Models in environmental planning
selection of impact variables and estimation of impacts

Author(s):
Hansmann, Ralph; Mieg, Harald A.; Crott, Helmut W.; Scholz, Roland W.

Publication Date:
2002

Permanent Link:
https://doi.org/10.3929/ethz-a-004336177

Rights / License:
In Copyright - Non-Commercial Use Permitted
Models in Environmental Planning: Selection of Impact Variables and Estimation of Impacts

Ralph Hansmann, Harald A. Mieg, Helmut Crott, and Roland W. Scholz

April 2002
Publisher:
Prof. Dr. Roland W. Scholz
Umweltnatur- und
Umweltsozialwissenschaften (UNS)
ETH Zentrum HAD
Haldenbachstrasse 44
CH-8092 Zürich
Tel. ++41-1-632 5892
Fax ++41-1-632 10 29
E-mail: scholz@uns.umnw.ethz.ch

Corresponding authors:
Concerning the two group experiments:
Ralph Hansmann
Umweltnatur- und
Umweltsozialwissenschaften (UNS)
ETH Zentrum HAD
CH-8092 Zürich
Tel. ++41–1-632 6316
Fax ++41–1-632 1029
E-mail: hansmann@uns.umnw.ethz.ch

Concerning the individual experiment
and research on expertise:
Prof. Dr. Harald A. Mieg
Mensch-Umweltbeziehungen (MUB)
ETH Zentrum HAD
CH-8092 Zürich
Tel. ++41–1-632 4903
Fax ++41–1-632 1029
E-mail: mieg@uns.umnw.ethz.ch

Co-authors:
Prof. Roland W. Scholz
Umweltnatur- und
Umweltsozialwissenschaften (UNS)
ETH Zentrum HAD
CH-8092 Zürich
Tel. ++41–1-632 5891
Fax ++41–1-632 1029
E-mail: scholz@uns.umnw.ethz.ch

Prof. Dr. Helmut W. Crott
Universität Freiburg,
Psychologisches Institut
Niemensstr. 10,
D-79098 Freiburg
Tel. ++49-761-203 2480
Fax ++49-761-203 9271
E-mail: crott@psychologie.uni-freiburg.de
Models in Environmental Planning: Selection of Impact Variables and Estimation of Impacts

Ralph Hansmann, Harald A. Mieg, Helmut Crott, Roland W. Scholz

Contents

Contents ........................................................................................................................................................................................................ 1
Abstract .......................................................................................................................................................................................................... 2
Parameter Selection and Collective Estimation of Interactions between Impact Variables in Models Concerning Environmental Planning ....................................................................... 2
Experimental Context ...................................................................................................................................................... 5
Experiment 1: Repeated Measurement Analysis of Students Individual Estimates Concerning Expert and Student Selected Impact Variables ......................................................................................... 7
Overview ................................................................................................................................................................................... 7
Method ....................................................................................................................................................................................... 7
Results ....................................................................................................................................................................................... 9
Experiment 2 and 3: Group Estimates Concerning Impacts of Environmental Variables ................................................................................................................................................................. 10
Method .................................................................................................................................................................................... 10
Results ...................................................................................................................................................................................... 13
Discussion ................................................................................................................................................................................................. 19
Experiment 1: Experts in Environmental Planning ............................................................................................. 19
Experiment 2 + 3: Collective Judgment on Variable Impacts ......................................................................................... 20
References ................................................................................................................................................................................................. 22

1 Research was carried out at Eidgenössische Technische Hochschule Zürich (ETH) and at Albert-Ludwigs-Universität Freiburg im Breisgau. We thank Bertrand Lisbach, Petra Kielchling and Marc Schäli for their assistance in conducting and analyzing the 1998 group experiment. Additionally, we thank Marcus Cheetham and Debbie Johnson for their assistance in correcting the english manuscript.

* Eidgenössische Technische Hochschule Zürich (ETH), Switzerland

** Albert-Ludwigs-Universität Freiburg i.Br., Germany
Abstract

This paper includes an experiment concerning the selection of impact variables in environmental planning and two uniform group experiments concerning the quality of group estimates of impacts. Participants were students of environmental sciences at ETH Zurich. Experiment 1 revealed that during participation in an environmental case study, students’ individual estimates of impacts of expert selected variables increased, as compared to the estimates of impacts of variables selected by students. Further impacts were estimated in two group experiments. The quality of the estimates was analyzed referring to expert estimates. Individual estimates at the end of group discussions and group estimates were more accurate than prediscussion estimates. However, within group means of the individual prediscussion estimates were as accurate as group estimates. A higher accuracy was obtained by the mean group estimates aggregated over all groups.

key words: parameter selection, collective estimation, group accuracy, expert judgments, judgment bootstrapping

Parameter Selection and Collective Estimation of Interactions between Impact Variables in Models Concerning Environmental Planning

Environmental planning involves the problem of estimating the impacts of certain variables on other variables (Faludi, 1987; Selman, 1992). This problem is encountered in planning local sustainable urban development as well as in global climate change policies. For instance, traffic and industrial production influence the concentration of CO₂ in the atmosphere. In this case, we have three potential impact variables, (a) traffic facilities, (b) industrial production, and (c) atmospheric CO₂ concentration. The problem consists in assessing the strength of mutual impacts of these variables, for instance the impact of traffic facilities on industrial production or the impact of production on the atmospheric CO₂ concentration. The estimation of the impact that variables have on other variables involves two steps; the definition and selection of relevant variables and, thereafter, the estimation and aggregation with regard to the interaction between the variables.

In order to define relevant impact factors we often have to refer to experts (Mieg, 2001). In psychology, there are two lines of research on experts and expertise, respectively. One line focuses on experts’ cognitive skills, in particular on their ability to define and recognize relevant problems. From this perspective experts’ performance has been found to be on a high level: experts have excellent diagnostic capabilities (Chase & Simon, 1973; Chi, Glaser & Farr, 1988; de-Groot, 1965). The other line of research focuses on the judgment and decision making of experts. In the 1950s, Meehl and others compared clinical and statistical prediction, finding statistical models superior to the doctors’ predictions (Meehl, 1954). Subsequently, a phenomenon called judgment bootstrapping was described: Regression models using the experts’ predictions correlate closer with the criterion than the expert judgments the models are based on (Blattberg
Models in Environmental Planning: Selection of Impact Variables and Estimation of Impacts

& Hoch, 1990; Camerer, 1981; Dawes & Corrigan, 1974). Consistent with this finding, Hogarth and Makridakis (1987), who reviewed the literature on expert prediction, recommended computed aggregations of expert judgments. However, expert performance depends on the field of expertise. According to Shanteau (1992), we have to divide the problem areas into two classes: One where the performance of expert judgments is consistently high, e.g., in meteorology, and one where it is low, e.g., management. Environmental planning combines expertise from both classes. Mieg (1993) argued that the bootstrapping effect is due to the reliability of automated aggregation of judgments. However, the definition of the relevant variables to be computed remains the task of experts. Experts are indispensable in identifying impact variables (first step) but, in some cases, could be substituted when it comes to aggregation (second step). The flexibility of human expert cognition is necessary to adapt to changing conditions (Winograd & Flores, 1986), in particular when being faced with ill-defined problems (cf. Scholz, Flückiger et al., 1997).

