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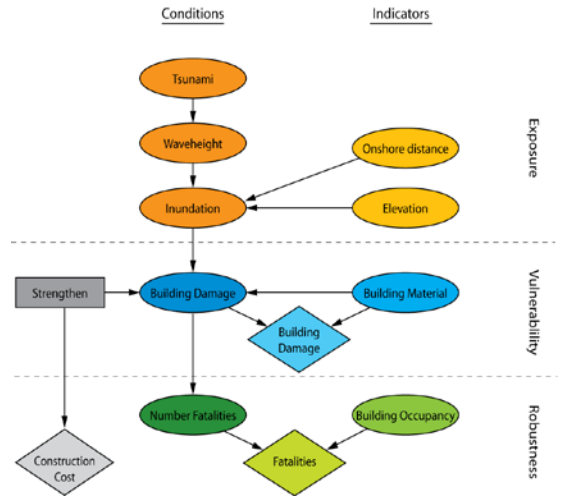

On the Compatibility of the LQI with Present Best Practice Safety Regulation

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Motivation

Life safety and life safety risks play an important role for sustainable societal developments

Decision makers and politicians are under significant pressure to make the right decisions – under intensified public awareness

Best practices for life safety regulation have developed over time without a real solid scientific basis

Large diversity and arbitrariness can be observed in best practice life safety risk regulation

We actually know how to do things better!

Motivation

Life safety is an issue of decision making at different societal levels

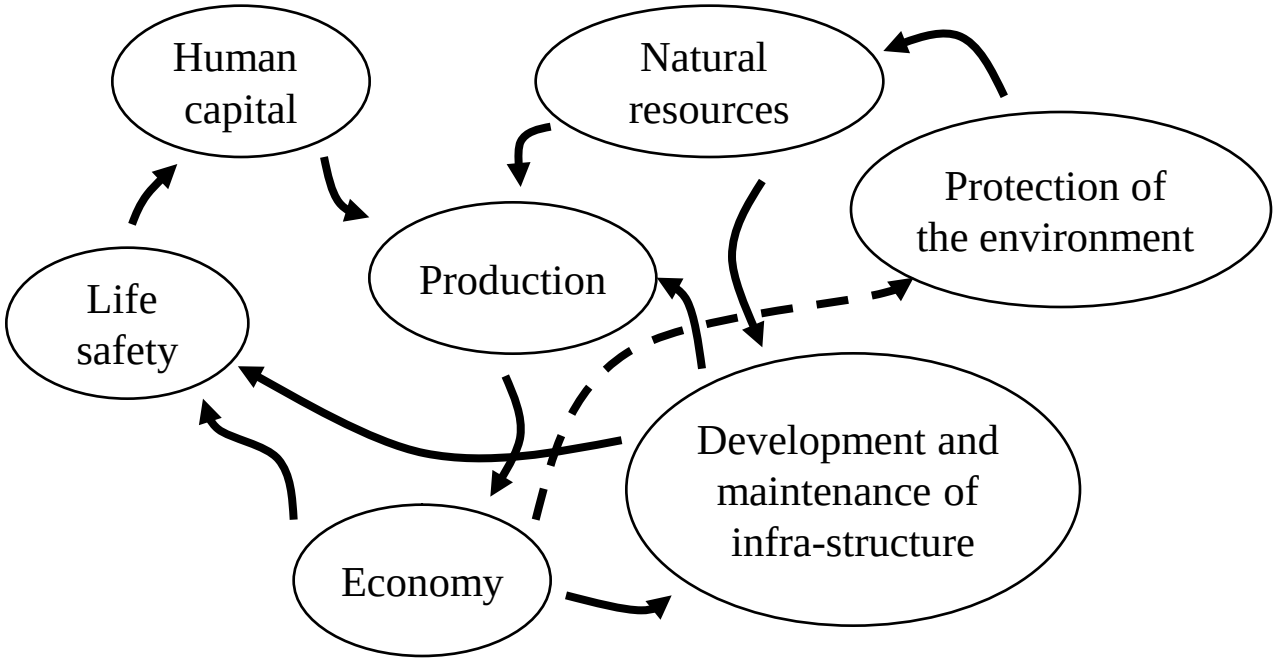
- Supranational
- International
- National
- Regional
- Industrial sectors

In the following focus will be directed on safety regulation at the national level

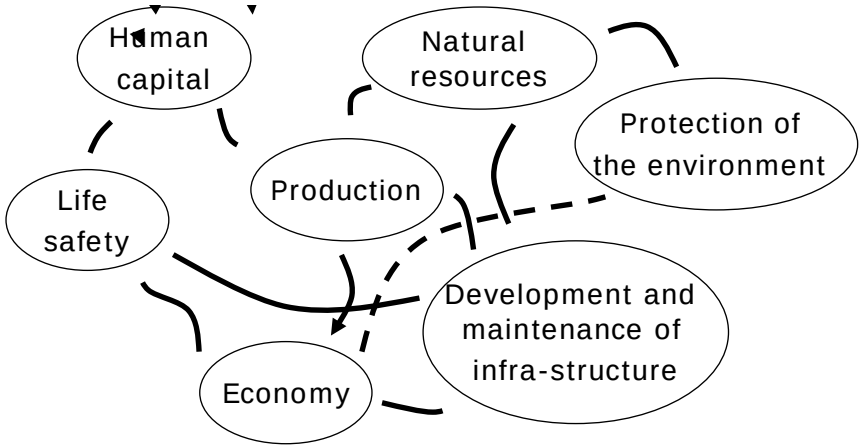
Thereafter decision making at supranational level in regard to investments into life safety will be discussed

Motivation

Before proceeding it is necessary to recall the interaction between life safety and socio-economics



Motivation



In assessing life safety requirements the socio-economic capacity must be considered

Marginally: assuming that changes in life safety regulation will not affect economical capacity

Non-marginally: taking into account the effect of changed life safety regulation on economical capacity

