS), electronic meeting system (EMS), computer-aided visualisation (CAV), spontaneous decision conferencing (SDC).

8 Discussion

In Fig. 2, results of analysis of literature are presented in cross-sectional surface to frame the synthesis of the potential of GDSS to wood procurement. The following discussion about GroupWare and its subset GDDS is concentrated to needs of managers (Fig. 1.) which is difficult to facilitate using DSS. The discussion is also related to future research trends. It can be stated that the conversion to teamwork-based organisations has succeeded surprisingly well in Finnish wood procurement. However, it seems, as Leppänen et al. (1999) suggest, that the share of the management based on approaches of group decision-making is still increasing, so as a conclusion, also teamwork is still looking for its niche. For example, there are needs for shifting from small procurement teams to very large field teams, which would be responsible for large geographical areas. These teams could also be vertically integrated with the upper levels of the organisation on the basis of function. In this kind of arrangement, face-to-face communication may become more difficult, so the reliance on SDC and EMSs will probably increase. Therefore, research should be focused on the use of the both for internal relationships of groups and between different hierarchical levels of organisations.

Although SDC is not yet structured for computer use and in that sense useful in wood procurement, it seems to be helpful and effective meeting strategy for management. Related to GDSSs, a very important research problem of SDC structuring would be to examine how two new leadership styles, transactional leadership and transformational leadership, effect on the efficiency of a group during SDC. It is obvious that one of these leadership styles should be selected, but it is not clear on what grounds. The selection could be based on research into GDSSs; it has already been determined that the different styles of leadership influence the creativity of GDSS groups (Couger et al. 1993, Nunamaker et al. 1991, Sosik and Avolio 1998). It has also been noted that the creativity and performance of a group have a positive impact on each other. Then, the effect of the behavioural components of the leadership styles as grounds on the performance of a group in a task requiring creativity could be found out.

Despite new structures of organisations and management, expectations for at least as fast wood flow remain, which may demand faster decision making. In this kind of situation, Linked GroupWare and EMS could provide communication facilities for increasing use of GDSSs. Furthermore, the increasing needs of decision-making groups for collaboration may lead to integration of EMSs and GDSSs. In theory, desktop GroupWare of videoconferencing could support communication processes between teams in their remote locations. Therefore, for future improvement of GDSS, the most important technical research problem related to EMSs would be to find out how and to what extension GDSS can be combined with desktop videoconferencing. So far, the data conferencing properties of desktop videoconferencing systems have turned out to be useful for decision process (Koskinen 2000). In that case GDSS included not only the use of software and document sharing, but also collaboration. This is in accordance with the suggestions of Cohen and Mankin (1999), that technical tools are needed during the decision process to solve conflicts, to support the process, and to find optimal solutions.

There are several collaborative phases needed for decision-making processes of wood procurement (Palander 1998c, Toivonen and Palander 1999, Toivonen et al. 2001). Therefore, besides the features related to EMSs, numerical technology is also needed for GDSSs to process information files to be used before a meeting as well as after it. Information is needed to aid in producing alternatives (e.g. brainstorming, optimisation) and in analysing them (e.g. visualisation). It seems that the elements of GroupWare applied to optimisation, visualisation, information storing and handling could be programmed for GDSSs based on the available literature. However, it is better to keep in mind that the optimisation models should include special heuristic support and heuristic guidelines, so that group decision-making could be effective and also innovative.

Aside the technological features for GDSSs, knowledge about the applicability of GDSSs for the social communication is needed for group processes and group dynamics. Furthermore, research findings from psychology, education science, sociology, and forestry should be utilised to determine how GDSSs influence human behaviour in organisation. According to literature, if new GroupWare is established, it may have two kinds of effects: either it creates new obligations for the workers, in which case it will be considered an extra charge and will be rejected, or it replaces traditional work, then its use will be easily adopted (Finholt 1997). So far, only the attitudes of wood procurement managers towards EMSs have been surveyed (Palander et al. 2001). According to the results, there are plenty of prospects for application, if technical function of EMSs is reliable. However, there are also a lot of prejudices and resistance to change in working competence, which conservative managers should overcome either alone or using supportive training and demonstration.

