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Editors

Malavika Kapur

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Proceedings of the Seminar on
PUBLIC RISK PERCEPTION



NATIONAL INSTITUTE OF ADVANCED STUDIES

Bangalore, India

Proceedings of the Seminar on
PUBLIC RISK PERCEPTION

Seminar held on 29th & 30th September 2011

Editors

Malavika Kapur
Dilip Ahuja
Sangeetha Menon



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PREFACE

A brainstorming seminar on public risk perception was organized at the National Institute of Advanced Studies on 29th and 30th September 2011. The aim was to explore the possibility of bridging the gap in communication between the public and the technocrats on a variety of topics such as use or abuse of alcohol, cell phones, genetically modified (GM) crops, climate change and nuclear energy.

Introducing the theme of the seminar, Prof. V S Ramamurthy, the Director, NIAS pointed out that the media has a major role in shaping public risk perception and acceptance. The crux of the matter of risk acceptance is the issue of who decides what risks are to be taken especially in the public arena. Should it be the specialist who has the technical knowledge or the layperson who is the actual stakeholder? In the public arena, we have witnessed waves of anxiety and sometimes even pandemics, when it comes to issues of risk like nuclear decisions or epidemics like H1N1, SARS etc. If there is public anxiety, it means that nothing was done to remove it. It means that the specialist has not communicated the right information to the lay people. What is significant is that risk response is something yet to be understood and this is due to a cluster of factors including sociological and cultural. Yet at the end however, risk acceptance by individuals is highly personal.

The seminar had three sessions followed by discussion and a panel discussion. The first session provided the background to public risk perception and psychosocial aspects of risk perception. Prof. Sangeetha Menon proposed that desire, fear, insecurity played a major role in our choice and decision making regarding risk experience. Prof. Malavika Kapur focused on the conscious and unconscious psychological processes that mediate the risk perception at individual and at social levels. Dr. M G Narasimhan analyzed the nature of risk communication, risk perception and risk management.

The second session focused on specific risk and public risk perception regarding these risks. Prof. Vivek Benegal spoke on alcohol use/abuse and highlighted that despite the public health risk alcohol posed, it was not associated with fear as with life threatening diseases like cancer, as it is thought to be voluntary. He also highlighted the role of brain in risk perception. As discussed by Prof. SenGupta and Dr Vani Sanosh, cell phone use remained a risk of unknown quality without substantive research. The other three topics namely GM Crops, Climate Change and Nuclear Energy were much on the public domain and provided platform for polarized opinions. In the Indian context, Prof. Mahadevappa held GM crops to be beneficial and negative impacts were entirely due to systems failures. On the other hand Mr. Nagesh Hedge had series of examples to contrary to the claims of safety of GM technology. Prof. Dilip Ahuja and Dr Ravi Srinivas spoke on Climate change and carbon sequestration and pointed to the fact that climate change did not receive the attention it deserved. Prof. Parthasarathy highlighted the safety of nuclear safeguards, while Prof. Atul Choksi focused on the fallibility and uncertainty of expert opinions and role of vested interests in the decision making. The third session was a panel discussion on nuclear energy moderated by Prof. R Rajaraman. The debate highlighted the lack of consensus among the experts, communication gap between the experts and the public and failure to recognize the public as equal partners. The brainstorming seminar at

NIAS aims at evolving strategies for bridging the gaps in risk perception, risk communication, and risk management between the experts and the public.

Malavika Kapur
Dilip R Ahuja
Sangeetha Menon

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Special thanks are due to Prof. V S Ramamurthy, Director, NIAS for mootng the idea of this seminar. The editors would like to acknowledge the help of the NIAS administration in organizing the seminar. Special thanks are due to all the participants, the volunteer post-graduates who lent helping hands. This volume is the product of hard work put in by all the contributors. A special mention needs to made of Ms. V B Mariyammal of NIAS for great involvement in organizing the seminar and bringing out the proceedings.

Editors

Part I

BACKGROUND AND PSYCHOSOCIAL ASPECTS OF RISK PERCEPTION

Chapter 1

INTRODUCTION: PERCEPTION AND ACCEPTANCE OF PUBLIC RISKS

V S Ramamurthy

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Let me start with some recent newspaper headlines which I found somewhat disturbing.

- i. Public agitation against the Kudankulam nuclear power project
- ii. National moratorium on Bt Brinjal
- iii. Inter-state controversy over the Mullaperiyar Dam

The Nuclear Power Corp. of India is building two 1,000-megawatt nuclear power plants on Tamil Nadu coast at a cost more than Rs.10000 crores. The plants have been under construction for nearly a decade and are almost ready for commissioning. Suddenly, there is a public uproar against the safety of the plants, presumably in the backdrop of the Fukushima nuclear event, with a demand that the project be scrapped. Repeated assurances by the experts do not seem to be convincing the agitators. That this country can not afford to say NO to nuclear power is also not convincing to the agitators.

The Bt brinjal is a suite of transgenic brinjals created by inserting a crystal protein gene from the soil bacterium, *Bacillus thuringiensis*, into the genome of brinjal cultivars. The Bt brinjal has been developed to give resistance against specific insects, in particular the Brinjal Fruit and Shoot Borer. The Bt brinjal was approved for commercialization in India in 2009, but after a public outcry, the Indian government applied a moratorium on its release.

The Mullaperiyar Dam is a masonry gravity dam on the Periyar River in Kerala. The dam was constructed between 1887 and 1895 by the British Government to divert water eastwards to Madras Presidency area, the present-day Tamilnadu. The dam and the river are located in Kerala but the dam is controlled and operated by Tamilnadu state under a period lease. The dam is an 'endangered' scheduled dam under the Kerala Irrigation and Water Conservation (Amendment) Act, 2006. The control and safety of the dam and the validity and fairness of the lease agreement have been points of dispute between Kerala and Tamilnadu states.

All the above projects are clearly in public interest but unacceptable public risks as perceived by a section of the population are prompting them to agitate against the projects. Repeated assurances by the specialists do not seem to be cutting ice with the agitators. It is also unrealistic to expect full consensus in matters of public perception. Are the long term interests of the country being compromised by these agitations? What is the way forward?

One would be tempted to say "Well, it is the responsibility of the government to protect the interests of the public and take appropriate decisions based on a majority view". There are two wings of the government that are mandated to take decisions in public interest- the bureaucracy and the elected representatives. What are their past records? Let us take two examples- the introduction of Euro-II cars and CNG in Delhi.

Both these decisions came through judicial interventions, neither executive nor legislative interventions. One might say “after all, we are a democracy. Let the public decide”. But the question is “Is the public informed enough, particularly on issues that are highly technical?” especially when there is no consensus? Are there channels to express and force their choices other than the periodic elections? How to protect the system from vested interests? This indeed is a challenge to the democracies.

Let me start with a simple analysis of our day-to-day decision making processes. We are all used to a Cost-Benefit analysis in most of our decisions. When the decision also involves a risk, a Risk-Benefit analysis also becomes important. The issue becomes complex if costs, benefits and risks are spread over long periods of time. Sometimes, the costs of not making the right decision at the right time also becomes important and have to be taken into account in the decision making process. All of us make such choices in our day to day life almost on a daily basis. Let me take for example the purchase of a house that most of us have done at some time or another. We need to worry about the cost, the rental value, anticipated appreciation, potential risks etc. Some of us have delayed the decision for so long that we lost golden opportunities that we repent later. Sometimes, the costs, the benefits or the risks need not all be financial. Take the case of adventure sports like bungee jumping. While the costs are financial, the benefits are psychological and the risks are extreme. When the choice involves matters of new and emerging technologies, the choice indeed becomes complex. I always say don't offer to buy a color television or a cell phone to your family because by the time you purchase the item, it is already out-of-date and you may be open to ridicule. In some areas like the emerging stem cell therapy, we are as ignorant as any other non-specialist. But in all these cases, the costs, benefits and risks are confined to individuals or a small group of people like a family and they make the choices. When the costs, benefits and risks are not limited to an individual or a family but involve the public at large, the decision making process is indeed very complex and may involve not only financial and

technical but also ethical and moral issues. More importantly, the population benefiting from the choice may not be the one that bears the costs and the risks. In such cases, it is nearly impossible to have a consensus leaving pockets of disgruntlements. They are also open for exploitation by vested interests.

Let me take one well known example, the Singrauli resettlements. The area in the eastern part of MP and the adjoining southern part of Sonbhadra district in UP is collectively known as Singrauli. Due to rich coal districts in the area, Singrauli is often referred to as India's energy capital. A cluster of thermal coal plants, both government and private owned, dot the area with a declared potential for 35,000 MW of generation capacity. The history of displacement in this area is indeed revealing. The entire area of Singrauli was originally covered by dense forest. The river, Rihand, dammed in late 1950s (Govind Vallabh Pant Sagar Dam) to create an artificial lake called the Rihand reservoir. The building of the dam displaced around 200000 people. However due to a misjudgment of the catchment area, people had to move again as reservoir area expanded in the early 1960s. In 1975, people were again displaced for the NTPCL Shaktinagar thermal project. Not only tribals were disproportionately affected but the so called compensatory development had little to talk about- no schools, no health centers, no roads, not even electricity and clean drinking water. A very high unemployment amongst the displaced communities has also been noted. It is not surprising that in 1993, a proposal to expand the Rihand Ash Dike through World Bank financing met with stiff resistance from the villagers. The pattern is replicated across India souring relations between the government, corporates, NGOs and the public.

In contrast, there are important lessons to be learnt in another case- relocation of yeravadi tribes in Sriharikota, the hub of India's space launch programme. By a conscious decision, the strategy was to co-habilitate rather than rehabilitate the locals which made them partners. The island has seen no conflicts during the last few decades. One may also recall some of the

recent discussions on human-animal conflicts where even ethical and moral issues surface. Sometimes, specially, in the case of new and emerging technologies, neither the cost nor the risks can fully be enumerated. A hope to arrive at a consensus through truly democratic means is indeed a utopia. We also seem not to learn from our past experiences.

While costs and benefits and risks at the public level are complex issues, risks are even more complex. The insurance people have always been doing risk analysis but mostly based on past experiences. We all know that risk perception is a highly personal affair. It is said that pleasure and pain are personal and subject to individual experience. It could be your own experience or that of your close ones. Risk defined as unexpected pain is no exception and is highly personal. On the other hand, personal experiences however extensive they are, cover a miniscule of risks one faces in one's life time. Risk perceptions are therefore not always logical, they are often psychological. Much of superstitious beliefs and phobias that one sees around belong to this category. I was surprised to discover at the age of 60 that I am afraid of space constrictions during my visit to Cu Chi tunnels in North Vietnam. Technology risks are even more complex. Sometimes these risks are totally futuristic. Risk communication therefore plays a very important and challenging role in molding individual risk perceptions, especially when the risks are of technical, futuristic and probabilistic. It is also important to note that not only media play a major role in molding risk perceptions but this is also most effective on the younger population. On matters that depend on public perceptions, I believe that widespread contacts with the student community is the most effective way of communication.

Risk acceptance is even more complex. Acceptance at the personal level is highly individualistic. I mentioned about adventure sports where even a risk to life is willingly taken. Risk acceptance at the personal level and at the collective level need not be the same. At the collective level, sociology and culture play a very important role in defining public risk acceptance.

Let me ask you a simple question “What is the most serious risk to life that an average Delhi resident faces?”. Is it Pollution, Terrorist attacks, Acts of war, Natural disasters like floods and earthquakes, Traffic accidents, anything else? Following the devastating earth quake in Bhuj, I had received an international delegation to discuss strategies for earthquake proofing Delhi. One of the delegation members remarked that the biggest risk that an average delhiite faced was fatal traffic accidents. He was wondering why India is paying so little attention to regulating traffic while worrying about a possibility of an earthquake. Clearly public perceptions and acceptance of risks differ widely. Here again, media play a major role but a sustained campaign and demonstrated compensatory benefits to offset the risks accepted are more likely to be effective.

Some times it is argued that why should any one opt for a risky choice at all. Why can't we take only safe choices? At the outset, we all know that there is nothing that is absolutely safe. More importantly, a safe choice of today may not remain so over a period of time. On the other hand, a risky choice of today may turn out to be more safe in course of time. Let me take the example of jet engines for passenger travel. The first few years of experience with COMET engines in the fifties were disastrous with a series of accidents. We now know why but at that time the feeling was “say no to jet engines”. Great Britain precisely did that. Fortunately the world didn't and moved forward. Britain lost the opportunity to be the world leaders in this technology though they were the pioneers. When India introduced the fly-by-wire aircrafts, A-320, in the early nineties, we opened our account with the air crash on the outskirts of Bangalore. The memory of another A-320 air crash in 1988 in Habsheim, France in the prestigious Air Show was still fresh in our memory. We grounded the entire fleet of A-320's for a long period but fortunately resumed after convincing ourselves that there was no safety issue with the aircraft. In fact, our airports were underprepared to exploit some of the safety features of the aircraft. When our airports were ready, still an accident took

place in Mangalore. They said “Ah, the pilot was sleepy”. When they were negotiating with the pilots, yet another aircraft landed on the nose wheel. They said “Ah, the pilot had a fake certificate”. When DGCA is tightening the licensing procedures, I continue to travel by air. My wife believes that the road journey to the airport is more risky than the air journey itself. Any time I overhear some one whispering “Svalpa adjust madi”, I feel a chill in my spine. Still I take the plane knowing fully well that any thing can happen but the balance of advantage lies in utilizing this technology while continuously upgrading the safety features.

In contrast, one accident in the early days of air ship development led to complete denial of this technology for public use. While we are discussing a ban on the use of helicopters in the North-Eastern states, it hurts to think that the air ship could have provided a safer option. The message is clear. The answer does not lie in saying NO to any technology option in our search for an absolutely safe option. Such an absolutely safe option does not exist either. We need to continuously evaluate the advantages and the risks and prepare the public to take informed options.

What is the dynamics of public risk perception and public risk acceptance? How does one translate financial and technical risk assessments into public perceptions? How do public perceptions mould public acceptance of the risks? What is the role of the media in this? These are complex issues that warrant an interdisciplinary research and debate. Unfortunately, neither the research funding agencies nor the mandated departments support such multidisciplinary research and advocacy.

NIAS has a unique advantage in having technologists, sociologists, psychologists and even philosophers under one roof with no walls and is ideally placed to analyze and understand public risk perception and public risk acceptance. In due course we hope to contribute to the policy making process in matters not only of new and emerging technologies but also in matters of social conflicts.

Chapter 2

RISK PERCEPTION AND THE SENSE OF SECURITY: A HUMANITIES APPROACH

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na āpadām asti maryāda na nimittam na kāranam

There is no limit to outcomes [dangers]; and also its
efficient and final causes are unknown.

Sabha Parva: Yaksha Prasna

Mahabharata

You have to risk going too far to discover just how far
you can really go.

T.S. Eliot

Technical discussions aside, the view of the common man, the person in the street, is also equally important to understand the intricacies of risk perception. It will not be incorrect to say that at some point each one of us is 'someone in the street'. This is because, in spite of our respective disciplinary training and professions, we have a private mind, and a personal life to lead.

Our objective and rational thinking are often subjected to the vagaries of a subjective, personal mind.

My Yatra to Mt. Kailash

People tell me that a trip to Mt. Kailash (in Tibet) is one of the severest risks one could take, because even the trade-offs are not too encouraging: you either break a bone, or you die of high altitude pulmonary or cerebral oedema. Possibility of death is commonly perceived not as a risk but a blessing, over there. So, even helicopter evacuation for the accident victims is not taken very seriously!

Mt. Kailash trekking involves reaching altitude which is technically qualified as “extremely high”. Altitude is defined on the following scale: high (8,000 - 12,000 feet), very high (12,000 - 18,000 feet), and extremely high (18,000+ feet). There are no specific factors such as age, gender, or physical condition that correlate with susceptibility to oedema. Some people get it and some people don't, and some people are more susceptible than others. Altitude was no beckoner for me to retract from the decision to do the *Yatra*. Because, I hardly knew about the technical details of the scales of altitude and the possible adverse outcomes. I did not think what I did not know will be a possible threat for me.

The four threats, in an increasing order of difficulty, I faced during the *Yatra* were:

- a. Climbing to Dolma La Pass, of plus 19000 ft, and the immediate descend
- b. Weak knees
- c. Sense of privacy
- d. Sensitive stomach (being allergic to unclean bathrooms)

Fortunately, I did not have to receive both the trade-offs I mentioned in the beginning. I did not break a bone, and did not

die. After the return from the *Yatra* I found that what gave me the toughest challenge was not what I did not fear, that is, high altitude -- because of my lack of knowledge and previous experience. But what gave me the toughest challenge was what I did fear, which was lack of privacy and bathrooms, of which I had some idea and previous experience through other trekking experiences.

But I learnt later that the first one in the list is the most challenging threat to anyone who makes the *Yatra*. Since I did not know about it and have had little previous experience, it was hardly considered as a threat by my mind before I started the *Yatra*. And that lack of knowledge was crucial for me to make the decision of going for the *Yatra* and taking the risk.

This is the closest experience I have to place behind my speculations about risk perception that I wish to share.

Etymology of 'Risk'

The etymology of 'risk' goes back to classical Greek origin. It was a nautical expression. The term risk may be traced back to classical Greek ριζα (pronounced as per-ree-za), meaning root, later used in Latin for cliff. The term is also used by the greatest Greek Epic poet Homer in his *Odyssey*. Dictionaries confirm that the Latin word (*resicum, risicum, riscus*) comes from a Greek navigation term rhizikon, rhiza which meant "root", and was a metaphor for the challenge given by a barrier reef to the sailor. Only in later times, in French (*risqué*), German (*rysigo*) and English risk came to mean "to dare, to undertake, enterprise". (Rolf Skjong, 2005.)

And today the common interpretation for 'risk' in vogue is a challenge, and point to "adverse outcomes". 'Risk' to a commoner implies something negative than positive.

A Humanities perspective

A humanities perspective would take its wisdom from the human experiences expressed and interpreted by culture, arts,

psychology and philosophy. Such a perspective would primarily bring into question the psychological and philosophical forces that underlie risk perception, risk-taking tendencies and abilities.

Such a perspective would assume two issues:

- i. 'who is at risk' (actual risk), and
- ii. 'one's feelings about risk'

And, that these two issues cannot be reduced to each other. One would *feel* at risk when there is no risk and vice-versa. Feelings about risk and actual risk need not be always corresponding to each other. At the same time, one cannot be undermined in the face of the other.

What this means is that the information on quantified (actual) risk assessment will not be sufficient to address the *feelings* about risk one would have. Risk perception and risk alleviation becomes highly individualistic, and directed by differences in cultural, psychological and moral underpinnings.

The Sense of Security

A fundamental factor necessary in distinguishing between feelings about risk and the actual risk is the *sense* of security. The sense of security is constituted by: (a). fears that decide biases in responding to risks, and, (b). nature of desire and its purpose. Just as we have a sense of our body and a sense of our mind, the *sense* of security is fundamental to our physical and psychological equilibrium. Often, we are oblivious to the subtle existence of such a sense playing a crucial role in our decision-making activities.

Fears, desire and its purpose are invariably related to our sense of security. Here once again, what we are talking about is not only the quantified amount of security in the

areas of national, health, nuclear etc., based on probabilities and statistical data, but also the subliminal *sense* of security. All our actions and responses are founded on our sense of security.