Best Practice Life Safety Risk Regulation

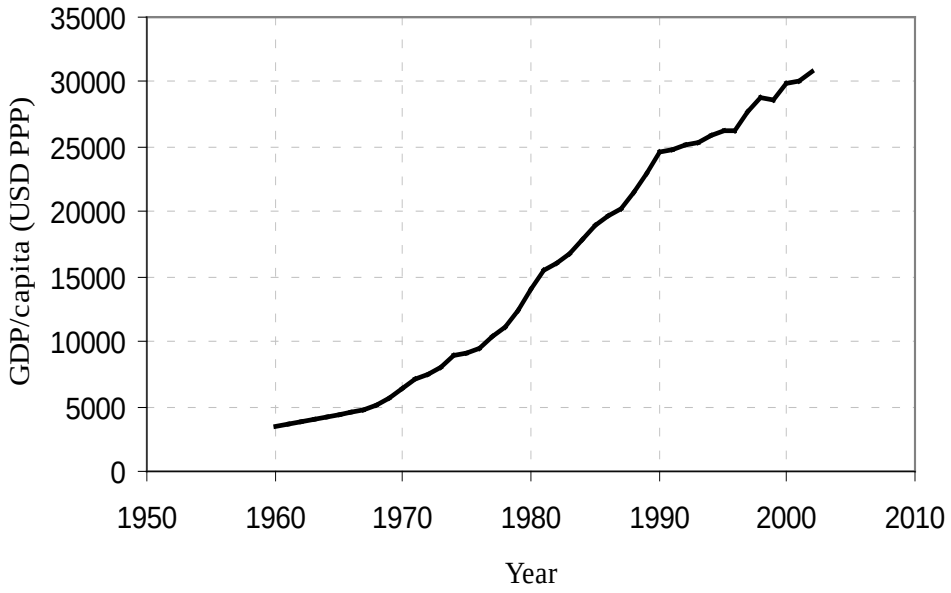
Ideally life safety risk regulations should fulfill the following requirements (Elvik, 2008):

- Regulations must respect and build upon fundamental values related to human rights and safety for individuals.
- They must conform to socio-economical mechanisms and resources.
- They must be coherent with and manageable in relation to existing socio-political management processes.
- They must be implementable and unambiguous in practical applications.

Best Practice Life Safety Risk Regulation

Demographical indicators

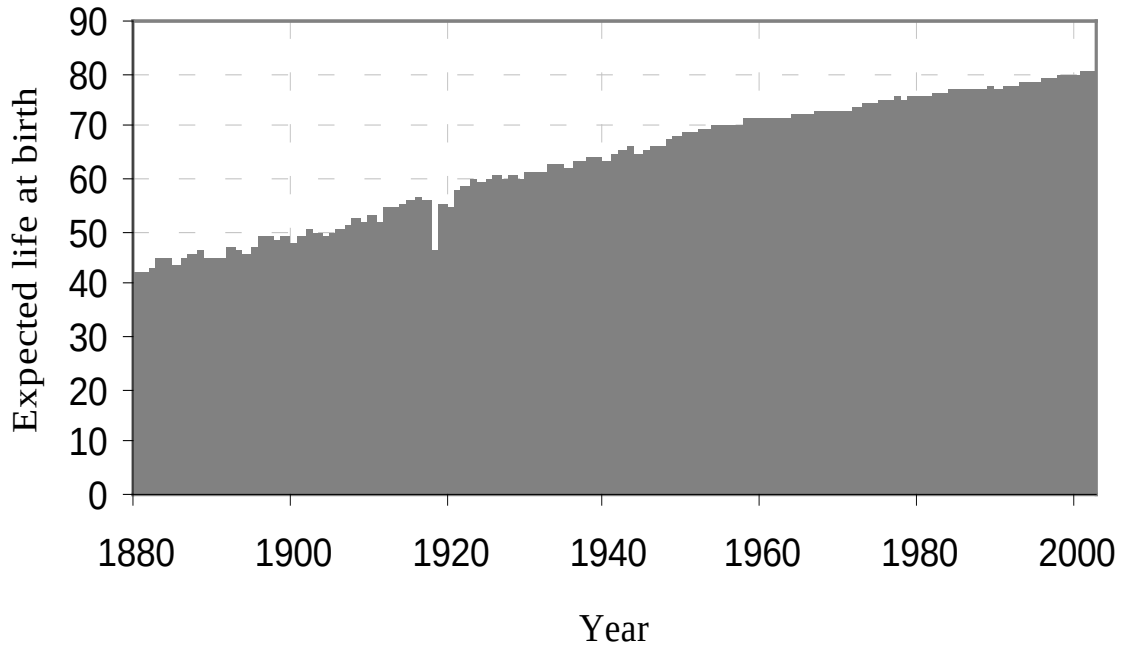
- Gross domestic product (GDP) per capita