Use of CAV as an element of GroupWare is just its beginning. To support timber trading and customer meetings in future, CAV of forests could be used for presentations to participants of meetings. Then, it could be an effort to promote understanding of wood procurement processes. To facilitate both, it would be useful if remote sensing methods, and through them the stand selection system, could be joined to a graphically simulated virtual forest. More comprehensive CAVs could also be used for decision making about customer satisfaction. In that respect, CAV of forest alone could help participants by giving them information about forest area and by illustrating changes in the landscape caused by the implementation of various forest management and logging operations on the area and on different stands. If CAVs were a part of GDSSs, more advanced support would be available for customer satisfaction, but managers would have to be educated to show the effects of logging on other forest values. Probably then, GDSS with CAV could show the effects of wood procurement on biodiversity, landscape, logistics, multiple-use values, as well as on the future production profitability of a forest stand.

An important research task would be to study whether customers need or desire to use CAVs for customer satisfaction, when wood procurement functioning is discussed with customers. The initial research would discern whether CAVs could encourage customers to be more receptive to co-operation. There is no doubt that the theory of group decision-making may be applicable to relationships with customers and interest groups. Furthermore, wood procurement seems to consist of interactive functions between forest owners, public and managers, between whom broad use of GroupWare-like telecommunication is possible. In order for this vision to become a reality, further research must be done before conclusive GroupWare for this purpose can be developed.

Based on this selective review of literature, the decision making of wood procurement could be supported by active elements of GroupWare. However, development of it supposes experiments and empirical studies in the entire group decision-making process. In addition to the already mentioned study areas, testing the practicality of user interfaces for specific GDSSs is a necessity for different organisations and interest groups. By analysing interviews and written reports of experiences, conclusions could be made about the innovations needed for development. Later study could then evaluate what and how the elements of GroupWare have been adopted and accepted, as well as how GDSSs are realistically used. Moreover, modern knowledge about the process could produce a general theory describing GroupWare and GDSSs.

It can be concluded that research should be carried out to investigate experiences of managers, customers and test groups to create 'core' knowledge for educating group members. First of all, the behavioural sides of organisation and interest groups should be studied, as well as management competence, to observe how personnel development for the utilisation of potential computer applications has been undertaken. Perhaps main contribution of this paper will be to stimulate others to treat the topic or subtopics in more depth. The final aim could be to develop a virtual reality model to be used for research and education. This kind of virtual environment could even be used as part of a distance learning/teaching technology directed at the personnel of organisations (Palander 1999b, 2000a). According to the vision, repetitive conclusions could be made on how to improve the competence of the decision-making group.

Acknowledgements

This review is part of a research project entitled 'Group Decision Support in Wood Procurement', led by Professor Pertti Harstela at the University of Joensuu. The authors wish to thank the Academy of Finland for providing financial support for the research project.

References

Ancona, D.G. 1987. Groups in organizations. In: Hendrick, C. (ed.). Group processes and intergroup relations. Sage Publications, Newbury Park. CA. p. 207–230.

Anson, R., Bostrom, R. & Wynne, B. 1995. An experiment assessing group support system and facilitator effects on meeting outcomes. Management Science 41(2): 189–208.

Baron, R.S. 1992. Group process, group decision, group action. Open University Press. 231 p.

Beck, M.P. & Lin, B.W. 1983. Some heuristics for the consensus ranking problem. Computers and Operations Research 10(1): 1–7.

Benayoun, R., de Montgolfier, J., Tergny, J. & Larichev, O. 1971. Linear programming with multiple objective functions: step method (STEM). Mathematical Programming 1(3): 366–375.