The present study was conducted in the context of an environmental case study at the Chair of Environmental Sciences Natural and Social Science Interface (UNS) at the Swiss Federal Institute of Technology (ETH) Zurich. In UNS case studies, the definition and selection of impact variables for the construction of models of environmental systems, is usually done by graduate students. Thus the question arises: What would be the improvements, if some variables were selected and defined by experts? This question will be addressed in Experiment 1 which concerns the process of parameter selection.

On a local level, environmental planning today often takes place in planning groups that combine experts, politicians and citizens. Particularly in Europe, we find round table discussions and so-called focus groups (Kasemir et al., 1997; Krueger 1988) in which decisions concerning environmental planning are made. In the Experiments 2 and 3 the processes of collective judgment in tasks concerning environmental planning will be analyzed. The two group experiments focus on whether, or to what extent, environmental judgments resulting from mathematically aggregating the judgments of different independent groups can be more appropriate than the judgments of single groups. A further interest of the group experiments was to find out, whether there was a systematic tendency in the direction of the opinion changes during the discussions. In psychological research, such shift phenomena (Lamm & Myers, 1978; Stoner, 1961, 1968) have been observed for a variety of discussion tasks (choice dilemma items, mock jury deliberation etc.). Normative influences and informative influences have been used as an explanation for such opinion shifts during discussions (Burnstein & Vinokur, 1977; Deutsch & Gerard, 1955; Goethals & Zanna, 1979; Stasser & Davis, 1981). Moreover, Social Decision Schemes (SDS; Davis, 1973, 1992) can also account for choice shifts with respect to group decisions. SDS can even be applied as an explanation for opinion shifts on the individual level, if the marked tendency of opinion convergence within groups (e.g., Crott & Werner, 1994; Godwin & Restle, 1974; Sherif, 1935; Stasser & Davis, 1981) and cognitive processes that tend to reduce cognitive dissonance (Festinger, 1957) are considered (see Crott, Zuber & Schermer, 1986). It was analyzed whether systematic choice shifts of this kind took place during the experimental group discus-
sions, and whether the discussions where connected to an increase of the appropriateness of the individual judgments.

The judgmental tasks that were used in the experiments do not have exact solutions that are objectively correct. Human expert cognition provides the most reasonable and valid judgments concerning impacts in environmental systems (Mieg, 2001). Therefore, the mean estimates of independent experts were used as the point of reference for the accuracy of students’ judgments. In the group experiments (Experiment 2 + 3) the accuracy of individual prediscussion and postdiscussion estimates and of the group estimates was analyzed to find out whether the group discussions were connected to a qualitative improvement of the judgements. A further interest of the group experiments was to compare the accuracy of statistically aggregated estimates and conventional group estimates with respect to their accuracy. This question is of major importance in practical processes of environmental forecasting. In the case of many political and organizational group decision processes, the decisions that are reached are binding. However, considering group discussions concerning estimates that serve to specify environmental models, there might exist other possibilities then to rely on the judgment of a group as the parameter estimate that enters a model. Another possibility would be to assess the individual postdiscussion estimates within the group and to use the resulting arithmetic mean of these individual judgments in the model. According to research on SDS, in judgmental tasks the median of the initial preferences in a group often results as the group decision (Black, 1948, 1958; Crott, Szilvas & Zuber, 1991; Crott, & Werner, 1994; Crott et al., 1986; Zuber, Crott & Werner, 1992). Furthermore, if the median SDS is applied on the individual opinions, immediately before the group decision is formed, then it is able to achieve very exact predictions which are significantly more accurate than if it is applied on the initial opinions; sometimes even predictions with hit rates of 90% of correct predictions or more are reached (Crott, Giesel, Hansmann & Hoffmann, 1997; Hansmann, 2001; Werner, 1992).

However, if we assume that all group members have the potential to contribute to the accuracy of an estimate, the arithmetic mean of the individual postdiscussion preferences has a theoretical advantage, as compared to the median of the postdiscussion preferences. The arithmetic mean of the individual postdiscussion preferences includes the quantitative information of all group members’ estimates on an interval scale level, whereas the median results from rank-ordering the group members’ estimates (Crott et al., 1986). Thus, the arithmetic mean of the individual postdiscussion preferences might represent a more accurate judgment than a group decision, because the group decision often does not take into account the exact quantitative information of the opinions of all group members, but rather results as the median of these individual judgments. The group process itself might moderate qualitative differences between group decisions and aggregated individual judgments at the end of discussions. As estimates usually tend to converge during discussions, differences between the within group mean of the individual estimates and the median estimate also tend to get smaller in the course of a discussion. Moreover, if we consider the use of group techniques, the Method of Group Consensus for example, intends to eliminate these differences completely (Hall & Watson, 1971).
Empirical results on group accuracy show that even the arithmetic means of the individual prediscussion judgments of group members (statisticized group judgments) are sometimes as accurate as the collective group estimates. But they also show that group estimates are usually more accurate than single individual estimates before the beginning of a group discussion (for a review, see Gigone & Hastie, 1997; Hastie, 1986). Other studies have compared the performance of individuals and statisticized groups in judgmental tasks. These studies showed that the arithmetic mean of the estimates of a number of persons who do not interact or communicate with each other (= statisticized group estimate) is more accurate on the average than the estimate of a single individual (see McGrath, 1984). This represents a statistical effect that is based on the compensation of judgmental errors in opposite directions (Stroop, 1932; Crott, 1979). If there is no systematic bias in one direction, then this statistical effect enables us to obtain an exact value of any matter of fact just by averaging the independent estimates of a huge number of persons. A study done by Gordon (1924) demonstrated this effect very markedly. There, the mean correlation between a subjective rank order of ten different weights and the actual rank order of those weights increased from \( r = 0.41 \), for a single person, to \( r = 0.68 \) for an average rank order of five persons, to \( r = 0.79 \) for an average rank order of ten persons, to \( r = 0.93 \) for an average rank order of 50 persons.