Philosophically or otherwise there is agreement that desire invokes action. Desires produce intentions, and intentions lead to actions. Desire refers to having an urge for something in the distant, feeling to possess or dispossess, intend to achieve. On one side when all types of desires have cognitive elements constituting them, on the other they are ridden with unarticulated emotions, values, and world-views. The psychology of desire is a subject that has brought in controversial theories of the unconscious and personality traits that arise from that space. In the context of risk-taking behavior and risk perception, what comes to focus is that the nature of desire aligned with fear, desire and its purpose.

What causes a desire, and what is achieved through the fulfillment or non-fulfillment of the desire? How does desire and its ultimate purpose of wellbeing or common good (in risk assessment) influence our biases in risk perception? How objective are we in considering the merits and adverse outcomes without downplaying or exaggerating either? How do the bias interfere in decision-making process?

The last two questions are significant in understanding the processes that go into risk assessment particularly when studies have shown that when making choices and solving problems of complexity, rational elements are found missing and we are influenced by 'a-rational' factors. "People do not typically solve problems, make decisions or reach conclusions using the kind of standard, conscious and rational processes that they were more or less assumed to be using. ... When people were observed making choices and solving problems of interesting complexity, the rational and the logical elements were often missing" (Reber, 1993).

Desire motivates action. And, the sense of security decides the emergence of desires. Both risk aversion and risk-taking tendencies are dependent on our *sense* of security which in turn is driven by fear and anxiety. And it is established theory that while fear and anxiety to a certain extent perform functions evolutionarily engraved by our biology (fight or flight) they also create health hazards when taken out of proportion.

Fear of the unknown is a psychological force that overrides any rational and quantified account of possible threats and adverse outcomes. Subjective identity is defined by the fear of the unknown which is a crucial deciding factor in risk taking behaviors and risk perceptions. A person who would not take a risk as an individual may choose to do so as part of a group. The fears of the unknown (consequences) are seemingly distributed when one is a part of the group: 'I alone is not affected, but others also'; 'Since many are, there mitigation would be better'. This is evidenced by the common practise of pedestrian crossing. We feel more assured in crossing when a few more people are with us to cross the zebra lines. And as far as the personal anecdote shared in the earlier part of this paper goes, perhaps I took the risk of a trip to Mt. Kailash because twenty six people were with me, or perhaps the leading light of our spiritual teacher was with us.

The fears and the sense of security one would have independently and as part of a group would vary. And, this is important when risk perceptions are evaluated. The influence of group-processes and individual processes in decision-making and risk-acceptance is central to understanding the psychology of risk.

What I wish to call a "Humanities approach" would consider apart from the mathematical calculations, probabilities and statistical data, the 'a-rational factors', the fundamental motivations that lead people to risk taking behavior and framing risk perceptions. After all here we are dealing with the

minds and mindsets of individuals, when risk perceptions are discussed.

Let me come back to the question I asked in the beginning:

What is the feeling of being at risk?

What is it to be at risk?

How alternatively can we describe the experience of being at risk?

Let us look at some instances, narratives —

i. I said something hurtful to A

Because of which I do not know what might A's response would be in the near and long term future.

Did I say something wrong?

What are the consequences and relevance for me?

ii. I desired for something. And have engaged in relevant action leading to its fulfilment.

Did I put myself in an unknown space in the course of my action?

Was my desire legitimate?

Can I analyse my actions and reason for that particular desire objectively?

Am I in control?

What are the fundamental mental forces behind these motivations?

i. Desire for something which is yet to be achieved,

ii. Inability to gauge (long-term) consequences, and,

iii. Anxiety and discomfort

Are human actions, in general, free of these three fundamental mental forces? Can we be free of desires? We wish to control outcomes. But do we have control on the multiple factors that decide the outcomes?

In fact, we could say that, no action can be performed without the motivation of a desire. No amount of consequential thinking and conceptual tools will give us an exhaustive scale of outcomes. And, no action is free from some amount of expectation.

All actions are founded in desire; anticipation of outcomes, and some degree of anxiety. These three subliminal psychological forces together determine our *sense* of security.

Sense of security is the sense we have of displacement (or its absence); of losing (or not); and being (or not) in control. As individuals, and unique individuals with our makings determined by a host of private factors which are psychological and cultural, we perceive risk determined by our sense of security.

Risk experience is that which disturbs an equilibrational state of our sense of security, and,

- i. Warns displacement
- ii. Generates fear of loss, and
- iii. Fear of absence of control.

Risk experience belongs to a person, with its impact on his mind and body. Every individual is important. It is the collective experiences of individuals that contribute to a larger conception of risk.

Even when we analyse public risk, let us keep in mind that it is an individual who perceives the risk and becomes the

partaker of the outcomes, along with other stakeholders. Let 'public' do not become a chimera for us, and let us not return to the age-old horns of the dilemma, 'is individual more important, or is the public more important?' There is no scope for public risk without the conception of an individual and the risk to the individual.

How to address and work for an optimal sense of security?

An optimal sense of security is decided by the nature of choices and decision-making, and also our tolerance to outcomes.

i. Choice and decision-making

Are our choices well-informed? Have the subliminal forces behind the nature of choice been brought to the light of conscious analysis? Have we addressed the 'what -if' question (e.g.: what if something goes wrong)? Do we make better decisions when there are more choices? Sheena Iyengar writes: Perhaps it is not that people are made unhappy by the decisions they make in the face of abundant options but that they are instead unsure – that they are burdened by the responsibility of distinguishing good from bad decisions (Iyengar, 2000).

While receiving options and making choices from the many available, our minds convert the objects we see to symbols. For e.g.: when I am given a range of soda drinks, though the content of all are the same, the one (or none) I would opt for is decided by the symbolic value I give for it. Often when we see objects, we then convert them to symbols so that we can make decisions in tune with our perceptions and beliefs. Our biases are tuned either by the apparent package of the object or its deeper content.

The question to explore is whether we make better decisions if we devise effective low-risk strategies for getting the 'small things' we desire in life?

ii. Tolerance of outcomes

Sense of security is not a sense for the absence of risk, but rather a sense that allows us to estimate our individual risk-tolerances. How acceptable is my choice to me and others? How poised are our choices for larger good?

The impact of choice and decision making in defining risk is best illustrated by a story from the Mahabharata. This is the story of the Pandava brothers' rendezvous with Yaksha, described in the Sabha Parva. The narrative below is adapted from Kamala Subramaniam's Mahabharata (1990).

Once, when the Pandavas were living in Dwaitavana--it was during their final stay of a few months--a brahmin came to Yudhishtira with an appeal. He said that a deer had entered his hut and carried away the sticks used for making fire, the Arani. The Pandavas left at once and went in pursuit of the deer. They followed it very far but suddenly it disappeared from their sight. Depressed in mind and fatigued by thirst and hunger, they sat down under the shade of a huge tree. They were very unhappy and all the brothers except Yudhistira started lamenting about the fate and the unending number of woes that follow them.

Yudhishtira smiled at them all and said: "This is not the time to look back and think of the might-have-beens. Our immediate worry is this: How are we to quench this dreadful thirst that has been troubling us since some time? Nakula, get up on the tree and look around. See if you can find any spot of water in the neighbourhood. We are all almost dying with thirst". Nakula did as he was told. He said: "I can see a lake just nearby". They were all so happy to hear it. Yudhishtira said: "My child, go at once and bring water for all of us". Nakula hurried to the lake.

He reached the lake. The water looked so cool and inviting. He went near it to drink it. Suddenly he heard a voice from nowhere. It said: "You must not drink the water of this lake, not

before you have answered certain questions of mine. You can neither drink this water nor can you carry it unless you answer my questions". Nakula did not pay any heed to this voice coming from nowhere. He was very thirsty. He rushed to the brink of the lake and drank the cold water eagerly. Immediately Nakula fell down dead. The others waited for him for a long time. But Nakula did not return.

Yudhishtira sent Sahadeva to go in search of his brother. Sahadeva reached the lake. He saw the dead form of his brother on the ground. He was shocked at the sight. But his thirst was so great that he rushed towards the water as Nakula had done. The same voice was heard with the same warning. But Sahadeva was like Nakula. He disregarded the warning and drank the water and suffered the same fate as his brother. Yudhishtira next sent Arjuna and then Bheema. Not one of them came back. Yudhishtira waited for a long time and yet they did not come back. Intrigued by this, and with misgivings of the mind, Yudhishtira walked towards the lake. He reached it soon. He stopped in his tracks, horrified by the sight that met his eyes. He saw all his brothers there, dead.

Yudhishtira was almost mad with grief. His roving eyes fell on the cool water and his thirst came back. His throat was parched and dry with unshed tears. He walked to the brink of the lake and was about to drink the water, when he was arrested by the unearthly voice. He was told that he should not drink until some questions were answered. Yudhishtira paused in the act of drinking. He looked around to locate the source of the voice. The voice said: "I saw your brothers come here one by one. I told them not to drink. They would not listen to me. They drank and died. I am the yaksha who owns this lake".

The story continues that Yudhishtira answers all of sixty odd questions of Yaksha, and to Yaksha's happiness he is not only granted water from the lake, but also the lives of the four brothers.

Yudhisthira and his brothers had to face two risks. One, the risk of having to die with no water to drink, and two, the risk of having to die by giving wrong or no answers to Yaksha. There was the risk of death in both options of choices and decisions.

The brothers were already fatigued by hunger, and also by their depressed minds. Their immediate worry being thirst Yudhishtira prods the brothers to find a water source.

Nakula and other brothers find a lake, and confront the owner of the lake –the Yaksha, but do not heed to his questions. With the desire for some drops of water, the surroundings did not matter much to them. They were unable to see and listen to the happenings of the immediate environment. At the same time the water of the lake was found so cool and inviting, that even death was not a concern. What was pulling them deeply was a haste to somehow quench the thirst. Hence they either did not hear the voice of Yaksha or ignored him who forewarned them of death. At that point, quenching thirst was the primary desire. Even the sights of the dead bodies of the brothers did not thwart the motivation of Bhima, Arjuna and Sahadeva, from stepping to the lake and drinking water.

Only Yudhishtira heard the voice of Yaksha, inspite of the desire to quench the thirst, and had the patience as well as courage to respond to Yaksha’s questions.

What we may conclude from the story is that when pushed to a corner, we are forced to take a risk, even if it is at the cost of a trade-off like death.

Can we stop desiring?

Can we stop engaging in actions? Can we objectify the subliminal forces that shape our choices? All these, so as to gain a stable sense of security? Not really. The only way to know the limits of our *sense* of security is to reset the limits every time we test them.

This is also because we know that individuals change, risks change, individual perceptions change, and also the outcomes change. The only way to know if yesterday's risk is still a risk today, and whether we perceive it differently, is to continue to take risks. At any case there is no human action whose course of outcomes can be chartered for an infinite future. We take risk, as long as we cherish desires – small or big.

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Chapter 3

ROLE OF RISK COMMUNICATION IN RISK STUDIES

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Introduction: On the origins of the concept of Risk

In this chapter I describe and examine the nature, role, and significance of Risk Communication in the field of Risk Studies. The field of risk studies emerged in response to various debates concerning environmental degradation and related issues in the second half of the last century is an interdisciplinary enterprise comprising studies from the vantage point of natural and engineering sciences, social sciences and humanities. Within its ambit are located subfields such as Risk Perception, Risk Communication, Risk Management and Risk Governance. Risk Communication emerged from risk perception in the mid-eighties and has made rapid progress both in terms of quantity and quality of publications. In addition to a broad based description of the nature of risk communication, I deal with an important issue in the fields of risk perception and risk communications i.e., the issue of Knowledge Discrepancy in risk studies. Also known as Experts vs Lay people divide, the issue of knowledge discrepancy has been a source of deep concern for risk managers and theorists. Following this in

conclusion this I will briefly present certain important attempts made in order to bridge the gap.

The Emergence and Evolution of Risk Communication constitutes an important chapter in the field of risk studies (see Fig. 1). In terms of its own origin and development the concept and study of risk emerged in the seventies and eighties in the context of wide spread concern about environmental degradation and its short term and long term consequences. Although the phenomenon and experience of risk has been a part of human social existence since early times (Covello and Mumpower, 1985), the conceptualization and professionalization of risk studies has been a matter of recent development and in particular, has been closely associated with the major transition from traditional to modern society (Plough and Krimsky, 1987; Beck, 1992; Luhmann, 1996) Luhmann (1996) points out that the term “risk” is a neologism that came into use with the transition from traditional to modern society. He adds that In the Middle Ages the term “riscium” was used in highly specific contexts, above all in sea trade and its ensuing legal problems of loss and damage. Further, Luhmann observes that in the English language the term *risk* appeared only in the 17th century, and seems to be imported from Continental Europe.

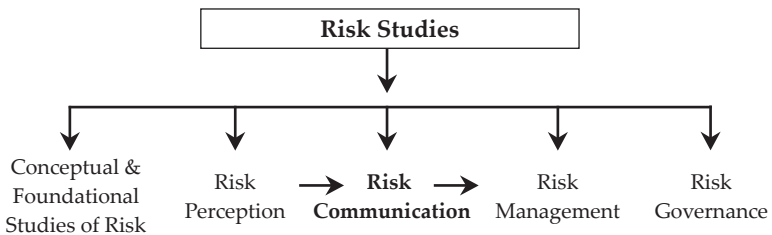


Figure 1. An overview of Risk Studies^{1,2}

¹ Other terms used in this context: Risk characterization, risk assessment, Risk analysis.

² I have used the term Risk Studies as a disciplinary term which encompasses all the other studies done within the inter disciplinary frame work.

Risk Studies: The beginning

Two major consequences emerged from this conceptual evolution. Firstly, the concept of risk became an analytical category with the help of which one could identify the major transitions of social evolution. This kind of analysis is particularly well presented by Beck in his work "Risk Society: Towards a New Society". In this work, Beck traces the emergence of what he calls as "Reflexive modernization" from the earlier phase of tradition, i.e., premodern societies to the current phase of modernity via the phase of early modernity. (Beck, 1992). Secondly, the emergence of the concept of risk paved the way for the birth of important research fields such as (a) risk analysis, (b) risk perception and (c) risk management (Luhmann, 1996). One major omission from this list of what Leiss calls "risk subfields" is "Risk communications research" (Leiss, 1996).

From the Study of Risk to Risk Communication Research

Describing the sociohistorical backdrop within which the theme of risk communication emerged, Plough and Krinsky (1987) observe, "That the emergence of risk communication as a research theme cannot be fully appreciated or accounted for without understanding its link to a set of issues that symbolize *the discord* between scientific experts and the public around the issue of risk. These tensions are played out in disputes between different research traditions on fundamental questions regarding the perception of risk and the essential nature of human rationality".

Two important issues deserve to be noted here. First, there is the critical issue related to "the discord between scientific experts and the public" and second, there is the reference to "the perception of risk" and its relation to "essential nature of human rationality".

Leiss in his important historical study of risk communication offers similar observations, and hence notes that

“Risk communication research..., is the newest of the four risk subfields, the phrase itself appears to have been coined during 1984” (Leiss, 1996). He then explains that it arose out of the problems being investigated in the risk perception area, which since its inception had concentrated on the disparities between risk as assessed by experts on the one hand and as understood by the general public on the other hand. Further more, Leiss points out that while risk perception studies have focused attention on explaining these disparities risk communication has from the beginning had a “practical” intent, i.e., given the fact that there are disparities between experts and general public in understanding each other, risk communication has to respond to two important challenges. First, there is the question, how can we improve the quality of the dialogue about risk across the gap the separates experts and the general public? And, secondly, how can we apply this improved dialogue to achieving a higher degree of social consensus on the inherently controversial aspects of managing environmental and other risks?

Apart from Plough and Krinsky, and Leiss, Fischhoff also has explored the developmental history of risk communication. In his entertaining essay “Risk Perception and Communication unplugged: Twenty Years of Process” (Fischhoff, 1995) identifies seven stages in the evolution of Risk Management:

- All we have to do is get the number right.
- All we have to do is tell them the numbers
- All we have to do is explain what we mean by the numbers.
- All we have to do is show them that they have accepted similar risks in the past.
- All we have to do is show them that it is a good deal for them.
- All we have to do is treat them nice
- All we have to do is make them partners
- All of the above.

Commenting on this list, Leiss (1996) argues that Fischhoff's stages can be regrouped into three phases of evolution of risk communication practice. Accordingly, the first two stages of Fischhoff's list corresponds, roughly with Phase I, (which in chronological terms spans the period from and to 1975-84), wherein quantitative estimates were predominant. In Phase II (about 1985-95) aspects of successful communications were emphasized and the final phase coming after 1995. The idea behind this regrouping, Leiss observes, is that it highlights the radical nature of the transition that has characterized the growth of risk communication. While Leiss' account traces development from 1975 to 1996, McComas (2006) in her recent study identifies what she terms as "Defining Moments" in Risk communication research where in she covers a period of about a decade, i.e., from 1996-2005. After, listing most important mishaps, both natural and man-made (this including the terrorist attack on World Trade Centre on September 11, 2011), which raised the level of 'risk awareness', McComas (2006) describes the various ways in which risk communication research had been transformed. New avenues such as the media and new forms such as strategic risk communication had emerged making the risk communication process, more complex and also expanding it in terms of stakeholders' role and coverage.

Risk Communication

(a) Definitions

One important point which emerges out of the above historical account is that although the field of risk communications is fairly young, it has shown rapid growth within the overall framework of Risk studies testifying to its importance and centrality in the discipline. As such risk communication occupies a middle ground linking risk perception with risk management (Fig. 1).

According to the document titled "Improving Risk Communication" published by the National Research Council (USA), Risk Communication is defined as follows:

“Risk Communication is an interactive process of exchange of information and opinion among individuals, groups and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, the express concerns, opinions or reactions to risk messages or to legal and institutional arrangements for risk management”, (Improving Risk Communication, 1989)”. Commenting on this definition, Ropeik (2007) observes, that risk communication should be considered a dynamic two-way street. Both sides get to talk, and both sides have to listen and respond to input from the other. As has been pointed out by many commentators this definition signifies an improvement over earlier ones which treated risk communication as a one way, top down transmission of information.

The Codex Alimentarius Commission of Food and Agricultural Organization also offers a somewhat similar definition of risk communication: According to it risk communication involves, ...

“The interactive exchange of information and opinions throughout the risk analysis process concerning risk, risk related factors and risk perceptions, among risk assessors, risk managers, consumers, industry and the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions”, (cf. Lupin 2007).

Taking the two definitions together the following aspects of risk communication process can be identified:

- a. Risk communication is primarily an interactive exchange, i.e., communication should be two way or multiway process.
- b. In terms of content Risk communication should be more than presenting a list of bare facts. It should be a composite message combining information and opinion

- which accounts for the affective components in people's perception of risk of bare facts. (Ropeik, 2007).
- c. Risk communication is a continuous and on going process especially in the context of risk analysis which is itself a continuous process.
 - d. The participants of risk communication process are all those who are affected by risk, risk assessors, risk managers, consumers, industry, the academic community and other interested parties. In other words, all the stake holders are involved.
 - e. The CAC definition requires recognition of the fact that "values are a key element in risk communication", (Lupin, 2007). While risk communication should concern itself with risk, risk-related factors and risk perceptions, it should not be confined to understanding only scientific (assessed/ measured) risk but (it should also include) the perceived risk and possible risk related factors".
 - f. Finally, the principal objective of risk communication should be to offer proper explanation, to explain how and why a certain set of decisions have been taken instead of any other. Also, explanation is needed because not all the stakeholders would have the necessary scientific and technical knowledge to grasp the nature of the risk.

