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MAPPING NOISE EFFECTS IN THE CONTEXT OF OVERALL WELL BEING

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ABSTRACT
Policy makers are faced with the difficult task of setting priorities in creating sustainable development. Such decisions have to be grounded in a deeper insight not found solely in a count of the number of people exposed to various levels of noise at their home. The importance of the burden of noise within a broader context of overall well being plays a crucial role. An analysis of existing data on valuation shows a consistent trend with reported annoyance. A more direct question on policy priorities included in a survey in Flanders, shows the same consistence. However, in general the ranking of noise is low compared to other factors of sustainable development.
We analysed this problem by critical evaluation of the place that urban noise could take within four different future world views and derived, amongst others, indicators that match each future. These indicators were selected from the enormous variety of available ones. Previous studies (e.g. in The Netherlands) have derived the adherence of the population to such future world views. This information can help politicians to choose the most appropriate noise policy.

INTRODUCTION

The risks for adverse health effects of exposure to high levels of environmental noise have been well documented [1]. To asses the severity of the health effect and make it comparable to other health risks, the DALY (Disability Adjusted Life Year) has been introduced. The correlation between reported annoyance or sleep disturbance and exposure was summarized in overall well accepted exposure effect relationships for large populations of “average” people [7]. The severity of being annoyed or sleep disturbed in comparison to suffering from a classical health deficit is hard to judge. Based on a literature database search the strength of currently available knowledge is shown as the weight of connecting lines in Figure 1.

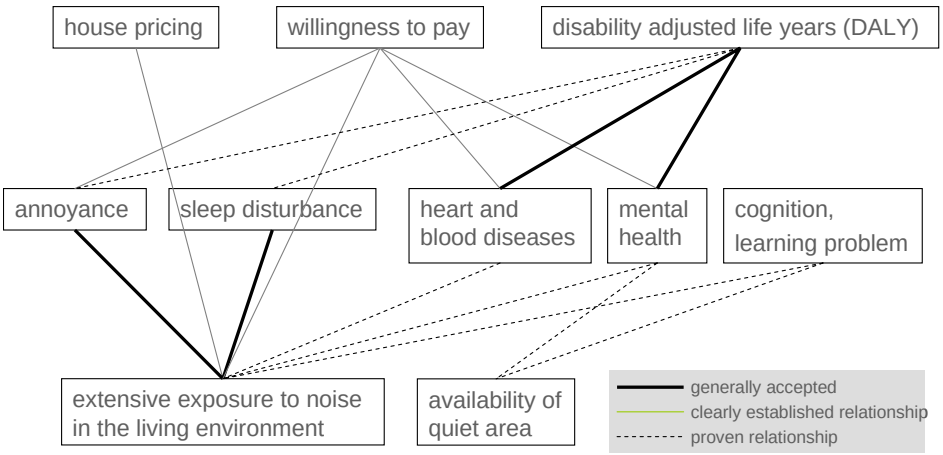


Figure 1.- analyses of available knowledge relating different effects of noise..

Although this scientific knowledge helps to interpret exposure, it is not sufficient to set limits and outline areas where effects are unacceptable. Valuation may help, but it is well known that the value of one euro strongly depends on context as well. In this paper a different approach is taken. Rather than to propose one clear choice, the *plausible futures methodology*[1] – a framework previously used in sustainable development studies [2][3] – leads us to suitability