This points to the possibility of improving the accuracy of parameter estimates via aggregation of the estimates in a number of groups that work independent of each other. Calculating the mean of these independent group estimates effectively counteracts unsystematic inaccuracies. This is simply a statistical effect that is based on the reduction of the standard error of an estimated mean with growing sample size (\( SE_{\text{Min}} = \frac{SD}{\sqrt{n}} \)). There will always result a positive effect from the aggregation of group judgments, as long as the systematic bias of the single group judgments in one direction does not completely dominate over the unsystematic bias. That means, if some groups exist that are overestimating the true criterion and other groups exist that are underestimating the criterion, then the arithmetic mean of the group estimate of a number of groups is always more accurate, on the average, than the estimates of the single groups that are the basis of this arithmetic mean. Similarly, an advantage in estimation precision might be achieved by using the arithmetic mean of the individual postdiscussion preferences aggregated over many groups as parameter estimate instead of the mean individual postdiscussion estimates within a single group. To analyze these effects, the judgment accuracy of individual estimates, and of group estimates was also compared to the accuracy of aggregated estimates.

**Experimental Context**

The experiments that are presented in this article were conducted within two environmental case studies of the institute UNS at ETH Zurich. ETH-UNS case studies are university-based environmental projects for urban and regional development in Switzerland. In their eighth semester, as part of their curriculum the students of Environmental Sciences at the Swiss Federal Institute of Technology in Zurich altogether participate in a case study. These case studies have a strong practical orientation. They involve cooperation with scientists, municipal authorities,
citizens, professionals, and representatives from various companies (e.g. Mieg, 2000; Mieg, 1996; Scholz, Bösch, Mieg & Stünzi, 1997; Scholz, Mieg & Weber, 1997; Scholz & Tietje, 2002). Combining practical application of knowledge, collaboration with experts, research, and teaching, these case studies set forth a new type of instructional design (Gagne & Briggs, 1974). ETH-UNS Case Studies have three main objectives:

1. Education

In their fourth year, all students of Environmental Natural Sciences have one year to work together on one project. The educational aim is to improve the environmental problem solving ability of the students, to enhance their cognitive competence when it comes to mastering complexity, to improve their ability to cooperate in teams, and to enlarge their practical experience in transdisciplinary work (Oswald & Scholz, 1999; Scholz & Tietje, 2002).

2. Research

An objective of the case studies is to facilitate ecological problem solving by structuring the processes involved. In the ETH-UNS case studies, we develop scientific methods for the integration of knowledge from different disciplines and different types of sources (science, federal offices, industry, local stakeholders...).

3. Problem solving

ETH-UNS case studies are denoted as transdisciplinary activities (Häberli, Scholz, Bill & Welti, 2000). They support the ecological problem solving process and thus, foster sustainable development. At the end of each case study a report on the environmental system that was analyzed is accomplished. These reports serve as an informative decision aid for the administrators that are involved in corresponding planning processes.

For instance, the 1996 ETH-UNS case study Zentrum Zürich Nord (ZZN): The ZZN (Central Zurich North) has been the largest urban re-integration project in Switzerland. The background of the project is the rapid change and transition of industrial production. The area under planning is about 64 ha. The main landowner is the manufacturer Asea Brown Boveri (ABB). The ZZN re-integration project will create housing for 5,000 persons and 12,000 workplaces. The task of the ETH-UNS case study 1996 was to contribute to the planning process by integrating data about the site and evaluating the feasibility of the ZZN urban planning project (Scholz, Bösch, Mieg & Stünzi, 1997). This case study was the setting and contextual basis of the individual Experiment 1 and group Experiment 2.

Experiment 3 was part of the ETH-UNS case study 1998 in the Klettgau region (Scholz, Bösch, Carlucci & Oswald, 1999) that focused on regional development in the Swiss-German border-straddling region of Klettgau. This rural area is situated in the peripheral agglomeration of Zurich and shows a rapid development. Moreover, the Klettgau serves as an important groundwater reservoir. Today, the groundwater is threatened by anthropogenic nitrate emissions caused by agriculture. The ETH-UNS case study 1998 supported the cooperation of the Swiss-
German public administration, in order to find solutions for the groundwater problem and to foster regional development. The ETH-UNS case study 1998 cooperated with the European Union Regional Groundwater Protection Program Interreg II (see Regli, Roth, Biedermann, Pabst & Scholz, 1998).

Experiment 1:
Repeated Measurement Analysis of Students Individual Estimates Concerning Expert and Student Selected Impact Variables

Overview

In the experiment students individually estimated the impacts that selected variables exert on other variables. Some of the impact variables were selected by experts and the remaining impact variables were selected by students at the beginning of their case study work. The impact estimates were assessed two times: At the beginning and at the end of the environmental case study 1996 (ZZN). It was assumed that the students would gain expertise in the course of the case study. Accordingly, it was hypothesized that students’ estimates concerning relevant impact variables would increase between the two assessments. Moreover, in accordance with previous research on expert cognition, it was assumed that experts have the ability to identify the important and thus influential impact variables of an environmental system. Consequently, it was hypothesized that the estimates concerning impacts of expert selected variables on student selected variables would increase more than the estimates concerning impacts of student selected variables on expert selected variables.

Method

In the preparatory phase of the 1996 ETH-UNS case study, a student commission working in collaboration with scientific experts compiled a list of 16 potential impact variables. Seven independent experts, who were familiar with the ZZN site, rated the importance of these impact variables for the specific situation of ZZN. The student commission rated the relevance of these variables as well. The experts identified the following four major impact variables: (a) contaminated soil remediation, (b) urban quality, (c) traffic network, and (d) profitability. For the final set of key factors, the student commission added three more factors: (e) communal politics, (f) quality of the environment (besides contaminated soils), and (g) general economic situation. To identify powerful impact variables and to determine which influences these variables exert on each other was important for the performance of a computational scenario analysis concerning the ZZN planning project. Scenario analysis is a means for strategic planning that was developed by Rand Corporation in the 1950s and 1960s (Kahn & Wiener, 1967). It is a prominent technique for environmental planning in ETH-UNS case studies because it allows the integration of knowledge, and the modelling of complex processes via fast data aggregation (Scholz & Tietje, 2002). Scenario analysis is also used in other domains e.g., for traffic planning (Forschungsverbund Lebensraum Stadt, 1994) and for predicting climate change (Houghton, Jenkins & Ephraums,
The experimental task was itself part of the scenario analytic process concerning the ZZN planning project.

