Egyptian Society of Chemical Engineers
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Siting of chemical industry, the context of land use planning

Ahmed Gaber - November 25, 2008

v2

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outline

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2. Statement of the problem
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4. Egypt industrial geography, illustrative examples
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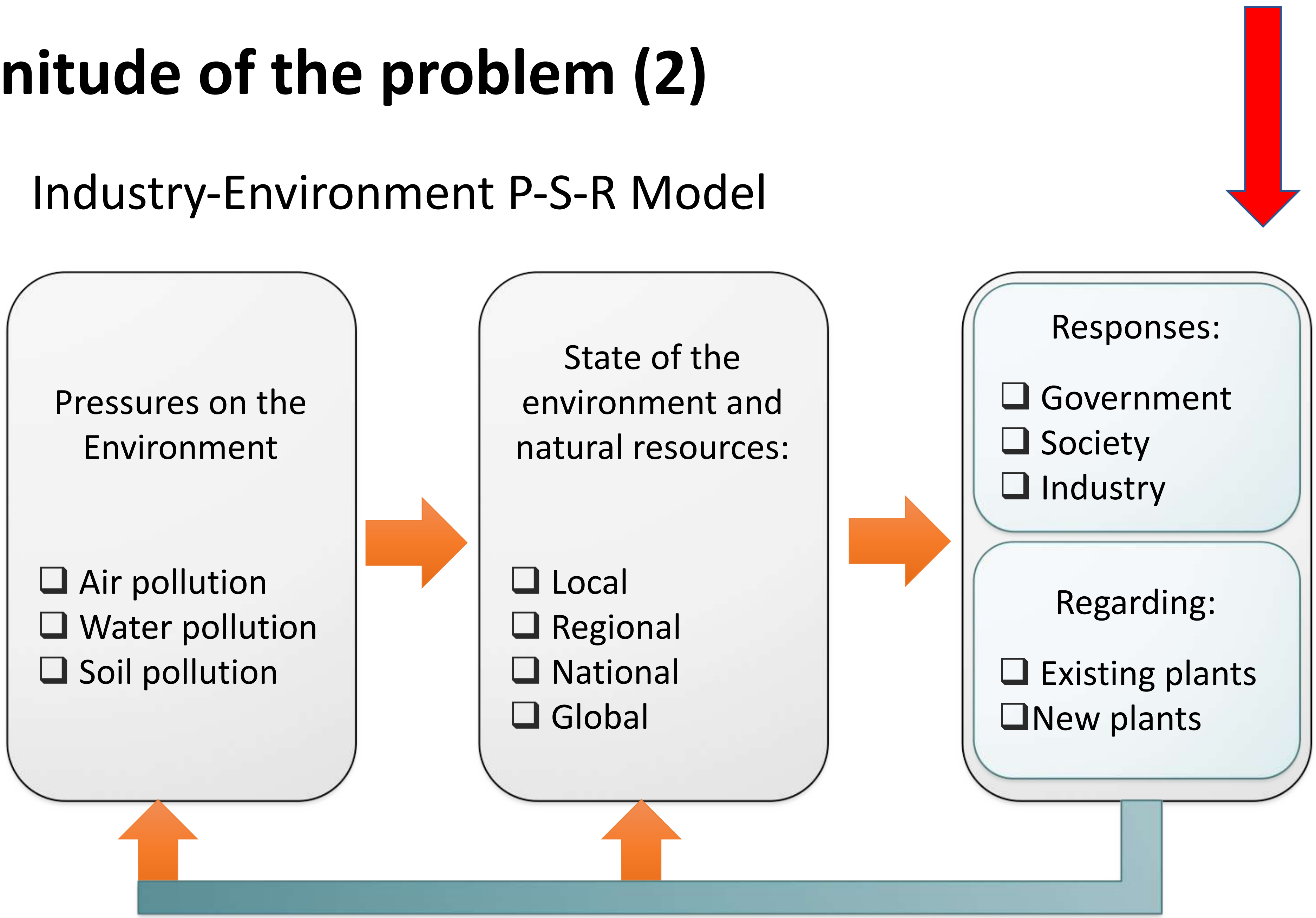
Magnitude of the problem (1)

- According to the International Labour Organization (ILO 2001), the number of occupational accidents and diseases is increasing, in particular in developing countries (internal risk).
- Every year, over 1.2 million workers are killed due to work-related accidents and diseases, and 250 million occupational accidents and 160 million work-related diseases are occurring (internal risk).
- The economic loss related amounts to 4% of the world gross national product (internal risk).

Magnitude of the problem (2)

Industry-Environment P-S-R Model



Magnitude of the Problem (3)

Major industrial disasters

FLIXBOROUGH, UK - June 1, 1974

In 1974, cyclohexane vapor leaked from ruptured pipework at the Nypro (UK) site at Flixborough. This resulted in an explosion that killed 28 people and injured 36.

Offsite, 53 injuries were reported. Property in the surrounding area was also severely damaged.

The disaster led to the Health and Safety at Work Act, introduced the same year.

SEVESO, ITALY - July 10, 1976

On July 10, 1976, in a small Italian town north of Milan, a reactor at the ICMESA chemical plant overheated, resulting in an explosion and the first, and highest known exposure, to dioxins in a residential area. A toxic cloud containing 2,4,5-Trichlorophenol - used to make pesticides and antiseptics - spread to the densely populated city of Seveso.

This became the catalyst for the Seveso Directive, in 1982, which has since undergone numerous amendments. It was replaced by the Seveso II directive in 1996.

TOULOUSE, FRANCE - September 21, 2001

Around 300 tons of ammonium nitrate (AN) exploded, destroying the site and affecting buildings 3km away in the city center.

The blast left a crater 50m wide and 10m deep. It was responsible for the death of 30 people, and 10,000 injuries.

Magnitude of the problem (3)

BHOPAL, INDIA - December 3, 1984

A gas leak at Union Carbide's pesticide plant in Bhopal, India, is cited as one of the chemical industry's greatest tragedies.

On December 3, 1984, methyl isocyanate gas leaked from the facility during the early hours of the morning while local residents slept. Around 2,000 people died immediately, with another 13,000 dying later.

The initial investigation suggested that large volumes of water had entered the chemical tank, which caused a chemical reaction and led to the leak. The incident highlighted the problem of urbanization and having a plant located near a densely populated area.

TEXAS CITY, TEXAS, US - March 23, 2005

The 2005 disaster at UK oil major BP's Texas City refinery, in Texas, US, was considered the nation's worst industrial disaster in 15 years.

A series of explosions occurred when a hydrocarbon isomerization unit was restarted and a distillation tower flooded with hydrocarbons. As a result, 15 were killed and another 180 were injured.

JILIN CITY, CHINA - November 13, 2005

A series of explosions rocked China-based Jilin Petrochemical's 70,000 tonne/year aniline complex in Northeast China, killing five and injuring 70. Benzene also leaked into the Songhua river and caused millions of people to go without drinking water.

Initial investigations suggested the explosion occurred after operators attempted to unblock a nitrobenzene rectification tower. Jilin's Bureau of Production Safety Supervision and Administration concluded that a valve was left open, causing temperatures to rise rapidly.

Nearby equipment and storage tanks containing nitrobenzene, benzene and nitric acid feedstocks also caught fire and exploded. Water and electricity supplies had to be cut off as local residents reported tap water turning red or yellow. There were also concerns that water supplies to some Russian towns could be affected by the contamination of the river.

CPI accident database

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Development of a new chemical process-industry accident database to assist in past accident analysis

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ABSTRACT

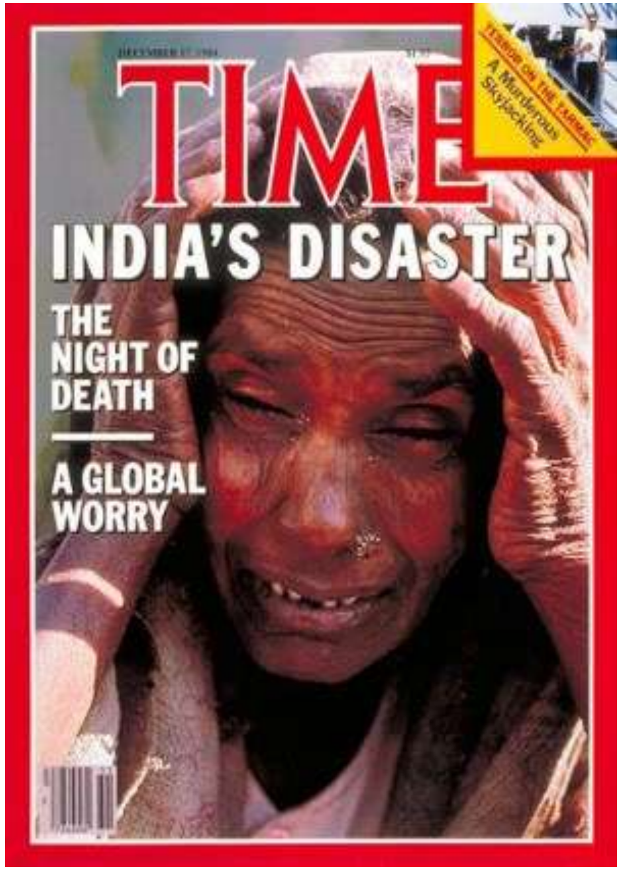
Past accident analysis (PAA) is one of the most potent and oft-used exercises for gaining insights into the reasons why accidents occur in chemical process industry (CPI) and the damage they cause. PAA provides invaluable 'wisdom of hindsight' with which strategies to prevent accidents or cushion the impact of inevitable accidents can be developed.

A number of databases maintain record of past accidents in CPI. The most comprehensive of the existing databases include Major Hazard Incident Data Service (MHIDAS), Major Accident Reporting System (MARS), and Failure and Accidents Technical Information Systems (FACTS). But each of these databases have some limitations. For example MHIDAS can be accessed only after paying a substantial fee. Moreover, as detailed in the paper, it is not infallible and has some inaccuracies. Other databases, besides having similar problems, are seldom confined to accidents in chemical process industries but also cover accidents from other domains such as nuclear power plants, construction industry, and natural disasters. This makes them difficult to use for PAA relating to CPI. Operational injuries not related to loss of containment, are also often included. Moreover, the detailing of events doesn't follow a consistent pattern or classification; a good deal of relevant information is either missing or is misclassified.

The present work is an attempt to develop a comprehensive open-source database to assist PAA. To this end, information on about 8000 accidents, available in different open-source clearing houses has been brought into a new database named by us PUPAD (Pondicherry University Process-industry Accident Database). Multiple and overlapping accident records have been carefully eliminated and a search engine has been developed for retrieval of the records on the basis of appropriate classification. PUPAD doesn't aim to replace or substitute the well established databases such as MHIDAS and MARS but, rather, aims to compliment them.