Benson, R.G. 1975. Interactive multiple criteria optimization using satisfactory goals. Ph.D. thesis. University of Iowa.

Bergström, J. 1998. Effectivare virkesköp med GIS. Skog Forsk Resultat 18. 4 p.

Blahna, D.J. & Yonts-Shephard, S. 1989. Public involvement in resource planning: toward bridging the gap between policy and implemention. Society and Natural Resources 2(3): 209–227.

Carlsson, C. 1991. New instruments for management research. Human Systems Management 10(3): 203–220.

— & Walden P. 1995. More effective strategic management with hyperknowledge: the Woodstrat case. Institute for Advanced Management Systems Research, Research Report 3. 26 p.

Chatterjee, K., Kersten, G. & Shakun, M.F. 1991. Introduction to focussed issue on group decision and negotiation. Management Science 37(10): 1219–1220.

Cohen, S.G. & Mankin, D. 1999. Collaboration in the virtual organisation. Trends in Organisational Behavior 6: 105–120.

Cohon, J.L. & Marks, D.H. 1975. A review and evaluation of multiobjective programming techniques. Water Resources Research 11: 208–220.

Connolly, T., Jessup, L.M. & Valacich, J.S. 1990. Effects of anonymity and evaluative tone on idea generation in computer-mediated groups. Management Science 36(6): 689–703.

Corner, J.L. & Kirkwood, C.W. 1990. Decision analysis applications in the operations research literature, 1970–1989. Operations Research 39(2): 206–219.

Couger, J., Higgins, L. & McIntyre, S. 1993. (Un)structured creativity in information systems organisations. MIS Quarterly 17(3): 375–397.

Cox, D.J. 1990. The art of scientific visualisation. Academic Computing 4(6): 20–56.

Cramton, P.C. 1991. Dynamic bargaining with transaction costs. Management Science 37(10): 1221–1229.

Creighton, J.L. 1993. Involving citizens in community decision making. Program for Community Problem Solving. Washington, D.C. 227 p.

Dauer, J.P. & Liu, Y.-H. 1990. Solving multiple objective linear programs in objective space. European Journal of Operational Research 46(3): 350–357.

— & Saleh, O.A. 1990. Constructing the set of efficient objective values in multiple objective linear programs. European Journal of Operational Research 46(3): 358–365.

Dennis, A., Nunamaker, J. & Vogel, D. 1991. A comparison of laboratory and field research in the study of electronic meeting systems. Journal of Management Information Systems 7(3): 107–135.

DeSanctis, G. & Gallupe, B. 1987. A foundation for the study of group decision support systems. Management Science 33(5): 589–609.

Dyer, J.S. 1972. Interactive goal programming. Management Science 19: 357–368.

— 1977. On the relationship between goal programming and multiattribute theory. Management Science Study Center, Graduate School of Management, University of California, Los Angeles, Discussion Paper 69. October.

Ellis, C.A., Gibbs, S.J. & Rein, G.L. 1991. GroupWare: some issues and experiences. Communications of the ACM 34(1): 38–58.

Finholt, T.A. 1997. The electronic office. Trends in Organisational Behavior 4: 29–41.

Fish, R.S., Kraut, R.E., Root, R.W. & Rice, R.E. 1993. Video as a technology for informal communication. Communications of the ACM 36(1): 48–61.

Geoffrion, A.M., Dyer, J.S. & Feinberg, A. 1972. An interactive approach for multi-criterion optimization, with an application to the operation of an academic department. Management Science 19(12): 357–368.

— & Hogan, W.W. 1972. Coordination of two-level organizations with multiple objectives. In: Balakrishnan, A.V. (ed.). Proceedings of the Fourth IFIP Colloquium on Optimization Techniques. Academic Press.

Hackman, J. & Kaplan, R. 1974. Interventions into group process: an approach to improving the effectiveness of groups. Decision Science 5: 459–480.