In Experiment 1, male and female students of Environmental Natural Sciences at ETH Zurich, who took part in the 1996 case study ZZN, individually estimated the impact that each of the seven selected impact variables (a-g) exerts on each of the other six variables. More precisely, the students individually estimated the strength of 38 out of these 42 (= 7 x 6) directed impacts within the possible pairs between the seven impact variables (e.g., impact of the general economic situation on urban quality in the new ZZN). They were asked to denote their estimates in a matrix of impacts. In this matrix, the students estimated each of these 38 impacts on a rating scale, that reached from 1 = very low impact, 2 = low impact, 3 = medium impact, 4 = strong impact to 5 = very strong impact. These individual estimates were assessed in the starting phase of the case study and a second time at the end of the project. Both times 105 students took part.

The remaining 4 impacts, whose fields were blackened on the matrix of impacts, were used for Experiment 2. The first experimental assessment of Experiment 1 and the ZZN group experiment (Experiment 2) were conducted jointly on the same day in rooms on the ZZN site. In each of five experimental sessions that took place on that day, the group experiment was conducted immediately after all the participants in the individual experiment had denoted their individual estimates. Figure 1 shows the general time schedule for the three experiments that are reported in this article, that is Experiment 1 concerning individual estimates, and the two group experiments (Experiment 2 and 3).

Among the 38 impacts that had to be estimated individually were 12 impacts of expert selected variables on student selected variables, 12 impacts of student selected variables on expert selected variables, 8 impacts of expert variables on expert variables, and 6 impacts of student variables on student variables. However, concerning the individual Experiment 1 only analyses and results regarding the 24 heterogeneous impacts will be described in this article.
Models in Environmental Planning: Selection of Impact Variables and Estimation of Impacts

Figure 1. Time schedule and context of the three experiments on estimations for environmental impacts in the ETH-UNS case studies ZZN (1996) and Klettgau (1998). N_ind = number of individuals, N_grp = number of groups, S_grp = group size.

The first assessment in Experiment 1, immediately preceded Experiment 2 in each experimental session. At each experimental session, 15 to 24 students arrived. All these students took part in the (individual) Experiment 1. However, as only five-person groups were used for Experiment 2 only three or four groups could be randomly formed out of the students that were present in one experimental session. Thus, the number of five-person groups in Experiment 2 was lower than the number of participants in the individual experiment would indicate.

Results

Table 1 shows the results with regard to the paired variables, that is each time one expert selected variable and one student selected variable; one factor was the impact variable and the other the influenced variable. As we expected, the mean estimates for the impacts of expert selected variables increased between the two measurements more often than the mean estimates for impacts of student selected variables, \( \chi^2(1, N = 24) = 4.44, p < .05 \).

We found an additional effect when comparing the variances of the estimations at the beginning and at the end of the project phase. A decrease in variance may indicate that the students develop a more converging opinion on this particular variable impact. Variances did not decrease for all variable impacts. Particularly, the variances decreased for expert selected impact variables, \( \chi^2(1, N = 24) = 2.74, p < .10 \). The decrease in the diversity of the students’ estimates for the expert selected impact variables speaks for the validity of these judgments (consensus validity). It also indicates that the students have less difficulty in using the expert selected impact variables than in using own ones. They achieved more consistent estimations using expert selected impact variables than using the own ones. This can be called a lay bootstrapping effect.
Table 1. Comparison of Estimations for Expert Selected Impact Variables Versus Student Selected Impact Variables at the Start and the End of the ZZN Case Study 1996

<table>
<thead>
<tr>
<th>direction of impact</th>
<th>expert selected impact variable on student selected variable</th>
<th>student selected impact variable on expert selected variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean impact estimation$^a$</td>
<td>estimation increases 10</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>estimation decreases 2</td>
<td>7</td>
</tr>
<tr>
<td>variance of impact estimations$^b$</td>
<td>variance increases 3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>variance decreases 9</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Note. This table shows numbers of pairs of impact variables (one expert selected variable and one student selected variable) for which estimations (or variances of estimations) increase or decrease, respectively. 

$^a$ The differences between expert selected impact variables vs. student selected impact variables in the numbers of increases/decreases of impact estimations are significant: $\chi^2(1, N = 24) = 4.44, p < .05.$

$^b$ For the differences between expert selected impact variables vs. student selected impact variables in the numbers of increases/decreases of variances of impact estimations we obtained: $\chi^2(1, N = 24) = 2.74, p < .10.$

Experiment 2 and 3: Group Estimates Concerning Impacts of Environmental Variables

Method

Overview and Participants

In the two experiments, 18 (ZZN) and 16 (Klettgau) five-person groups, respectively, discussed about the impact that selected environmental variables exert on other variables. In both experiments, each group had to discuss four impacts and to agree on a corresponding group estimate of each of these four impacts. In the ZZN study, the following four impacts had to be estimated: (a) The impact of urban quality on profitability, (b) the impact of traffic development on urban quality, (c) the impact of traffic development on profitability, and (d) the impact of profitability on urban quality.

In the Klettgau experiment, the following four impacts had to be discussed: (e) the impact of nature protection on the Swiss-German coordination of regional development planning, (f) the impact of support for local economy on local nature protection, (g) the impact of nature protection on the regions’ attractiveness for tourism, and (h) the impact of the Swiss-German coordination of regional development planning on the region’s economic situation.$^2$ These

$^2$ Experiment 3 included an experimental manipulation that varied the communication of expert opinions before the beginning of the group discussions. For the two variable impacts (g) and (h), the expert opinions were disclosed
eight impact estimation tasks of the two experiments were selected by the experimenters in collaboration with the case study management. All eight tasks differed in content. In general, the tasks of Experiment 2 concerned sustainable urban development and those in Experiment 3 concerned sustainable rural development.

Experimental Procedure

The participants of each experimental session were randomly assigned to five-person groups that were guided to separate rooms by an experimenter. Before the group discussion on the first impact, the group members were given two minutes of time to think individually about the strength of this impact, and to denote their prediscussion estimates on a rating scale, reaching from 1 = very low impact, 2 = low impact, 3 = medium impact, 4 = strong impact to 5 = very strong impact. In this period of individual work on a task, participants also had to allocate 100 points of confidence on the five possible impact levels according to how likely they thought that each of these levels might represent the correct impact level. After denoting the individual prediscussion judgments and allocating the 100 confidence points, the participants began to discuss about the strength of the first impact (e.g., impact of traffic development on profitability). The students discussed for 6 minutes on each impact. This short discussion time was set to ensure that the group discussions would concentrate on the exchange of opinions and arguments. Discussion pauses of long duration and irritations by task-irrelevant behavior were minimized that way.