[1] Also called *four futures methodology*

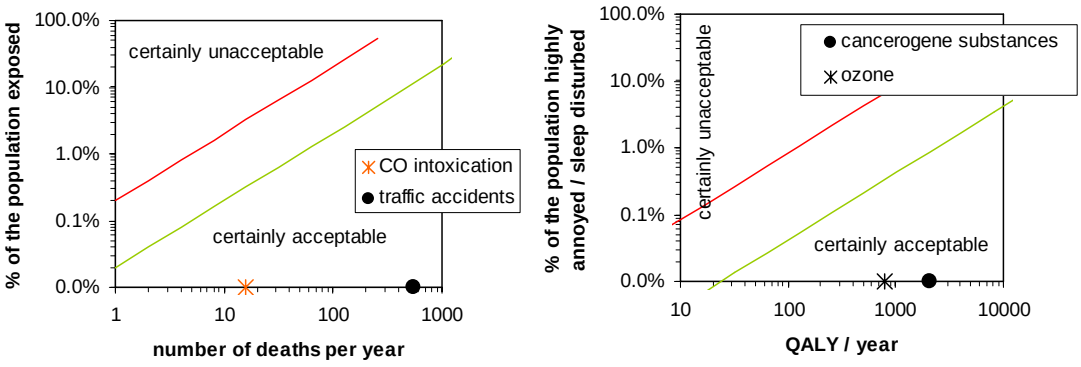
indicators and long term policy goals within several well-defined, explicit context. The choice of a preferred future for a region is a political one and the approach taken allows postponing it. The scientific community can further support this choice by suitable querying of the population.

USEFUL BACKGROUND KNOWLEDGE ON IMPORTANCE OF EFFECTS

To create the opportunity to take the debate on acceptable noise exposure beyond the topic of noise alone, effects have to be expressed on comparable scales. In the written paper we focus on two trans-disciplinary effects: number of deaths and QALY. The first effect has the advantage of being very clear albeit rather drastic. Uncertainty arises from incomplete knowledge on exposure effect relationships and risk. This leads to the broad transition region shown in Figure 1a for the relationship between percentage of the population exposed to an unhealthy environmental noise climate and number of deaths. The numbers are obtained for the Flemish population (6 000 000 inhabitants). For comparison statistical data on death by traffic accidents and death by CO intoxication are included because the causal reason for these deaths can be well established. If 10 deaths indirectly caused by noise per year can be accepted by the Flemish society, this directly leads to a statement that exposure of less than 0.1% of the population to unhealthy noise levels is certainly acceptable while about 2% is certainly unacceptable.

Similarly, Figure 1b can be used to extract acceptable number of people highly annoyed. The uncertainty on the relationship between the QALY (or DALY) indicator and the percentage annoyed is mainly caused by the estimated severity of the condition “high noise annoyance” on quality of life.

These two examples are just there as an illustration of how scientific knowledge on effects can be brought into the discussion on long term noise policy goals. Many other examples could be given.



a) b)

Figure 2.- Possible noise effect indicators as a function of trans-disciplinary effects.

NOISE POLICY AND MULTIPLE FUTURES

Multiple future approaches can be used in two ways. One way is to overcome the large uncertainty in the environment where current decisions will have their future impact. In this case, considering multiple futures allows reducing the risk involved in taking decisions. Policy goal setting can also be based on analysing plausible futures. The futures considered in this case determine the future world that the population would prefer. It is the latter use that is envisaged here. A quite popular model positions four futures along two axes: a local versus international access often appears; the second axes could distinguish between private / public responsibilities. This leads to four quadrants that could be described as:

- *Mundial / international solidarity*: equitable distribution of welfare is a key issue in this world view, economic growth at a stable rate, solidarity with the most vulnerable groups.
- *Caring regions, regional communities*: equitable distribution of welfare at a local level, severe strain on economy, several trading blocks within Europe and the world, local sustainability.
- *Safe regions, conflicting cultures*: Role of the state is limited in favour of market mechanisms, trade mainly with few partners, increasing inequality.

- *Global economy*: Governments engage less in income redistribution and public insurance, private initiative and market-based solutions for all problems.

In each of these futures a certain noise policy could fit, but it turned out that defining it is not an easy task. Hence four *noise policy futures* were designed instead. Each of them fits to some extend in one of the above mentioned more general descriptions for the future of the society.