Hadley, G. 1962. Linear programming. Addison-Wesley Publishing Company. Inc., Reading, MA.

Hämäläinen, R.P. & Leikola, O. 1995. Spontaneous decision conferencing in parliamentary negotiations. In: Proceedings of the 28th Annual Hawaii International Conference on System Sciences, Vol. VII. IEEE Computer Society Press. p. 290–299.

Harrald, J., Leotta J., Wallace, W.A. & Wendell, R.E. 1978. A note on the limitation of the goal programming as observed in resource allocation for marine environmental protection. Naval Research Logistics Quarterly 25: 733–739.

Harstela, P. 1997. Decision support systems in wood procurement. A review. Silva Fennica 31: 215–223.

Hayes, N. & Walsham, G. 2000. Competing interpretations of computer-supported co-operative work in organisational contexts. Organisation 7(1): 49–67.

Hiltz, S. & Turoff, M. 1985. Structuring computer-mediated communication systems to avoid information overload. Communications of the ACM 28(7): 680–689.

— , Johnson K. & Turoff, M. 1991. Group decision support: the effects of designated human leaders and statistical feedback in computerized conferences. Journal of Management Information Systems 8(2): 236–244.

Hoffman, L. & Maier, N. 1959. The use of group decision to resolve a problem of fairness. Personnel Psychology 12: 545–559.

Hogg, M.A. & Abrams, D. 1988. Social identifications: a social psychology of intergroup relations and group processes. Routledge. 268 p.

— & Vaughan, G.M. 1995. Social psychology: an introduction. Prentice Hall. 663 p.

Huber, G. 1991. Organizational information systems: determinants of their performance and behavior. Management Science 28(2): 138–153.

Iz, P.H. 1992. Two multiple criteria group decision support systems based on mathematical programming and ranking methods. European Journal of Operational Research 61: 245–253.

— & Jelassi, M.T. 1990. An interactive group decision aid for multiobjective problems: An empirical assessment. International Journal of Management Science 18: 595–604.

Jelassi, M.T. 1986. MCDM – from 'stand-alone' methods to integrated and intelligent DSS. Proceeding of the VII-th International Conference on Multiple Criteria Decision Making, Kyoto, Japan, Vol. 1. p. 250–262.

Johnson, D.W. & Johnson, F.P. 1987. Joining together: group theory and group skills. Prentice-Hall. 510 p.

Johnson, R.L., Brunson, M.W. & Kimura, T. 1994. Using image-capture technology to assess scenic value at the urban forest interface: a case study. Journal of Environmental Management 40: 183–195.

Kärhä, K. 1998. Managing forest owners' satisfaction in timber-sales transaction. D.Sc. (Agr. and For.) thesis summary. University of Joensuu, Faculty of Forestry, Research Notes 70. ISBN 951-708-628-8.

— 1999. Modelling of the ancedents and consequences of forest owners' satisfaction in timber-sales transactions. Journal of Forest Economics 5: 389–411.

Karppinen, H. 2000. Forest values and the objectives of forest ownership. Doctoral dissertation. Finnish Forest Research Institute, Research Papers 757. 55 p.

Keen, P.G. 1981. Information systems and organisational change. Communications of the ACM 24(1): 24–33.

— 1987. Decision support systems: the next decades. Decision Support Systems 3(3): 253–265.

Kersten, E.G. 1987. A procedure for negotiating efficient and non-efficient compromises. Decision Support Systems 4: 167–177.

Keskiäijö, O., Kivijärvi, H. & Tuominen, M. 1996. Decision support for managing intangible investments: a two-phased approach. Lappeenrannan teknillinen korkeakoulu, Tuotantotalouden osasto, Tutkimusraportti 90. 42 p.

Kilvert, S.K. & Griffith, J.A. 1996. New technologies for the simulation and assessment of forest landscape change. New Zealand Journal of Forestry Science 26(1–2): 235–240.