Bhopal Gas Tragedy

- Worst industrial disaster in history
- A cloud of MIC remained for one hour over the highly populated city
- 2,000 people died on immediatly
- Another 13,000 died in next fifteen years
- 10-15 persons dying every month
- 520,000 diagnosed chemicals in blood causing different health complications
- 120,000 people still suffering from
  - Cancer
  - Tuberculosis
  - Partial or complete blindness,
  - Post traumatic stress disorders

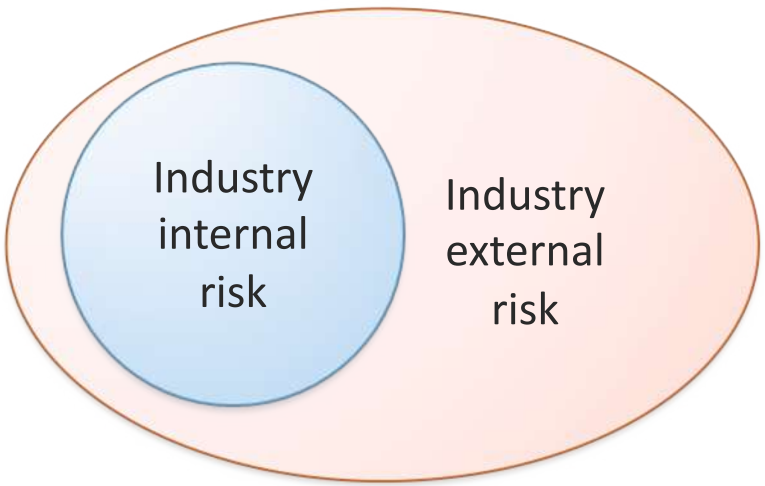


Buncefield December 2005

Statement of the problem

Siting of chemical process plants

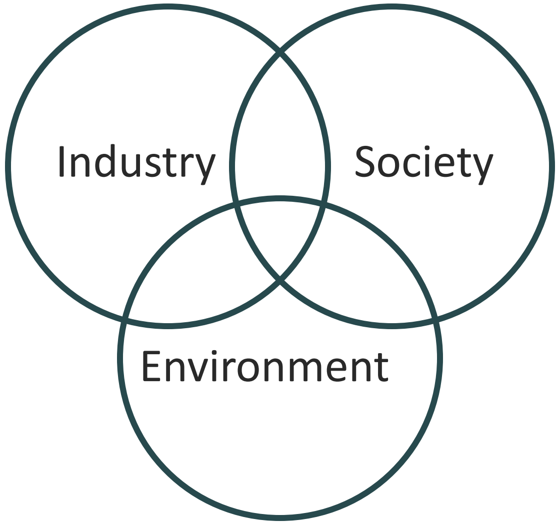
1. Two risk domains



The field of technological risk assessment

GAP

2. Three layers of interaction



The field of land-use planning

Definitions of Risk

The Seveso II Directive defines "risk" as follows:

Risk: the likelihood of a specific effect occurring within a specified period or in specified circumstances

The definition according to ISO/IEC 51 reads:

Risk: the combination of the frequency or probability of occurrence and the consequence of a specified hazardous event.

Risk Assessment:

Risk Assessment: the overall process comprising a risk analysis (the systematic use of available information to identify hazards and to estimate the risk) and risk evaluation (procedure whether the desirable level of risk has been achieved)

Risk Management:

Risk Management: Systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating and controlling risks

Risk Measures for Loss of Life

Risks to people may be expressed in two main forms:

1. Individual risk – the risk experienced by an individual person
2. Societal (or group) risk – the risk experienced by the whole group of people exposed to the hazard. Where the people exposed are members of the public, the term societal risk is often used. Where workers are isolated and members of the public are unlikely to be affected, the term group risk is often used.

Individual risk

- Individual risk is used to indicate the distribution of the risk over various individuals in the (potentially) exposed population. Ichem (1985) defines the individual risk as "the frequency at which an individual may be expected to sustain a given level of harm".

- In the Netherlands it is defined as "the probability that an average unprotected person, permanently present at a certain location, is killed due to an accident resulting from a hazardous activity" (Bottelberghs, 2000). Due to the assumption of permanent presence, the individual risk becomes a property of a location and as such it may be useful in land use planning. Following this definition the individual risk can be displayed on a map with so called (iso-) risk contours.

IRPA

Individual risk criteria are most commonly expressed in the form of individual risk per annum (IRPA).

Today, the following IRPA values for these criteria are generally regarded internationally as applicable for hazardous industries:

	Workers	**Members of Public**
Maximum tolerable criterion	10^{-3} per yr	10^{-4} per yr
Broadly acceptable criterion	10^{-6} per yr	10^{-6} per yr

Risky Activities

Activity	Number of activities in one year that equals an IRPA of 10^{-3} per year
Surgical anesthesia	185 operations
Scuba diving	200 dives
Rock climbing	320 climbs

Individual Risk Per Annum

Industry sector	Annual risk	Annual risk
Mining and quarrying of energy producing materials	1 in 9 200	$109 \cdot 10^{-6}$
Construction	1 in 17 000	$59 \cdot 10^{-6}$
Extractive and utility supply industries	1 in 20 000	$50 \cdot 10^{-6}$
Agriculture, hunting, forestry and fishing (not sea fishing)	1 in 17 200	$58 \cdot 10^{-6}$
Manufacture of basic metals and fabricated metal products	1 in 34 000	$29 \cdot 10^{-6}$
Manufacturing industry	1 in 77 000	$13 \cdot 10^{-6}$
Service industry	1 in 333 000	$3 \cdot 10^{-6}$

- Data from "Reducing risks, protecting people" (HSE 2001)

Source: System Reliability Theory (2nd ed.), Wiley, 2004

Risks that increase probability of death by one in a million

Activity	Cause of Death
Smoking 1.4 Cigarettes	Cancer, Heart Disease
Traveling 10 miles by Bicycle	Accident
Traveling 300 miles by Car	Accident
Flying 1000 miles by Jet	Accident
One Chest X-Ray	Cancer from Radiation

Source: Wilson, R., "Analyzing the Risks of Daily Life," Technology Review, 81, (1979).

Societal risk

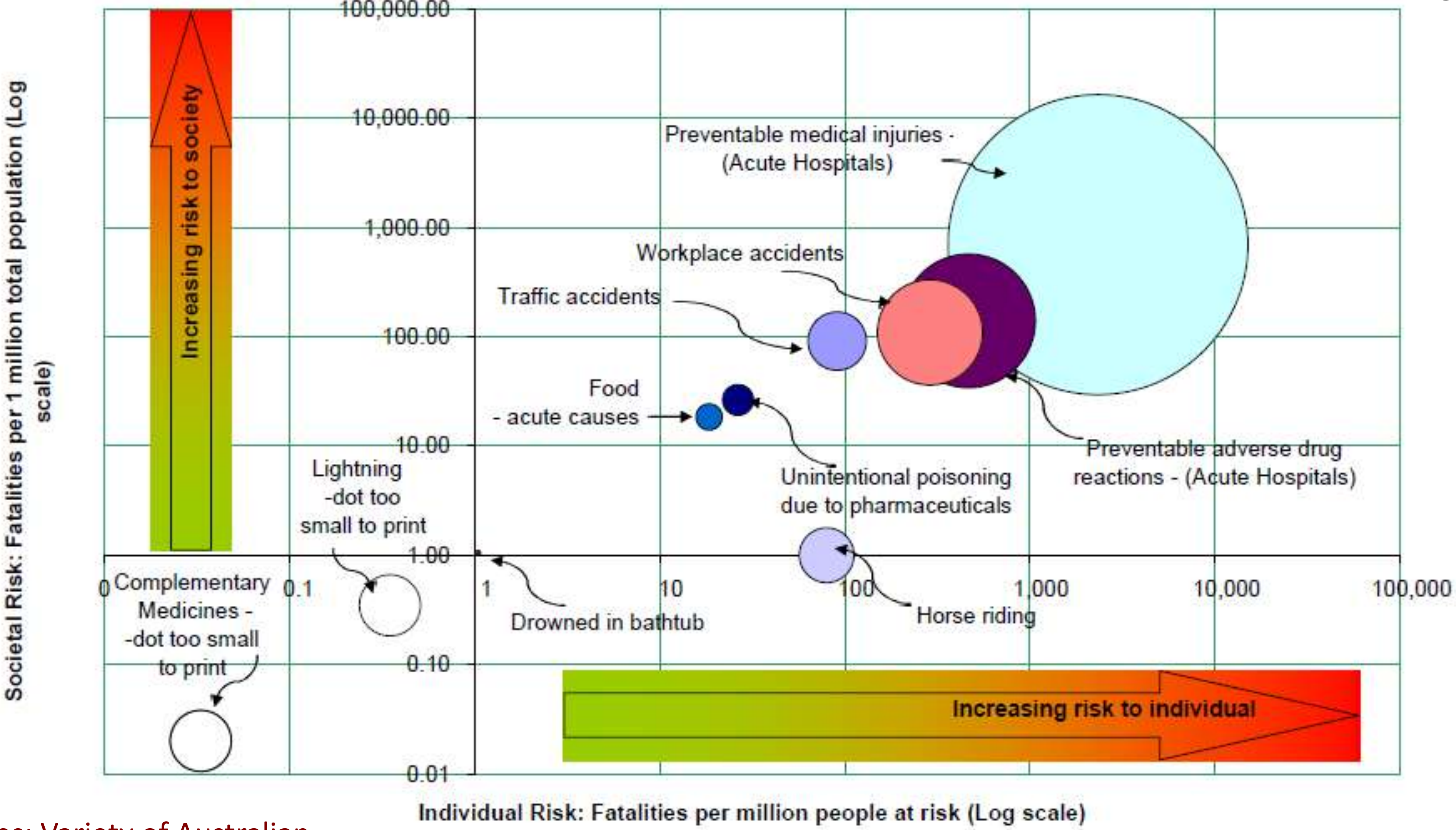
Ichem (1985) defines societal risk as “the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards”.

Societal risk is expressed as the probability of exceeding certain number of fatalities in one year due to certain event in a given population.

Societal risk can be depicted in an FN curve, which displays the probability of exceeding certain number of fatalities on a double logarithmic scal0e.

Societal vs Individual Risk in Australia

Bubble size represents risk relative to 1: million individual risk
or equivalent to the risk of a single flight on a Boeing 747
anywhere in the world.
Note: Log scales



Sources: Variety of Australian Government and NGO databases and reports.