1. *Market driven, minimal government interference*: noise policy is limited to preventing theft of ones right to control ones own acoustic environment. This right can nevertheless be "sold" to some extend and market mechanisms regulate the noise intrusion of the living environment of a family. Efficiency is a point of concern of the government. This leads to setting product noise emission standards and stimulating new developments that reduce noise.
2. *Socially driven, maximal protection of the individual*: Noise policy is aimed at providing a living environment where noise levels are at the control of the occupant for each member of the society. All noise sources are targeted. Quiet areas within reach of every member of society are guaranteed.
3. *Strong focus on nature and environment*: In this noise policy future, the presence of men is of low importance in designing the ideal noise policy. This policy tries to keep the largest possible portion of the territory quiet. This implies concentration of noisy activities.
4. *Limited focus on noise, small government budget for noise policy*: Noise policy focuses on information campaigns and uses regulations to prevent extensive exposure. Quiet technologies are stimulated. Noise policy is not on the priority list of the government.

As mentioned in the introduction, a policy maker gains from knowing roughly which part of the population adheres to each of these futures. Adherence to the four overall future world views described above was measured in The Netherlands [5]. This information can be used to calculate suitability and preference for the noise policy futures. An estimate of the degree of fit of each of these policies to each of the overall world views is used for this purpose. This degree of fit (Table I) is an estimate by a couple of researchers only. Table I shows that a socially driven noise policy (2) seems to be preferred by the larger fraction of the population while the limited government budget approach (4) is acceptable for most.

Table I.- Estimate of preference and acceptability of the four noise policy futures.

	Adherence in the Netherlands (2004)		Market driven	Socially driven	Nature and environment	Limited focus on noise
		preferable	33%	45%	0%	22%
		acceptable	35%	58%	43%	63%
Mundial solidarity	22%	degree of fit of this noise policy	0.15	0.55	0.7	0.85
Caring regions	45%		0.05	0.95	0.55	0.7
Safe regions	27%		0.9	0.1	0.05	0.35
Global economy	6%		0.9	0.05	0.25	0.5

INDICATORS MATCHING EACH FUTURE

Indicators are used to express noise policy goals and to monitor and map effects. The OECD definition [4] of an indicator is followed: "Indicator: a parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value".

The choice of indicators already implies particular goals. Hence this choice depends on the future selected in the previous section. After scanning available indicators from several sources: WHO[2], END[3], OECD, EEA[4], local environmental policy plans etc, a selection of matching indicators was derived for each of the four noise policy futures outlined above (Table II).

[2] World Health Organisation
[3] EC Environmental Noise Directive
[4] Eueropean Environmental Agency

Table II.- Indicators matching the four futures (*effort measuring indicators are shown in italics*)

noise policy future	Indicators
(1)	Percentage of the population exposed to a noise climate deemed unhealthy by the WHO. *Efficient handling of complaints, noise regulation violations, stimulating building quality.* *Budget of actions taken by the government to stimulate use of best available technology for vehicles, machines, etc*.
(2)	Percentage of the population exposed to a noise climate deemed unhealthy by the WHO (for each community). Percentage of the population highly annoyed or highly sleep disturbed (by community). Access to green area of superior acoustic quality. Percentage of the children learning in a high quality school environment.
(3)	Percentage of the territory disturbed by non-matching noise.
(4)	Percentage of the population exposed to a noise climate deemed unhealthy by the WHO. Decoupling between percentage of the population highly annoyed or highly sleep disturbed and trend in activities. *Efficient handling of complaints, noise regulation violations, stimulating building quality.* *Budget of actions taken by the government to stimulate use of best available technology for vehicles, machines, etc*.

In the first noise policy future (1) only health effects and efforts for guaranteeing efficient use are measured by the proposed indicators. An advantage of the indicator based on WHO guidelines is that it will follow new insights on health effects as they are getting formally accepted by the WHO. Annoyance, sleep disturbance and other nuisances are in this future world handled by market principles. An individual decides how much money he or she is willing to pay for quietness as long as its choice does not imply a high health risk.