Klen, T. 1998. Job stress and mental symptoms in forestry operations. Finnish Institute of Occupational Health, People and Work, Research Reports 16. 134 p.

Knopp, T.B. & Caldbeck, E.S. 1990. The role of participatory democracy in forest management. Journal of Forestry 88(5): 13–18.

Korhonen, P. & Laakso, J. 1986. A visual interactive method for solving the multiple criteria problem. European Journal of Operational Research 24: 277–287.

Koskinen, R. 2000. Tietokoneavusteinen tiimityö ja synkronisesti hajautetun työryhmäohjelmiston hyödyntämien Stora Enso Metsän Keski-Savon alueella. Master's thesis. University of Joensuu, Faculty of Forestry. 41 p. (In Finnish).

Leinonen, T.A. 1998. Puunhankinnan tulevaisuusanalyysi. Licentiate thesis. University of Helsinki, Department of Logging and Utilization of Forest Products. 138 p. (In Finnish).

Leppänen, V., Kärhä, K. & Palander, T. 1999. Työnjohtajien ryhmäpäätöksenteko ja tiimityö puunhankintaorganisaatiossa. Metsätieteen aikakauskirja 4: 711–719. (In Finnish).

Lewandowski, A. & Wierzbicki, A.P. 1989. Decision support systems using reference point optimization. In: Lewandowski, A. & Wierzbicki, A.P. (eds.). Aspiration based decision support systems. Springer-Verlag, Berlin. p. 3–20.

Lewis, H.S. & Butler, T.W. 1993. An interactive framework for multi-person, multiobjective decisions. Decision Sciences 24(3): 1–21.

Manheim, M.L. 1989. Issues in design of a symbiotic DDS. In: Proceedings of the 22th Annual Hawaii International Conference on System Sciences, Vol. VII. IEEE Computer Society Press. p. 14–23.

McCarter, J.B., Wilson, J.S., Baker, P.J., Moffett, J.L. & Oliver, C.D. 1998. Landscape management through integration of existing tools and emerging technologies. Journal of Forestry 96(6): 17–23.

McKelvey, R.D. & Wendell, R.E. 1976. Voting equilibria in multidimensional choice spaces. Mathematical Operations Research 1: 144–158.

Meriläinen, A., Sikanen, L. & Harstela, P. 1995. Puunhankinnan suunnittelujärjestelmät suomalaisessa puunhankintaorganisaatiossa. Folia Forestalia 1: 35–49. (In Finnish).

Mohrman, S.A. 1999. The contexts for geographically dispersed teams and networks. Trends in Organisational Behavior 6: 63–80.

Nakayama, H. & Sawaragi, Y. 1984. Satisfying trade-off method for multiobjective programming. In: Grauer, M. & Wierzbicki, A.P. (eds.). Interactive decision analysis. Springer-Verlag, Berlin. p.