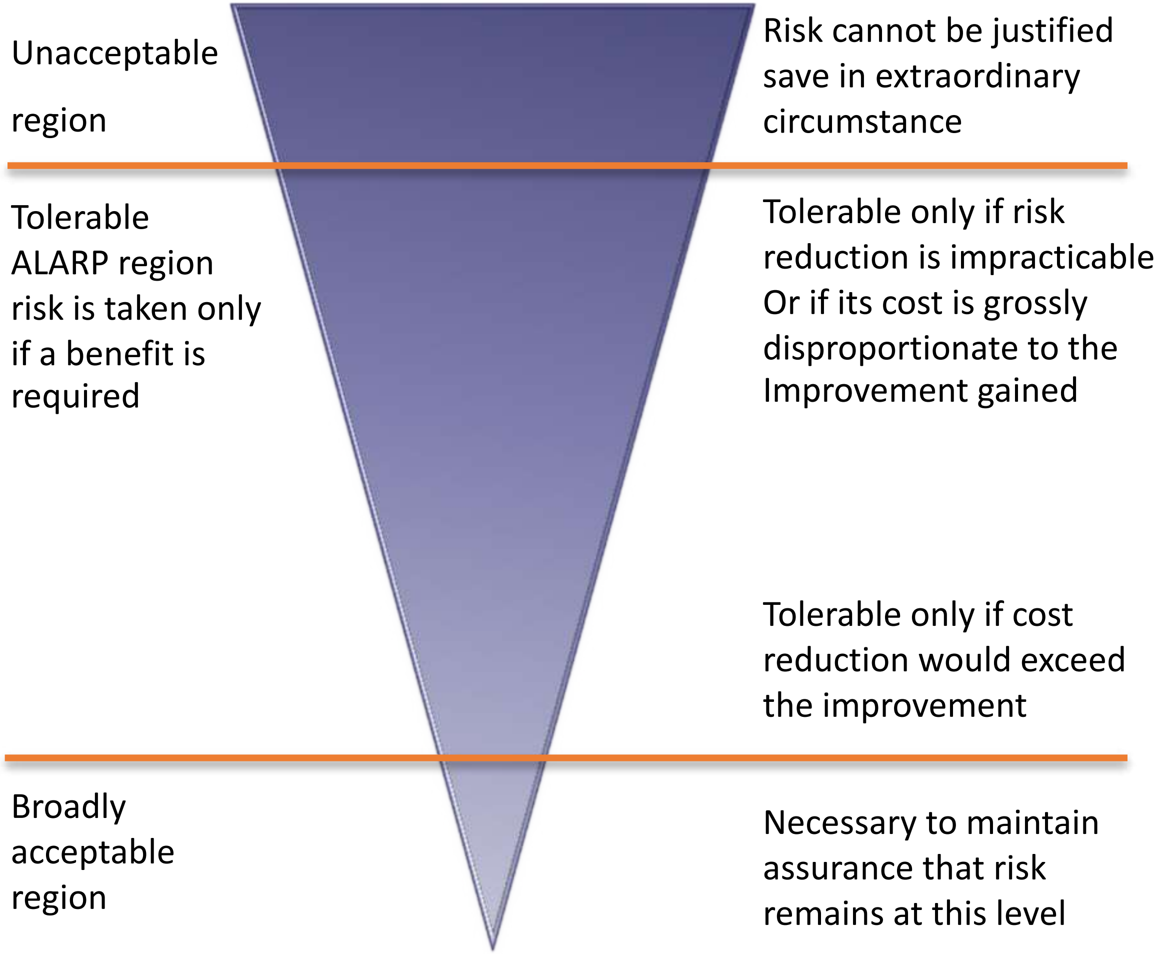
Bridging the gap between lup and rm

Assumption: Bridging the GAP between two traditionally independent disciplines: risk assessment and land-use planning will contribute in solving the problem

Aspect	**Risk assessment**	**Land-use planning**
Focus	Technology	Social Factors
Institutional	Safety authorities and plant operators	Planning authorities and project developers

Risk Criteria

Risks Criteria are standards used to translate numerical risk estimates, e.g
10^{-7} per year as produced by RA into value judgments such as "Unacceptable region"



ALARP: As Low As Reasonably Practicable

Evolution of EU regulations incorporating RA in LUP

1976: in the Italian north-eastern region of Brianza, in the city if Seveso, a major accidents causing a massive release of dioxin polluted an immense area where worker-class residences were present.

1st lesson learnt

1st implementation' phase

1982: emanation of the Directive 82/xx/xx concerning the risk of major accidents involving dangerous substances, the SEVESO DIRECTIVE

1984: accident in Bophal, India; thousands of injured and deaths.

2nd lesson learnt

2nd implementation' phase

1996: second version of the Seveso II Directive, introducing:
- the substances dangerous for the environment;
- the land-use regulation requirement.

1999: accident in Tolouse (France)

2000: accident in Enschede (Netherlands)

exchange of EU experiences

2003: 1st amendment of the Seveso II Directive, requiring to the Commission the elaboration of Guidelines for the implementation of the LUP regulation by the end of 2006

2003: EWGLUP- working group on land-use planning

The contribution of the research: elaboration of principles of "best practice" to support Member States land-use policy design and implementation

Land use planning

"Land Use Planning" can be defined as *"a systematic assessment of alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting a land-use option which is most beneficial to land users without degrading the resources or the environment.."*

Land Use Planning has to be understood as an aspect of "spatial planning"

Spatial planning

- Spatial planning refers to the methods used by the public sector to influence the future distribution of activities in a space

- Spatial planning applies measures to co-ordinate sectoral policies to achieve more even distribution of economic development between regions than would otherwise be created by market forces and to regulate the conversion of land and property uses.

Source: EC compendium of spatial planning, 1997

Link between LUP and RA (1)

- The protection of residential and other populated areas liable to be affected by a major accident is a key objective . Therefore, risk considerations have to be incorporated in LUP.

- For a given industrial establishment, a “consequence based” approach will show the location of the area of lethal effects and serious injuries resulting from the scenarios assessed, while a “risk based” approach will show an area within which there is a given probability of a specified level of harm resulting from the large number of possible accident scenarios

Link between LUP and RA (2)

- Land-Use Planning is based on the principle that incompatible uses of land should be separated by adequate distances.
- It then requires the establishment and application of constraints defining which uses of land are allowed at the various zones around the plant.
- Obviously, these zones depend on the risk profile and the relevant constraints should be proportional to the level of risk.
- This is the reason why hazard/risk assessment methods and criteria are so important for risk-informed LUP.
- Moreover, assessment methods and criteria should be compatible with the overall risk management culture and philosophy of each country.

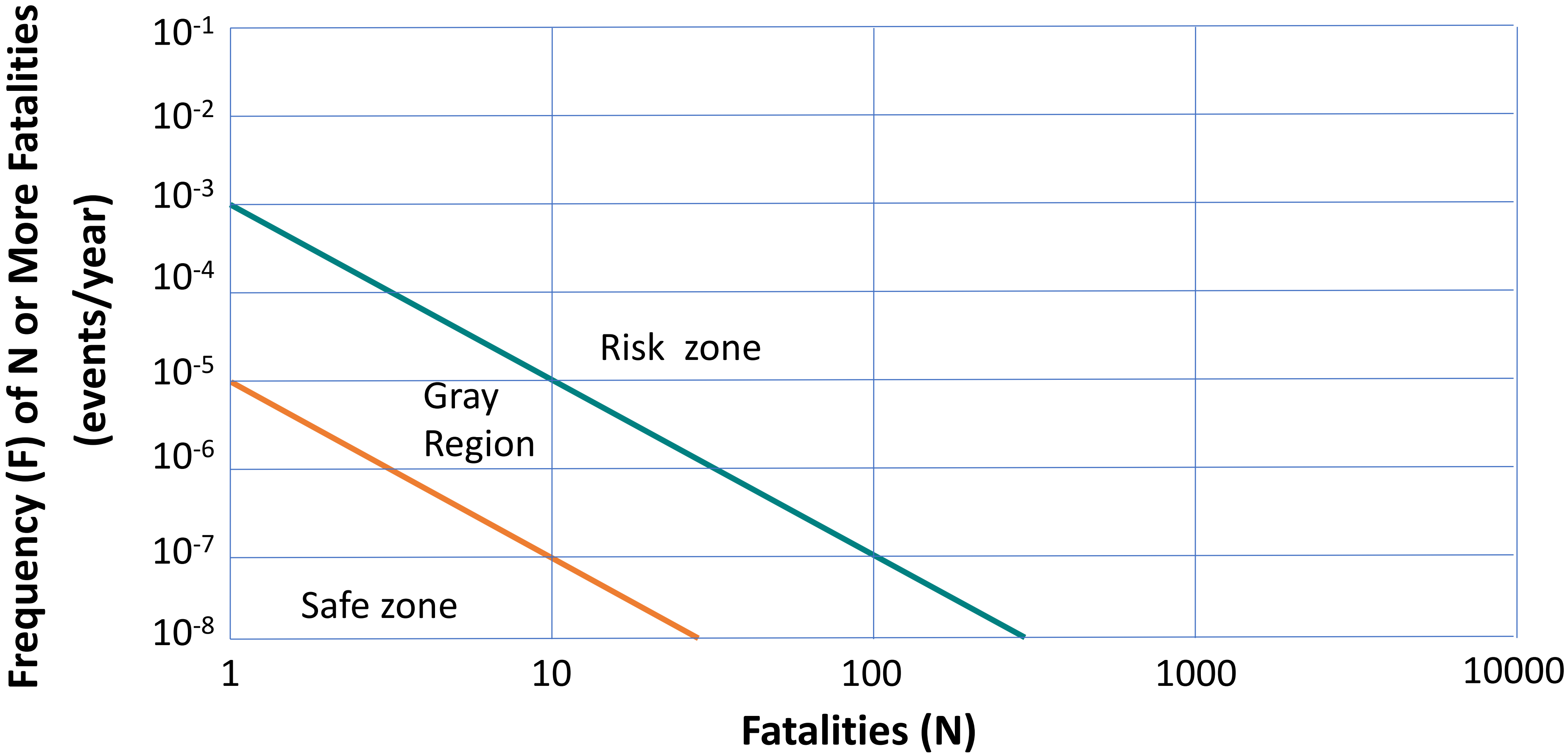
Commonly used approaches in support to Land-Use Planning decisions

Three broad categories can be distinguished:

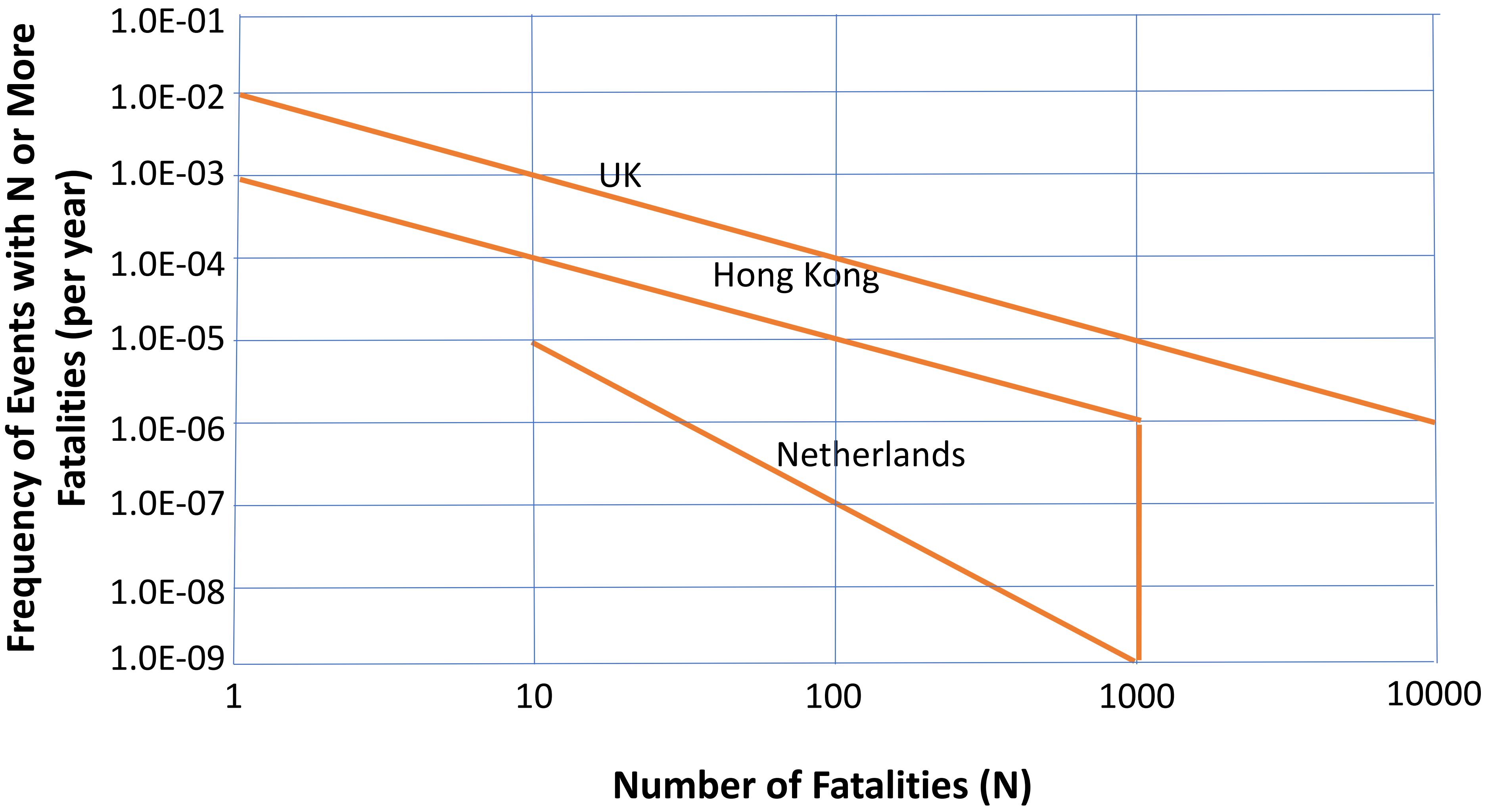
- ➢ "Generic" safety distances: Pre-defined distances depending on the type of activity and generic characteristics rather than on a detailed analysis of the specific site. Sometimes used for 'consultation' or 'screening' purposes.
- ➢ "Consequence-based" approach: Distances corresponding to certain levels of consequences (thresholds), viewed as representing the beginning of *lethal* and of *irreversible* effects. Assessment of consequences of a small number of 'reference' accident scenarios.
- ➢ "Risk-based" approach: Zones corresponding to certain levels of *individual risk* (isorisk contours), deriving from the assessment of both the consequences and the likelihood of the accident scenarios. Often, *societal risk* criteria apply, expressing the society's aversion to increased casualties.

Example Off-Site Societal Risk Guidelines for Land Use

Unfortunately, applicable only to point sources (e.g., chemical plants, but not pipelines)

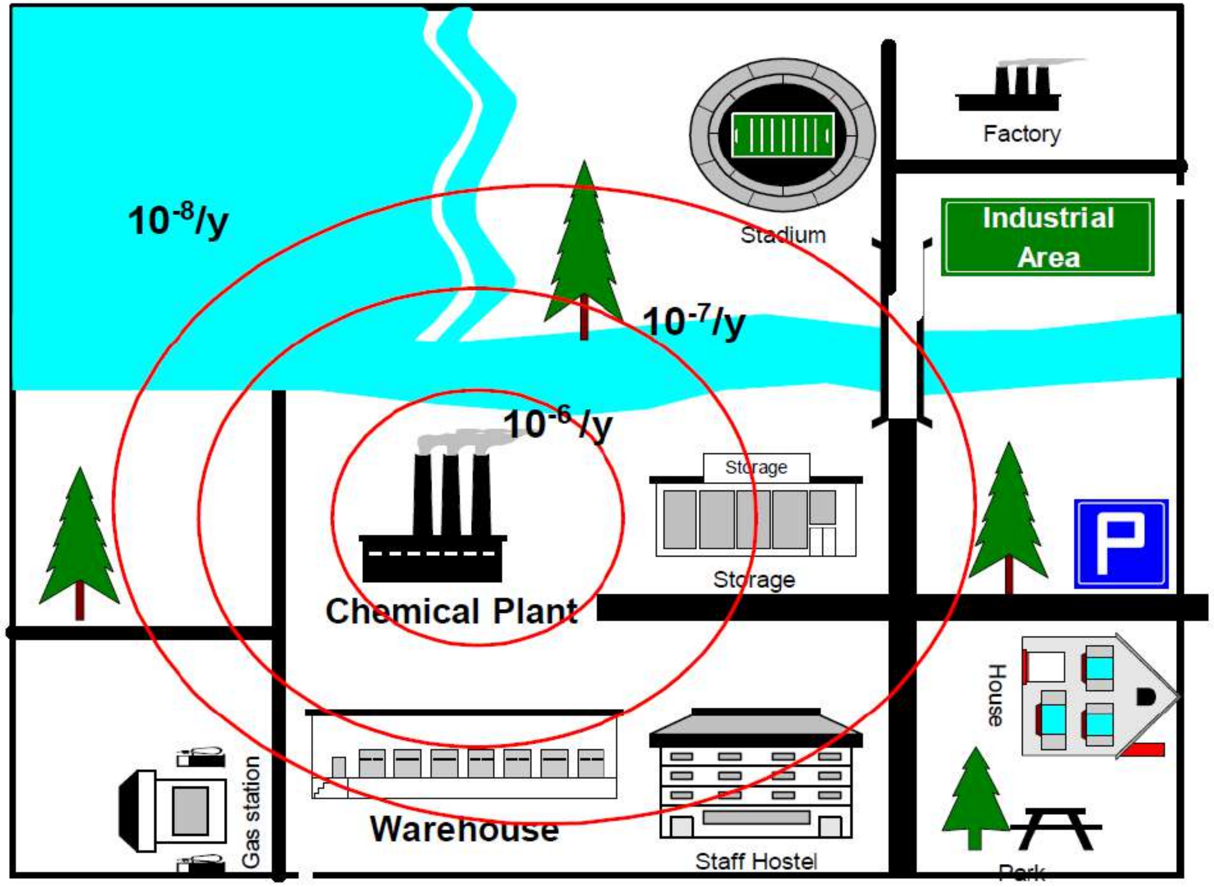


Regulatory Upper Tolerability FN-Criteria



Individual risk: --- Risk Contours

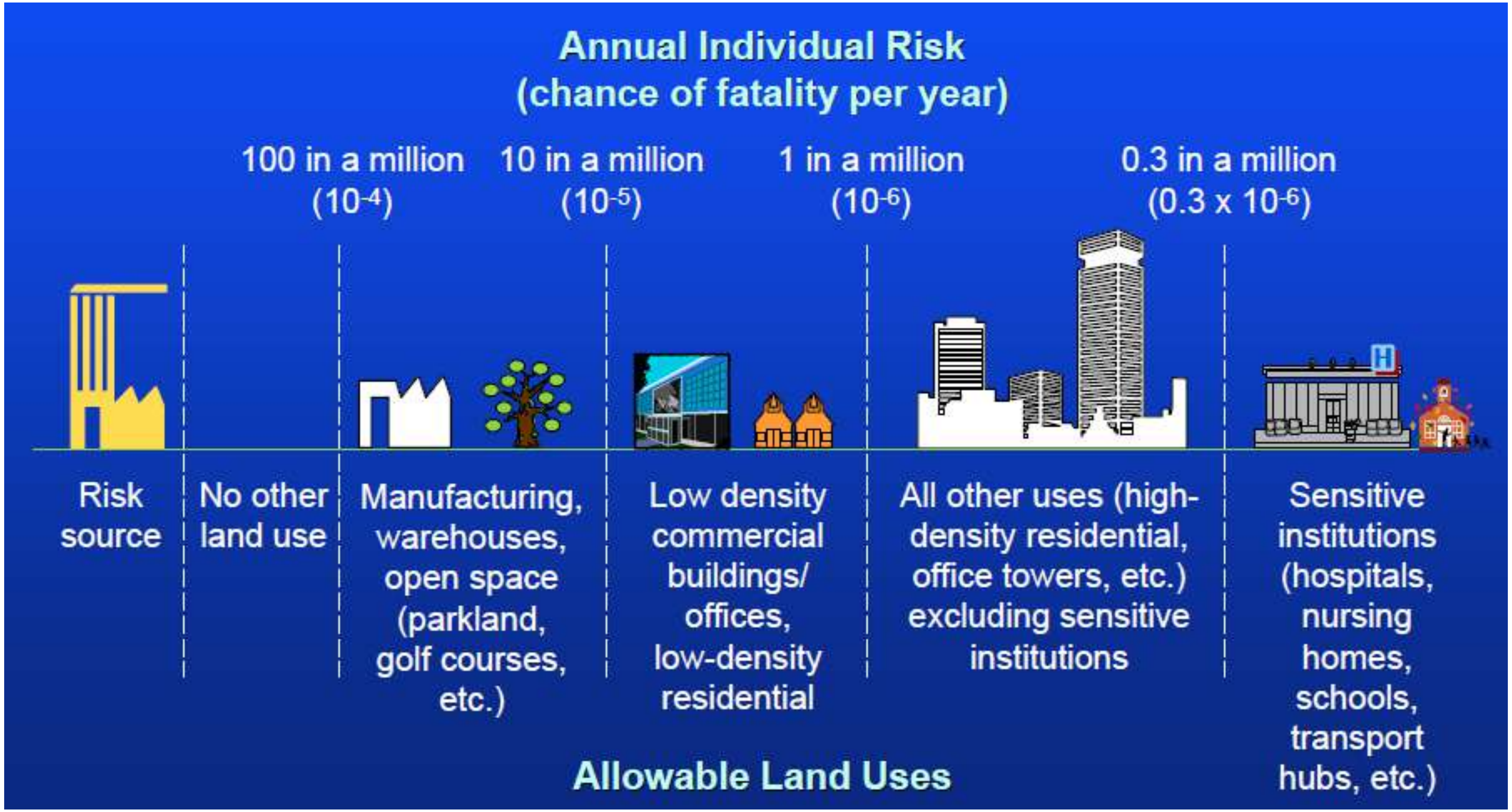
ISO-risk contours represent the geographical variation of the risk for a hypothetical individual who is positioned at a pacticular location for 24 hrs/day, 365 days / year.