Best Practice Life Safety Risk Regulation

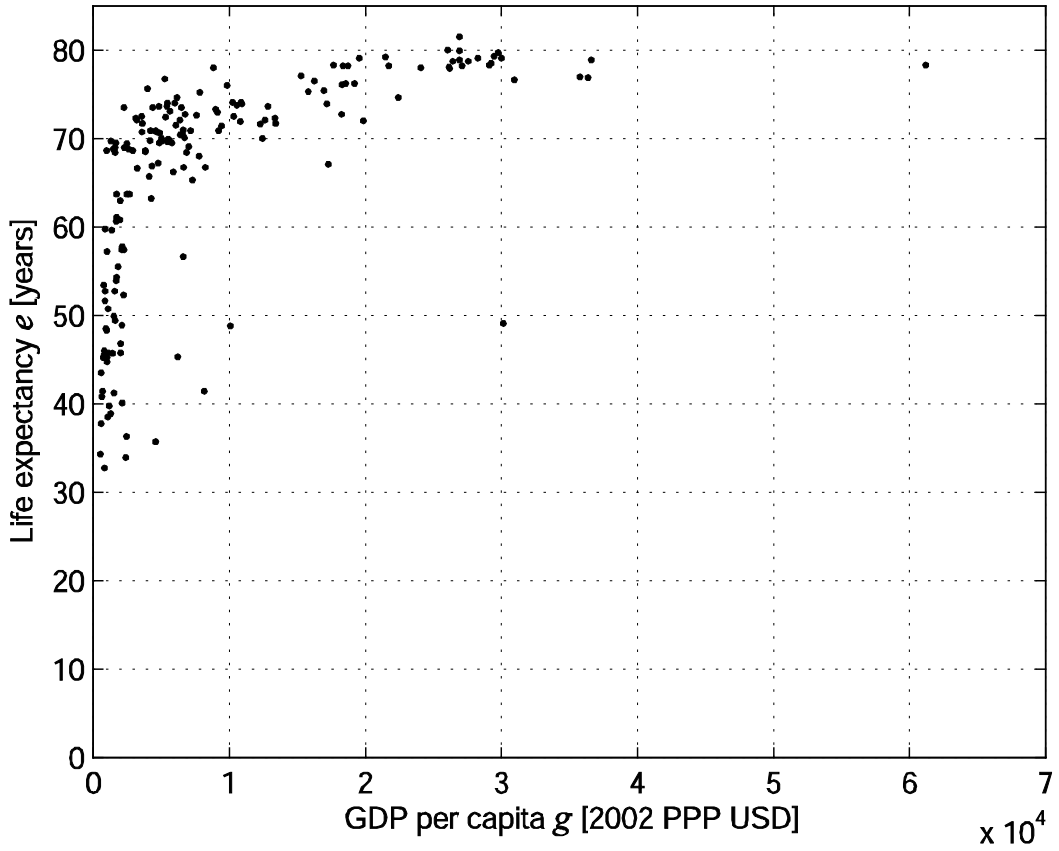
Demographical indicators

- Life expectancy at birth



Best Practice Life Safety Risk Regulation

Life-Expectancy and economical capasity are correlated



Best Practice Life Safety Risk Regulation

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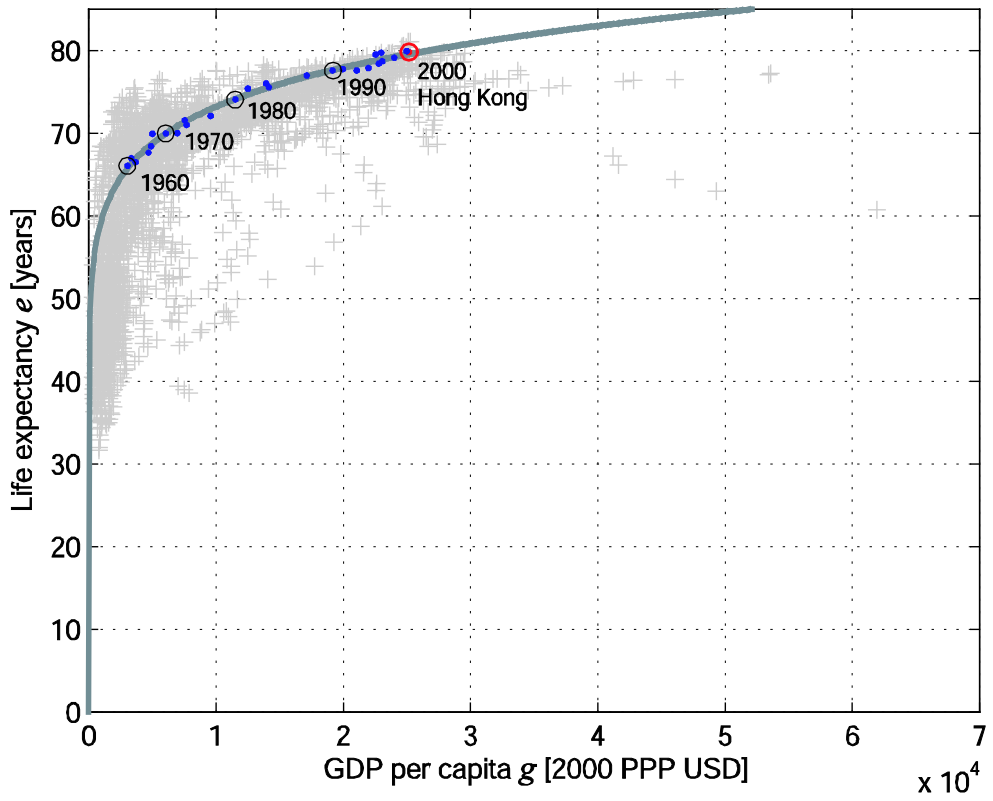

Best Practice Life Safety Risk Regulation

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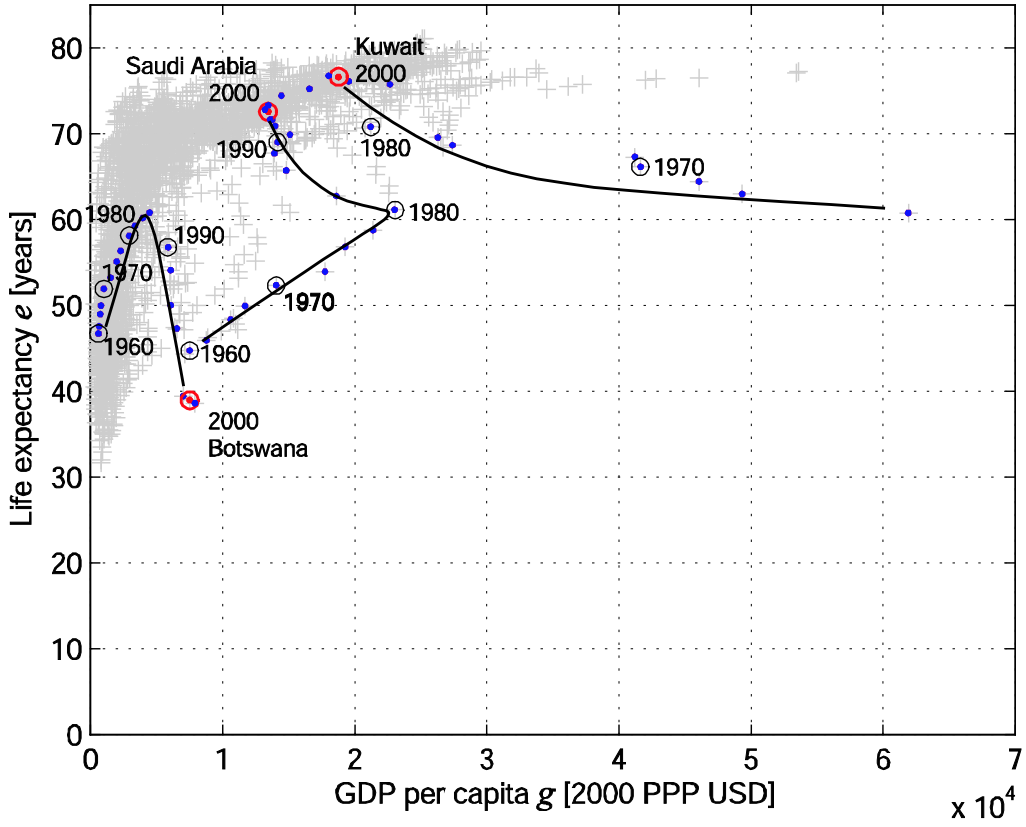
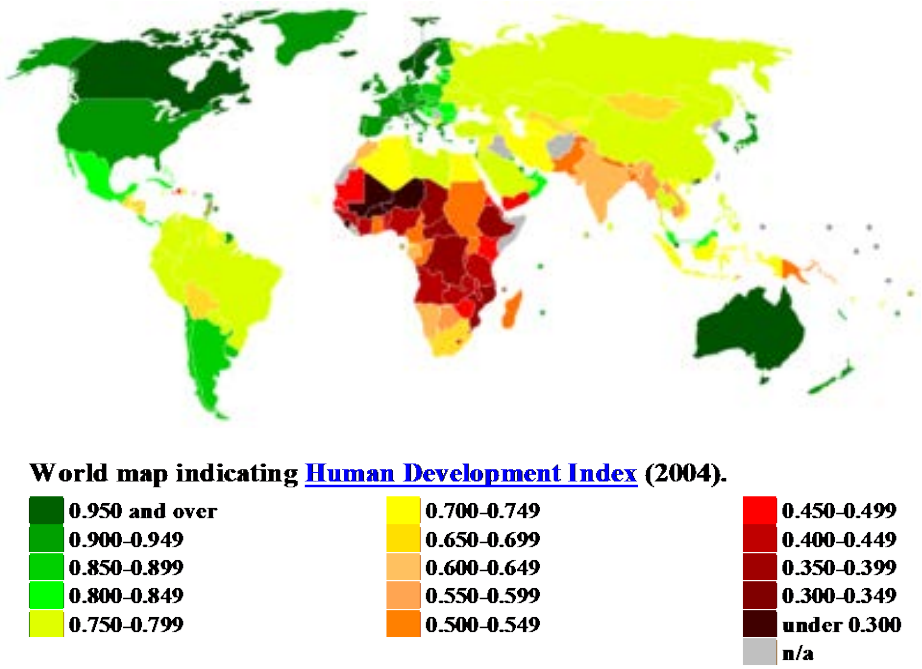