During the discussions, every 90 seconds an acoustic signal sounded, and the group members then denoted on a five point rating scale the impact estimate that they most favored at this point of time. However, the participants were instructed not to let themselves be irritated by these sounds, and to continue the group discussion with the least interruption possible, after having denoted their current opinions. At the end of the 6 minutes of discussion, the group members denoted their final estimates and again, distributed 100 points of confidence among the five alternatives. Then, the groups were asked to form a joint group judgment for the strength of the impact under consideration. This group estimate marked the end of the work on the first task. Then the experimenter presented the next impact relation to the group. The ex-

---

3 To introduce this procedure of periodic documentation of opinions was necessary for the performance of a PCD analysis of the opinion formation processes as described in Crott et al. (1999). However, previous studies in which the effects of similar procedures that required the participants to document their opinions periodically were analyzed showed no substantial influence of these procedures on the opinion formation processes during the group discussions (Crott & Werner, 1994; Kerr, 1981, 1982; Werner, 1992).

---

ETH-UNS Working Paper 32
experimental procedure was the same for all four tasks and the sequence of these tasks was balanced with the exception that was mentioned in Footnote 2. After the fourth task was finished, the experimenter answered any questions about the purpose of the research, and thanked the students for their participation. The students were not paid for their participation, but took part in the experiment voluntarily. Figure 2 gives a schematic description of the experimental procedure.

The estimates of independent experts were obtained for the eight estimation tasks, and the mean of these estimates was used as the expert estimate that served to determine the accuracy of students’ estimates for an impact. The experts for the 1996 group experiment were different from the experts for the 1998 experiment, because the problem areas of the two corresponding case-studies were different.

---

**Figure 2.** The basic, recursive procedure of group Experiment 2 and 3:
Results

Analysis of Group Polarization and Systematic Choice Shifts

We examined, whether the estimates at the end of the group discussions, and the group estimates were systematically higher or lower than the individual prediscussion estimates. With regard to discussion tasks as used in the two group experiments, it seemed plausible to assume that quite frequently a group member is able to demonstrate a connection between two impact variables that is new for the other group members, but that it is difficult to negate a connection between two variables that other group members judge to be important. This might have led to a systematic increase of the impact estimates during the discussions due to informational characteristics of the tasks.

To analyze changes in the level of the estimates an ANOVA was performed including the independent variable task (8 levels that represent the eight different tasks that were used in the two experiments), and the repeated measurement variable assessment (3 levels: Individual before discussion, individual after discussion, and group estimate). The dependent variable was the group mean of the members’ estimates of an impact at the beginning ($E_{i1}$), and at the end ($E_{i5}$) of the group discussion, and, correspondingly, the group estimate ($E_{grp}$).

The mean prediscussion estimate over all groups, and all impacts was $M(E_{i1}) = 3.57$, the mean of the postdiscussion estimates was $M(E_{i5}) = 3.59$, and the mean of the group estimates was also $M(E_{grp}) = 3.59$. These differences were not significant (main effect of the variable assessment), $F(1.93, 202.86) = 0.35$, $p = .70$. Thus, the analysis revealed no general tendency concerning the direction of the opinion changes. The main effect of task was highly significant, $F(7, 105) = 29.74$, $p < .001$, showing that the impact level estimates for the 8 impacts generally differed from each other. However, the interaction effect between the variables task and assessment was not significant, $F(13.52, 202.86) = 1.30$, $p = .21$. Hence, no opinion shifts were found in the impact estimation tasks that were used in the two experiments. Table 2 shows the mean estimates of the participants for the eight impacts before the beginning, and at the end of the group discussions, as well as the expert estimates.

---

4 Each group worked on four tasks, except for those groups in Experiment 3, which obtained the expert opinions for the two last impacts. For these groups, only the two discussions on the first two impacts are included in the analyses. The different tasks that were discussed by one group are not statistically independent. Therefore, including a repeated measurement variable task in the design of the ANOVAs, or conducting the analyses with average measures for each group as the unit of analysis is appropriate, in a strict sense. However, to avoid empty cells, and to simultaneously obtain an analytic design that distinguishes between the eight tasks, each group is considered as an independent case for each task in the following ANOVAs. This procedure has been common practice in the analysis of group processes (Davis, Stasser, Spitzer & Holt, 1976; Godwin & Restle, 1974; Kerr, 1981, 1992; Kerr & MacCoun, 1985). An entire and functionally independent group process takes place for each task. Moreover, as there is no comparison between experimental conditions in the present analyses, there is no possibility that the results might be distorted due to differences between groups with respect to members’ competencies and prior knowledge, which are often similar for related tasks.

5 There was occasional missing data in this and the following analyses. These missing values were not estimated, and therefore, are not included in the ANOVAs. In this F ratio, the number of the degrees of freedom in the denominator was 210 instead of 224, as a result of missing values. In addition, the degrees of freedom were corrected according to the Huynh-Feld-Epsilon ($\varepsilon = .966$), because of a significant violation of the sphericity assumption (Mauchly Sphericity Test, $p < .001$).
Table 2. Student and Expert Estimations for Environmental Impacts in ETH-UNS Case Studies

<table>
<thead>
<tr>
<th>Interactions of impact variables</th>
<th>Initial rating</th>
<th>Last rating</th>
<th>Expert rated impact(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1996 ETH-UNS case study ZZN (18 groups)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) urban quality / profitability</td>
<td>3.7</td>
<td>3.8</td>
<td>4.8</td>
</tr>
<tr>
<td>(b) traffic development / urban quality</td>
<td>4.2</td>
<td>4.4</td>
<td>4.0</td>
</tr>
<tr>
<td>(c) traffic development / profitability</td>
<td>4.2</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>(d) profitability / urban quality</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>1998 ETH-UNS case study Klettgau (16 groups)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) nature protection / coordination of planning</td>
<td>2.6</td>
<td>2.4</td>
<td>1.7</td>
</tr>
<tr>
<td>(f) support for local economy / nature protection</td>
<td>3.3</td>
<td>3.3</td>
<td>2.3</td>
</tr>
<tr>
<td>(g) nature protection / attractiveness for tourism</td>
<td>3.6</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>(h) coordination of planning / economic situation</td>
<td>3.1</td>
<td>3.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Note. The table shows arithmetic means. Scale from 1 to 5, 1 = very low impact, 5 = very strong impact. \(N_{\text{Groups}} = 18\) for (a) to (d), \(N_{\text{Groups}} = 16\) for (e) and (f), \(N_{\text{Groups}} = 8\) for (g) and (h).

\(^a\) All expert assessments are from April 1998, i.e., after the 1996 ETH-UNS case study but before the project phase of the 1998 ETH-UNS case study (the experts for the 1996 study are different from the experts for the 1998 study).

\(^b\) The exact values were 3.47 for the initial rating and 3.52 for the last rating.