(b) Models

As can be seen from the above risk communication (which can be treated as a special form of communication) is a process where information flow or exchange is made possible amongst different participants or stakeholders. One major implication of this interpretation is that the structure of risk communication can be best represented in terms of models. This, for example, can be seen in a simple communication model developed by Shannon and Weaver in their important paper published in 1949. Risk communication models are generally based on this model with additional features specific to risk perception (Fig. 3).

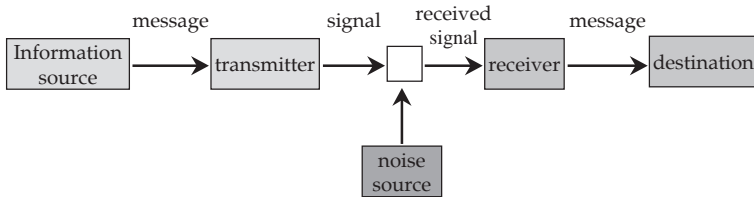


Figure 2. Shannon and Weaver's general model.

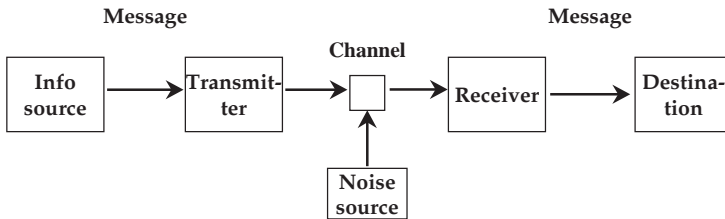


Figure 3. Model of Risk Communication: Risk message model based on generalized 'Shannon and Weaver' model (1949). Aim – efficient uninterrupted, clear communication of risk from sender to receiver. Model – Deficit model, linear, one way communication. (cf. Wardman, 2008)

This 'informational' model (see Figs 2 and 3) was the first of its kind and has been described as "... one of the main seeds out of which Communication studies has grown", (Chandler, 1994). Chandler in his discussion of the model points out the following advantages associated with the model. It is characterized by:

- i. Simplicity
- ii. Generality
- iii. Quantifiability

The last feature was particularly important as the model was developed mainly to assist in the formulation of the mathematical theory of communication. Wardman (2008) observes that the model is a deficit model (i.e., a model where information flow is top down), linear one and is characterized by one way communication.

Although the Shannon and Weaver model (also known as Sender–Receiver model) was very useful for some purposes, it was beset with serious shortcomings – the most important being – there was no role for ‘SEMANTICS’ IN it. Weaver (1949) makes this amply clear. According to him “the word *information* in this theory, is used in a special sense that must not be confused with its ordinary usage. In particular, *information* must not be confused with meaning. In fact, two messages, one of which is heavily loaded with meaning and the other of which is pure nonsense, can be exactly equivalent, from the present viewpoint, as regards information. It is this, undoubtedly, that Shannon means when he says that ‘the semantic aspects of communication are irrelevant to the engineering aspects’” (Weaver, 1949). In other words, as Chandler (1994) observes “meaning making is not central in transmission models”.

Now given the problematic nature of the classical communication model, several risk communication theorists such as Renn (1992), Rohrman (2008), and Wardman (2008) have proposed models which are based on semantics, i.e., models in which meaning making plays an important role. One such model is presented by Renn (1992) (See Fig. 4)

In this model, which Renn describes as an ‘Organizational structure of communication’ he includes all the important participants who are involved in the process of risk communication – senders, transmitters, and receivers. Further, within each group he includes variety of contributors - for example, in this model the term ‘interest group’ refers to what is generally known as the ‘civil society’ and within the larger group of sources Renn provides important roles to scientific communities, public agencies and eye witnesses hereby broadening the scope of community participation in the process of risk communication. Similarly he has in his model made provision for those communities which are involved in transmission and reception of communication. (Renn, 1992). One important innovation made by Renn is availability of ‘feed

back' loops and these indicate the fact that his model is an 'interactional' model.

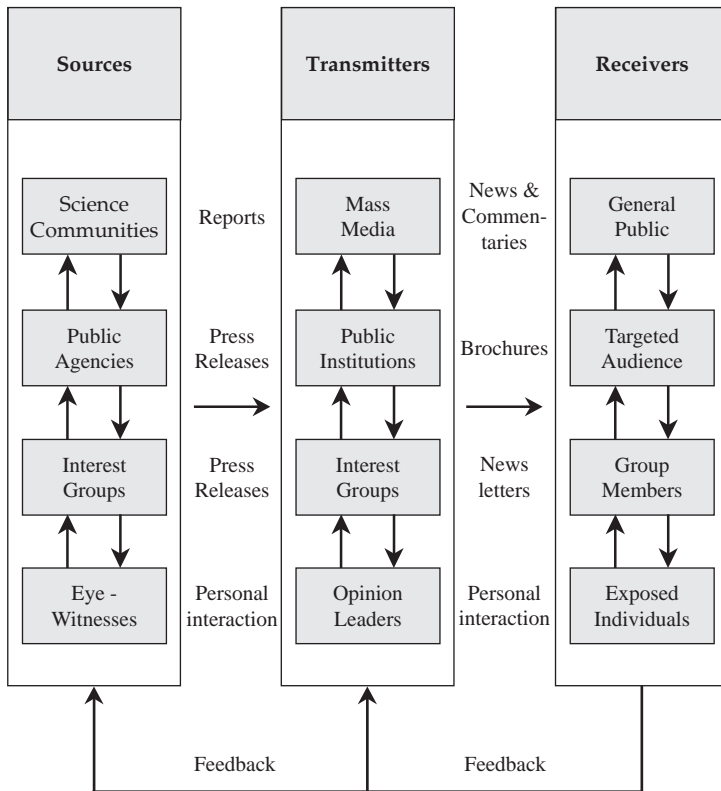


Figure 4. Models of Risk communication (Renn 1992).

While describing the actual manner in which his model operates Renn observes that the sources, as noted earlier, are basically made up of a variety of participants – scientists, institutions associated with science like the Environmental Protection Agency (EPA), USA and other agencies. These initially provide information in the form of formal communications to others i.e., transmitters or receivers (under certain circumstances) and this information leads to further interaction. Following this initial step, the involvement of public through transmitting

agency is made possible and finally the end receivers respond to the initial messages either in terms of support for or rejection of the source message.

In other words, Renn's model shows that "communication must happen within all sources, all transmitters, and all receivers respectively, in order for the correct information to be conveyed and then received appropriately by the various receivers".

(C) On the Significance and Complexity of Risk Communication

Ever since the emergence of the concept of risk, two areas (amongst others) have acquired deep significance in the overall discipline of risk studies. They are 'risk perception' on the one hand and 'risk communication' on the other. As mentioned earlier (Leiss, 1996) risk communication emerged from risk perception and in turn developed as an important component of Risk Management. Plough and Krimsky (1987) while tracing the history of the concept observe, "Risk Communication is more than a research frame work. It has become a concept that is strongly marketed by specific interest groups and used instrumentally to achieve particular ends. At the federal policy level, the environmental protection agency (EPA) has been the strongest marketer of the concept of risk communication". Its (i.e., EPA) chief administrator has stated: "On the national level, we will build risk communication into regulatory policy whenever possible". The EPA has elevated the concept of risk communication to a strategy level of importance in both its regulatory activities and its research agenda. Industries that are regulated by the EPA also seek risk communication as a key policy and management issue" Plough and Krimsky, 1987 (P. 4). Thus risk communication has acquired the status of a state subject.

Given this significance of the concept, it is important that we understand its nature properly, specifically in terms of the fact that it is essentially a process which involves continuous exchange of critical information. An important aspect of emphasis

is the recognition that risk communication is a complex process with a variety of participants and stakeholders interacting with each other. This complexity is graphically presented in the following figure: (Fig. 5)

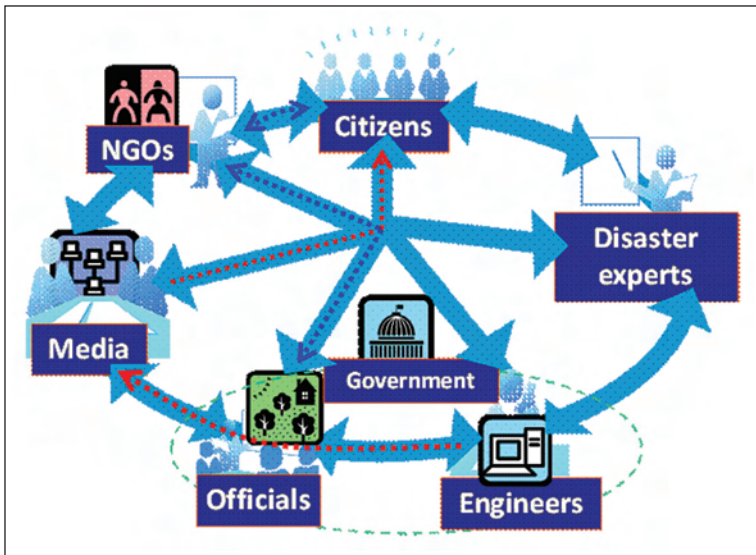


Figure 5. On the complexity of Risk communication – Multiple stakeholder idea. Source Web communication: Pathak.

A key issue: Experts’ vs. Lay People Dichotomy in Risk Perception and its implications for Risk Communication

One of the most important aspects of all studies related to risk, being perception, communication or management is the problem of ‘Knowledge discrepancy’ that exists between experts’ perception and understanding of risk and lay persons’ perception and understanding of the same phenomenon. Merkelson (2011) points out “the most studied and debated differences in risk perception are those found between experts and lay people. This gap, which is often described in terms of a knowledge discrepancy emerged in various risk perception studies in the seventies that were conducted as a consequence

of a general public skepticism towards nuclear technology” (P-10). He adds that in the course of last four decades studies have persistently pointed to the existence of such a knowledge discrepancy more or less regardless of risk or hazard type”. The gap indicates that there are major differences almost making them seem like polar opposites. The following table gives us a broad based picture of the dichotomy: (See Table 1).

Table 1. Experts’ vs. Lay People Dichotomy: Important differences between the perception of experts and lay public of risk.

No.	Experts	Lay Public
1	Quantitative	Qualitative
2	Experts pay more attention to probability	Public to consequences
3	Objective	Subjective
4	Physically given (risk seen from the view point of Realism)	Socially constructed
5	Technical Rationality	Cultural Rationality

While some of the differences could be attributed to a certain set of biases, other differences have had their origin in the presence of presuppositions in experts’ perception. This is particularly true in the case of the Psychometric paradigm which had and still has considerable influence on the way in which risk was perceived and interpreted. The psychometric paradigm is characterized by emphasis on quantitative and probabilistic analysis (Bostrom, 1997). Bostrom in her detailed study of the problem argues that although experts operate with formal definitions of risk, there was no reason to think that the definitions agreed and thereby indicate the fact that experts operated with a shared and consensual viewpoint. In other words, as she puts it: “Thus technical risk assessments by experts can disagree dramatically” (Bostrom 1997, P-105). From a philosophical viewpoint a critical issue in this context is rationality. While experts operate with the notion of ‘Technical rationality’, lay public operate in terms of what Plough and Krimsky (1987) call as ‘Cultural rationality’. Explicating the two concepts Plough and Krimsky observe “This form (technical

rationality) rests on explicitly defined sets of principles and scientific norms. These include hypothetico – deductive methods, a common language for measurement and quantification and comparison across risk events”. Contrasting this with Cultural rationality the two authors argue “Cultural rationality can only be understood when people’s cognitive behavior is observed as they are threatened by a real risk event. It is only then that the full panoply of factors come into play that create a complete picture of a public response. To understand cultural rationality, one must address anthropological and phenomenological issues as well as behavioral ones”.

A Conceptual Intervention: On the role of Trust and Expertise in Risk Communication

A major casualty emerging from this persisting knowledge discrepancy is the concept of ‘Trust’. The lack or absence of trust between the experts (generally policy makers and industry officials) and the lay public has been responsible for the failures of risk communication (Loftstedt, 2003). In response to the problems created by this divide some social scientists have examined the possibility of redefining the notion of trust in such away as to create a level playing ground which would enable experts and lay public to negotiate on equal footing. In the same context, the notion of ‘expertise’ has also been examined by philosophers and sociologists (Rask, 2008; Collins, 2004). The primary motive behind these investigations seem to bring together more nuanced notion of trust and a broad based idea of ‘expertise’ which would provide a common ground for all the stakeholders in the risk communication process.

Loftstedt (2003) defines trust as follows, “The term Trust can be an expression of confidence between the parties in an exchange transaction and can be both process/ system or outcome based”, (P-419). Elaborating his concept of trust Loftstedt identifies three important components – Fairness, Competence, and efficiency. In Loftstedt’s terms “Impartiality and Fairness are an important element of any regulatory decision that will have

an impact on public trust ... Fairness is usually defined a view of the process or outcome as being impartial". As far as competence is concerned he observes, "Public perceptions of risk managers' competence is viewed as the most important component of trust. Did the regulators handle the process as proficiently as possible? Did the risk managers have the necessary scientific and practical background to deal with the range of issues associated with the process?" – are some of the questions which the lay public are likely to ask in the context of the issue of competence. Finally, the third component of trust efficiency is related to the question "How taxpayers' money is used in the regulatory process...". The point here is efficiency refers to a sense of accountability in respect of proper utilization of taxpayers' money. Apart from Lofstedt other risk communication experts also have offered similar lists of attributes concerning the trustworthiness of expert opinion (Renn and Levine, 1991; Kasperson, 1992).

In sum then, there seems to be a general accord amongst risk communication specialists to the effect that trust in risk communication holds a key position in risk management and plays a critical role in perception and acceptance of risk.

In addition to trust, the concept of expertise has also acquired a significant role in risk studies. The Business Dictionary.com defines "'Expertise' as the basis of credibility of a person who is perceived to be knowledgeable in an area of topic due to his or her study, training or experience in the subject matter". According to Rask (2008) expertise is understood "generally as either experience based or academically certified knowledge, skills and competences", (P-22). Rask adds that the structural form of expertise is called a 'Profession'. Concomitantly an expert "is a person with extensive knowledge or ability based on research, experience or occupation in a particular area of study" (Wikipedia). An important dimension of expertise is the kind of epistemic authority or in a larger sense, cultural authority it is normally endowed with. Given this fact, the role of experts in risk situations is critical. It is

this critical positioning which comes into play in expert vs. lay public risk perception. In response to this somewhat mutually exclusive positioning of expert and lay public, Rask argues in favour of Expansion of Expertise in science and technology management. By that he means, "The process of involvement of new actors and knowledge perspectives beyond technically and professionally certified elites" (Rask, 2008). He adds that this will open up the process of negotiation as the new actors bring a long different professional cultures, world views and knowledge perspectives.

On bridging the gap and a way forward

To conclude then what needs to be done in bridging or closing the gap between experts and lay public is that we need to provide a role for democratically broad based notion of expertise and more nuanced interpretation of trust in the overall process of risk perception, communication and management. In addition one could also deploy constructively the seven cardinal rules of communication as proposed by Covello and Allen (1988). The rules are as follows :

1. Accept and Involve the Public as a Legitimate Partner.
2. Plan Carefully and Evaluate Performance.
3. Listen to your Audience.
4. Be Honest, Frank and Open.
5. Coordinate and Collaborate with Other Credible Sources.
6. Meet the Needs of the Media.
7. Speak Clearly and with Compassion.

As can be clearly seen these rules are based on concepts such as fair play, commitment to openness, clarity of articulation and finally compassion. It is a well known fact that risk communication is a complex process and achieving effective and successful communication is an arduous exercise. But achieve

we must in order to overcome many a barrier on the way and eliminate risk as successfully as possible.

Additionally we need to consider further the following issues:

- a) Risks have become pervasive and its experience, ubiquitous (Remember Bhopal tragedy). So much so that the modern society has to accept risk as one of its defining features.
- b) In the light of this all aspects of Risk Studies, i.e., Conceptualization, Perception, Communication, Management and Governance have to be examined with great responsibility and accountability to the society as a whole.
- c) Success / Failure in any of these domains can have far reaching implications not only for the present but also for the future.

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Chapter 4

Psychological, Social and Cultural Perspectives on Risk

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The word 'risk' has been used to mean different things and depends on who uses the word. In everyday language it is the possibility of the occurrence of an undesirable event. When used by a scientist in a technical sense, it is something quantifiable – such as probabilities or a numerical representation of severity (Hansson, 2009). A psychologist on the other hand uses the term such as risk and at risk with reference to health or mental health.

Studies on risk have adopted two different approaches. One views risk as a physically given attribute of hazardous technologies, leading to traditional and technical approach to risk assessment while the other is psychometric and social science approach (Bradbury, 2009). Foundations of risk lie in decision theory – that focuses on uncertain choice. This has led to collaborations among multiple disciplines including natural scientists, social scientists, mathematicians, philosophers, computer scientists, psychologists, sociologists and politicians.

Some risks have immediate effects (tainted food, physical and psychological injuries). Some affect people, others affect the environment. Some are voluntary while others are not. Risk may deal with premature babies, vehicle insurance, sex education and so on. Some risks may have varied effects at various developmental stages of the person. Some even may affect subsequent generations (Fischhoff and Kadwany, 2011).

A historical evolution of the concept of risk by Beck (2010) highlights the evolving of the concept over a period of time. He sees darker dimension to developments in science and knowledge consequences of scientific and industrial development are a set of risks unlike what we have ever seen before. These dangers are not limited to the present time as future generations too are affected. Their spatial consequences are not answerable as they cross geographical and national boundaries. Further it is impossible to compensate those who are touched by the hazards. Beck saw it as a three stages modernisation and social change. First being *pre-modernity*, second *simple modernity* where the fruit of modernity is reaped by everyone in the industrialised society and the third new *reflexive modernity* representing a risk society reaping goods and dangers. We are faced with choosing wealth production and risk production. Progress remains under the jurisdiction of business, science and technology for whom democratic procedures are invalid. In addition, the risks are not only more widespread, these are not visible and thus escape perception. These dimensions studied often may be on chemical, biological, technological toxins on the environment, rarely does it focus on social, cultural and political impacts.

The socio cultural approaches deny the possibility of a standard absolute risk. Improved technical risk analysis is not the answer. The three key aspects namely, risk perception, risk communication and risk management are inextricably linked to the larger socio-cultural debate on the nature and role of our own modern industrialized civilisation. The socio-cultural approaches have contributed to the following insights.

- In risk perception there will be new areas such as nanotechnology, terrorism, climate change, public health and food scares (Lofstedt and Boholm, 2010).
- Concepts in risk communications have almost peaked.
- Mental models and social application research have matured. Bradbury (2010) sees social trust as a key issue. The role of feelings has been highlighted.
- The real growth area is of Risk Management and the whole topic of communicating *uncertainty*. Greater transparency and openness are needed to solve the issue of trust.

Thus we return to the role of psychology, in risk perception, communication and management involving the subjective aspect of risk – both in the “risk taker” and the “risk producer”. It all settles down in the crucible of man’s perception of risk for himself and others and his responses to these in terms of emotions and behaviour.