Best Practice Life Safety Risk Regulation

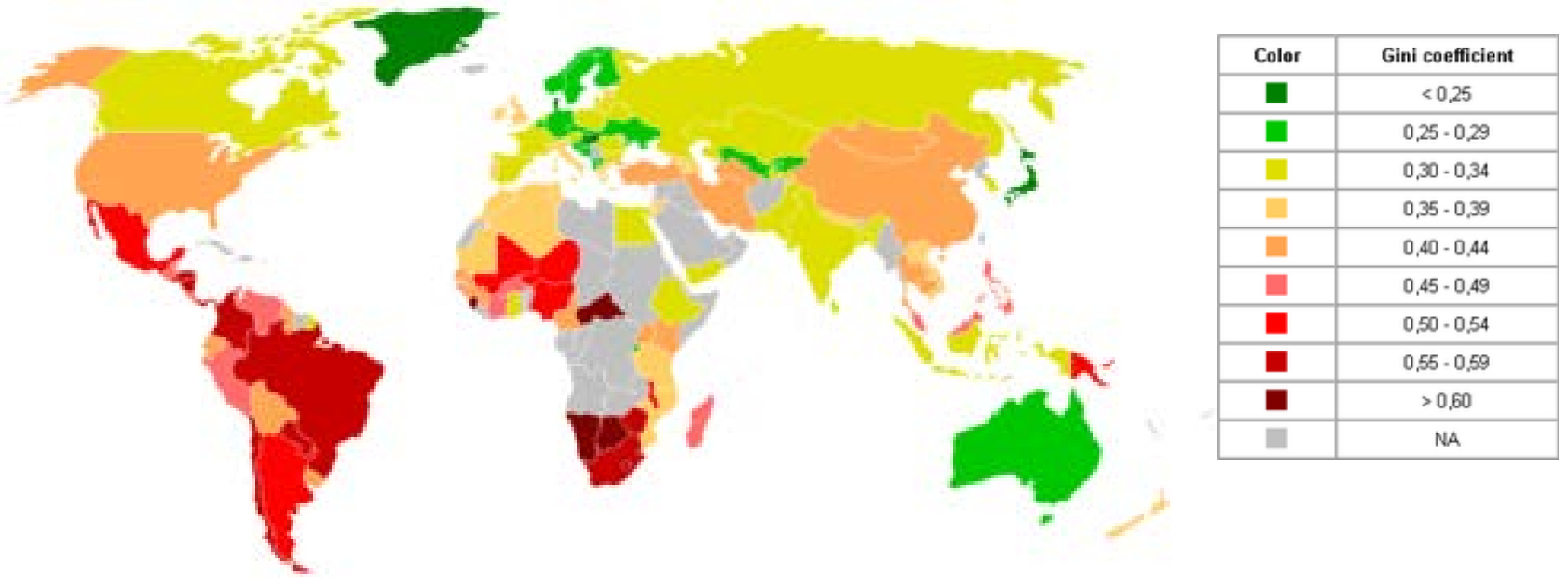
The performance of the nations of the world is measured through the *Human Development Index (HDI)*



$$HDI = \frac{1}{3} GDP\ Index + \frac{1}{3} EI + \frac{1}{3} LEI$$

Best Practice Life Safety Risk Regulation

It is also interesting to observe how the income of nations is distributed between the individuals of the nations (*Gini – Index*)



Color	Gini coefficient
	< 0,25
	0,25 - 0,29
	0,30 - 0,34
	0,35 - 0,39
	0,40 - 0,44
	0,45 - 0,49
	0,50 - 0,54
	0,55 - 0,59
	> 0,60
	NA

$$HDI = \frac{1}{3} GDP\ Index + \frac{1}{3} EI + \frac{1}{3} LEI$$

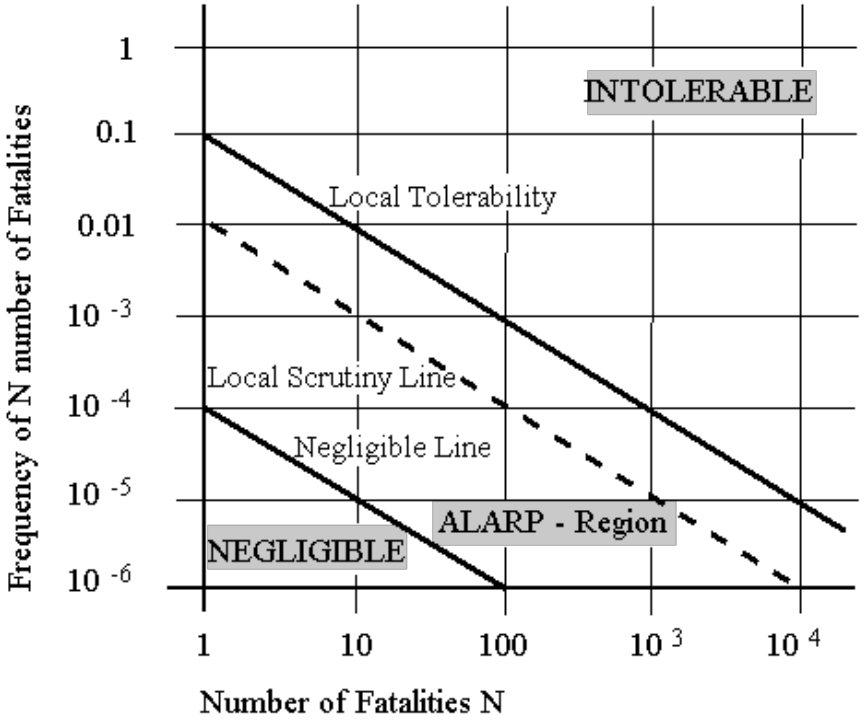
Best Practice Life Safety Risk Regulation