Convergence of Opinions

As mentioned above, previous research on opinion formation in small groups showed that the opinions within a group generally tend to converge during a group process. To analyze the convergence of opinions during the discussions an ANOVA was performed with the independent variable task (8 levels) and the repeated measurement variable assessment (2 levels: divergence of estimates before the beginning of the discussions vs. divergence at the end of the discussions). The standard deviation of the individual estimates within a group (SD) served as the dependent variable.

As expected, the estimates within the groups converged significantly during the discussions, \(F(1, 120) = 85.44, p < .001\). Before the beginning of the discussions, the mean divergence within the groups was \(M_{\text{SD}} = 0.71\), as compared to a divergence of \(M_{\text{SD}} = 0.41\) at the end of the discussions. The main effect of task was also significant, \(F(7, 120) = 6.24, p < .001\). This reflects, that the mean divergence of the opinions within a group differed between the tasks. The highest mean divergence of the estimates resulted for the impact of nature protection on the Swiss-German coordination of regional development planning in Klettgau \((M_{\text{SD}} = 0.88)\), and the smallest divergence was observed for the estimated impact of traffic development on urban quality in ZZN \((M_{\text{SD}} = 0.39)\).
Accuracy of Individual Estimates, Group Estimates, and Aggregated Estimates

Comparison Between Individual Prediscussion Estimates, Individual Postdiscussion Estimates, and Group Estimates Concerning Accuracy

The differences between the accuracy of the individual estimates before the beginning of the group discussions, the accuracy of the individual estimates at the end of the group discussions, and the accuracy of the group estimates were analyzed. An ANOVA with the independent variable task (8 levels), and the repeated measurement variable assessment (3 levels: individual before discussion, individual after discussion, and group estimate) was conducted. The dependent variable was the group mean of the absolute deviation of each group members’ estimate from the expert estimate for a task at the beginning ($D_{i1}$) and at the end ($D_{i5}$) of the group discussion, respectively. Correspondingly, the absolute deviation of the group estimate ($D_{grp}$) from the expert estimate for a task served as the accuracy measure for the group estimates.

There was a significant main effect of the repeated measurement variable assessment, $F(1.85, 194.67) = 5.61, p < .01$. The mean deviation of the individual prediscussion estimates from the expert opinions was $M_{D_{i1}} = 0.88$. The corresponding simple contrasts revealed that the prediscussion estimates proved to be significantly less accurate than the individual postdiscussion estimates ($M_{D_{i5}} = 0.80$), $F(1, 105) = 5.24, p < .05$, and as the group estimates ($M_{D_{grp}} = 0.73$), $F(1, 105) = 7.81, p < .01$. However, the difference between the accuracy of the individual postdiscussion estimates and the accuracy of the group decisions was not significant, $F(1, 105) = 2.01, p = .159$. The main effect of task was highly significant, $F(7, 105) = 10.05, p < .001$, showing that the estimates of the eight impacts generally differed with respect to their accuracy. Averaged over the three assessments, the strongest deviation of the estimates ($D$) resulted for the impact of the Swiss-German coordination of regional development planning on the region’s economic situation in Klettgau ($M_D = 1.38$). The highest accuracy of the estimates was obtained for the impact of traffic development on urban quality in ZZN ($M_D = 0.46$).

Comparison Between Within Group Means of Individual Prediscussion Estimates, Within Group Means of Individual Postdiscussion Estimates, and Group Estimates Concerning Accuracy

The second analysis compared the accuracy of the arithmetic mean of the individual estimates of the group members at the beginning and at the end of the group discussions, and the accuracy of the group estimates. An ANOVA with the independent variable task (8 levels), and the repeated measurement variable assessment (3 levels) was conducted. The dependent variable was the absolute deviation of the within group mean of the group members’ estimates from the expert estimate for an impact at the beginning ($D_{Mi1}$) and at the end ($D_{Mi5}$) of the group discussion, respectively. As in the previous ANOVA, the absolute deviation of the group estimate from the expert estimate ($D_{grp}$) served as the accuracy measure for the group estimates.

---

Because of a significant violation of the sphericity assumption (Mauchly Sphericity Test, $p < .001$), the degrees of freedom were corrected according to the Huynh-Feld-Epsilon ($\varepsilon = .927$).
The mean deviation of the within group means of the individual prediscussion estimates from the expert opinions was $M_{D_Mi1} = 0.73$. At the end of the discussions, the mean deviation of the individual estimates was also $M_{D_Mi5} = 0.73$. The corresponding simple contrast was not significant. There was also no significant difference between the accuracy of the aggregated estimates and the group decisions ($M_{D_{grp}} = 0.73$). This means, that the aggregated estimates of the group members at the beginning and at the end of the discussions were not qualitatively different from each other, and that the group decisions did not reach an improvement as compared to these within group means.

**Comparison Between Individual Prediscussion and Postdiscussion Estimates With the Corresponding Within Group Means Concerning Accuracy**

In the first of the two following analyses, the mean accuracy of the individual prediscussion estimates is compared to the accuracy of the within group mean of the individual estimates at the beginning of the discussion. In the second analysis the same comparison is accomplished for the individual postdiscussion estimates. It is inherent in the computation of the arithmetic mean of the individual estimates within a group that the deviation of this mean estimate from a criterion is always lower or equal to the average deviation of the single individual estimates in a group. As a descriptive measure for this improvement in accuracy that results from averaging the individual estimates within a group, the corresponding percentage, of the reduction of the deviation from the expert judgments in relation to the average deviation of single individual estimates, is presented. In addition, to depict the significance of the statistical advantage of the within group means, as compared to the single individual estimates two separate ANOVAs were performed. One ANOVA with respect to the individual prediscussion judgments and one ANOVA with respect to the individual postdiscussion judgments. The independent variable task (8 levels), and the repeated measurement variable level of aggregation (2 levels: Individual estimates within a group vs. mean of individual estimates within a group) were included in the analyses. As in the previous analyses, the dependent variable was the absolute deviation from the expert estimates.