114–122.
Nalli, A., Nuutinen, T. & Päivinen, R. 1996. Site-specific constraints in integrated forest planning. Scandinavian Journal of Forest Research 11: 85–96.
Nousiainen, I. & Pukkala, T. 1992. Use of computer graphics for predicting the amenity of forest trails. Silva Fennica 26(4): 241–250.
— , Tahvanainen, L. & Tyrväinen, L. 1998. Landscape in farm-scale land-use planning. Scandinavian Journal of Forest Research 13: 477–487.
Nunamaker, J.F., Dennis, A.R., Valacich, J.S., Vogel, D.R. & George, J.F. 1991. Electronic meeting systems to support group work. Communications of the ACM 34(7): 40–61.
— , Briggs, R.O. & Mittleman, D.D. 1995. Electronic meeting systems: ten years of lessons learned. In: Coleman, D. & Khanna, R. (eds.). GroupWare: technology and application. Prentice Hall, Upper Saddle River, NJ. p. 149–193.
Orland, B. 1988. Video-imaging: a powerful tool for visualisation and analysis. Landscape Architecture 78(4): 78–88.
— 1991. Digital image processing aids for visual simulation of forest management practices. In: Daniel, T.C. & Ferguson, I.S. (eds.). Integrating research on hazards in fire-prone environments. Proceedings of the US-Australia workshop, Melbourne, Australia. Washington DC. p. 73–86.
— 1992. Evaluating regional changes on the basis of local expectations: a visualisation dilemma. Landscape and Urban Planning 21: 257–259.
— 1994. Visualisation techniques for incorporation in forest planning geographic information systems. Landscape and Urban Planning 30: 83–97.
— , Daniel, T.C., LaFontaine, J. & Goldberg, C. 1990. Visual effects of insect damage in western mixed coniferous forests. Final report, co-operative research project, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Imaging Systems Laboratory, Department of Landscape Architecture, University of Illinois. 80 p.
— , LaFontaine, J. & Daniel, T.C. 1991. Alternative futures for forested landscapes. In: Proceedings of Resource Technology 90 – Second Symposium on Advanced Technology in Natural Resource Management, Washington D.C. American Society for Photogrammetry and Remote Sensing. p. 48–57.
— , Daniel, T.C., Lynch, A.M. & Holsten, E.H. 1992. Data-driven visual simulation of alternative futures for forested landscapes. In: Integrating forest information over space and time. Proceedings of the International Union of Forest Research Organisations, Canberra, January 1992. p. 368–378.
— , Obermark, J., LaFontaine, J. & Suter, T. 1993. Model and data-driven visualisation of forest health dynamics. In: Liebhold, A.M. & Barret, H.R. (eds.). Spatial analysis of forest pest management. USDA Forest Service, General Technical Report NE-175. p. 65–72.
Palander, T. 1995. Local factors and time-variable parameters in tactical planning models: a tool for adaptive timber procurement planning. Scandinavian Journal of Forest Research 10: 370–382.
— 1996. Interaktiivinen päätöksenteko puunhankintatiimin puskurivarantojen määrittämisessä. University of Joensuu, Faculty of Forestry, Research Notes 51. 27 p. (In Finnish).
— 1997. A local DLP-GIS-LP system for geographically decentralized wood procurement planning and decision making. Silva Fennica 31(2): 179–192.
— 1998a. Influence of local dynamic conditions on logistics costs of timber procurement: analyzed by applying a technique of geographically decentralized decision making. Journal of Forest Engineering 9(2): 61–75.
— 1998b. Tactical models of wood-procurement teams for geographically decentralized group decision-making. D.Sc. (Agr. and For.) thesis summary. University of Joensuu, Faculty of Forestry, Research Notes 81. 49 p. ISBN 951-708-705-5.
— 1998c. Tactical models of wood-procurement teams for geographically decentralized group decision-making. D.Sc. (Agr. and For.) thesis. University of Joensuu, Faculty of Forestry. Academic dissertation. ISBN 951-708-705-5.
— 1999a. A hierarchical participatory methodology for tactical decision-making based on a decision-analytic model for balancing timber stock. Scandinavian Journal of Forest Research 14: 567–580.
— 1999b. Informaatio- ja yhteydenpitoteknologian sovellus virtuaalisessa oppimisympäristössä. Hämeen opettajakorkeakoulun julkaisuja 122. 22 p. ISBN 951-784-052-7. (In Finnish).
— 2000a. Information and communication technology in virtual learning environment. EVAonline. http://evaonline.euro.org/
http://gis.joensuu.fi/staff/person/palandeE.html
— 2000b. A group decision-making method for balancing timber stock in a management process.

In: Sjöström, K. (ed.). The Inaugural, 1st World Symposium on Logistics in Forest Sector, May 15–16, 2000, in Helsinki, Finland. p. 251–269. ISBN 952-91-1942-9.

— & Toivonen, M. 1999. Puunhankinnan taktisen suunnittelun apuvälineet ja menetelmät. Metsätieteen aikakauskirja 4: 740–743. (In Finnish).