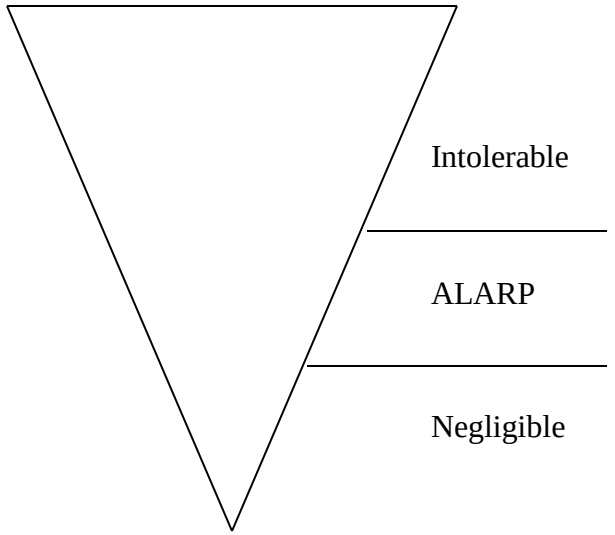
Considering national/industrial level regulation of life safety a number of formats are applied

- Offshore safety:	Potential loss of life (PLL) Fatal Accident Rate (FAR)
- Structural Safety:	Annual probability of failure
- Traffic safety:	Loss of lives per million km
- Land use planning:	Annual probability of death
- HSE:	Annual probability of death

Best Practice Life Safety Risk Regulation

The ALARP principle, whereby collective risks and individual risks are differentiated.





Individual risk criteria

Best Practice Life Safety Risk Regulation

Typically applied ALARP related acceptable risks

Annul fatality rate	UK	Netherlands	Hungary	Czech republic
10^{-4}	Intolerable limit for members of the public			
10^{-5}	ALARP region	Limit for existing installations (ALARP)	Upper limit	Limit for existing installations. Risk reduction must be carried out.
3×10^{-6}	Land Use Planning (LUP) criteria		Lower limit	Limit for new installations
10^{-6}	Broadly acceptable	Limit for new installations and general limit after 2010 (ALARP)		
10^{-7}	Negligible			
10^{-8}		Negligible		

Premises for Accepting Life Safety Risks

Despite the present best practice the fundamental question remains:

What risks can consciously be exposed to third parties?

Many different approaches to treat this question have been followed – a common perspective is to take basis in observed preferences – what risks do people actually buy into?

E.g. the PLANAT (2004) approach where acceptable risks are assessed based on degree of control and degree of voluntariness

Premises for Accepting Life Safety Risks

It is possible to organize activities according to the degree of voluntarism and degree of personal influence/control

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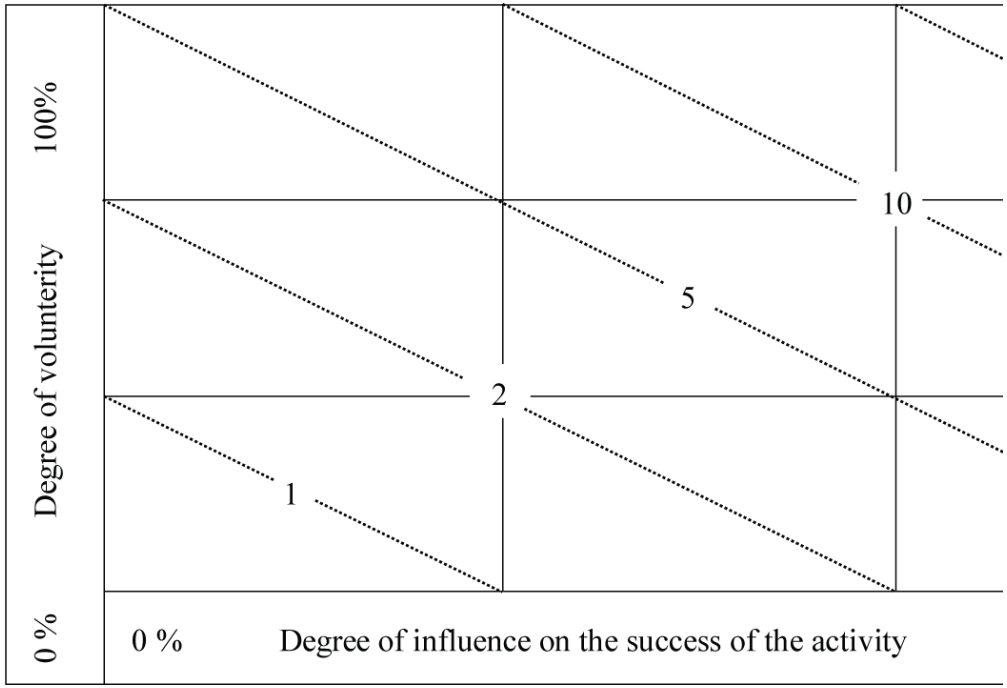
Premises for Accepting Life Safety Risks

By study of statistics it is then possible to organize revealed risks according to degree of voluntarism and degree of personal influence/control



Premises for Accepting Life Safety Risks

Basic values, however, say we are not allowed consciously to take the life of other persons -

This implies that we are also not allowed consciously to take the life of an unknown person out of a group of persons –

This fact renders the whole discussion on acceptable life safety risks MEANINGLESS!

It is necessary to take another perspective !