The second noise policy future (2) strives to absence of noise annoyance whether or not a person is willing to invest in it. This future view assumes that strong regulation by government should protect also the financially weak.

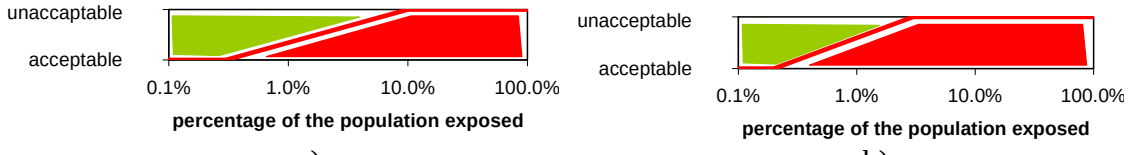
In noise policy future (3) effects on man are only avoided by reducing overall exposure of the territory. But as resources for noise abatement are limited, this may lead to higher exposure of parts of the population.

The final noise policy future (4) is not very different in indicators from the first one. The underlying philosophy is quite different however: it is not a strong believe in free market that limits the efforts but a lower priority (thus budget) for environmental noise management.

LONG TERM GOALS MATCHING EACH FUTURE

The noise policy futures do not only determine the choice of indicator but also the targets imposed on it. Indeed, more risk taking policy can be expected in a future world view based on strong belief in the market (1) while a risk avoiding policy would fit a very social future world view (2). A similar observation holds for the quantification of acceptability of e.g. a health effect. As an illustration, a long term goal related to health that could be derived is:

- If noise policy future (1) (market driven) is chosen, than a matching goal could read: *reduce the fraction of the population that is exposed to a noise climate deemed unhealthy by the WHO to an acceptable level, where acceptable is defined in Figure 3a*.
- If noise policy future (2) (socially driven) is chosen, than a matching goal could read: *reduce the fraction of the population that is exposed to a noise climate deemed unhealthy by the WHO to an acceptable level, where acceptable is defined in Figure 3b*.



a) b)

Figure 3.- Acceptable percentage of the population exposed to noise climate deemed unhealthy by the WHO; a) market driven scenario, b) socially driven scenario.

To account for the imprecision and uncertainty involved in deriving these goals, the concept of fuzzy limits that was introduced before [6], is used. The fuzzy set of acceptable exposure in Figure 3a is based on a relatively high acceptable number of deaths and the area of certain unacceptability in Figure 1a. The fuzzy set in Figure 3b tends to unacceptability faster expressing less acceptance of death and following the risk free region of certain acceptability in Figure 1a.

MONITORING AND PREDICTING

The feasibility and cost of reaching the proposed goals can be investigated by simulating noise exposure of the population after a set of well chosen action plans have been implemented. For consistency of the future view, the style of action plans has to fit in the future considered. In a socially driven future for example, action plans will put equity as a first priority, also when deciding how the action plan will be financed. Suitable packages of action plans for each of the four futures introduced above were compiled. The effect of introducing them over the next 20 years was simulated. As an example, the percentage of the population highly annoyed or highly sleep disturbed (by community) in a socially focused future is discussed. Figure 4 shows the degree of acceptability of the value of this indicator with respect to targets that fit in this future. In several of the larger communities, the noise annoyance situation is quite unacceptable.

It should be noted that indicators used for expressing long term goals (Table II) are rather abstract. In order to simulate the effect of action plans, these indicators have to be concretized. This translation is based on the current state of knowledge and can change over time. Future epidemiologic research may reveal new health effects. The abstract indicators will survive this evolution but the concretization may change. The calculation of noise annoyance that forms the basis of Figure 4 is based on L_{den} high annoyance relationship from [7] for example.