— , Toivonen, M. & Malinen, J. 2001. Attitudes of team workers towards new information and communication technology. In: Pawar, K. & Muffatto, M. (eds.). Logistics and the Digital Economy. The 7th International Symposium on Logistics 8–10 July, 2001, Saltzburg, Austria. p. 63–68. ISBN 0-85358-099-5.

Piippo, P., Torkkeli, M. & Tuominen, M. 1999. Teknologiavalintojen tukeminen ryhmäpäätöksenteon tukisysteemeillä. Lappeenrannan teknillinen korkeakoulu, tuotantotalouden osasto, Tutkimusraportti 107. 35 p. (In Finnish).

Pukkala, T. & Kellomäki, S. 1988. Simulation as a tool in designing forest landscape. Landscape and Urban Planning 16: 253–260.

— , Nuutinen, T. & Kangas, J. 1995. Integrating scenic and recreation amenities into numerical forest planning. Landscape and Urban Planning 32: 185–195.

Pykäläinen, J. & Kangas, J. 1996. Interaktiivinen metsäsuunnittelu. University of Joensuu, Faculty of Forestry, Research Notes 39. 34 p. (In Finnish).

— , Kangas, J. & Loikkanen, T. 1999. Interactive decision making in participatory strategic forest planning: experiences from state owned boreal forest. Journal of Forest Economics 5: 341–364.

Rao, V.S. & Jarvenpaa S.L. 1991. Computer supports of groups: theory-based models for GDSS research. Management Science 37(10): 1347–1362.

Reeves, G.R. & Franz, L.S. 1985. A simplified interactive multiple objective linear programming procedure. Computers & Operations Research 12(6): 589–601.

Ripatti, P. & Reunala, A. 1989. Yksityismetsälöiden lukumäärän kehitys rekisteritietojen perusteella. Folia Forestalia 739. 23 p. (In Finnish).

Robak, E.W. 1991. OR in forest operations: new environments, tools and approaches. In: Proceedings of IUFRO XIX World Congress, Division 3, August 5 –11, 1990, Montréal, Canada. p. 9–19.

Sauter, V. 1997. Decision support systems: an applied managerial approach. John Wiley and Sons, Inc. ISBN 0-471-31134-0.

Schauman, S. 1988. Scenic value of countryside landscapes to local residents: a Whatcom County, Washington. Landscape Journal 7: 40–46.

Scott-Morton, M.S. 1971. Management decision systems: computer-based support for decision making. Harvard University, Boston. 216 p.

Sen, A.K. 1970. Collective choice and social welfare. Holden-Day, San Francisco, CA.

Shaw, M. 1981. Group dynamics: the psychology of small group behavior. 3rd edition. McGraw-Hill, New York.

Sikanen, L. & Oikarinen, V-M. 1998. Metsänomistajien asenneilmasto puunhankinnan uusia tietojärjestelmiä kohtaan. Metsätieteen aikakauskirja 4: 573–575. (In Finnish).

— 1999. Discrete even simulation model for purchasing process of marked stands as a part of customised timber procurement in Finland. D.Sc. (Agr. and For.) thesis. University of Joensuu, Faculty of Forestry. Academic dissertation. ISBN 951-708-828-0.

Silver, M.S. 1991. Systems that support decision makers. John Wiley & Sons, Chichester. 254 p.

Simon, H.A. 1955. A behavioral model of rational choice. Quarterly Journal of Economics 69: 99–118.

Siskos, J. & Despotis, D.K. 1989. A DSS oriented method for multiobjective linear programming problems. Decision Support Systems 5: 47–55.

Sosik, J.J. & Avolio, B.J. 1998. Inspiring group creativity. Group Research 29: 3–29. ISSN 1046-4964.

Spector, B.I. 1993. Decision analysis for practical negotiation application. Theory and Decision 34: 183–199.