The Marginal Life Saving Costs Principle

Taking basis in the philosophical insight that the basic asset individuals have is time – Nathwani, Pandey and Lind developed the – a preference model – which at a societal level acts as a revealed preference on how we weight money against life time and time for private activities

$L(g,\ ) = g^q$

g : is the part of the GDP available for investment into life safety

: is the life expectancy at birth

w : is the part of life spent for work

$$q = \frac{1}{\beta}\frac{w}{1-w}$$

β : is a factor which takes into account that only a part of the GDP is based on humal labour

The Marginal Life Saving Costs Principle

Based on the LQI – the consideration that every investment into life safety should lead to an increase in life-expectancy results in a risk acceptance criterion:

$$\frac{dg}{g} + \frac{1}{q}\frac{d}{} \geq 0$$

which leads to the important Societal Willingness To Pay (SWTP) criterion:

$$SWTP = dg = -\frac{g}{q}\frac{d}{}$$

GDP	59451 SFr
l	80.4 years
w	0.112
β	0.722
g	35931 SFr
q	0.175

The Marginal Life Saving Costs Principle

The SWTP criterion is readily applied for the purpose to determining acceptable structural failure probabilities

$$\frac{d}{} \approx C_x d\mu = C_x k dm$$

where

C_x is a demographical constant

k is the probability of dying in case of structural failure

m is the failure rate of a considered structural system

The Marginal Life Saving Costs Principle

The SWTP criterion is readily applied for the purpose to determining acceptable structural failure probabilities

$$dC_y(p) \geq -\frac{g}{q} C_x N_{PE} kdm(p)$$

where

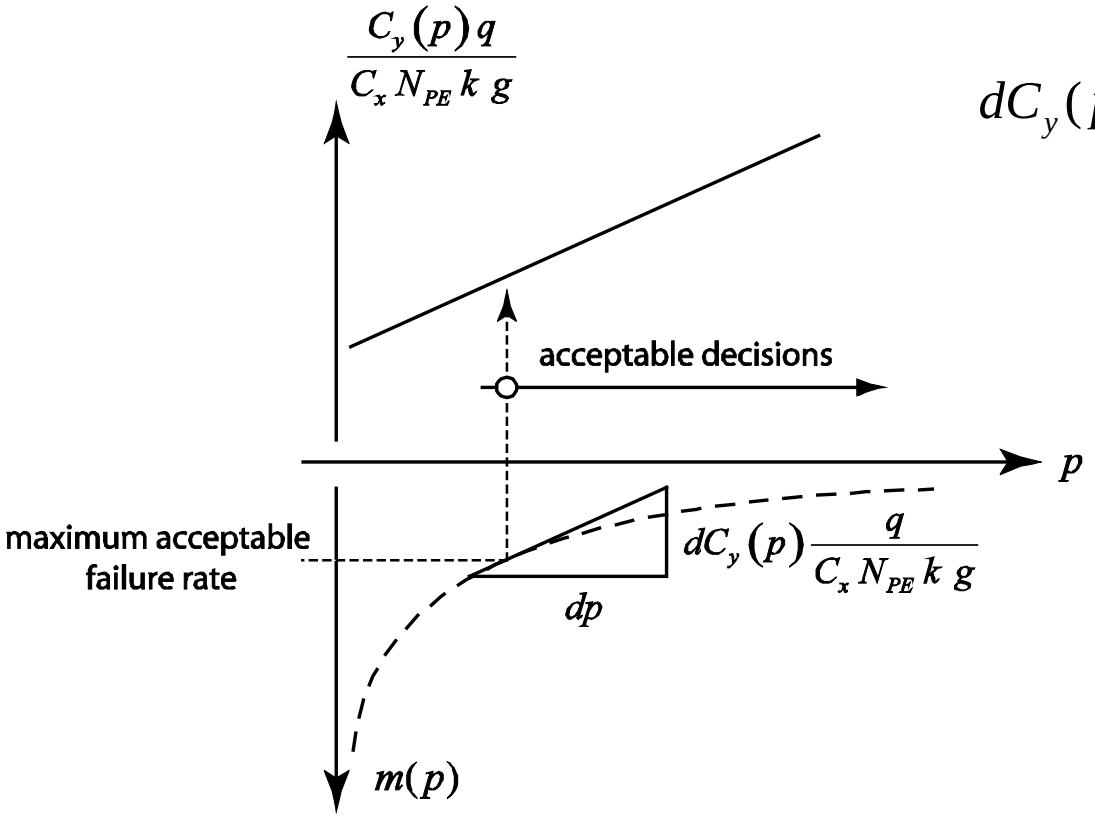
$dC_y(p)$ are the annual costs spent for risk reduction

N_{PE} is the number of people exposed to the structural failure

p is a decision alternative e.g. a structural dimension

The Marginal Life Saving Costs Principle

The SWTP criterion can be visualized



$$dC_y(p) \geq -\frac{g}{q} C_x N_{PE} k dm(p)$$

The Marginal Life Saving Costs Principle

Based on the LQI – also the costs of compensation for a lost life can be assessed – Societal Value of a Statistical Life (SVSL).

$$SVSL = \frac{g}{q} E$$

For Switzerland this amounts to about 6 million SFr

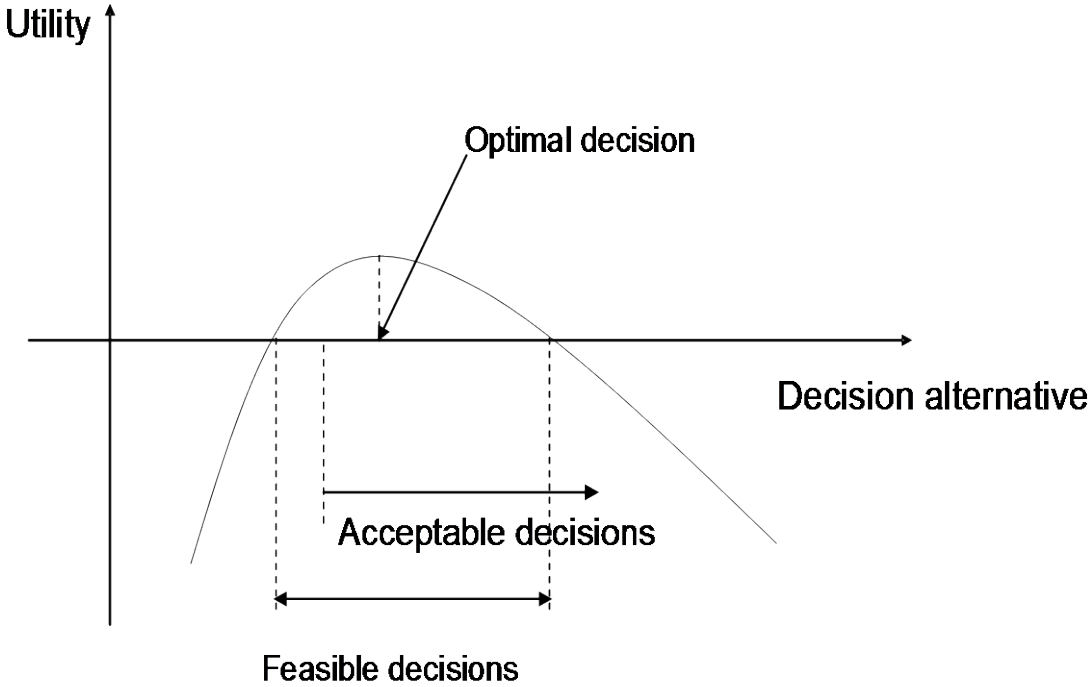
It should be noticed that instead of the LQI – other preference models may be used such as e.g. the UN Human Development Index (Schubert, 2009)