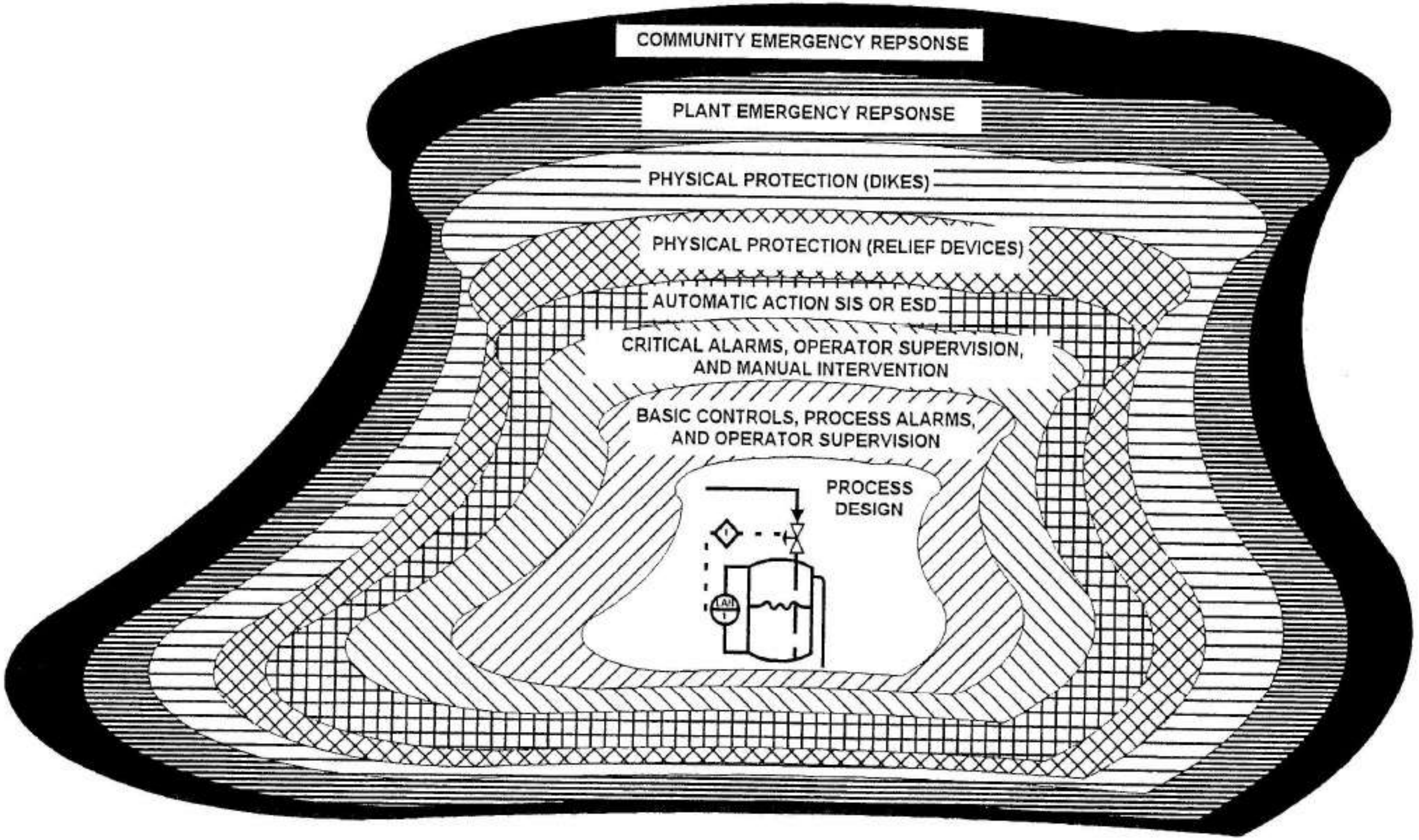
LSIR: Location specific individual risk

Use of Individual Risk Information for Land Use

Risk Acceptability Criteria for Land-use Planning (Proposed;extension of MIACC, 1995)



Layer of Protection Analysis (LOPA)



Risk based approach

The *"risk based" approach, that focuses on the assessment of both consequences* and probabilities of occurrence of the possible accident scenarios. The results are quantified in terms of individual risk and societal and criteria have been set for both these measures.

In the Netherlands a case resulting in individual risk higher than 10-6 or in societal risk above the 10-3 / N2 line in the F-N curve is considered unacceptable, while for lower risk always the ALARA

(As Low As Reasonably Achievable) principle is applied.

In UK, three zones are determined, corresponding, for toxic releases to 10-5, 10-6, and 3×10-7 levels of individual risk of receiving a dangerous dose or worse, and for thermal and explosion effects to certain levels of dose. In each one of these zones, the types of developments allowed are then specified.

Egypt Industrial Geography

Illustrative examples:

Alexandria

Damandour

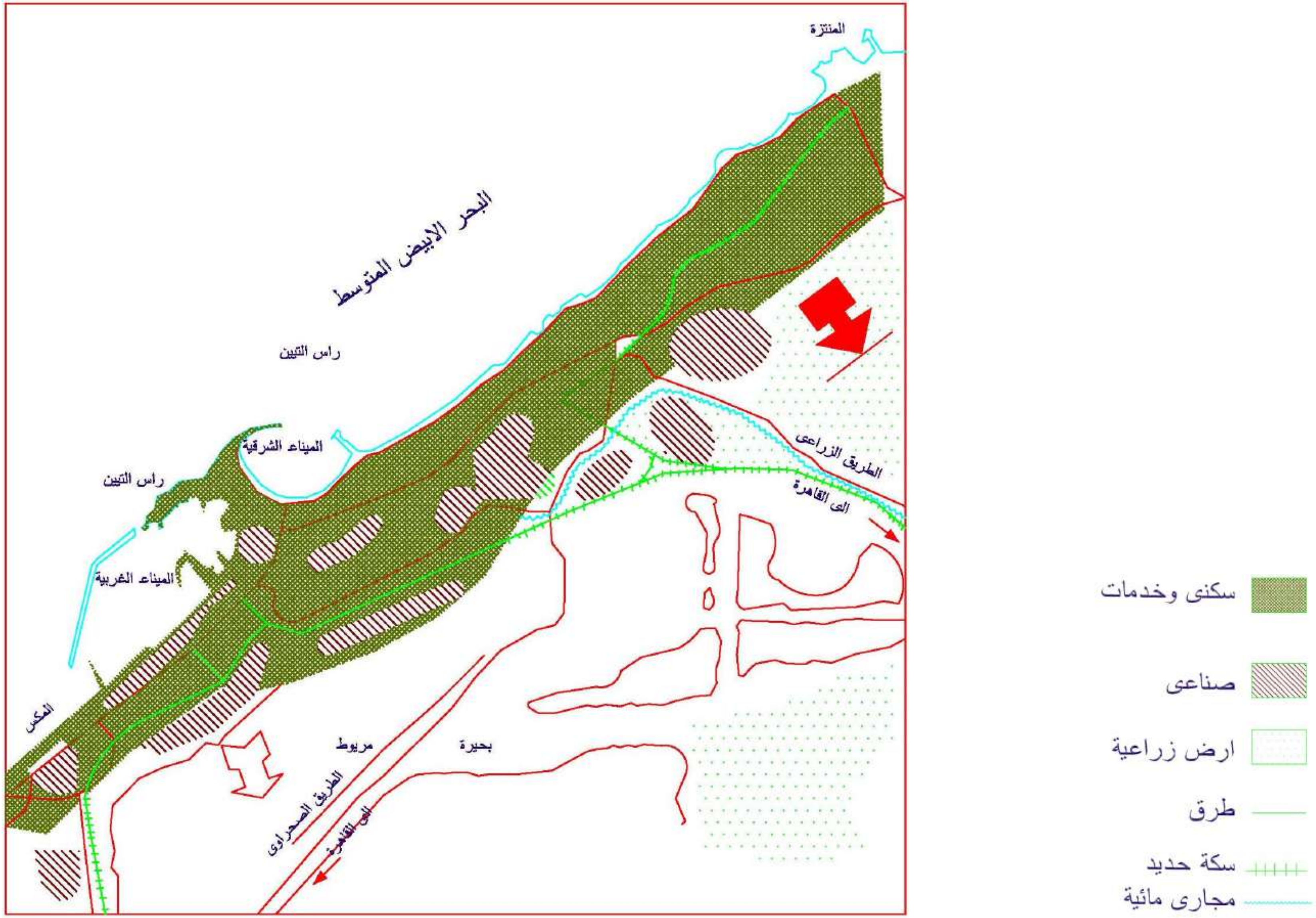
Kafr el dawar

Kafr el zayat

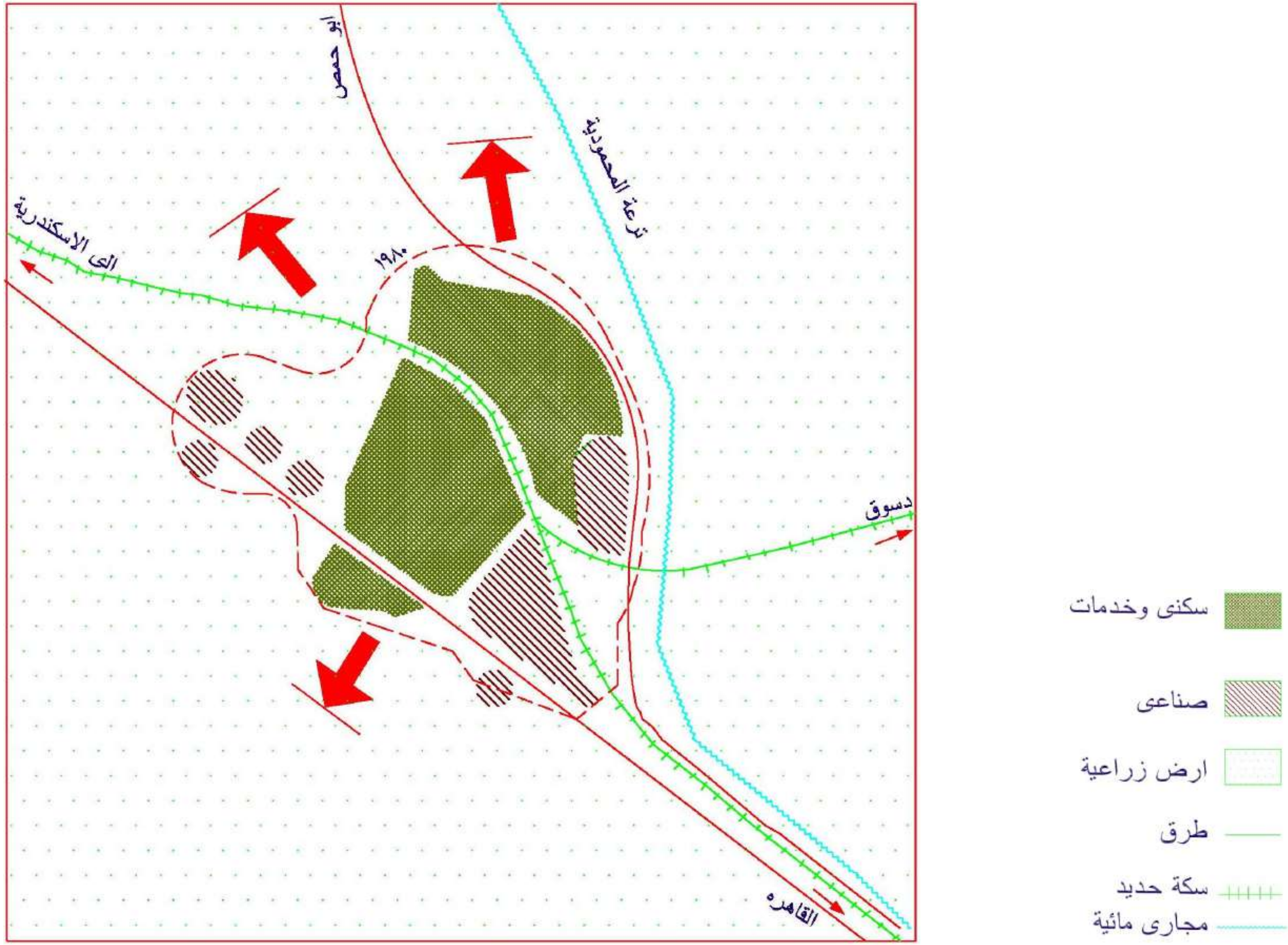
Mansoura

Shoubra el Kheema

Alexandria


المنتزة
البحر الابيض المتوسط
راس التين
الميناء الشرقية
راس التين
الميناء الغربية
المكس
الطريق الزراعى
الى القاهرة
مريوط
بحيرة
الطريق الصحراوى
الى القاهرة
سكنى وخدمات
صناعى
ارض زراعية
طرق
سكة حديد
مجارى مائية