Risk Perception

(a) *Psychology of perception in general and risk perception in particular. Perception is commonly view as a conscious process involving attention learning and memory. These follow normal psychosocial and psychological rules. These are laws of recency, novelty, repetition, spacing etc.*

Carl Jasper’s (1963) seminal work on psychopathology, focussed on the very aspect that causes distortions in perception. He grouped these distortion mechanisms as ‘prejudice’ and likened them to blinkers limit our perception. These are:

- Quantification: Assessment, quantification, objectivity and diagnosis.
- Theoretical
- Somatic
- Psychologising

- Philosophical (moralistic / theological)
- Use of false analogy

The above prejudice renders one to lose sight of multiple facets of the same observed phenomenon. Risk perception is not uniform. It is determined by the blinkers worn by the perceiver.

(b) *Perception leading to responses in the realm of emotions and behaviour.*

Emerging out of the evolutionary biology, illustrated by 'flight or fight' in the face of danger response of the man that he with the animal, we have, come a long way. Man's response to 'real' 'impending' (Risk) and even 'imagined' dangers have examined in realm of psychology, especially from the vantage points of cognitions and emotions. In this context some psychological processes will be described. These are ones described earlier conscious and unconscious processes of coping with fears and anxieties. When a threat is perceived real or imagined, the body responds to these by the activation of autonomic nervous system. The manifest symptoms are rapid breathing, palpitation, sweating, abdominal discomfort to site a few of them. The immediate response is that of heightened emotional state of fear, anxiety or even confusion. Cognitive evaluation also occurs along with. But all these are intermixed strands that are hard to separate.

Conscious and Unconscious Processes of Normal Human Mind

The ways of conscious coping could be problem solving, blaming an external agent, manipulation of another person's mind through persuasion, advertisement, propaganda and even more recent phenomenon of 'spin doctoring' – are examples all in the familiar realm of marketing strategies.

Freud's pioneering insights in uncovering the unconscious, processes that he termed 'defense mechanisms' is of relevance

here. Cognitive assessment of perceptions leads conscious strategies of coping with the perception, threats or risks.

Freud's concepts of defense mechanisms have been elaborated by Anna Freud C A Greud. Freud's unique contributions of the defense mechanisms have received no attention except from the practising clinicians dealing with human mind. Even then, there is scepticism that these concepts have not been empirically validated. However it is essential for us to understand these concepts in the background of risk perception. The linkages will become apparent as one goes through the gamut of risk studies. It is proposed that the human mind in a vast reservoir of which only some parts available to conscious examination. Much of our minds contain unconscious material consists of images, repressed thoughts or unpleasant dreams and many more aspects. It is proposed that under the state of anxiety some of the unconscious material escapes and enters the conscious realm. He suggested the following defense mechanism commonly used by us. Defense mechanisms work by changing unacceptable impulses into acceptable forms, or by unconsciously blocking such impulses, and this reducing anxiety.

- (i) Repression: Longstanding unconscious suppression of unacceptable feelings / thoughts / actions, events and to storing these in the unconscious – thus denying its existence, a kind of non deliberate one / fools oneself that the unpleasant event never happened / or it is completely forgotten.
- (ii) These do not resolve the conflict but alleviate anxiety to a great extent.
- (iii) Rationalisation: Tendency to explain one's behaviour as rational with conviction even though it is not.
- (iv) Projection: To attribute one's own thinking to other people – while in reality it may be totally untrue.
- (v) Displacement: To displace one's emotions on an object or person when it cannot be expressed at the legitimate source.

- (vi) To deny the existence of painful emotions to oneself and consequently to others.
- (vii) Introjection: Completely absorbing and making one's own thought, feelings and identification behaviours of people significant in our lives. This has an enormous role in the building of what is termed 'conscience'.
- (viii) Reaction Formation: A person may disguise his motivation and conflict by believing that his motive is exactly opposite of what it is.
- (ix) Sublimation and Compensation: This is a process – where unacceptable impulses are converted into socially productive altruism behaviour.

The above mechanisms form a part and parcel of our day-to-day behaviour repertoire – without our being aware of it. But we can access them if we open ourselves to this kind of introspection.

There are also some other conscious and partly unconscious mechanisms such as empathy versus bystander apathy. These are important to our responding to subjective and objective risks. The point where all the conscious and unconscious defense mechanism coincide is where the perception of risk is divided into subjective or objective.

In the risk studies, importance of social networks, risk communication and risk management, role of feelings in perceiving risk and role of 'Trust' in risk management are highlighted. Thus the 'risk taker' and 'risk giver' are both share the human foible of conscious and unconscious mechanisms coming in the way of effective dialogue leading effective management.

The term individual risk is a misnomer – as all risks are public risks in view of collateral damage such as family distress in fluid through accidents etc – of which individual is only a small part.

Subjective risk perception can be mediated, yet the studies on tobacco / alcohol misuse, despite best risk communication and management have proven to be very resistant to change at the level of the individuals. When one examines the public risks, which are continuously being objectively assessed, fortunately are more amenable to effective management. The issue is that in a risk society, the onus of risk management cannot be with either the experts or the lay public alone. The broader risk perceptiveness across multiple disciplines, taking into account feelings and trust being central to it.

Some examples of the distance between the 'risk taker' and 'risk giver' will illustrate the point. For example, be it war, or any other manmade catastrophe, there is a tendency to the perpetrator to view the victims – as non human, demonised or considered expendable. The poor, backward, disadvantaged are only there to enable us to grow rich or powerful.

Example: Iraq war displaying the Hussein Government functionaries as and the pack of playing cards – promoted by the US war machine is one such example.

Handling of crisis – through 'empathy' and 'bystander apathy' are two contracting behavioural approaches to some one in distress risk perception, communication and management and contradictions within these concepts can be resolved with clear and specific instances and areas. These need to be viewed from vantage points of multiple disciplines. Psychology of risk perception and management is one of the areas that has been paid only scant attention. Risk research should focus not only on the end but the means as well. It is important to remember that anticipation of risk as that produces fear is psychologically as damaging, if not more, as the actual physical harm. Thus risk management in the biological, psychological and social realms are equally important.

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DISCUSSION

Prof VS Ramamurthy aptly pointed out that the media has a major role in shaping public risk perception and acceptance. The crux of the issue of risk acceptance is the issue of who is to decide what risks are to be taken especially in the public arena – should it be the specialist who has all technical knowledge or the layperson who is the actual stakeholder. In the public arena, we have witnessed waves of anxiety and sometimes pandemics when it comes to issues of risk like nuclear decisions or epidemics like H1N1, SARS etc. As Prof pointed out, if there is public anxiety it means that nothing was done to remove anxiety. It means that the specialist has not communicated the right information the laypeople. What is significant is that risk response is something that have not yet learned and this is due to a cluster of factors including sociological and cultural. In the end however risk acceptance by individuals is highly personal.

Namitha Kumar

Dr. Sangeetha Menon began the session with her talk titled 'Risk Perception and the *Sense* of Security: A Humanities Approach'. In the backdrop of her personal experience of a trip to Mt. Kailash, she presented the concerns of individual risk perception. The fundamental basis of her talk was the 'sense of security'. Our actions and responses are founded on a sense

of security. She discussed keenly phenomenological aspects of who is at risk and what is at risk. Dr. Menon's basic tenets were desire, fear and insecurity play a major role in our choice and decision-making regarding risk experience.

Dr. Narasimhan presented a detailed analysis of 'Risk Communication'. The various mediating sources in risk communication were discussed at length. He mentioned the concept of 'knowledge-discrepancy' which highlighted the gap between experts and lay people. Experts are credible sources of information with sufficient training and experience and they are invested with the responsibility of transmitting the information to the lay people.

Dr. Malavika Kapur spoke on the 'Psychological, Social and Cultural Perspectives on Risk'. She spoke of the "blinkers" that we adopt (using a term from Jasper's theory). Blinkers are theoretical frameworks which orient our thinking process and decide how we view phenomena. For instance, one may adopt a 'methodological blinker' through which everything is 'quantifiable.' The other theory that Dr. Kapur referred to was Freud's psychodynamic approach. She discussed the various defense mechanisms which are not to be considered as risks themselves but rather as consolidating the person for perceiving risks in a controlled manner. She also discussed importantly Empathy and Bystander apathy which foster feelings of trust or hostility. These psychological factors affect the individual's risk perceiving modes and thereby also influencing his responses and behaviours.

The discussions that followed these talks drew attention to the aspects of trust, fear, uncertainty, anxiety that underlie in perceiving risk. The ideas of sense of security, emotional valences, defense mechanisms, evolution of psychological mechanisms of coping for transformed risks, and the various communication aspects were brought to the fore and debated upon which resulted in a clearer analysis of salient features in

risk perception. The individual and his/her psychological forces are primary in understanding the situation and also making the choice of action, as well as negotiating the consequences. However, the individual is also acted upon by the social and cultural factors which make key impacts on perception of risk. Communication of risk in the public sphere is exigent to the perception of risk and the subsequent courses of action.

K. Lakshmi

Part II

NATURE OF SPECIFIC RISKS AND THE PUBLIC PERCEPTION

Chapter 5

Risk Perception: Alcohol, Tobacco and other Drugs

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Alcohol and Risk

I begin with the idea of alcohol as a risky commodity. We are not talking about something that is “maybe”, “perhaps”, etc. Alcohol is a definitely risky commodity, but unfortunately in the public mind it is not how it is viewed.

Risk is focused on a particular form of alcohol use which is called *alcoholism*, *alcohol dependence*, etc. Unfortunately there is another spectrum of alcohol use which is called *hazardous and harmful use*, about which there is no public discourse. Unfortunately, in the public discourse, we all think that anyone who uses alcohol or uses alcohol in greater measures is an alcoholic. I will come to why I am making this distinction. When you look at hazardous and harmful use, there is a potential harm from the use of alcohol. People who drink too much, drive and have an accident. When you drink too much, get disinhibited, or go beat your wife and children. The harm from this kind of use without you having satisfied criteria for alcoholism is much

more harmful than the harm from alcoholism. Unfortunately for our policymakers, this does not exist. What exists is the alcoholic.

So what has happened is that for our policy makers, for people who dream up treatment interventions in this country, we have spent our money in creating systems for alcoholics who have this particular spectrum of behavior. It is a brain disorder, like diabetes is a particular disorder of the body. Alcohol dependence affects less than 5% of adult Indian males. 25% of adult Indian males have harmful and hazardous use. Unfortunately all our treatment systems are made for the 5% and not the 25%.

Alcohol Use Disorders: Hazardous and Harmful use:-

- Hazardous use: pattern of consumption carrying a *risk of harmful consequences* – physical, mental, social consequences to self or others.
- Harmful use: *already causing damage to health* - consequences, interactions; Strongly affected by sociocultural and economic factors Involves approximately 15% of male adult population
- Greater social costs than dependent users
- Common risk factor implicated in >60 diseases
- 25% of adult males

Dependent use/Addiction:-

- Chronic relapsing brain disorder → interactions of host (genetic *susceptibility*) agent (ATOD), mediated by environmental factors (availability, social factors, stress etc).
- Cluster of: strong desire to consume alcohol; impaired control over its use; persistent drinking despite harmful consequences; higher priority given to drinking than to

other activities and obligations; increased alcohol tolerance, and a physical withdrawal reaction when alcohol use is discontinued. (5% of adult males)

The figure below shows how public perception of risk also determines, the public spending on health and other things. So basically people are spending only on that small part and not the larger portion of the pyramid.

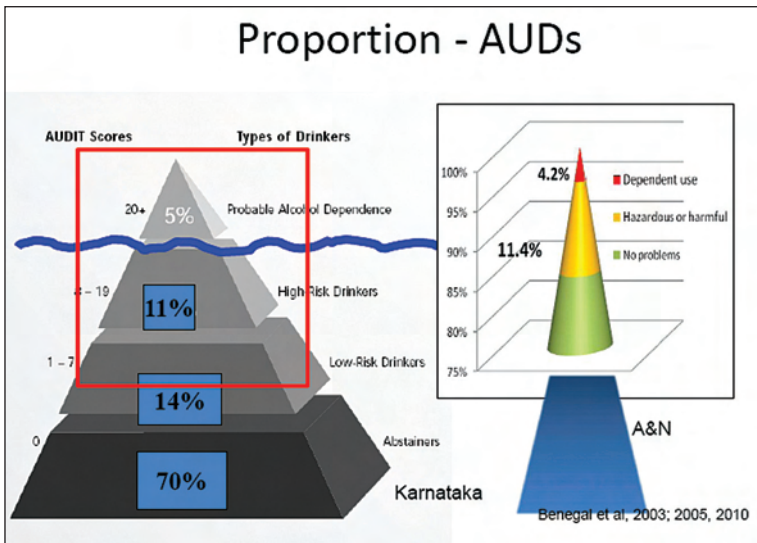


Figure 1.

It has been invariably been discussed that experts and lay people differ over the risk perception about the various technologies, natural hazards etc as far as its amount of risk concerned. People do not typically respond to the real risks, they act out on their own beliefs and perceptions.

What is not realized is that as far as the global burden of disease is concerned, alcohol use causes as much mortality much as mortality from contaminated water and poor sanitation. Proportion the risks are not perceived as the same.

But despite all the harm, alcohol is a low risk perception in public discourse. Unlike some of the topics that we will talk about, which without proper evidence have a huge risk perception. Risk perception is a subjective judgment that people make about the characteristics and the severity of the risk.

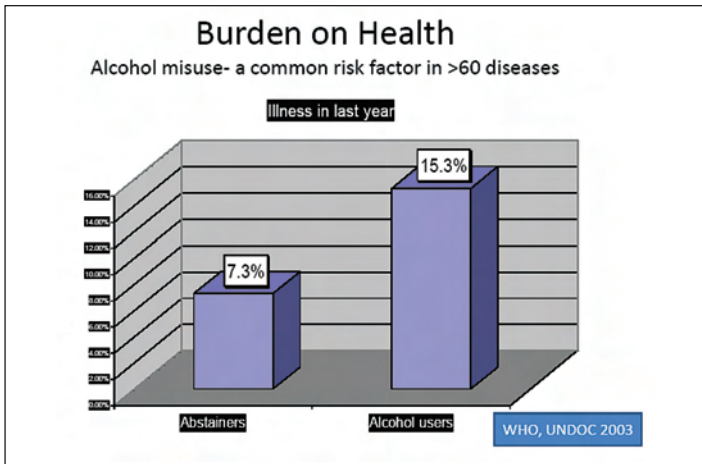


Figure 2. Burden on Health: Alcohol misuse- a common risk factor in >60 diseases.

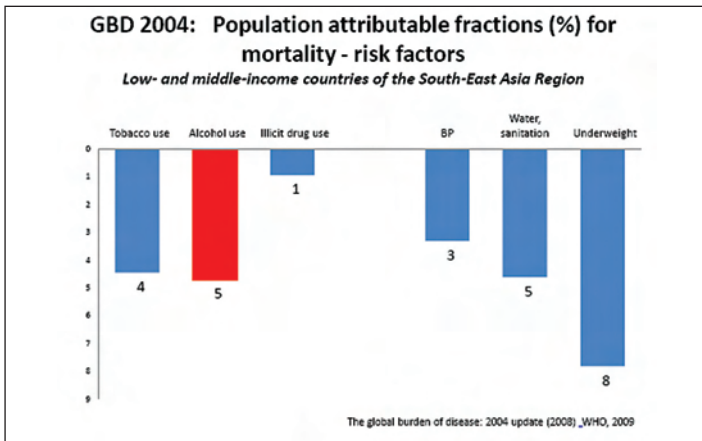


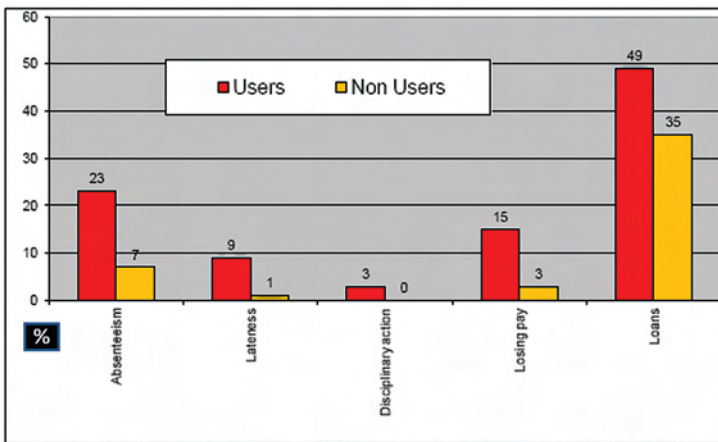
Figure 3. The global burden of disease 2004: Population attributable fractions (%) for mortality – risk factors (low- and middle-income countries of the South-East Asia region).

Alcohol and Infections

There is significant relationship between high risk sexual behaviour, HIV risk and alcohol use (Chandra et al 1999).

Alcoholism has been found to be an important factor in delay of diagnosis of tuberculosis in South India (Rajeswari et al 2002).

Occupational Problems



Gururaj, Girish & Benegal (2006) Burden & Socioeconomic Impact of Alcohol; WHO-SEARO

Figure 4. Occupational problems (Gururaj, Girish and Benegal, 2006: Burden and socioeconomic impact of alcohol, WHO-SEARO).

Now they use a number of heuristics to evaluate the information. Usually these are useful short cuts based on what people already know. Now the acceptance of a risk is related to how large it is, the benefits associated with the risk generating activity, for example, how beneficial is a nuclear power plant, versus how dangerous is it? And such qualitative factors determine the voluntariness of the risky activity.

Now these are some of the things which are also interesting to look at. Things which are imposed upon us cause greater fear.

Things which are likely to lead to more pain and sufferings like cancer cause greater fear. Human made events cause less benefit, greater fear. Uncertainty and risk to children – these are some of the things which generate more fear in the public discourse.

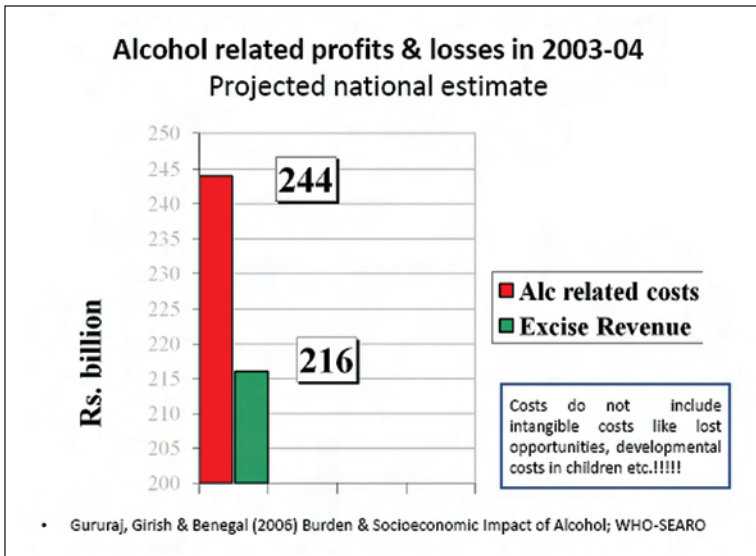


Figure 5. Alcohol related profits and losses in 2003-04 : Projected national estimate. (Gururaj, Girish and Benegal, 2006: Burden and socioeconomic impact of alcohol, WHO-SEARO).

Risk perception

- Subjective judgment that people make about the characteristics and severity of a risk.
- Experts and lay people often disagree about how risky various technologies and natural hazards.
- People typically do not respond directly to the real risks, they act on their beliefs or perceptions.