The Marginal Life Saving Costs Principle

Now the optimization problem can be reassessed –

Acceptable decisions are limited by the SWTP criterion

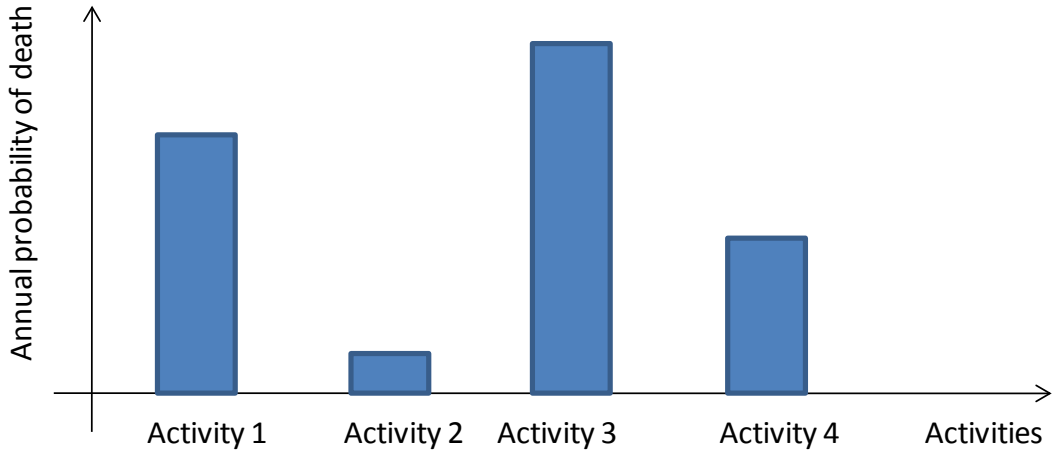
Costs of failure include compensation – through the SVSL



The Marginal Life Saving Costs Principle

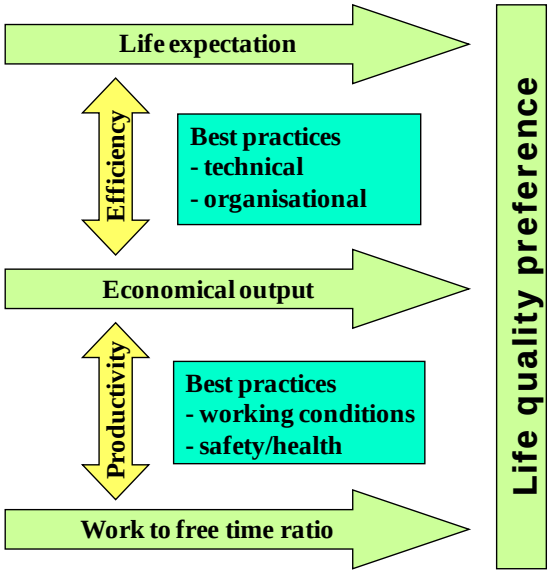
Using the LQI principle as basis for assessing the conformity of investments into life safety redirects the focus from the acceptable level of risk to the necessary and affordable investment into life safety

However, after optimization we have the following situation – what does that mean?



The Marginal Life Saving Costs Principle

Considering the philosophical basis for the derivation of the LQI we may interpret the underlying mechanisms for life safety "implementation" in society from an operational and a strategic perspective -



The Marginal Life Saving Costs Principle

Operational life safety risk management (i.e. for one project or activity) includes:

- Allocation of resources to a given project in accordance with the efficiency of relevant best practice risk reduction measures.
- Implementation of these measures.

Strategic life safety risk management includes:

- Prioritization of available economical resources between projects and activities in accordance with life saving efficiency.
- Monitoring and improving best practices.

Representing Life Safety Risks

Over the different application areas there are many different measures in use for assessing risks

It is necessary to assess risks in a straightforwardly comparable manner

It is suggested to use the fatality rate assessed as:

ratio between expected number of annual fatalities and expected number of exposure man years per year

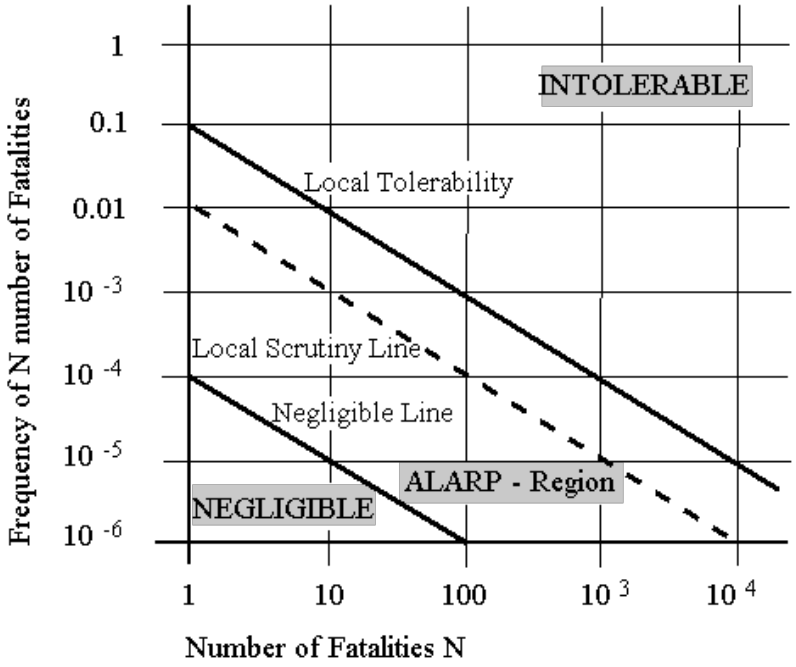
This differs from the traditionally used measures – however, facilitates modeling, statistical assessments as well as comparisons.