The first of the two ANOVAs showed that the within group means of the individual prediscussion estimates were significantly more accurate than the single individual prediscussion estimates ($M_{D_Mi1}$ vs. $M_{i1}$), $F(1, 110) = 64.03$, $p < .001$. In comparison to the single individual estimates, the arithmetic mean of the individual prediscussion estimates within a group achieved a reduction of 18.0% in the deviation from the expert estimates. Similarly, the second ANOVA showed, that the within group means of the individual estimates at the end of the discussion were significantly more accurate than the single individual postdiscussion, estimates within a group ($M_{D_Mi5}$ vs. $M_{i5}$), $F(1, 110) = 22.80$, $p < .001$. To average the individual postdiscussion estimates within the groups resulted in a reduction of 8.5% in the deviation from the expert estimates in comparison to the single individual postdiscussion estimates.
Comparison Between the Accuracy of Aggregated Estimates Within Single Groups and the Accuracy of Estimates Aggregated Over all Groups

The previous analyses showed a higher accuracy of the mean individual estimates in a group in comparison to the accuracy of single individual estimates. Similarly, it could be expected that the calculation of the arithmetic mean of the impact estimates over all groups would lead to a further improvement in accuracy in comparison to the within group means of the individual estimates, and in comparison to the single group estimates, respectively. Again, it is inherent in the computation of an arithmetic mean that the deviation of the mean estimate over all groups from the expert estimate is always lower (or equal) than the average deviation of the within group means of the individual estimates in the single groups that are the basis of this arithmetic mean. The same is true for the group estimates. The deviation of the arithmetic mean of the group estimates for an impact over all groups from the expert estimate is always lower (or equal) than the average deviation of the single group estimates that are the basis for this arithmetic mean.

Nevertheless, three ANOVAs were performed to analyze whether this statistical advantage of the mean estimates over all groups was significant: One ANOVA concerning the individual prediscussion estimates, one concerning the individual postdiscussion estimates, and one concerning the group decisions. The independent variable task (8 levels), and the repeated measurement variable level of aggregation (2 levels) were included in each of these ANOVAs. The first ANOVA analyzed the accuracy of the individual prediscussion estimates on the two levels of aggregation. That is, the accuracy of the within group means of individual prediscussion estimates (D_Mi1) and the accuracy of the means of the individual prediscussion estimates of the impacts over all groups (D_OMi1) were compared. The second ANOVA compared the accuracy of the individual postdiscussion estimates on the two levels of aggregation, namely the within group mean (D_Mi5) and the overall mean (D_OMi5). Correspondingly, the third ANOVA compared the accuracy of the single group estimates (D_grp), and the accuracy of the mean of the group estimates over all groups (D_Ogrp). As a descriptive measure for the improvement that was achieved by the aggregation of the estimates over all groups, the percentage of reduction in the error of these estimates as compared to the deviation of the aggregated estimates within the single groups will be presented.

The first of the three analyses showed that the accuracy of the mean individual prediscussion estimates for the tasks over all groups was significantly higher than the accuracy of the mean prediscussion estimates within the single groups, $F(1,110) = 5.15, p < .05$. The mean deviation of the overall mean of the individual prediscussion estimates for a task was $M_{D_{OMi1}} = 0.63$. As compared to the mean estimates within single groups, this represented a reduction of 13.8% in the deviation from the expert opinions.

Analogously, the second analysis showed that the accuracy of the average individual postdiscussion estimates for the tasks over all groups was significantly higher than the accuracy of the corresponding mean estimates within the single groups, $F(1,105) = 9.62, p < .01$. The mean deviation of the overall mean of the individual postdiscussion estimates for a task was $M_{D_{OMi5}} = 0.74$. The third analysis reported similar results.
0.61. As compared to the mean postdiscussion estimates within the single groups, this represented a reduction of 16.8% in the deviation from the expert opinions.

Similarly, the third analysis revealed that the accuracy of the mean of the group estimates over all groups was significantly higher than the accuracy of the group estimates, \( F(1, 105) = 9.01, p < .01 \). The mean deviation of the overall mean of the group estimates for a task was \( M_{D_{Ogrp}} = 0.61 \). As compared to the single groups’ estimates, this represented a reduction of 17.6% in the deviation from the expert opinions.

A further ANOVA concerning the accuracy of the mean estimate for each task over all groups that included the repeated measurement variable assessment (3 levels: individual predis- 
discussion, individual postdiscussion, and group estimate) showed no significant differences between the accuracy of arithmetic means of the individual predisussion estimates over all 
groups, the accuracy of arithmetic means of the individual postdiscussion estimates over all 
groups, and the accuracy of the group estimates aggregated over all groups, \( F(2, 14) = 0.60, p = .561 \).

Figure 3 shows the means of the absolute deviation of the estimates from the expert 
judgments for the individual predisussion (i1) and postdiscussion estimates (i5), the group 
estimates (grp), the individual predisussion and postdiscussion estimates aggregated within the 
groups (Mi1, Mi5), the individual predisussion and postdiscussion estimates aggregated over all 
groups (OMi1, OMi5), and the aggregated group estimates over all groups (Ogrp).

Figure 3. Mean of the absolute deviation of the estimates from the expert estimate: i1 = individual predisussion estimates, i5 = individual postdiscussion estimates, grp = group estimates, Mi1 = within group means of the individual predisussion estimates, Mi5 = within group means of individual postdiscussion estimates, OMi1 = mean of the individual predisussion estimates for a task over all groups, OMi5 = mean of the individual postdiscussion estimates for a task over all groups, Ogrp = mean of the group estimates over all groups.
Group Members’ Confidence in Their Estimates

Research on collective opinion formation in judgmental tasks shows that the confidence group members have in their estimates generally increases during group discussions (Sniezek, 1992). Before the beginning and at the end of the discussions, the group members had to allocate points of confidence to the five proposed impact levels. The confidence points a participant allocated to his own estimate, therefore represent a measure of the confidence in the correctness of one’s own estimate. We compared the confidence at the beginning and at the end of the discussions in an ANOVA with the independent variable task (8 levels) and the repeated measurement variable assessment (2 levels: Individual confidence at the beginning vs. at the end of the discussions). The dependent variable was the mean confidence within a group.

The analysis confirmed the results of previous studies. The subjective confidence of the group members in the correctness of their answers increased significantly during the discussions, $F(1, 101) = 18.09, p < .001$. Before the discussions, the mean confidence was 56.14 points out of 100 and at the end of the discussions it was 60.91%. The main effect of the variable task was also significant, $F(1, 101) = 2.37, p < .01$, showing that the average confidence that the participants had in their estimates differed between the tasks. The highest confidence values were observed for estimates concerning the impact of traffic development on profitability in ZZN (63.4%), and the lowest mean confidence was obtained for the estimates concerning the impact of profitability on urban quality (54.9%).