Damandour


ابو حمص
ترعة المحمودية
الى الاسكندرية
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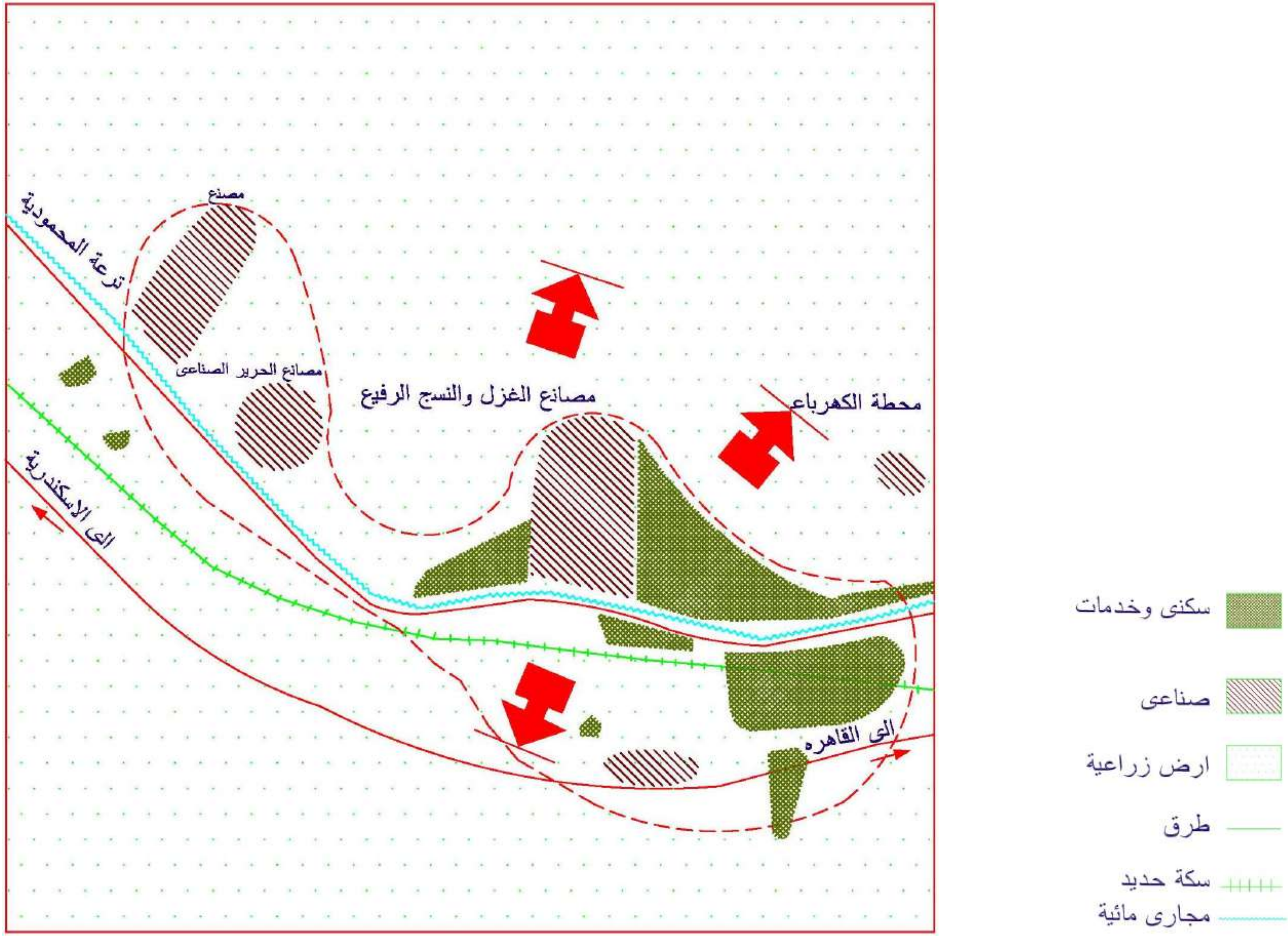
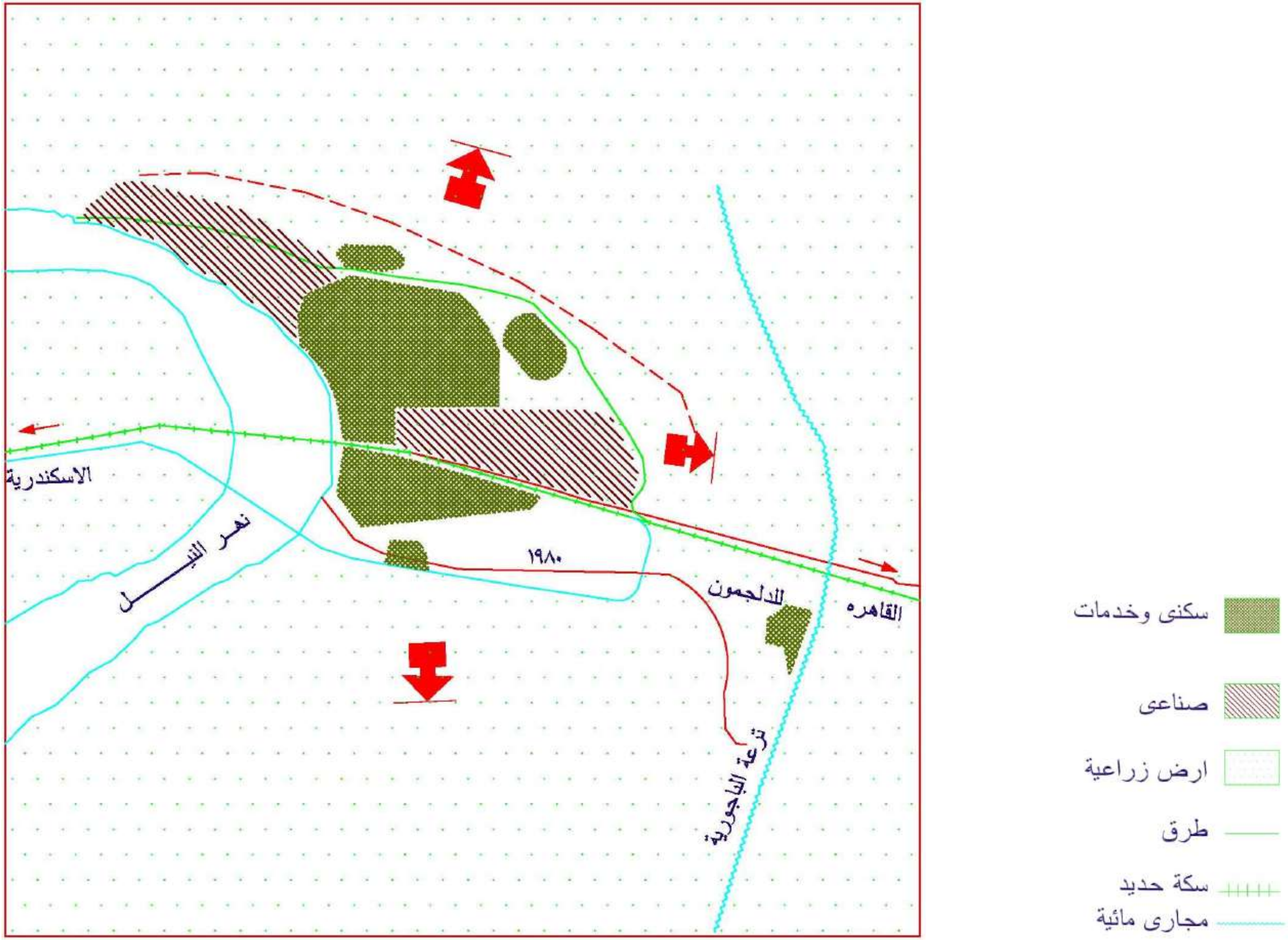
دسوق
القاهره
سكنى وخدمات
صناعى
ارض زراعية
طرق
سكة حديد
مجارى مائية