Representing Life Safety Risks

Some examples:

Cases	Man years of exposure per year	Fatalities per year	Fatality rate
Construction USA (2007)	2,433,820	1,204	$4.9470\ 10^{-4}$
Construction UK (2007)	481,133	72	$1.4965\ 10^{-4}$
Construction Singapore (2007)	91,688	24	$2.6176\ 10^{-4}$
Construction New York (2007)	70,120	99	$1.4120\ 10^{-3}$
Transportation and materials moving USA (2007)	2,344274	890	$3.7965\ 10^{-4}$
Transport and storage Singapore (2007)	49,806	7	$1.4055\ 10^{-4}$
Roadway traffic in Changsha City China (2007)	4,117,188	416	$1.0100\ 10^{-4}$
Gotthard road tunnel, Switzerland (1996)	408	2	$4.9000\ 10^{-3}$

Consistent Format for Life Safety Regulations



Conformity with requirements by Elvik (2008)

ALARP shall be proven based on the LQI principle

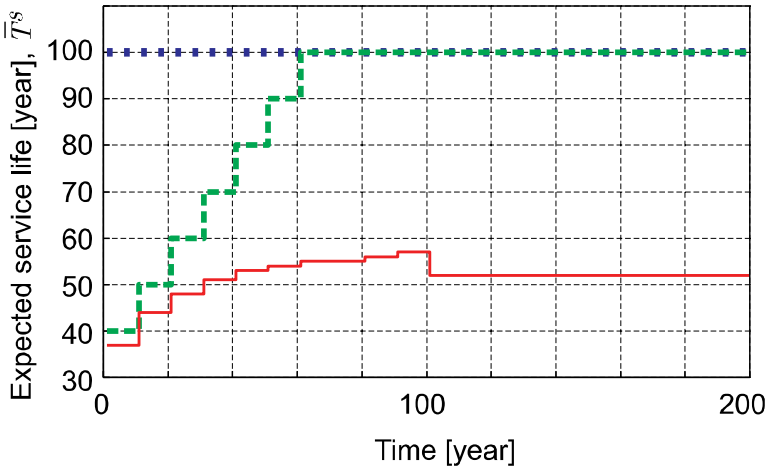
However, an upper bound based on the principle of scrutinization as well as the precautionary principle should be implemented

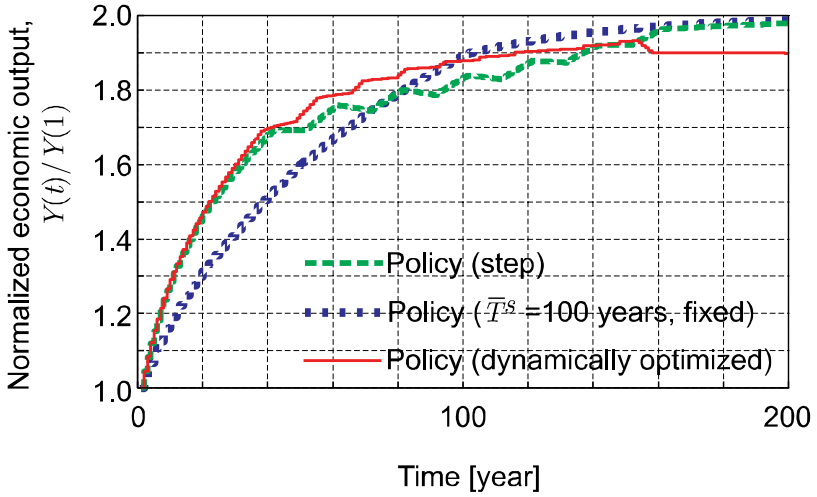
A lower bound can be suggested to avoid meaningless risk assessments

Effects of non-marginal life safety optimization

Optimally and especially for economies in development the decision in regard to affordable performance of infra-structure, including safety issues, must be seen in close relation to the interaction between performance and economy.

In Nishijima and Faber (2009) this is investigated.





Supranational support to developing countries

Support by supranational organizations such as the United Nations for developing economies often directly targets improvement of life safety or improvement of infrastructure

The fundamental question has been whether it is correct to apply the preferences for investments into life safety from highly developed countries when deciding on the use of monetary resources in helping developing countries

Supranational support to developing countries

The foregoing shows that life safety and performance of infrastructure must be seen in relationship with the general economical development in a given country

A development support which does not respect this relationship will effectively prioritize the lives of selected groups of people in the beneficiary country

This would clearly be unethical

Therefore the socio-economical preferences in regard to investments into life safety must form the basis for decisions in regard to development support

Conclusions

Present best practice life safety risk regulation is not based on a holistic rationale and shows large diversity

The marginal life saving cost principle hereunder the LQI principle or the UN HDI provide a sound basis for deciding on investments into life safety and regulation of life safety

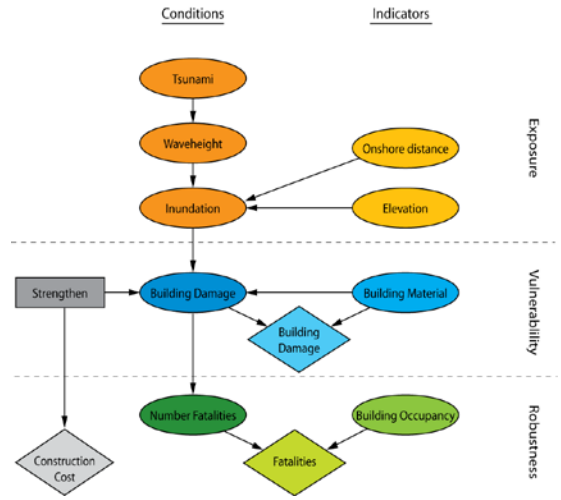
The ALARP principle which largely forms present best practice on life safety regulation may be easily adapted to comply with the marginal life saving costs principle

Conclusions

A measure of life safety which relates directly to the general mortality of human beings has been proposed; this greatly enhances transparency and comparison.

It has been shown that non-marginal decision analysis in regard optimization of infrastructure performance provides a strong tool in making to most of limited societal resources

Finally, aid to third parties, such as developing countries must be allocated in coherence with the preferences to investments into life safety and the economical capacity of the beneficiary country



Thanks for your attention !