Psychometric Model

Greater Fear	Less Fear
Imposed (nuclear accident radiation)	Voluntary (medical radiation)
More Pain and Suffering (cancer)	Less Pain and Suffering (heart disease)
Human-made (radiation from technology)	Natural (radiation from the sun)
Less Benefit (vaccines for diseases that have been mostly eliminated)	More Benefit (vaccines for new strains of influenza – H1N1/"Swine flu")
Uncertainty (nuclear radiation – because we can't detect it, science doesn't have all the answers, or we don't understand all the science.)	Certainty/Familiarity – (motor vehicle crashes)
Risks to Children (childhood vaccines)	Risks to Adults (adult vaccines)

There is less fear – if it is voluntary, for example, the fact that I am going and having 20 X-rays and probably getting the same radiation of in voluntary nature does not cause so much fear in my mind. When it is no pain and suffering, natural radiation from the sun, that doesn't cause as much fear. When it has more benefit and it has certain familiarity with that particular technology, etc. and that is has more risks to adults than children, then fear about it comes down.

Alcohol is risk is perceived as old and well known. It has been with human beings since the beginning of time and has low and disastrous potential. This is what is there in public perception of the risk from alcohol. And so there is obviously a schism between what is really true and what is the public perception.

Compared to things like ageing, lightning, traffic accidents, industry pollution, etc, the difference between personal risk and general risk ... that is "I am at risk" to the "Population at risk" is

maximum for alcohol and it is probably minimal for other things like global warming, etc. Whereas here, there are other things like depletion of Ozone layer, global warming, there is quite a lot of concordance between "I am at risk" and "Everybody else is at risk".

People generally expect others to be more affected by alcohol than they would be themselves. With the exception of problem drinkers – people who drink a lot and who experience equally positive and much smaller negative effects than others. Generally personal risk is rated as greater – the higher the level of alcohol consumption that one has, there is a clear under-estimation of personal risk from alcohol.

Questions about smoking risk also show the same trend. The reason why we need to be worried about it is that it is well known that health promotion by means of campaigns is usually quite ineffective.

These difficulties may be related to the lack of insight into the personal risk the people frequently face. Perception of risk also differs with age and gender. With younger people, as far as drugs and alcohol are concerned, younger people less likely ... to actually twelve to thirteen year-olds, perceive smoking, drugs, marijuana to be than older people. This perception also differs with gender.

Women tend to look at some of these behaviours as of greater risk than men, in fact this is a study the 23 country study that we did, basically on nonrated use of alcohol in men and women in India, and what we found was that women tend to have more negative effects from alcohol than men did. Now, the second point I wish to make is that the public discourse on alcohol consumption like it has started off is very different from the reality. The public discourse is focused on the alcoholic and therefore it marginalizes and minimizes the risk as belonging to a small group of others. Not us. So the people who are at

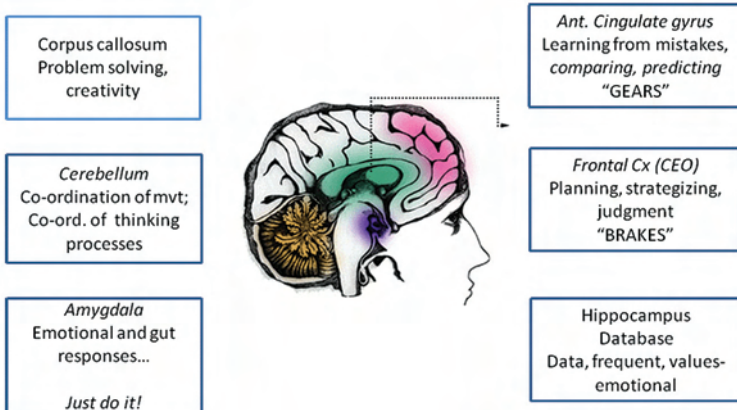
risk are what I call the four “P”s. the Poor – they drink because they don’t know what to do, the Primitive – the tribals drink because they are not educated enough. The Perverted, that is the rich and that kind of thing ... they drink ... what can we do? They have too much of money for their own good and lastly the Privileged.

So, if it is a problem related to a small proportion, then shut them up. This is the way we looked at asylums, this is the way we looked at sanatoria. We don’t know the reason why this is happening, if we don’t know why tuberculosis happens, so shunt the person off to a hill station where the cold climate will make the person better. And that is how we have looked at alcohol problems and how we have dealt with them.

Neurobiology of Risk perception and Communication

I have put these in deliberately because we were talking about some of these things.

How the Brain Works



Now it is important to understand how the brain perceives reward and risk. Now the most important things that the brain does is that it propels and motivates.

So, in other words, this is how people perceive risk. The other thing that you need to know is this perception is about general risk. They are parts of the brain which Ramachandran (2000) has famously alluded to as mirror neurons that mirror where the activity and thoughts reflects those of other people. This may happen in risk perception too.

The human brain has this capacity of filling in the dots or gaps. And this is very important when it comes to risk perception. I have some amount of information ... it is not full ... but my brain fills in the gaps, and makes a rope into a snake.

The take away from neurobiology is that we could use is that risk is related to high emotional value or failure. Something which has greater emotional value will always be perceived as the right message.

We should have for scientific communicators, a learning that we need to be able to pick up the game form the people who do advertising. We need to be able to sell scientific facts in the same way they sell soaps! Obviously people in science are not paid to do it. Then you should have someone who does that! First, it is always how you dress up the message. Second, you need to reduce cognitive dissonance. For example, whether I feel it for something or not depends on what is there in my database. What is there in my database is my father saying "Do not steal ... do not take anything from ... " ... there is no way I am going to do it or no way I am going to consider it. If I have to consider it, then the alarm bells will ring ... "Risky, risky, risky, risky ... don't do it!".

So when you give a message, you need to reduce the cognitive dissonance. Everybody's database, is full of "My god! We are all going to die!" as opposed to "we need lots of energy" That is a new fact. I mean, it does not ... it cannot come "My god! You are going to die!". The message should be openness and trust worthy.

One also needs to appear as open and trustworthy, because the brain also reacts and have a mechanism to look at and say this is pure stimulus and this is non –pure stimulus. This is an open phase, this is a closed phase.

The last is “reasoned evidence”. The problem with evidence is that we believe that “Oh! You must get evidence ... and evidence will trump all”. Unfortunately evidence creates more confusion.

As far as drugs and alcohol is concerned, adolescents and young adults are at risk, people who have this whole external behavior where they are impulsive, have more process of attention allocation, planning some mistake, hyperactive, you know... these are the same parts of the brain that I talked about which are involved in motivation and risk perception...

Kids have a poorer ability because the brain has not matured. The myelination or the insulation of the wiring of the brain does not occur till 23 or 25 and these areas of the brain are the last to mature. So, young people do not have the ability to really perceive risk. Of course, people who have had developmental stresses, people who grow with malnutrition, uncongenial environment, poverty in childhood, all these go to delay in maturation of the brain. So what we have been finding consistently in this spectrum of people. There is a need of impulsive experimentation, novelty seeking, peer influences is greater than parental warnings, and difficulty in learning from prior mistakes, and difficulty from assessing risk benefits. But what we do find is that adolescents have poorer risk perception because their brains are not mature or grown up enough and it is still a work of art in progress. But what we have been consistently finding. That when you look at children who are at high risk of developing problems, who have poorer risk perception, you will find in comparison, the children with better risk perception.

In children with poor risk perception that there are certain areas of the brain that are consistently smaller, grow at a slower pace, than children who are not at risk. And this is the pre-frontal area of the brain.

Offering more recent information is much better than peer campaign, as far as all the things are concerned. Peer campaign usually leads to immediate desire to experiment and try it out. So all the advertising that we do for drugs and alcohol are useless, a waste of money, because they only make young people go "Oh! That? Let's go and try that!".

To conclude, this is what we have learned from neurobiology;

- (i) It is that any information should have high emotional value, balance of emotional values, or failures. It must be something which is important, and it should strike an emotional chord in the person.
- (ii) It is that it should aim to reduce the cognitive dissonance or the gap between what I already know and what I really believe in and what you are telling me. And if it is out of sync with what I know, I am going to reject it.
- (iii) It is that it should be presented in a matter that it should be in an open and confidence inducing.
- (iv) It is that there should be presentation of reasoned evidence, not a huge mass of unsuitable evidence

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Chapter 6

Cellphones, Possible Risks: Can it Cause Brain Cancer?¹

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Introduction

There has been a sudden explosion in the use of cell phones over the last ten years. In India, millions of cell phones are being used, at all economic levels, with a significant impact on the economy and living style of individuals. As may be expected, the younger generation are the largest users of cell phones. Some of them use cell phones for hours.

In India, cell phone base stations are spread all over a city. There do not seem to be much concern expressed at any level

¹ (This article has two sections. In the first, the essential features of Cell phones and the Electromagnetic radiations are discussed. In the second section, the possibilities of brain Cancer emanating from the use of cell phones are discussed)

about health hazards, if any, caused by the proliferation of cell phones and base stations. Several International studies have been carried out. Some of the results do not warrant concern. Some of the studies are inconclusive.

It has been reported that reduction of population of some insects such as bees, has been observed in some places. It has been suspected that intense microwaves may be causing disorientation of some insects and birds. Birds are seldom seen to rest on the roof top towers that are cluttered all over Indian cities, possibly against rules which we seldom like to adhere to.

A brief account of Electromagnetic waves, used as carrier waves in Cell phones, is provided, with particular emphasis on thermal effects that it causes due to dielectric heating. This calls for a brief account of the structure of a cell phone and the transmitter and aerial where maximum intensity of the EM waves occurs.

Electromagnetic Waves and microwaves

We seldom realize that we are immersed in electromagnetic waves. Solar energy comes as electromagnetic waves, largely as visible light and infrared or heat. Besides, radio waves are all pervasive which enable us to tune in any station anywhere in the world. Light and heat waves are essential for life rather than being harmful. What is most important is the intensity of these waves. Intense light may be blinding and intense infrared may scald.

Figure 1 gives an Electromagnetic wave band and one may see that microwave occupies the range of about 800-2000 MHz (million cycles per second) placed between infrared and radio waves. At the high frequency and short wavelength end ,we have Gamma Rays, X'rays, which are high energy waves and can ionize an atom. It is known that Extensive exposure to X'rays can cause cancer.

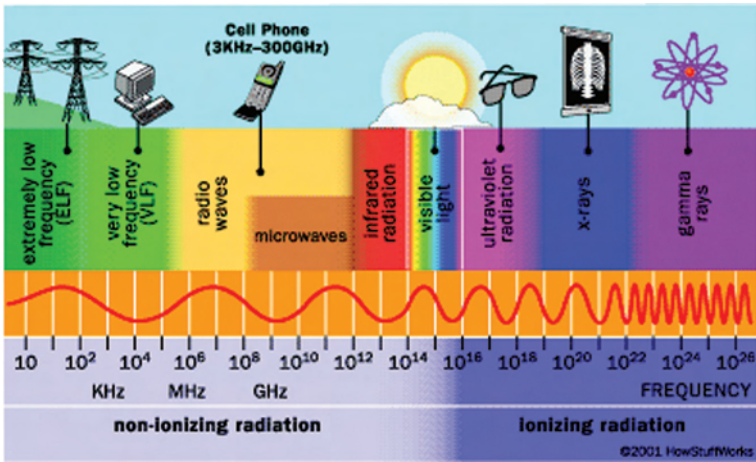


Figure 1:

Source: <http://electronics.howstuffworks.com/cell-phone-radiation1.htm>

These rays are *ionizing* and can break a DNA leading to cancer. Excessive exposure to ultra violet rays are also undesirable.

Microwaves are non-ionizing, much as visible light and infrared are, have lower frequency, longer wavelength (in mm-cm range) and less energy.

The energy from Infrared incident on a body is absorbed leading to the increase in molecular velocity and the temperature of the body increases (heating water by applying heat in a gas cooker). The thermal effect in a microwave oven is different. This is caused by what is known as di-electric heating.

Consider a molecule of water (or of some fatty tissues). In water two Hydrogen atoms are attached at an angle (almost 105 deg). The Oxygen end is more electronegative than the Hydrogen end and the molecule with opposite polarities at two ends acts as an electric dipole. When subjected to an alternating electric field, the dipoles try to align themselves with the direction of the field. In a microwave oven, this happens say

1000 million times in a second (the frequency of the microwave chosen) and the water. Molecules constantly hit each others and the "friction" generates heat. We shall presently see that although non-ionizing, a microwave operated cell phone has thermal effects which need to be considered for their possible ill effects.

A cell phone

A cell phone is so called not for its cellular structure but because the operational area of a phone is divided into a number of hexagonal cells. The frequency selected for one cell is different that of an adjacent cell but may be the same as a cell with any other non-adjacent cell. When a cell phone owner moves from one cell to the adjacent cell she is locked into a different frequency and that is what makes the cell phone a "mobile phone". A cell phone is some what like the chord-less phone in which the telephone behaves like the "base station" with the user "locked" into the base wireless with one frequency and within a limited range. The base emits the audio signal it receives from a caller using an electromagnetic wave as the carrier wave modulated by the audio signal. The intensity of the signal diminishes as one moves farther away from the base, becoming inaudible beyond a point. In a mobile phone the signal is picked up at a different frequency without interrupting the conversation.

Unlike in a telephone, the caller's audio signal is also delivered chord-less with the help of a carrier wave. In a radio, audio signals which are slow (1.6km in five seconds and get attenuated) are "carried" as it were by an Electromagnetic wave which travels at 300,000 km in one second and at the filtered by the receiver at the other end and amplified.

A cell phone has both a "Transmitter" an "antenna" and a "receiver" all built into a small place with the rechargeable battery, providing the power for transmission, reception and amplification occupying a disproportionately large space.

As has been stated earlier it is the intensity of the signal which is important and in the case of cell phone *Specific Absorption Rate (SAR)* is of significance. It measures the electromagnetic energy absorbed in a human body in weight in unit time and the unit of SAR is Watts/kg. (Watt is the unit of power or energy in unit time) The U.S., Canadian and Australian legal limit for SAR is no more than 1.6 W/kg, taken over a volume of one gram of tissue.

Cell phone generates di-electric heat in the tissues in the area against which the cell phone is kept pressed, the power density in the antenna being maximum. Since the user of cell phones is habituated to use the same side of the head and the same area the tissues tend to get heat heated and it is essential to study whether the thermal effect, which is likely to be cumulative, may cause any damage after several years of cell phone use.

Since microwaves, as stated earlier, are non- ionizing, the cumulative effects of ionization as may be in ultraviolet or X'rays may be ruled out where microwave or radio frequencies are concerned.

Health hazards of base stations

The base stations which monitor hundreds of cell phone all the time have antennas which are constantly receiving and transmitting signals may cause harm to the immediate neighbourhood since the signals are operative most of the time and may add up to cause more harm. The intensity of the signal decays inversely as the square of the distance and if the tower is tall the intensity of the signal reaching the ground is not sufficiently strong to be harmful.

A 2005 recommendation from a group of experts in France considered it mandatory that antennas should be located at more than 100 meters from primary schools or childcare facilities.

As stated earlier, rules and regulations in our country are violated with impunity and no studies seem to have been made about the hazardous effects, if any, of base stations on humans, like a shopkeeper who sits in a shop all day under an antenna, not very far above.

It is desirable that such studies be carried out by governments and regulatory bodies so that legislations, if required, may be passed to protect people from what may be a long term hazard from the use of telephones and/or base stations scattered all over a city.

Can cell phones cause cancer?

Cell phones emit radiofrequency energy (radio waves) is a form of electromagnetic radiation(non-ionizing radiation). Tissues nearest to where the phone is held can absorb this energy. Electromagnetic radiation can be categorized into two types: ionizing (e.g., x-rays, radon, and cosmic rays) and non-ionizing (e.g., radiofrequency and extremely low-frequency or power frequency) Exposure to ionizing radiation, such as from radiation therapy, is known to increase the risk of cancer. However, although many studies have examined the potential health effects of non-ionizing radiation from radar, microwave ovens, and other sources, there is currently no consistent evidence that non-ionizing radiation increases cancer risk .The only known biological effect of radiofrequency energy is heating. Radiofrequency exposure from cell phone use can cause heating but it is not sufficient to measurably increase body temperature. A recent study showed that when people used a cell phone for 50 minutes, brain tissues on the same side of the head as the phone's antenna metabolized more glucose than did tissues on the opposite side of the brain .

Although there have been some concerns that radiofrequency energy from cell phones held closely to the head may affect the brain and other tissues, to date there is no evidence from studies of cells, animals, or humans that radiofrequency energy can cause

cancer. It is generally accepted that damage to DNA is necessary for cancer to develop. However, radiofrequency energy, unlike ionizing radiation, does not cause DNA damage in cells, and it has not been found to cause cancer in animals.

Researchers have carried out several types of epidemiologic studies to investigate the possibility of a relationship between cell phone use and the risk of malignant (cancerous) brain tumors, such as gliomas, as well as benign (noncancerous) tumors, such as acoustic neuromas (tumors in the cells of the nerve responsible for hearing), most meningiomas (tumors in the meninges, membranes that cover and protect the brain and spinal cord), and parotid gland tumors (tumors in the salivary glands) In one type of study, called a case-control study, cell phone use was compared between people with these types of tumors and people without them. In another type of study, called a cohort study, a large group of people is followed over time and the rate of these tumors in people who did and didn't use cell phones was compared. The results of these studies have generally not provided clear evidence of a relationship between cell phone use and cancer, but there have been some statistically significant findings in certain subgroups of people.

Examples of case control studies:

The Interphone Study, conducted by a consortium of researchers from 13 countries, is the largest health-related case-control study of use of cell phones and head and neck tumors. Most published analyses from this study have shown no statistically significant increases in brain or central nervous system cancers related to higher amounts of cell phone use.

A cohort study in Denmark linked billing information from more than 420,000 cell phone subscribers with brain tumor incidence data from the Danish Cancer Registry. The analyses found no association between cell phone use and the incidence of glioma, meningioma, or acoustic neuroma, even among people who had been cell phone subscribers for 10 or more years.

Early case-control studies in the United States, Europe, and Japan were unable to demonstrate a relationship between cell phone use and glioma or meningioma. Some case-control studies in Sweden found statistically significant trends of increasing brain cancer risk for the total amount of cell phone use and the years of use among people who began using cell phones before age 20.

However, another large, case-control study in Sweden did not find an increased risk of brain cancer among people between the ages of 20 and 69. In addition, the international CEFALO study, which compared children who were diagnosed with brain cancer between ages 7 and 19 with similar children who were not, found no relationship between their cell phone use and risk for brain cancer.

Reasons for these discrepancies include the following:

- Recall bias, which may happen when a study collects data about prior habits and exposures using questionnaires administered after disease has been diagnosed in some of the study participants. Many epidemiologic studies of cell phone use and brain cancer risk lack verifiable data about the total amount of cell phone use over time.
- Inaccurate reporting, which may happen when people say that something has happened more or less often than it actually did. People may not remember how much they used cell phones in a given time period.
- Morbidity and mortality among study participants who have brain cancer. Gliomas are particularly difficult to study, for example, because of their high death rate and the short survival of people who develop these tumors. Patients who survive initial treatment are often impaired, which may affect their responses to questions
- Participation bias, which can happen when people who are

diagnosed with brain tumors are more likely than healthy people (known as controls) to enroll in a research study. Also, controls who did not or rarely used cell phones were less likely to participate

- Changing technology and methods of use. Older studies evaluated radiofrequency energy exposure from analog cell phones. However, most cell phones today use digital technology, which operates at a different frequency and a lower power level than analog phones. Digital cell phones have been in use for more than a decade in the United States, and cellular technology continues to change. Texting, for example, has become a popular way of using a cell phone to communicate that does not require bringing the phone close to the head. Furthermore, the use of hands-free technology, such as wired and wireless headsets, is increasing and may decrease radiofrequency energy exposure to the head and brain.