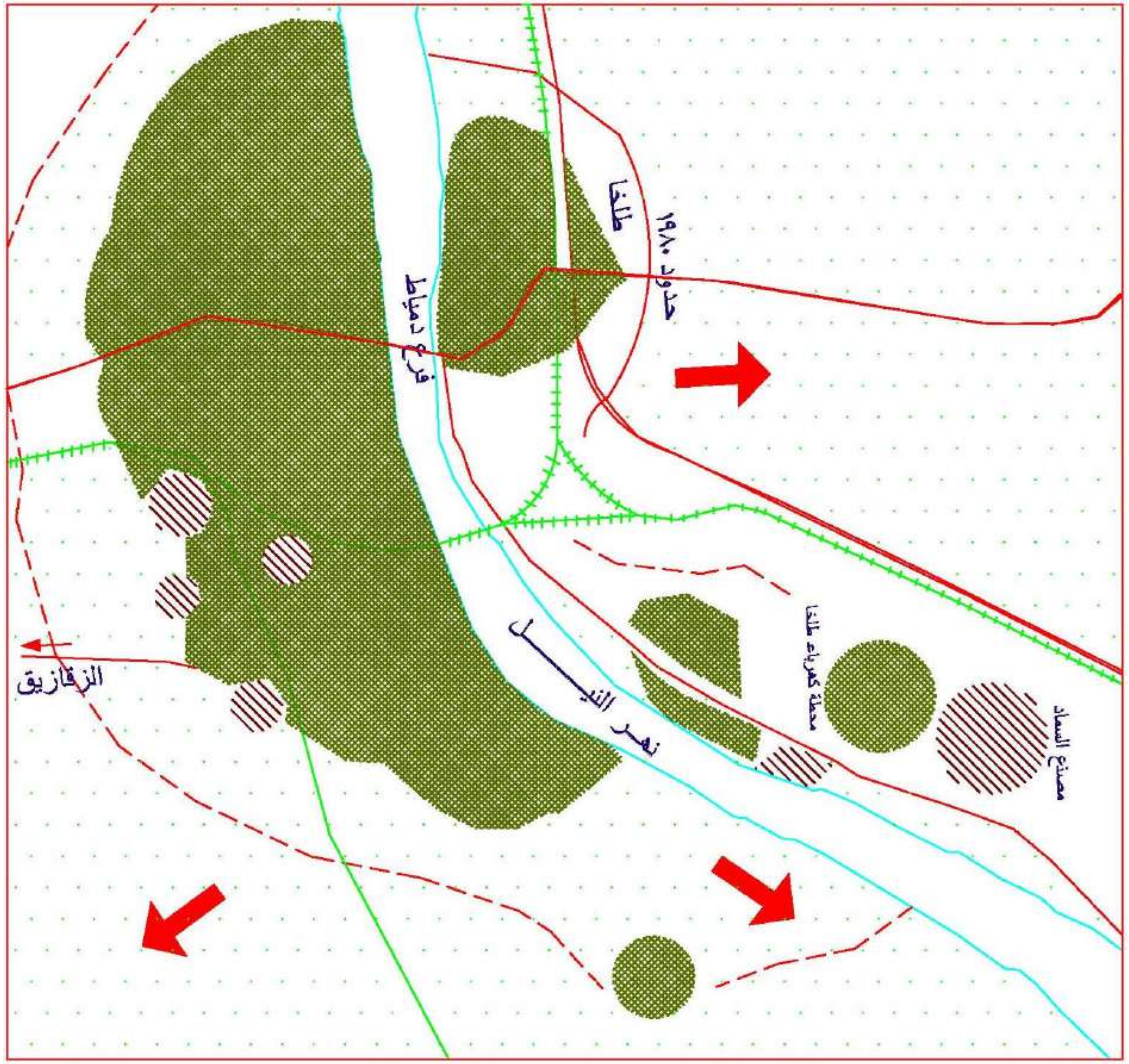
Kafr el dawar



Kafr el zayat



Mansoura



سكنى وخدمات

صناعى

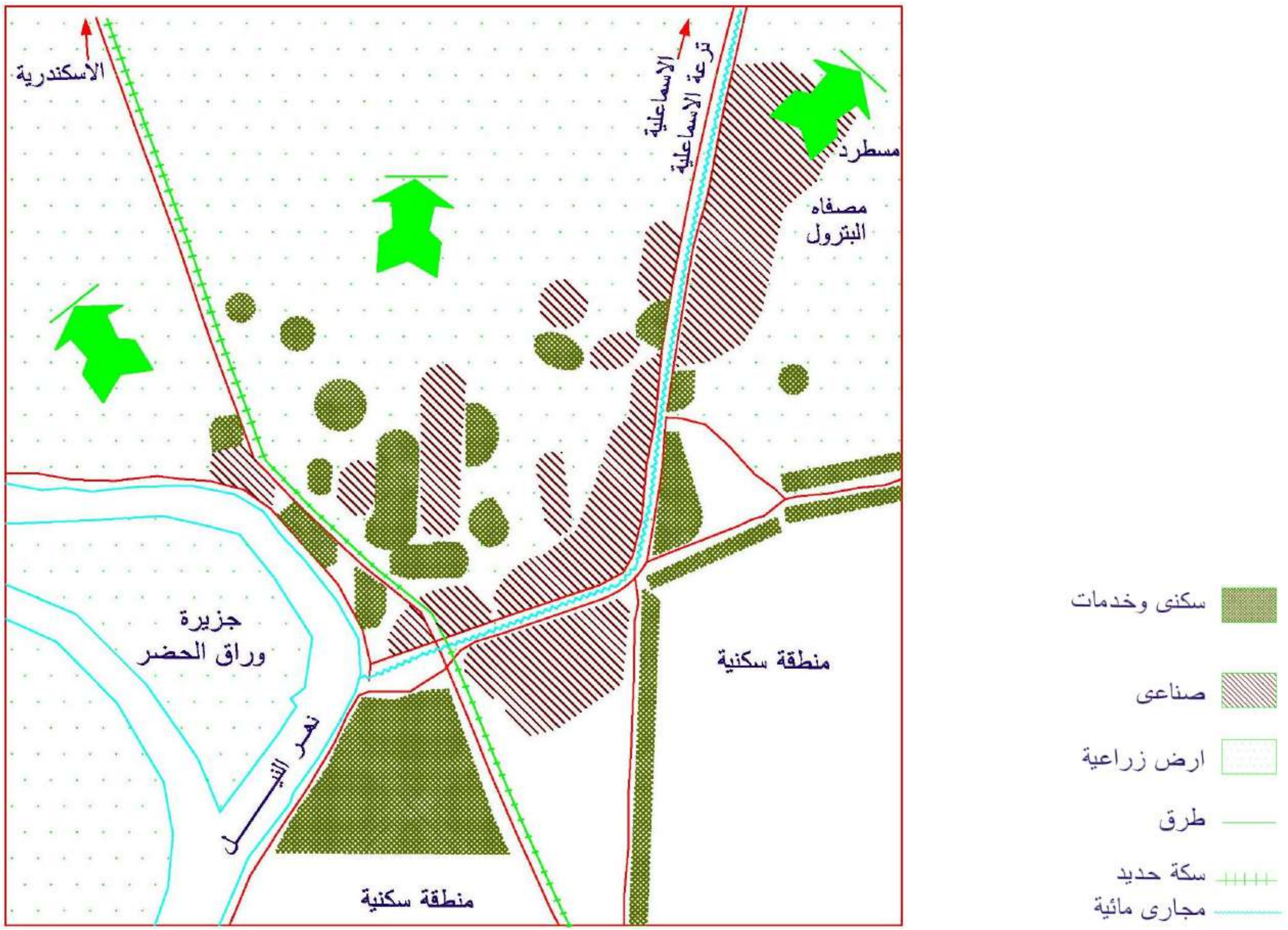
ارض زراعية

طرق

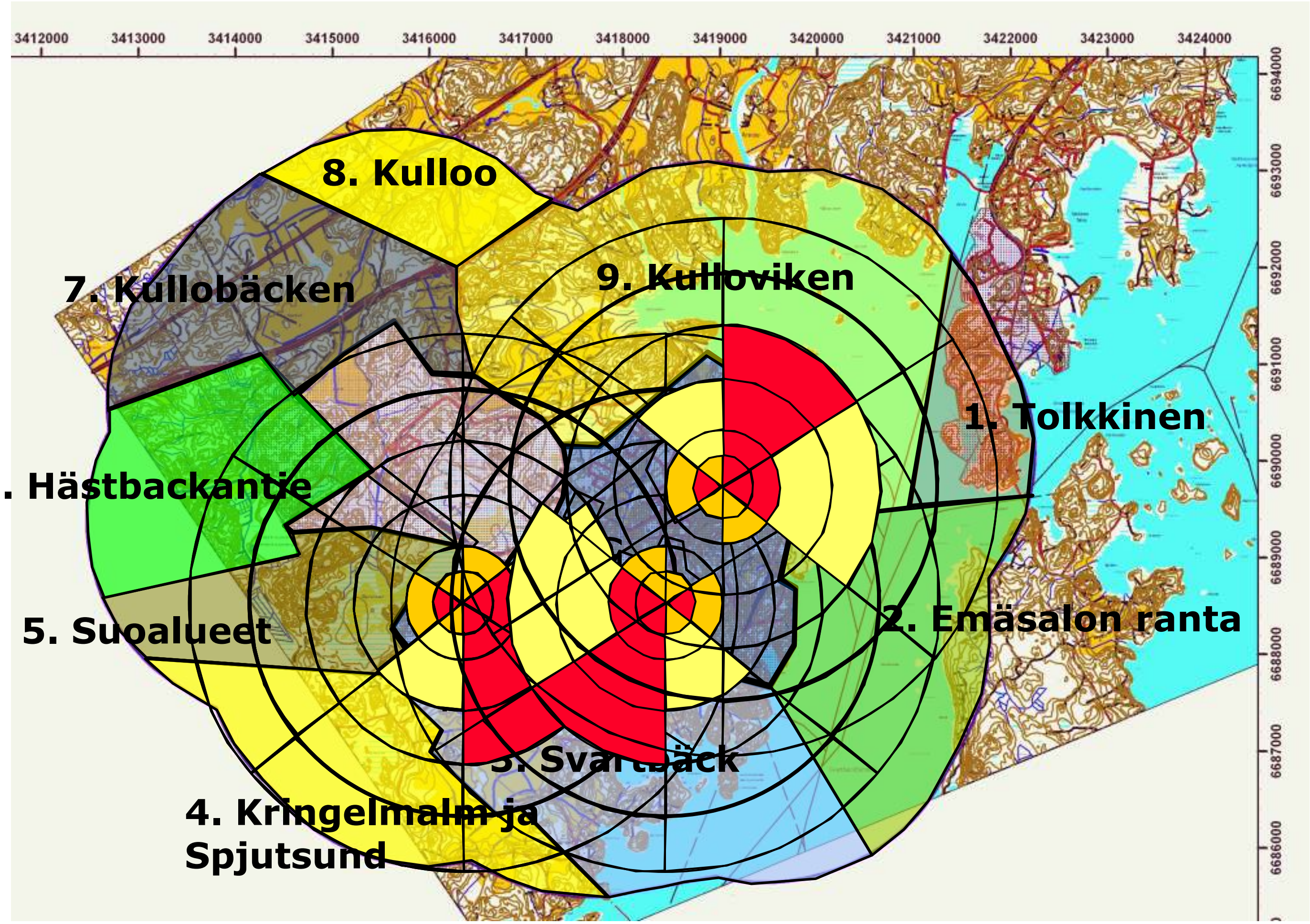
سكة حديد

مجارى مائية

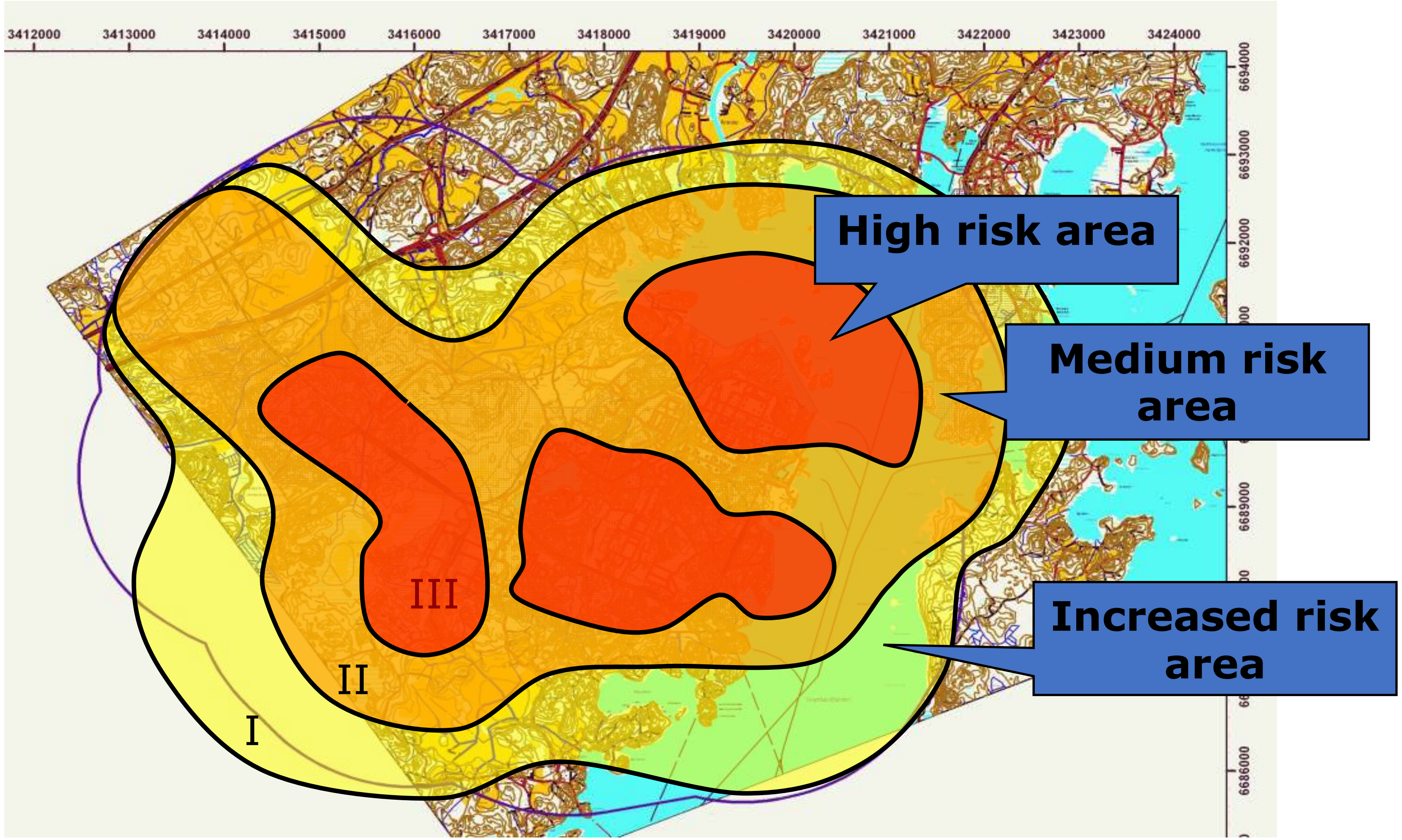
Shoubra el Kheema



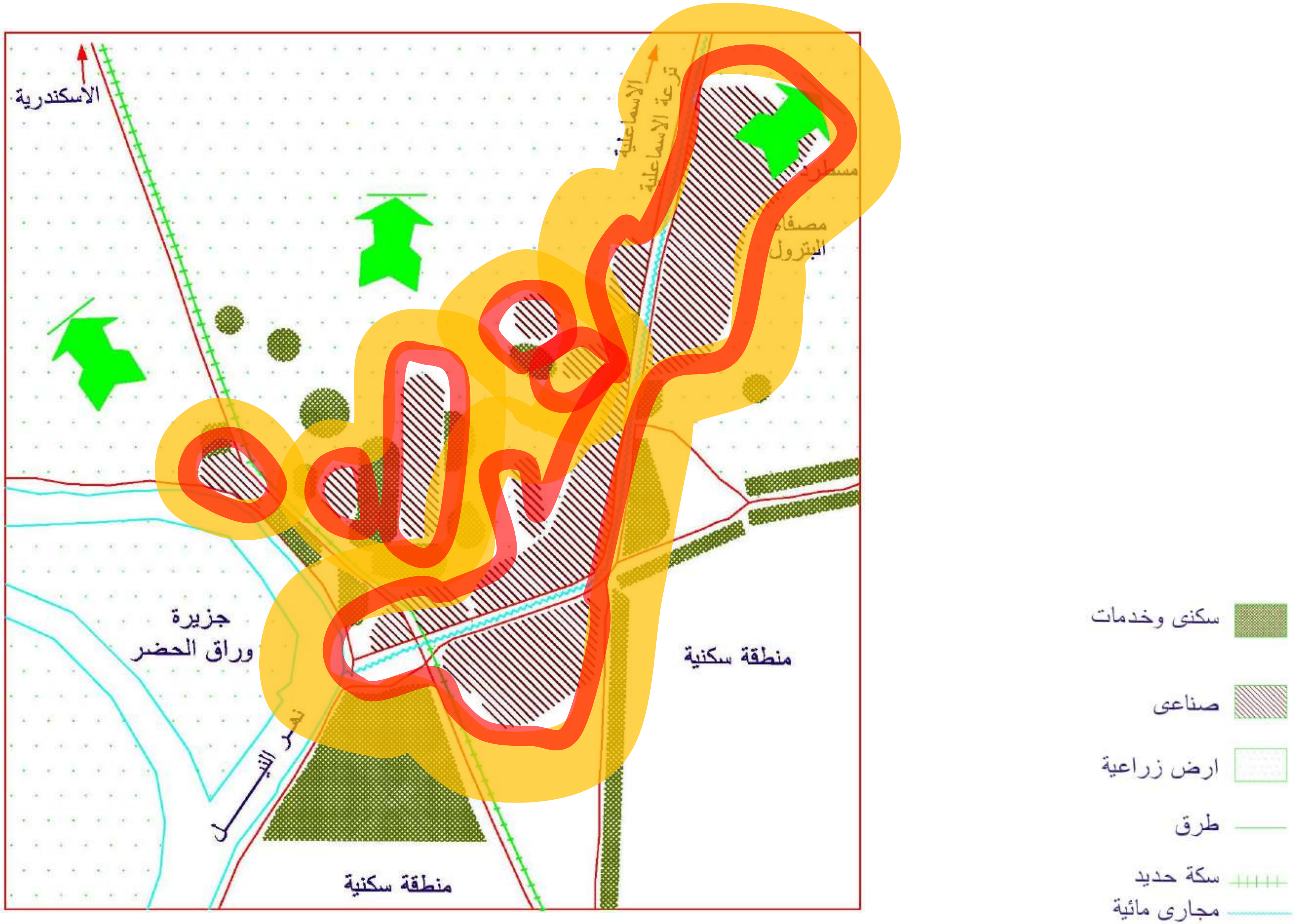
Zones filled out by companies



Aggregated initial (unofficial) results



Shoubra el Kheema



Concluding remarks

1. We need to apply the best practice of risk assessment and risk management on the existing industrial establishments

   Legal framework

   Guidelines and tools

   Implementation of mitigation measures

2. We need to establish the link between land use planning and risk management in siting new industrial establishments

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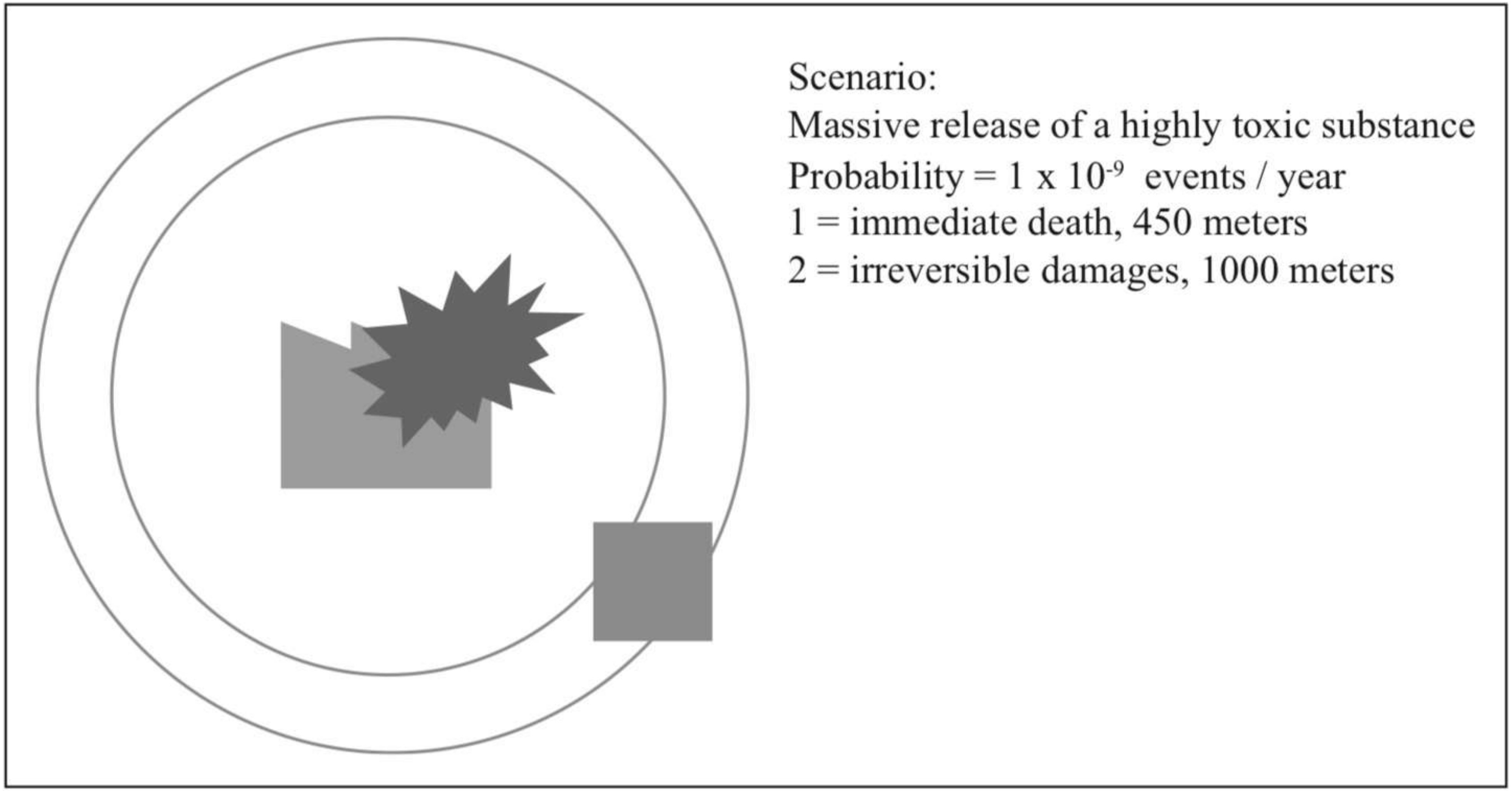
8. *حسين كفافى، رؤية عصرية للمدن الصناعية في مصر، الهيئة المصرية العامة للكتاب (1985)*

A simple illustration of a major accident scenario: release of a toxic substance.



Source: Siting risky facilities Probabilism, determinism and beyond Author(s): Claudia Basta
Source: Planning Theory, Vol. 13, No. 1 (Febuary 2014), pp. 44-64

Review Questions

1. In the lecture on siting of chemical industry within the context of land use planning, the P-S-R model was used to discuss the magnitude of the problem. Present the model diagrammatically and comment.
2. Show diagrammatically the gap between the two fields of technological risk assessment and land-use planning
3. Present and discuss four different risk definitions in the context of chemical plant siting. Elaborate on the methods applied to risks to people.
4. Present diagrammatically the risk acceptability criteria for land-use planning based on the allowable land use at different distances from risk source.