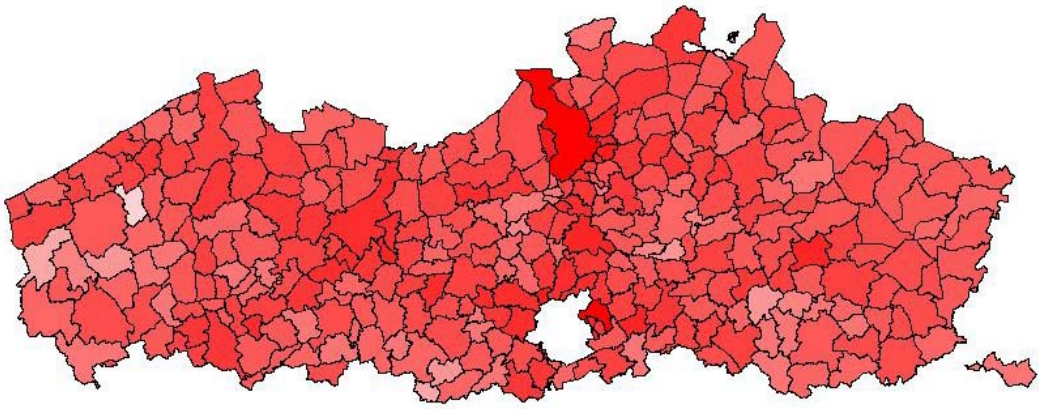


Figure 4.- Predicted percentage of the population annoyed by traffic noise per community in Flanders in 2030, expressed as degree of acceptability (the more intense color, the more unacceptable) within a socially driven future.

DISCUSSION

In this paper a method is introduced for selecting suitable indicators and long term goals to be used in noise policy. By defining several futures, the social, economic, and societal context is made more explicit. This context has an influence on several aspects of the process. It determines the choice of indicators since preferences for the future world determine which effects of noise need to be focussed on. It determines the goals via both acceptability of effects and typical risk management. Finally it outlines which action plans will find a broad basis in this future society. Discussion of all of these aspects is detached from preferences of the scientist involved whose tasks shift more towards formulating causal relationships and guarding consistence in the picture of a future that is sketched.

Although defining several possible futures removes the uncertainty caused by society preferences and offers a clearer thinking frame for the stake holders involved, it became clear that several causes of imprecision remain. Thus it is necessary to formulate goals in a vague and imprecise way. Rigid frameworks are however available for working with such imprecise formulations.

Finally, the adherence of the population to each of the futures has to be estimated. Since the surveying required for this is a rather tedious task, it will be done at a supra-disciplinary level. Since it remains more easy to use more precise futures for noise policy itself, a two step procedure is proposed. Several futures for noise policy are defined which are in a later stage connected to the interdisciplinary future world views to derive the acceptability and preference by the population.

ACKNOWLEDGEMENT
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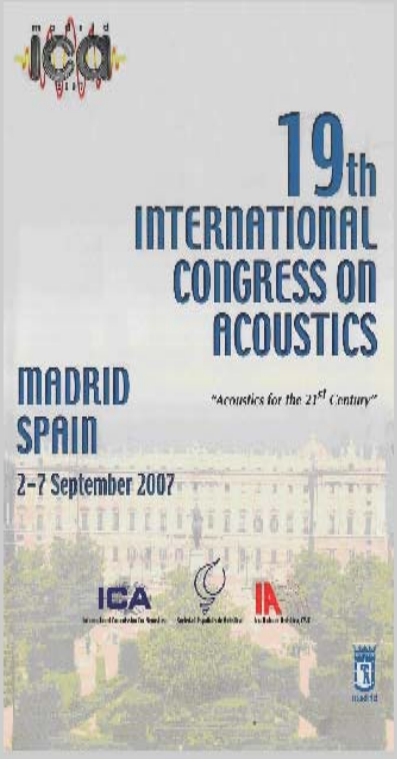

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