Discussion

Experiment 1: Experts in Environmental Planning

The individual Experiment 1 showed that in the course of the case study the students’ mean estimates concerning impacts of expert selected variables increased more often than those concerning the impacts of student selected variables. Moreover, the diversity of the students’ estimates concerning impacts of expert selected variables decreased more often than the diversity of the estimates concerning impacts of student selected variables. These results indicate that expert select variables are more influential than student selected variables, and that the students are using expert selected impact variables more consonant than student selected variables. The results of the individual experiment, therefore, support the use of expert defined variables in the first step of using impact variables in non-expert groups, i.e., when defining and selecting variables. This speaks for the common practice in environmental planning groups, which usually start with expert generated information (e.g., Wates, 1996). However, expert advice supposedly contributes to the whole process of environmental planning on the basis of impact variables, including the second step of estimation and aggregation. As far as aggregation is concerned, there is also growing evidence supporting the use of general expert decision aids based on multi-attribute evaluation, in particular in combination with scenario analysis (Scholz & Tietje, 2002; Vlek, Mesken & Steg, 1997).
There are some problems concerning the strength of the experimental evidence of the individual Experiment 1, which are due to the context of this field experiment. In the ETH-UNS case study, the project objectives, and therefore defining useful impact variables, took priority over experimental considerations. Consequently, the distinction between expert selected impact variables and student selected impact variables in Experiment 1 was not really sharp. It is possible that the student commission would have selected at least some of the expert variables without expert support. For experimental clarity, it would be necessary to absolutely separate expert and non-expert selection.

Experiment 2 + 3: Collective Judgment on Variable Impacts

The individual estimates of the participants at the end of the discussions were more accurate than the individual estimates before the beginning of the discussions. This shows that the process of collective opinion formation was connected to an individual gain in judgment accuracy. Therefore, the group discussions were useful on the individual level. Moreover, the group decisions were also more accurate than the individual prediscussion estimates. This represents a positive result on the group level. However, neither the group decisions, nor the within group means of the individual postdiscussion answers resulted in an improved accuracy in comparison to the within group means of the individual prediscussion estimates. According to this result the group discussions are unnecessary to obtain accurate estimates. If the sole objective would be to arrive at accurate parameter estimates for an environmental model, it would have been sufficient to use the aggregated arithmetic means of the individual prediscussion judgments over all groups. The aggregation of the individual prediscussion judgments over all groups reached a comparable accuracy as the aggregation of the individual postdiscussion judgments over all groups and the arithmetic mean of the group estimates of all groups. These three different aggregates over all groups reached an accuracy that significantly surpassed the average accuracy of the aggregates within single groups. This is simply a statistical effect that results because judgmental errors in different directions are balancing each other out. However, it appears advisable to take this statistical effect into account when estimating parameter impacts, and to take advantage of this effect by using aggregated judgments from groups that work independently from each other as the parameter estimates in environmental models. However, if we consider the effectiveness, and the usefulness of the group discussions, these results are not satisfying.

One explanation that is often used to account for bias in group judgment is group polarization and choice shift, respectively (Lamm & Myers, 1978). However, no polarization was detected in the analysis of the group discussions in the two group experiments. This result negates the existence of specific patterns of group polarization in group discussions concerning environmental impact estimations, and contrasts with a former analysis that revealed opinion shifts in direction of higher impact estimates in the course of group discussions (Crott et al, 1999). Without any doubt, further research is needed in this context.
The objective quality of group performance in tasks such as those that were used in the present experiments is difficult to determine, because there are no objectively correct answers for such tasks, and the expert judgments themselves may be more or less accurate. Accordingly, even the significant differences in accuracy that were reported in this article have to be regarded with caution. However, especially in tasks without an objectively correct answer, normative influences tend to have a strong influence on the formation of opinions (Crott & Werner, 1994; Sherif, 1935; Festinger, 1954). Indeed, an analysis of the opinion formation processes in Experiment 2 (Crott et al., 1999) that was performed using the Probabilistic Model of Opinion Change Including Distance by Crott, Werner and Hoffmann (PCD model; 1996) revealed that the influence factor size of a subgroup (Crott & Werner, 1994; Stasser, Kerr & Davis, 1989), which is predominantly connected to normative influence, was the most powerful source of influence in these processes.

The avoidance of disadvantages connected with normative pressures was a major point in the development of group techniques such as the Delphi Technique (Dalkey & Helmer, 1963), the Nominal Group Technique (Van de Ven & Delbecq, 1971) and the Method of Group Consensus (Hall & Watson, 1971). This intention is congruent with a widely shared perspective which assumes that normative pressure and conformity generally have a negative influence on group processes. It is, however, questionable whether this perspective is correct. According to formal models of collective opinion formation, e.g., the Social Interaction Sequence model by Stasser and Davis (1981), and the PCD model, as well as according to the median and the majority SDS, respectively, conformity pressures have a rather positive effect on group decision processes in easy tasks, where large factions often prefer correct answers. Therefore, it might rather be the case that conformity tendencies have positive or negative effects depending on the difficulty of a task. An elaborate group discussion technique that enhances group performance should take these considerations into account (Hansmann, 2001), and it should be able to structure and enrich group processes (Hackman & Morris, 1975). Moreover, we have to think about more effective combinations of group work and expert evaluations (e.g., Stewart & Stasser, 1995).
References


Davis (Eds.), *Understanding group behavior. Consensual action by small groups* (Volume I). Mahwah, NJ: Erlbaum.


Forschungsverbund Lebensraum Stadt (Ed.). *Szenarien und Handlungswege [Scenarios and ways for action]*. Berlin: Ernst & Sohn Verlag.


Models in Environmental Planning: Selection of Impact Variables and Estimation of Impacts


UNS-Working Paper 8 (Out of Print)


UNS-Working Paper 15

(Published as: Jungbluth, N. (1997). Life-Cycle-Assessment for stoves and ovens. 5th SETAC-Europe LCAS Case Studies Symposium, (pp. 121-130). Brussells.)

UNS-Working Paper 16 (Out of Print)

UNS-Working Paper 17


UNS-Working Paper 18

UNS-Working Paper 19 (Out of Print)

(Seventeenth World Congress of Engineering Educators and Industry Leaders (Vol. I, pp. 529-533). Reiskirchen: Catena.)

UNS-Working Paper 20

UNS-Working Paper 21

UNS-Working Paper 22 (Out of Print)

(Continued from previous page)

- Uns-Working Paper 23 (Out of Print)

(Published as: Güldenzoph, W., Baracchi, C., Fagetti, R., & Scholz, R.W. (2000). Chancen und Dilemma des Industriearbeitsmarktes: Fallbetrachtung Zentrum Zürich Nord (Opportunities and dilemmas in the recycling of industrial "brownfields". Case study city center Zurich North). DSP 143 [Docu-
ments and Information on Local, Regional, and Country Planning in Switzerland]. 36, 10-17.)

- Uns-Working Paper 24

- Uns-Working Paper 25

- Uns-Working Paper 26 (Out of Print)

(Continued from previous page)

- Uns-Working Paper 27

- Uns-Working Paper 28

- Uns-Working Paper 29

- Uns-Working Paper 30

- Uns-Working Paper 31

(Continued from previous page)

- Uns-Working Paper 32