Studies from major organizations

The International Agency for Research on Cancer (IARC), a component of the World Health Organization, has recently classified radiofrequency fields as “possibly carcinogenic to humans,” based on limited evidence from human studies, limited evidence from studies of radiofrequency energy and cancer in rodents, and weak mechanistic evidence (from studies of genotoxicity, effects on immune system function, gene and protein expression, cell signaling, oxidative stress, and apoptosis, along with studies of the possible effects of radiofrequency energy on the blood-brain barrier).

The National Institute of Environmental Health Sciences (NIEHS) states that the weight of the current scientific evidence has not conclusively linked cell phone use with any adverse health problems, but more research is needed.

The U.S. Food and Drug Administration (FDA), which is responsible for regulating the safety of machines and devices

that emit radiation (including cell phones), notes that studies reporting biological changes associated with radiofrequency energy have failed to be replicated and that the majority of human epidemiologic studies have failed to show a relationship between exposure to radiofrequency energy from cell phones and health problems.

The U.S. Centers for Disease Control and Prevention (CDC) states that, although some studies have raised concerns about the possible risks of cell phone use, scientific research as a whole does not support a statistically significant association between cell phone use and health effects.

The Federal Communications Commission (FCC) concludes that there is no scientific evidence that proves that wireless phone use can lead to cancer or to other health problems, including headaches, dizziness, or memory loss.

Studies that will help further our understanding of the health effects of cell phone use

A large prospective cohort study of cell phone use and its possible long-term health effects was launched in Europe in March 2010. This study, known as COSMOS, will enroll approximately 250,000 cell phone users ages 18 or older and will follow them for 20 to 30 years. Participants in COSMOS will complete a questionnaire about their health, lifestyle, and current and past cell phone use. This information will be supplemented with information from health records and cell phone records.

Do children have a higher risk of developing cancer due to cell phone use than adults?

In theory, children have the potential to be at greater risk than adults for developing brain cancer from cell phones. Their nervous systems are still developing and therefore more vulnerable to factors that may cause cancer. Their heads are smaller than those of adults and therefore have a greater proportional exposure to the field of radiofrequency radiation

that is emitted by cell phones. And children have the potential of accumulating more years of cell phone exposure than adults do.

So far, the data from clinical studies in children do not support this theory. The first published analysis came from a large case-control study called CEFALO, which was conducted in Denmark, Sweden, Norway, and Switzerland. The study included children who were diagnosed with brain tumors between 2004 and 2008, when their ages ranged from 7 to 19. Researchers did not find an association between cell phone use and brain tumor risk in this group of children. However, they noted that their results did not rule out the possibility of a slight increase in brain cancer risk among children who use cell phones, and that data gathered through prospective studies and objective measurements, rather than participant surveys and recollections, will be key in clarifying whether there is an increased risk.

Conclusion

It is difficult to give a definitive answer to the question of whether the use of cell-phone may cause brain cancer or other health problems. Since the extent and duration of the use of cell phones have been increasing, particularly among the younger population, certain precautions should be taken to avoid potential hazards that may not be totally ruled out.

The FDA and FCC have suggested some steps that concerned cell phone users can take to reduce their exposure to radio frequency energy.

- Reserve the use of cell phones for shorter conversations or for times when a landline phone is not available.
- Use a hands-free device, which places more distance between the phone and the head of the user.

Hands-free kits reduce the amount of radiofrequency energy exposure to the head because the antenna, which is the source of energy, is not placed against the head.

References

Fig 1 – Source quotes : Sites consulted: <http://www.cancer.gov/global/web/policies> <http://www.electronics.howstuffworks.com/cell-phone-radiations1.htm>

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Discussion

Prof Vivek Benegal: The issue of alcohol use/abuse is perceived usually as the problem of alcoholism which affects 5% of adult males. Public perception of alcohol use/abuse is usually restricted to the issue of alcoholism. Alcoholism tends to be viewed mostly as a general risk rather than a personal risk. There is less fear regarding this issue (because it is kind of voluntary, one gets into it and there are ways of getting out unlike diseases like cancer over which one has no control). The psychometric model views this issue as linked to developmental stresses. There are neurobiological reasons behind risk-related behaviors but this is not a simple deterministic model. What Prof Benegal rightly points out is that in deterring risk-related behavior when it comes to alcoholism, drugs or smoking is the need to personalize the message so that it hits home to the right spot.

Prof D P Sen Gupta, NIAS & Dr.Vani Santosh, NIMHANS: Cell phone usage and risks regarding brain cancers is a pressing issue given the widespread use even among children. As Prof Sengupta pointed out, microwaves used as carrier waves to transmit and receive audio signals are thought to cause brain cancers. However, as Dr Vani Santosh pointed out through reference to studies made, the induction time is over several decades. There does not seem to be conclusive studies regarding the magnitude of the risk involved. Some studies have shown

that the risk of developing brain tumor on the same side of the head preferred for cell phone use. Radiation used to kill primary tumors of the brain often leaves the patient with a risk of developing a secondary tumor post-treatment. This can in a way be linked to the risk of cell phone and brain cancers. (Gap – What about the other technologies associated with cell phones apart from the magnetic waves? Bluetooth, infrared, wireless etc.

We looked at the thermodynamic image of a brain that was under cell phone conversation for about 15 min. What does this imply? Does it mean that some sort of damage is done to the brain but it may not be cancer? (Just like TV, computers cause problems like Attention Deficit Disorders, are there any studies linking cell phone usage to such problems? What about stress etc?)

Namitha Kumar

Chapter 7

Demystifying GMOs in India (Public Risk Perception of – Genetically Modified (GM) Crops)

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While I hear and read a great deal in the media about concerns and apprehensions about GM foods these days, I am convinced that more efforts are needed on the part of the scientific community towards disseminating factual information related to GM technology and creating public awareness on the safety and benefits of this modern and potential technology. This note is a small step in this endeavor.

Application of modern biotechnology for crop improvement is one of the most significant technological advances to impact modern agriculture in the past twenty five years. Since their first approval for commercial cultivation in the USA in 1996, genetically modified (GM) crops, as of 2010, are grown on about 148 million hectares (650 m acres) in 29 countries, including India, by 15.4 million farmers (James, 2010). In India, *Bt* cotton which is the only GM crop approved since 2002, is cultivated on over

10.0 m ha by 6.0 m farmers, reflecting their vote of confidence in this technology (Manjunath, 2011). Researchers in this field are transferring genes into plants to impart resistance to herbicides, biotic and abiotic stresses (insects, disease, drought, low temperature and soil mineral stresses, storability of products etc), besides enhancing nutritional quality of foods and production of pharmaceutical and industrial products. Biotechnology can aid in producing new varieties more quickly and efficiently, and it can introduce desirable traits into plants that could not be established through conventional plant breeding techniques. Here are some scientific reasons as to why many apprehensions regarding biotechnology are unwarranted.

Mode of pollination

Adding some new genotypes through genetic engineering or conventional breeding techniques to the existing germplasm (varieties), for the benefit of the farmers, does not pollute or contaminate or destroy native germplasm. Life began with a single cell (unicellular) and multicellular organisms came into existence as the evolution progressed and diversity has been expanding all the time on account of genetic and environmental conditions and their interactions (Lemaux, 2009). Destruction of biodiversity is occurring by unscientific and irrational diversion of the pristine forest and agricultural lands for commercial purposes through land grabbing (habitat destruction), an all too common occurrence in the developing countries.

Though new genotypes are being added by nature and by human selection, the mode of pollination specific to crop does not change. There is no scientific evidence to suggest that GM varieties changed the mode of pollination, contaminated native species or destroyed the native germplasm after their introduction into the counties growing GM crops (Lemaux, 2009). Farming, which is constantly expanding for increasing food and fodder production, by itself, might have reduced habitats of wild germplasm to some extent. It is to conserve the germplasm many gene banks are in place in most countries. In India, National Plant

Genetic Bureaus (NBPGR, NBAGR, NBFGR, NBAIM and NBAII for plant, animal, fish, agriculturally important microorganism and insects, respectively), which are the third largest facility in the world, are conserving both wild and cultivated germplasm *ex-situ* and *in-situ*. Farmers are also participating in this activity as partners with National Active Germplasm Sites (NAGS) for *in situ* conservation.

Bt Cotton

Bt cotton is the first and the only GM crop under cultivation in India. The fact that Bt cotton revolutionized cotton production in India bringing it to second position from the fifth position in the world stands as testimony for success of the first GM crops technology. In addition, there is drastic reduction in use of pesticides obviating environmental pollution and enhancing the profit margin of farmers, a win-win situation in environmental economic terms (Naranjo and Ellsworth, 2009; Kalyan, 2010). This is an apparent illustration of the ways and means of conserving the genetic wealth of cotton adopting both *in situ* and *ex situ* methods. There is significant contribution from the farming community *in situ* conservation which needs to be recognized. In fact, for the first time in the history, the Prime Minister of India recognized farmers of Karnataka and Orissa states for their conservation efforts on July 16, 2011 on the foundation day of Indian Council of Agricultural Research, New Delhi.

Development of varieties in the National Agricultural Research System (NARS) in India

NARS in partnership with farmer/scientists, traditional way of selecting improved ones, hundreds of new varieties and hybrids are released both from public and private sectors. Most of these are improvements of the local traditional cultivations to meet the productivity and quality requirements. These efforts cannot be treated as biopiracy as some NGOs allege. NARS has the right to use varieties for improvement and has been doing since ages. The Seed Act and seed rules, under *sui generis* system

in vogue in India, clearly exempt the use of native germplasm by farmers and the researchers.

Challenges posed by climate change and diminishing forest area and shrinking agricultural land

With climate change destabilizing the agro climatic conditions in which water and arable land are reduced, modern biotechnology comes in handy to mitigate and improve productivity through varietal improvement, including hybrids which can tolerate harsh environments. Biotechnological tools are powerful and need to be exploited to meet the future challenges arising out of climate change and declining land productivity including large scale conversion of agricultural lands for non agricultural purposes.

Biosafety

It is a matter of serious concern in the minds of the public that needs to be addressed. Therefore, all biosafety issues become important that is the reason that, in all countries, biosafety committees are in operation. Government of India has established a statutory regulatory committee of experts to assess biosafety of biotechnology products. The biosafety committee should take care of this aspect and it is why it should be broad based representing all stakeholders with experienced and knowledgeable members to guide the research activities keeping biosafety as the prime concern. What is often not realized by the critics as well as by public is that in every country, every biotech product is subjected to stringent biosafety and agronomic tests before they are approved as safe for commercial cultivation. In India, *Bt* cotton has undergone such tests for 7-8 years and the safety data are posted by the Dept of Biotechnology (DBT), Govt of India, in the public domain (website of IGMORIS).

Intellectual Property Rights

There is general ignorance about the provision that plant varieties can be registered according to Protection of Plant

Varieties and Farmers' Rights Act (PPV & FRA). It is necessary to understand and appreciate that the crops and varieties can be registered with PPV & FRA as the property of individuals or organizations and that there is a system to conserve germplasm (Kowalski et al., 2002).

All the stakeholders involved in the research on transgenics, GMOs and genetic engineering need to be fully aware of the provisions in the genotypes for conversion through the related Acts (PPV & FRA; NBA; Seed Act & Rules etc.). While BD Act 2002 makes provision to use germplasm by the public institutions for the public good development, it also provides the necessary frame work for equitable sharing of profit among the people who conserved the germplasm. It is also the NBA's responsibility to educate the public and demystify all rules and regulations I on their website. Activists and NGOs also need to make use of the provision made in PPV &FRA, NBA and State and GoI Departments to create awareness on the new Acts.

Misconceptions

Many in the public have misgivings, apprehensions and misconceptions about the GM crops. It is important to realize that safety is accorded the highest priority in biotechnology and allay such fears by providing explanations based on scientific facts (Manjunath, 2011). Some of these are highlighted below:

GM crops have terminator gene: There is a fear that GM seeds have terminator gene blocking the germinating capacity of the seeds of next generation of a variety forcing the farmer to buy seed every time. There is no terminator gene being used in any breeding programme either with the public or with private sector.

The soil gets contaminated and fertility goes down: A vast area is planted to GM crops in many countries. There is no data or any scientific basis to fear this.

GM crops promote monocropping: It is often quoted that in India GM crops have promoted monocropping since Green Revolution time. The first GM crop to enter Indian soil was Bt cotton which was allowed for commercialization only during 2002. Green revolution in India was due to adoption package of high yielding and hybrid varieties with suitable package of practices and quick adoption by farmers, even before GM technology research commenced in India!

Safety of Bt Cry proteins: Be it cotton or brinjal, the cry 1 class of proteins have selective toxicity to certain category of insects called Lepidoptera. Cotton boll worms and fruit and shoot borers of brinjal, require certain specific conditions for their effective action. The protein has to be ingested by the target insects which happen when the caterpillars feed on the transgenic plant tissues. It requires an alkaline pH of 9.5 or above for effective processing and also specific receptors for binding before it can kill the target insect. All these conditions are available in cotton bollworms and brinjal fruit and shoot borers and, therefore, those caterpillars get killed when they feed on them. The protein cannot act in the human or animal intestine because their intestine is acidic, pH is about 3.5 and there are no receptors. Hence, *Bt* protein is safe to such non-target organisms. The cry proteins produced in *Bt*-cotton or brinjal have been shown to rapidly degrade when crop residues are incorporated into the soil. Thus, the impact of these crops on environment and human safety is negligible. This is further supported by the long history of safe use of *Bt* microbial spray formulations for control of insect pests on a variety crops all over the world for more than 40 years.

GM crop seeds can be produced and sold only by multinational companies: This is not true. Public organizations are researching now and will soon come out with GM varieties/ hybrids and private companies will have no role on seeds of such seeds unless there is agreement to that effect. Farmers can be trained to produce their own seeds. Only in respect of specific hybrids developed by private companies farmers will have to go to

MNCs. This could help to clear the doubts prevailing in minds of activists and some NGOs that this technology is the monopoly of MNCs. Bt brinjal varieties being developed at University of Agricultural Sciences, Dharwad are one such example where farmers can produce their own seeds and share with fellow farmers.

The traditional varieties will be contaminated and biodiversity disturbed: This is not true and has no scientific basis as explained above in this article. Several varieties have been co-existing and the new genotypes will be added as accessions to the existing germplasm. The nature of pollination does not change if a few new genotypes are added. There is no evidence that, with addition of new genotypes the traditional biodiversity is contaminated.

Inadequate testing: This seems to be a serious concern of many. There is a committee that evaluates the biosafety of every GM crop. This committee called GEAC has been doing its job competently for over 15 years now.

GM technology needs to be encouraged. Delaying their development and release for reasons which are not scientific is denying the Indian farmer the benefit of science! China is harvesting science and technology benefits through quick adoption of technologies that are developed from time to time and hence their productivity level is of the order of twice that of Indian farmer. Indeed, never before in the history of mankind the food crop varieties were subjected to the rigorous tests the GM crops are being subjected. If need arises, it can be made even more rigorous.

Benefits from Bt. cotton: Both pre- and post-commercialization studies conducted by several public and other institutions have clearly indicated that Bt cotton has been beneficial to farmers. The increase in yield due to effective control of bollworms was 37%, reduction in chemical sprays 41%,

increased in net profit to a farmer was about 89% that accounted for about US\$131 (Rs.7,750=00) per hectare (Qaim, Subramanian and Sadashivappa, 2009), acknowledging that benefits will vary from year to year depending upon the weather factors and pest intensity.

Conclusions

With a rising population, depleting land and water resources and rapidly increasing food prices, India needs cutting edge crop technologies to enhance farm output and achieve overall food security. The impacts of such changes have been significant in India's cotton sector, but less so in case of the country's main cereal crops, where both yield and output growth rates have been relatively stagnant. Genetically Modified (GM) technology is a globally recognized way to improve productivity, profitability and sustainability of farm production systems, including the small farm holdings. At present public perceptions about GM technology are often not based on scientific facts. It is an irony that on one side we are testing and releasing pesticides on a regular basis that are harmful to ecosystem and on the other we pose hurdles in releasing biotech products that reduce the use of pesticides quoting the same environmental concerns! Information communication system, including public extension and awareness services, need to be considerably improved in order to effectively deliver correct and unbiased information to farmers and the general public. The benefits of the technology far outweigh any risks and we must embrace the opportunities created by it. It should be realized that biotechnology research is meant for human welfare and should be harnessed for lifting people out of poverty.

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Chapter 8

Threat Perceptions of Gene Manipulation

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Modern agricultural technology was introduced to a largely uneducated Indian farmers through inputs distributed by untrained vendors. Our granaries are full and the agribusiness companies are rich but the public perception of the Green Revolution remains negative. Our farmers are in deep debt, sick with cancers and fluorosis, the fields have become contaminated with poison, groundwater is depleted and the pests have developed resistance. Consequently the public is wary of any new technology especially if it is pushed by a not-so-credible multinational company. Besides, arguments against GM technology are much stronger in Indian context than in Europe or any other developed society because of the vulnerability of the Indian farmers to manipulations by powerful lobby of some multinational corporations. While in Europe opposition to GM foods is consumer driven, in India it is driven by the farming community, backed by NGOs and proactive media. The threat perception is enhanced thanks to questionable integrity of the scientists and those sitting in the approval committees.

Karnataka has seen many battles against the GM technology. In fact, the first battle in India against Transgenic Species, i.e, Bt cotton took place here in Haveri district some 15 years ago. An army of farmers under the banner of Karnataka Rajya Raita Sangha (KRRS), went to the trial field of Bt cotton and uprooted the crop and put fire to it. 'We will not allow any multinational company to set foot in our land' said Prof. Nanjundaswamy, the then President of KRRS. It true that some individual farmers have since embraced Bt cotton, the farmers organization continues to oppose GM crops. There is no respite. Just last year there was another surprise attack on the testing fields of GM crops near Bangalore.

Controversy regarding the Genetic Engineering being largely an off-shoot of the prevailing Green activism in Karnataka it may be worthwhile to trace the evolution of environmental awareness in this state.

Karnataka was pioneer in many environmental movements. The first ever people's movement against major dams was witnessed here in Bedthi valley. The first ever National Seminar on Major Dams was organized 30 years ago in a place called Sirsi presided over by Dr. Shivaram Karanth, the Jnanapeeth awardee whose name I recall here with special reverence because he is considered as the father of Environmental movement in Karnataka. He took leadership not just against major dams like Bedthi and Sharavati but also against the Kaiga Nuclear Power Plant, Harihar polyfiber factory and Ecalyptus monoculture. He was the first to translate a huge volume of the first ever Citizens Report on India's environment. And was probably the only person in India to translate into a vernacular language 'Our Common Future' written by Gro Harlem Brundtland, the then Chairperson of the World Commission on Environment. Both these tomes were published by a very respectable Akshara Prakashana. Shivarama Karanth was very vocal in defending the common assets of the country in his speeches, articles and even letters to the editors. He even contested for a Parliament Seat

from South Canara constituency, thus becoming the first (and probably the only) Green Candidate.