Stefic, M., Foster, G., Bobrow, D.G., Kahn, K., Lanning, S. & Suchman, L. 1987. Beyond the chalkboard: computer support for collaboration and problem solving in meetings. Transactions of the ACM 30(1): 32–47.

Steuer, R.E. & Choo, E.-U. 1983. An interactive weighted Tchebycheff procedure for multiple objective programming. Mathematical Programming 26: 326–344.

— , Silverman, J. & Whisman, A.W. 1993. A combined Tchebycheff / aspiration criterion vector interactive multiobjective programming procedure. Management Science 39(10): 1255–1260.

Tan, B.C.Y., Wei, K.-K., Watson, R.T., Clapper, D.L. & McLean, E.R. 1998. Computer-mediated communication and majority influence: assessing the

impact in an individualistic and a collectivistic culture. Management Science 44(9): 1263–1278.
Toivonen, M. & Palander, T. 1999. Puunhankinnan ryhmäpäätöksentekoon soveltuvat henkilökohtaiset videoneuvottelujärjestelmät. University of Joensuu, Faculty of Forestry, Research Notes 98. ISBN 951-708-842-6. (In Finnish).
— & Palander, T. 2001. Tiimiorganisaation vaikutus työnjohtajien yhteydenpitoon. Metsätieteen aikakauskirja 1: 19–28. (In Finnish).
Tolvanen-Sikanen, T., Sikanen L. & Harstela, P. 1995. A game theoretic simulation model for quality oriented timber supply to sawmills. Silva Fennica 29(1): 71–86.
Turban, E. 1988. Decision support and expert systems – managerial perspectives. Macmillan Publishing Company, New York. 697 p.
— 1993. Decision support and expert systems – management support systems. Macmillan Publishing Company, New York. 833 p.
Tyrväinen, L. & Tahvanainen, L. 1999. Using computer graphics for assessing the aesthetic value of large-scale rural landscapes. Scandinavian Journal of Forest Research 14: 282–288.
Vanharanta, H., Pihlanto, P. & Chang, A.-M. 1997. Decision support for strategic management in a hyper-knowledge environment and the holistic concept of man. In: Proceedings of the 30th Annual Hawaii International Conference on System Sciences, Vol. V. IEEE Computer Society Press. p. 243–258.
Vetschera, R. 1994. Estimating aspiration levels from discrete choices – computational techniques and experiences. European Journal of Operational Research 76(3): 455–465.
Watabe, K., Holsapple, C.W. & Whinston, A.B. 1992. Coordinator support in a nemawashi decision process. Decision Support Systems 8: 85–98.
Wendell, R.E. 1980. Multiple objective mathematical programming with respect to multiple decision-makers. Operations Research 28(5): 1100–1111.
— & Lee, D.N. 1978. Efficiency in multiple objective optimization problems. Mathematical Programming 12: 406–413.
Wierzbicki, A.P. 1986. On the completeness and constructiveness of parametric characterizations to vector optimization problems. OR-Spectrum 8: 73–87.
Wiesenfeld, B.M., Raghuram, S. & Garud, R. 1999. Managers in a virtual context: the experience of self-threat and its effects on virtual work organisations. Trends in Organisational Behavior 6: 31–44.
Williams, J.C. 1978. Human behavior in organization. South-Western Publishing CO. 466 p. ISBN 0-538-07760-3.
Yu, P.L. & Zeleny, M. 1975. The set of all nondominated solutions in linear cases and a multicriteria simplex method. Journal of Mathematical Analysis and Applications 49: 430–468.
Zeleny, M. 1982. Multiple criteria decision making. McGraw-Hill, New York
Zionts, S. & Wallenius, J. 1976. An interactive programming method for solving the multiple criteria problem. Management Science 22(6): 632–663.
— & Wallenius, J. 1983. An interactive multiple objective linear programming method for class of underlying nonlinear utility functions. Management Science 29(5): 519–529.

Total of 137 references