Besides Shivarama Karanth, the Gandhian activist Sundarlal Bahuguna inspired young people here to initiate the first Appiko movement, the tree hugging satyagraha akin to Chipko in the Himalayan region.

Karnataka was fortunate to have many scientists from respectable academic institutions like IISc and IIM. Dr. AKN Reddy of IISc strived to take technology to rural areas by establishing an exclusive unit called ASTRA and Dr Madhav Gadgil worked on the ecosystem of certain sections of the Western Ghats. While Dr. DK Subrahmaniam worked on the energy scenario, Dr. K.S Jagdish worked on low cost construction materials. While Dr. Vandana Shiva of IIM worked on the farmers issues, Dr. Cecil Saldanha began publishing a series of volumes on the State Environment in Karnataka. Each of the of work of theses learned people had contributed towards raising public awareness about the impact of modern technology on our ecosystem and rural life.

No wonder Karnataka had so many firsts in the arena of green activism. No wonder it was the first to oppose nuclear hegemony in India. The people of this state opposed the setting up of a nuclear power plant at Kaiga. At this juncture I should also mention the name of Dr. DP Sengupta one of the participants of today's deliberations. While the majority of scientists were silent on the nuclear issue and while other scientists were giving silent blessing to the antinuclear groups, it was Dr. Sengupta's lone voice against nuclear technology that added the necessary impetus. For nearly five years he was the darling of the media which wanted some scientists who could be critical about our nuclear empire.

Awareness about destructive developmental projects touched not only the students community, Civil Society groups and the literary circle it also reached the farming community early in the

80s. Farmers groups were seen uprooting monoculture plantations raised by the forest department. There were demonstrations against the new patent regime. The farmers attacked the office premises of Cargill Seed Company and also Kentucky Chicken.

There is a strong reason for farmers being suspicious of modern technology. In the name Green Revolution what we have done to farming community is well known. More than 180,000 farmers have committed suicide. Modern agricultural technology was introduced to a largely uneducated Indian farmers through inputs distributed by untrained vendors. Our granaries are full and the agribusiness companies are rich but the public perception of the Green Revolution remains negative. Our farmers are in deep debt, sick with cancers and fluorosis, the fields have become contaminated with poison, groundwater is depleted and the pests have developed resistance. Consequently the public is wary of any new technology especially if it is pushed by a not-so-credible multinational company. It is quite natural that the farmers feel vulnerable to manipulations by powerful lobby of some multinational corporations. The threat perception is enhanced thanks to questionable integrity of the scientists and those sitting in the approval committees.

The threat of Transgenic Crops should be viewed with this backdrop.

Let us now look at the sources of these threats:

Issue of Concern No.1 :

It is a well known fact that the multinational company Monsanto has pioneered this technology. If we just type a search word 'Monsanto' in any internet browsers and look for images what we get is mostly a set of negative images. It is shown as a monster. A large number of entries in the internet in any browser paint a very disturbing pictures of this global giant. Most of its 100 years' history comprises of production of hazardous chemicals like DDT, PCBs, herbicides and bovine growth hormones. It

has faced several law suits by citizens and the US government agencies and has paid heavy fines for unleashing many unsafe products and careless disposal of hazardous wastes.

Issue of Concern No. 2:

There is no recall facility if the GMOs turn out to be rogue elements. Once you release a new organism in the open environment nothing can be done to retrieve it.

Issue of Concern No. 3:

Consumption of GM food may reduce immunity system in human body. Further, it also would affect the digestive, metabolic functions and may cause carcinoma.

There is no substantial research to look into the long term impact of GMOs.

Issue of Concern No. 4:

Threat to Crop diversity. Already crop diversity has been threatened due to overemphasis on certain crop varieties that are successful in the market. Moreover if this particular gene escapes into the environment it may contaminate the natural varieties. Especially India being a region of very rich biodiversity, precautionary measures should have been a top priority.

Issue of Concern No. 5:

Threat to Farmers freedom: Monsanto sued farmers who attempted to save the seeds. It hires detectives to spy on the farmers. Whistle blowers are harassed, marginalised, defamed or otherwise intimidated into silence. There were cases of organic farmers suing Monsanto for contaminating their field.

Issue of Concern No. 6:

Threat to India's sovereignty

Bypassing the Law of the Land: Mahyco, a partner of biotech giant Monsanto, and their collaborators have accessed

local brinjal varieties to develop Bt Brinjal without the prior approval of the National Biodiversity Authority of India.

These companies bypass the grassroot democratic institutions like Gram Panchayat and take up trial farming without informing the farming community.

Issue of Concern No. 7:

False Promises to farmers

Genetic Engineering has failed to increase the crop yield substantially. In a report, "Failure to Yield: Evaluating the Performance of Genetically Engineered Crops," Doug Gurian-Sherman, a biologist in the UCS Food and Environment Program says, "In comparison, traditional breeding continues to deliver better results." Indian Farmers, already under heavy financial burden, may lose both their profit and native gene pool. recent studies have shown that organic and similar farming methods that minimize the use of pesticides and synthetic fertilizers can more than double crop yields at little cost to poor farmers in such developing regions as Sub-Saharan Africa.

Issue of Concern No. 8.

Threat of Super Weeds and Super Insects: insects will become resistant to crops that have been genetically-modified to produce their own pesticides.

Issue of Concern No. 9.

Threat to scientific freedom: Unethical restrictions on scientists: The Bt gene 'Cry1' was given to academic scientists in Dharwar under the condition that they should not develop hybrid varieties of their seeds.

Issue of Concern No. 10

Unethical Approvals: GEAC has become Appraisal Committee, rather than Approval committee. And our scientists have become mere rubber stamps.

There are other issues like Labeling a genetically modified food item. Such proposals are highly untenable in India. GM Food labeling will not be practical where a large number of villagers are illiterate and where unpacked food items are sold in village markets or even in City Malls. Consumer protection will be compromised.

It is quite obvious that the multinational corporate bodies are planning to take over food production from Indian farmers. These are the very corporate bodies that have enslaved the farmers in the name of Green Revolution. They unleashed a series of deadly chemicals to our soil and water bodies and reaped enormous benefits in the name of the farming community. Now they are introducing a range of untested new organisms. We are compromising not only our food sovereignty but also the health of our future generation.

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DISCUSSION

Prof. Mahadevappa discussed that there is a need of public awareness education on GM Technology on part of scientific community. Though Professor was neither in favour nor against of the use of GM Technology but he talked of various apprehensions about genetically modified crops that exist in people's mind like idea of terminator gene, contamination of soil & decreased fertility, *Bt* cry protein safety, selectivity and spread, GM seeds production by multinational companies, loss of biodiversity etc.

Rising population, depleting land & water resources, rapidly increasing food prices puts India to adopt cutting edge technologies to enhance farm output & achieve overall food security. Genetically Modified (GM) technology can be a promising technology only if public perceptions about it are based on scientific facts and not just media speculations and in order to do that information communication system, including public extension and awareness services, need to be considerably improved to effectively deliver correct and unbiased information to farmers and the general public.

Dr. Nagesh Hegde discussed the ten issues of major concern of GM Technology like tainted flagship in Monsanto's hands to horizontal transfer of gene and superweeds, patenting the farmer's rights, gutter science etc. He said, while in Europe,

opposition to GM foods is consumer driven, in India it is driven by the farming community backed by NGO's and proactive media.

The question raised by him, whether GM crops are threat or boon will continue to remain if the scientist and approval committees do not do anything in mitigating these apprehensions from people's mind.

Geetanjali Yadav

Chapter 9

Public Perception of the Seriousness of Climate Change as a Problem

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After the almost saturation coverage by the print and television media of climate change as an issue leading up to the Copenhagen summit meeting in December 2009, the public perception of the seriousness of climate change as a problem has begun to decline. This is true in most of the countries where opinions are being tracked by the Pew Research Centre's Global Attitudes Project. Thus, whereas 67% of the respondents from India viewed climate change as a very serious problem in 2009, only 62% were of that view in 2010. The declines in many other countries have been more dramatic. In the US, only 37% of the respondents in 2010 viewed climate as a very serious issue, whereas 47% had done so in 2007. In Britain the decline was 16%, in Japan, Poland and Spain 20%. In France it was 26%, and in Pakistan 28%. This means at a time when scientific evidence was still accumulating, as much as a fourth or a fifth of populations in many countries stopped believing in the seriousness of the problem in a span of one to three years. There are dimensions

of risk, benefits and consequences that go to decide when a risk acceptance is a matter for individual determination and when it calls for public intervention. With these dimensions we can create typologies that can help us understand societal responses to risks. In the climate case, several factors make it a difficult problem to address and a different problem from that of stratospheric ozone depletion. The so-called climate sceptics and the media are important in determining the perception of the public.

Introduction

Almost everywhere where public opinion is being tracked from year to year, the perception of the seriousness of climate change as a problem has begun to decline. Before presenting the data on these declines and some of the reasons for them, I would like to discuss under what circumstances an environmental or a public health problem becomes a case fit for societal intervention and when society leaves it to individuals or individual companies to deal with. There are at least 5 broad dimensions which go enter into this consideration: risks, consequences, benefits, transaction costs and control costs. We will consider each briefly in turn.

Research in Risk Analysis has shown that whenever risks are voluntarily assumed (as in the case of bungee jumping), when they are occupational or concentrated to a few people (doubles in movies), when they are known, or if the exposure is a luxury, when there are alternatives available, then society leaves the decisions to deal with the risk to individuals or individual firms. On the other hand, when risks are involuntary, when they affect ambient concentrations, are diffused, uncertain, essential, without alternatives, then a case can be made for social intervention.

Similar sub-dimensions for consequences are when the effects are acute or immediate, they affect the average person, they are local, they result from use as opposed to misuse, they are not feared and have are high probability of low outcomes,

these cases are left for individual determination. A stronger case for societal intervention will be made when consequences are chronic or delayed, affect the sensitive part of the population, are global, when consequences are dreaded and have low probability of high consequence.

Similarly if the benefits from the activity are small and concentrated, society chooses not to intervene as opposed when these are large and widespread. When both transaction costs and costs of control are high, society is more likely to intervene.

Using some of these dimensions of risks and benefits, typologies are created to study societal responses to various problems. These typologies can be useful in predicting responses to new hazards when they arise. One example is given in Table 1 (Ahuja, 1981).

Table 1: Example of a Risk-Benefit Typology

		BENEFITS	
		Concentrated	Diffuse/Widespread
RISKS	Concentrated	Drugs	Occupational Hazards
	Diffuse	Pesticides	Automobiles, Climate Change (?)

Since both the risks and benefits (of not taking action) are widespread and diffuse, climate change is an appropriate arena for societal action and less so for individuals.

Public Perception of Climate Change

With the exception of Indonesia and Lebanon, wherever public attitudes towards climate change are being tracked by the PeW Research Centre's Global Attitude Project, they indicate a decline in the belief about its seriousness. Table 2 shows this data collected in 19 different countries in four successive years from 2007 to 2010. This data is consistent over several different surveys and seems insensitive to how exactly the questions are phrased.

In some countries, such as South Korea, Japan, Spain and the United States, interest has been lower in every subsequent year since 2007. Even though the interest in China was at a minimum in 2008, it has begun to pick up since then but had not reached the level in 2007. In another group of countries, such as France, Britain, Poland, Turkey, Germany, Russia, Argentina and Mexico, the interest peaked in 2008. In India, Pakistan, Jordan and Egypt, the belief peaked in 2009. Indonesia and Lebanon were the only two countries not showing a decline.

The percentage changes from the maxima have been most pronounced in France and Pakistan (26% and 28%) respectively. Japan, Poland and Spain have had declines of 20%. This means that in a period of one to three years, almost between a fifth and a fourth of the population in these countries stopped believing in the seriousness of climate change as a problem. In some countries the declines are lower, but the average belief may also have been lower to begin with, as in the United States.

Table 2: Percentage of Public believing that Climate Change is a serious or a very serious problem. (Source: Pew Research Centre's Global Attitudes Project)

Country	2007	2008	2009	2010	Reduction
Turkey	70%	82%	65%	74%	8%
S. Korea	75%	68%	68%	68%	7%
Japan	78%	73%	65%	58%	20%
Argentina	69%	70%	69%	66%	4%
Mexico	57%	70%	65%	68%	2%
France	68%	72%	68%	46%	26%
India	57%	66%	67%	62%	5%
Spain	70%	67%	61%	50%	20%
Germany	60%	61%	60%	52%	9%
Lebanon	41%	43%	53%	71%	--
Britain	45%	56%	50%	40%	16%
Indonesia	43%	46%	46%	47%	--

Russia	40%	49%	44%	43%	6%
Jordon	32%	41%	54%	47%	7%
USA	47%	42%	44%	37%	10%
Egypt	32%	38%	54%	44%	10%
Pakistan	41%	48%	50%	22%	28%
Poland	40%	51%	36%	31%	20%
China	42%	24%	30%	41%	1%

Table 3: Percentage viewing Climate Change as very serious is correlated with Ideological Beliefs.(Source: Pew Research Centre's Global Attitudes Project)

Country	Total	Left	Centre	Right	(L-R)
US	37	53	41	23	30
France	46	59	47	37	22
Germany	52	60	53	45	15
Britain	40	51	38	37	14
Spain	50	55	48	48	7

Ideology is a big determinant in beliefs about climate change. Table 3 shows a distribution of those who believe in the seriousness of climate change as an issue disaggregated by what the respondents acknowledged to be their political orientation—liberal or left of centre, moderate or centrist, or conservative or right of centre. As shown in Table 3, the polarization is most marked in the US, where registered Democrats are more than thrice as likely to believe in the seriousness of climate change than are registered Republicans. Although not to the same extent, this tendency is true in all western countries where this question was asked: France, Germany, Britain, and Spain.

Surveys conducted and reported in Table 4 indicate the responses to question asked as to which country could be most trusted to do the right thing when it came to dealing with climate change. As could be expected, the largest values of responses are along the diagonal. That is, respondents had the most favourable opinion s of their own countries. What is somewhat more

interesting is the fact that the matrix is asymmetric because people of a country A think differently of a country B than vice versa.

Table 4. Who can be most trusted to do the Right Thing in dealing with Climate Change?

	USA	Germany	Japan	China	Brazil	India	Russia
USA	57	12	8	3	3	1	2
Germany	8	77	2	2	1	1	1
Japan	8	32	38	2	3	1	0
China	15	4	4	57	1	2	1
Brazil	17	5	6	6	45	3	1
India	16	3	4	5	1	55	1
Russia	6	9	11	5	2	1	29

Why has Climate Change proved to be such a difficult problem to address?

I have my list of ten reasons why climate change is such a difficult problem to address. Different analyst might add a few reasons of their own or order this differently, but most of these reasons would be acceptable to most. Briefly,

1. Humankind has evolved to perceive and respond to immediate threats; we are not so pro-active at responding to slowly unfolding threats.
2. It is a “stock” problem rather than a “flow” problem, concentrations cumulative result of past emissions;
3. It is a global problem requiring a global solution (involves both free riders and victims);
4. The perception of developing countries changed from being aid recipients to competitors in the west (or in the north);
5. It involves trade-offs within and across generations, and across species;
6. There is asymmetry in distribution of costs incurred in the present and benefits being in future which poses difficulties for politicians tuned to election cycles;

7. Democratically elected governments are held accountable for economic performance but not for adverse climatic impacts;
8. Our public structures require a proof of need before they feel empowered to act. They do not respond to unsubstantiated probabilities;
9. A rich and influential lobby benefits from status quo and opposes action.
10. The tendency of the media to present both sides of the debate.

I will end by making a few comments on the role of the media. In 2009, before the Copenhagen summit, media gave extensive coverage to the climate issue. Rajamani (2009) has reported that the Indian Express, for example, carried on an average three stories every day on climate change, far in excess, I think, of the public interest in the subject. Al Gore has characterized the role of the media as a referee in a tag-team wrestling match. As a referee or an umpire in the interest of objectivity, the media chooses to give equal time or space to the 2-3% of climate skeptics as it gives to 97-98% of publishing climate scientists who believe anthropogenic climate change is real. Thus the public is left with an impression that the subject is more unsettled than it actually is.

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Chapter 10

Technology, Risk Perception and Acceptance: The Case of Carbon Capture and Storage

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Climate Change is a great challenge before human kind and among the solutions suggested in mitigating climate change, Carbon Capture and Storage (CCS) is an important one. While IPCC has suggested that as a potential solution, organizations like OECD, IEA and many national governments and private sector have been strongly in favour of it. But CCS has not made much head way despite much investment and demonstration plants. While there are regulatory issues that constrain its implementation on a massive scale, risk perception and uncertainties associated with CCS have been major factors in deciding the acceptance of CCS by public. It is obvious that without acceptance from public, particularly from communities that are closer to CCS plants and storage sites CCS will never be able to take off as a solution. While the supporters of CCS point out its merits and urge that it should be expeditiously implemented as a part of the mitigation strategy at the global level to avoid dangerous consequences of climate change, critics

and skeptics point out the risks, uncertainties and the various other issues that go against CCS to be considered as an acceptable solution. Thus even those who concede that CCS as a technical solution has many positive aspects are ambiguous in accepting it on account of risks, uncertainties and the long term costs and benefits of CCS. Public perception on CCS has been impacted by many factors and often Not In My Back Yard (NIMBY) attitude goes against accepting CCS as a solution. There are strong parallels between CCS and Radioactive Waste (RW) storage and the earlier experiences in RW are relevant because RW storage has also met with opposition from public and environmental NGOs. As a result of all these factors even those who are strongly in favour of CCS concede that in the absence of right strategies on risk communication and engagement with public, the negative perceptions, fears and perceived uncertainties would adversely affect acceptance and deployment of CCS. But whether plans for risk communication and more engagement with public make CCS more acceptable is a question for which there are no easy answers. CCS is thus simultaneously a global and local/regional issue and the interaction between the global, national, regional/local in deciding the future of CCS is complex. In this chapter I map some of these issues and point out that perceptions about CCS, its risks, uncertainties will play an important role in deciding the future of CCS. But this is not unique to CCS as perceptions about risk are important factors in public acceptance and understanding of many technologies, including nanotechnology, synthetic biology and biotechnology.

CCS: Its origins, Technology and Current Status

CCS is part of the geoengineering technologies and in the recent years there has been much debate on the pros and cons of deploying geoengineering technologies. In this chapter as the focus is on CCS the debate on other technologies which are part of the geoengineering solutions will not be taken in to account. Basically CCS is implementation of the idea that by trapping emissions at source and by storing them on a long-term basis, release of the emissions of Greenhouse Gases into the atmosphere

can be significantly brought down. The immediate fall out of this will be reductions in emissions of Carbon dioxide (CO₂). Since the sources of emission are spread all over the world deploying CCS would entail finding sources for storage in many places of the world and in ensuring that the long term storage does not pose significant risks. But translating this idea of capturing the emission at source and storing it involves large scale of integration of technologies for capture, transport and storage. While CCS can be integrated into existing sources of emissions like refineries, cement plants, steel plants etc. it is cost intensive and running and maintaining it involves considerable costs. Issues relating to regulation, liability, environmental safety and health have to be addressed and appropriate regulatory frameworks have to be developed before CCS is deployed widely. While governments have by and large, supported CCS their response has not been uniform.

Though CCS is an interesting option for large developing countries like India and China, it is yet to attain the level of maturity that facilitates quicker adoption in many countries. CCS technologies can be classified as post-combustion, pre-combustion and oxyfuel technologies. In post-combustion, after combustion of the primary fuel, CO₂ is separated from flue gases, while in pre-combustion CO₂ is removed before combustion. In the third category burning of the fuel in oxygen rich environment and CO₂ rich waste gas stream is generated. In all the three, CO₂ is dehydrated and compressed for transport/storage. (Mertz et. al. 2005, International Energy Agency, IEA 2012, Harvey 2010, Hester, Harrison 2010)

These processes are energy intensive and depending upon the industry the energy requirements vary. This obviously increases the cost of deploying CCS. IPCC acknowledges that in power generation a CCS plant would require 10-40% more energy than the equivalent plant without CCS (Mertz et. al., P22). While advocates of CCS acknowledge such factors they point out that as technology advances and matures, the costs on

account of additional energy use is likely to decrease and hence CCS is certainly viable in the long term. In fact the Road Map published by IEA acknowledges that while CCS is commercially available the associated costs have to be lowered, technology is yet to be demonstrated commercially (IEA 2012). It suggests that commercialization can be incentivized by tax breaks and funding for demonstration projects have to be hiked significantly, by OECD governments, and this is estimated to be \$ 3.5 to 4 billion per annum from 2010 to 2020. Since the costs are substantial including CCS under Clean Development Mechanism (CDM) of UNFCCC is an alternative option. Mandating CCS at large plants and sources of emissions will help its wider use but unless the costs are reduced further such mandates alone would not attract investments, as the energy requirements are substantial.

Given the current status of CCS, it is difficult to be overly optimistic about rapid deployment of CCS within the next few decades and stabilization of CO₂ emissions within the next few decades is critical to avoid dangerous consequences of global warming. Thus while deployment of CCS has to be expedited, there is no guarantee, given the current state of the technology, costs and other issues that affect its deployment, that it will be widely deployed by 2020 or 2030. Hence it is no wonder that documents from IEA, Global CCS institute and other agencies/bodies that advocate CCS as a solution call for more investments in R&D, more incentives, map the potential storage sites, address regulatory issues, concerns of the communities and more international collaboration, particularly in technology transfer.

At present the number of large scale integrated projects (LSIPs) is only 75 and while nine new projects were to be undertaken, for various reasons eight were cancelled. But to maintain the trajectory to 2 degree C target, by 2020, the number of operational projects must increase to about 130, from the current number of 16. To achieve the global targets in emission reduction, 70% of the CCS deployment will have to be done in developing nations by 2050 (CCS Institute 2012). But this would be feasible

only if CCS is supported through climate financing schemes, technology transfer, collaborative projects and incentives in developing countries. In other words unless developed and developing nations are willing to do all these together CCS will not be an attractive option for developing nations. So while deploying CCS in developed nations is necessary that it self is not sufficient to result in reductions in emissions on account of CCS, as emissions from developing nations are likely to increase significantly and on a faster rate in future. Thus unless CCS is given a big push and all the issues that affect its deployment are addressed and resolved, expectations of reductions in emissions on account of CCS appear to be over optimistic.

Although the idea behind CCS was articulated in the late 1970s it gained much attention only in the 1980s as the challenge of global warming was becoming obvious. International Energy Agency gave a thrust to research on CCS and interest on CCS was not widely shared. In fact the Second Assessment Report (SAR) of IPCC published in 1995 did not consider CCS as an important solution, while the Third Assessment Report in 2001n acknowledged that CCS was a potential option then than what was acknowledged in SAR. In 2001 the Seventh COP of UNFCCC requested IPCC to examine CCS more fully. The IPCC Special Report of 2005 (Mertz et.al 2005) gave a fresh impetus to the idea that CCS is a potential solution. Since then CCS has been acknowledged as an important option and in 2008 EU adopted a draft directive on CCS. Globally CCS has gained much attraction as a policy option, se for example Meadowcroft and Langhelle, 2010 on responses in some countries, while de Conick and Backstrand, 2011 give analysis of role of international organizations in promoting CCS Gokce G. 2012 provides an account of CCS being negotiated at one of COPs of UNFCCC and the articles in an issue of Global Environmental Change Vol 20 (2011) examine the various issues relating to CCS.

Since 2005, CCS has been debated widely and even those who acknowledge the technological hurdles, called for urgent

actions if CCS were to play an important role (Haszldine, 2009). The emergence of CCS as an important solution is not solely on account of technology. CCS is now promoted as a solution, partially because it lends itself as a solution that can be deployed (of course at considerable cost) in current and future sources of large scale emissions, which in reality means capturing the emissions from the source than reducing the emissions per se. Thus the emissions are not reduced but only their release into the environment is avoided. In other words, the limit to emissions and their storage is decided by the availability of storage space than by any other factor. While specific and time bound reductions in emissions reductions by countries is an issue that has eluded a solution, technical fixes like CCS can be used address the issue of reductions in emissions without making any firm commitment to reduce emissions per se over a period of time. Hence while international agencies like IEA, OECD call for reductions in emissions by countries, they are also strong advocates of strategies like CCS. From an international law perspective CCS is not a solution without problems and many conventions including London Convention have implications for deploying CCS (Proelss and Gussow 2011) and CCS has been debated in Conferences of Parties to UNFCCC and in Convention on Biological Diversity .

Framing and Understanding CCS: Of Faustian Bargains and Beyond

Is CCS really a fantastic solution as suggested by its advocates or is it a Faustian Bargain which calls for commitments and compromises from the users of the technology. Views on CCS have been varied ranging from optimists to critics, pessimists to those who urge that CCS should not be promoted at the cost of options like renewables (Chatterjee 2011). Social Scientists have examined CCS critically and have examined the politics, policy and regulatory issues that are often not discussed in the scientific and technical literature. (Backstrand, Meadowcraft and Oppenheimer 2011, See also articles in the special issue of Global Environmental Change on CCS). So although CCS is projected as

a technical solution, framing it is important to understand how such a technical solution is perceived, deployed and responded to.

Faustian Bargain is a familiar metaphor to describe technologies that seem to be offer sound solutions but not without any dilemmas or being perceived as a solution that demands too much in return. A well known example is that of considering nuclear power as a Faustian Bargain, popularized by Weinberg in an article published in *Science* in 1972. Interestingly in his last article published in 2007, Weinberg wrote

“CSS appears to be a classic Faustian Bargain. But, as in Faust’s initial bargain, it need not mean that our soul is left to the devil. It should mean that we accept the challenge of continual striving and vigilance, striving for more durable answers to global climate change and vigilance in assuring that stored carbon is not subsequently released to the climate system.”(Spreng, Marland, Weinberg, 2007, P 854).

Analyzing the two facets of this Faustian Bargain, Dominique points out that CCS proposes a solution without imposing constraints on consumption and economic growth and the contested risk frames in CCS. (Dominique 2011). According to Dominique “ .. CCS can be seen as a solution to a risk, as a risk itself, as an uncomfortable compromise between different risks, or a distraction from addressing a more imminent risk” (Dominique 2011, P21). So while international agencies and supporters of CCS describe CCS as a solution and point out that the risks from CCS are manageable, others who perceive the technological solution itself as a risk, understand CCS differently. Thus as Dominique points out there are ‘Reluctant Advocates’ also who consider CCS as a bridge and consider that risks from CCS are preferable to the risks from climate change and risks of nuclear energy. (Hansson 2008). According to Toikka even when countries perceive CCS as a solution, the uncertainties in CCS development are responded differently on account of institutional factors. (Toikka 2012).

CCS is framed differently by different actors and in the discourse on CCS, particularly on risks and uncertainties in deploying CCS, and, framing of CCS plays an important role in accepting/questioning the role and need for CCS. While advocates frame CCS as an important solution that has to be supported on an urgent basis, critics question whether it is a solution at all or is it an option that masks larger and important issues in favour of continued reliance on fossil fuels and increasing energy consumption. Associated with these understandings is the perception of risk which affects the acceptability of CCS.

Risk, Uncertainty and Risk Perception

Knight (1921) differentiated between risks and uncertainties and defined risks as uncertainties that are quantifiable while those that are not quantifiable are uncertainties. Risk is often constructed on the basis of technical parameters, probabilities and the outcomes. But is risk purely a technical issue or it is a social construct also. (Slovic, Finucane, Peters and MacGregor, 2003). Or is it something that can be reduced to quantified numbers and probabilities only. While in scientific and technical literature risk is often defined and discussed in terms of probabilities and numbers and comparative costs and benefits which again are expressed in quantities, social scientists have pointed out that this is only one part of the story as risk cannot be understood solely in terms of such numbers and probabilities.

In the last few decades or so, social scientists have pointed out the risk management based on such an understanding of risk, is not sufficient and instead called for a risk governance approach. (Renn, Klinke and van Asselt, 2011.) [For current perspectives in social sciences on risks and risk governance see Renn (2008), Lotsedt and Boholm (2010), and Roeser et. al. (2012)]. There are a variety of understandings, definitions and classifications of risk and uncertainty and there can be more than one level of uncertainty. Despite differences in perspectives on risk and uncertainty, an integrated idea of the interfaces among the different perspectives is important. (Riesch, 2012). According

to Riesch, in case of CCS there are five levels of uncertainties including the 'unknown unknowns' (Riesch 2012, P106). Hence different actors have emphasized on different types of uncertainties on CCS. Even those who agree that CCS is a potential option may give different weightages to different aspects, underplaying some risks and over emphasizing the benefits and vice versa. Thus, according to Hansson "The differences between the CCS proponents and opponents are generally not based on ideology or values, but instead on emphasizing different parts of the very same scientific reports (Hansson 2008 at P292). So it is no wonder that even reports which examine the long term feasibility of CCS also point out the uncertainties involved and how this will impact the future use and acceptance of CCS.

Acknowledging uncertainties does not mean that CCS is not a feasible option and not all the uncertainties need to be resolved to make CCS financeable (UKERC 2012). Heptonstall, Markusson and Chalmers (2012) have identified seven key uncertainties in their assessment of realizing the potential of CCS and 'policy, political and regulatory uncertainty', and 'public acceptance' are among the key uncertainties. Understanding the inter-linkages between uncertainties is important to understand the possible synergies and trade-offs and efforts to reduce or manage one uncertainty will impact others. Absence of credible regulatory regime can have adverse implications for gaining public acceptance, which is important for political support to CCS (Markusson, Kern and Watson 2010).

The issue 'lock-in' is important as CCS involves huge investments and long-term commitments in storage of captured CO₂. Will CCS result in a lock-in situation that reinforces the current energy paradigm and thereby result in lesser attention to and investments in other sources like renewables or will it be used more as a bridging solution enabling a low-carbon growth. While critics may argue that lock-ins are inevitable, Shackley and Thompson (2012) point out that the real issue is that of depth of lock-in than lock-in per se as deeper lock-in reduces the flexibility.

So the issue here is, not the support per se to CCS but to what extent and how it should be supported. The potential pathways for deploying CCS could thus be many and uncertainties impact these path ways, which in turn affect the uncertainties. This co-construction of pathways, risks/uncertainties means that CCS deployment is much more than demonstrating its technological and economical viability.

Regarding risks from CCS there is substantial discussion in the literature, which indicates that, there are risks in different phases and there are also unanswerable questions of long-term storage and liability (For an over view see Ekmann 2011). The *Table 1* below summarizes the commonly perceived benefits and concerns regarding CCS. (NCCS 2012).

Table 1. Commonly perceived concerns and benefits of CCS

Benefits	Concerns
A bridge to a low-carbon future	Safety risks related to a CO2 leak
Could avoid release of large quantities of CO2 into the atmosphere	The risk of ground water contamination
Allows for the continued use of fossil fuels	Harm to flora and fauna near storage sites
Should enhance energy security	Possible explosion of CO2
Helps to clean up coal-fired power plants in developing countries that require energy	Wrong solution to climate change
Allows reduction of emissions without necessitating much change to life style.	Low availability of storage sites, CCS technology and infrastructure
	Long term viability and economic cost of technology
	Scale required for mitigation of CO2
	Unknown technology
	Could draw funding from renewables

Adapted from Ashworth et. al. (2010) in NCCS 2012

While the uncertainties influence the risk perception, the weighing in of costs and benefits also affects risk perception. As the literature in risk perception points out catastrophic events can challenge the understanding of risks arising from a particular technology and trans-boundary risks pose challenge to geographical, political and regulatory boundaries [Kearnes, Klauser and Lane (2012)].

Thus there are risks and uncertainties, there is also the potential of unknown risks materializing in a way that was not anticipated. Once such incident is sufficient, to shake the public confidence in both technology and regulatory regimes. Both Chernobyl and Fukushima altered the public perception on nuclear energy. While these could be termed as exceptional events and rarest of the rare type of accidents, the changes in risk perception on account of such catastrophe play an important role in deciding the risk perception in future. On the other hand as Perrow pointed out in tightly coupled units the high potential for such catastrophic events could not be ignored and such risks and accidents are 'systematic' or 'normal' (Perrow 1984). CCS is technical system with many sub-components and the whole process of capturing and storage of CO₂ involves deployment of different technologies across different time scales and spaces. Hence while risks from CCS can be estimated, it is impossible to assert that a totally unanticipated 'accident' will never happen. This has implications for risk perception because even those who consider CCS as a solution may also be concerned with potential risks if their livelihoods and properties could be affected by CCS in one way or other. As pointed out in a subsequent section, risk perception on CCS is not uniform and the responses to CCS can undergo changes over the time. In other words as perceptions of risks on account of CCS can vary over time, public perception today can be taken at best as the current perception on CCS.

Public perception about risks is not solely based on what scientific and literature states as risks and rather it is a socially

constructed perception of risk which is based on, inter alia, self-perceptions, intuitive approaches to risk assessment. Ignoring them as proof for ignorance among public is not the right approach (Schwartzman, Ross, Berube 2011). This is all the more true of CCS as the public awareness is low and the public is informed of both the danger, climate change and the solution (CCS). For a climate change skeptic, CCS may not appeal as a viable solution or the risk perception may be distorted on account of the skepticism on climate change. For those who consider climate change as a risk, risk perception of CCS entails understanding the different risks and the long term consequences of both and risks in choosing CCS as a solution vis a vis not taking action against climate change.

Thus risk perception on CCS is impacted by many factors ranging from understanding the uncertainties to fear of the unknowns and the perceptions about the unknowable unknowns and perceptions about climate change as a risk to humanity and nature.

Public Perception of CCS

The perception of civil society actors, particularly NGOs on CCS plays an important role in shaping the public perception of CCS. But the environmental NGOs have not taken an uniform stand on CCS and their positions range from cautious support to outright rejection. For example while Green Peace does not accept CCS as a solution, some NGOs including Natural Resource Defense Council and World Resource Institute support CCS and also insist that environmental regulations should be in place and argue that no new, conventional coal-fired generation should be constructed without CCS (ENGO Network on CCS 2011). According to Corry and Reiner even environmentalists who are aware of the potential of CCS assign it a lesser priority and prefer renewables and reduction in demand as a solution and the nuclear debate has cast a long shadow over the CCS debate. (Corry and Reiner 2011).

By now there is a vast literature on public perception on CCS and factors that influence public perception. In this section I will highlight the findings from some studies so as to draw some general conclusions about public perception on CCS. By and large, the studies on public perception indicate that the level of awareness on CCS is low and the Eurobarometer study on perception on CCS in Europe confirms this. Since the awareness about CCS is low, increasing awareness about CCS is important to gain public confidence and this includes risk communication strategies (Global CCS Institute, 2011).

Although there is a risk of simplification, from the studies some broad conclusions can be drawn as below (e.g. Karuse, et. al., 2012, Upham, Roberts 2010, Poumadere, Bertoldo and Samadi 2011, Wallquits, Visschers and Siegrist 2010, Bradbury, et. al., 2009, Mander, et. al., 2011, Terwel, Daamen and Mors 2013, and Conick, et. al., 2006)

1. Not in My Back Yard (NIMBY) attitude affects the acceptance of CCS. Even those who support CCS are not greatly in favour of CCS in their community/neighborhood. Considerations on economic impact of CCS, world views also influence acceptance of CCS.
2. While concern about technological risks are expressed, factors like past experience with government, compensation, perceptions about economic benefits and costs play an important part in shaping the perception about CCS.
3. In general awareness on CCS is low; more knowledge need not necessarily translate into acceptance. It may result in changes in perception which may or may not result in more acceptances.
4. Public needs to be reassured about the risks of CO₂ storage. Hence it is important to involve trusted parties in communicating about CCS. In other words credibility of the communicator also matters in determining the public trust of this technology.

5. Social contract approach rather than technocratic approach is desirable and deliberations with public and opportunities to interact, discuss and debate with public may help in reducing the opposition to CCS.
6. As unexpected opposition from public has constrained progress in other technologies (e.g. nuclear energy, genetically modified organisms in agriculture) understanding the public acceptance/rejection is important. Public understanding and acceptance is contextual and in this case it is linked with perceptions about climate change and the proposed solutions. Public perception is also impacted by the costs on account of CCS and the willingness to pay more for energy/ electricity.

In case of Europe the Eurobarometer survey of 2011 provides an overview of the public perception on CCS and factors that influence the perception. (TNS Opinion & Social). One of the important findings of the survey is

“Correlations drawn from the results (knowledge of high CO₂ impact on climate change linked to health concerns, for example) clearly demonstrate the need to communicate the facts about CO₂ properties and the lack of risk regarding CO₂ storage. Furthermore, the better informed people are about climate change, the more supportive of CCS they are likely to be, highlighting the importance of explaining climate change if we seek widescale implementation of CCS.” (TNS Opinion & Social, 2011, P118).

These conclusions indicate that public perception of CCS is a complex affair and it cannot be taken as granted easily as local factors also play an important role in accepting it. Moreover public perception on CCS is likely to be impacted by many factors but trust is an important factor in shaping the public perception. Hence credibility of the communicators,

opponents and advocates of CCS also matters in shaping the public perception. While making more knowledge available and dissemination of information is necessary how it is being done (process of communication and sharing of information) is also important.

The case studies and a survey of the literature point out that as in the case of other technologies public perception of risks and experts' perception of risk need not be the same. The public acceptance of CCS is a must for CCS to succeed and as public perception on CCS is an important factor in molding the acceptance/rejection of CCS, developing plans to address the challenges posed by diversity in public perception is a challenging task for advocates and opponents of CCS.

CCS and Nuclear Waste Disposal

CCS has been compared with other technologies on some aspects and such comparative studies point out that while some features are unique to CCS there are common elements with other technologies (Rai, Victor and Thurber, 2011, Watson 2012). In the literature CCS has been compared with radioactive waste (RW)/nuclear waste (NW) disposal because both solutions are controversial and there are some common features. While nuclear waste (NW)/radioactive waste (RW) disposal has been an on going controversy CCS is a new technology. Responses to NW and RW, particularly the public perception of risk, acceptance of/opposition to NW/RW depositories/disposal will be useful in understanding the responses, resistance to and acceptance of CCS. In this section I highlight some inferences from the literature and for reasons of space a lengthy discussion is not provided.

Reiner and Nuttall point out the key features in public acceptance of CO₂ storage and disposal of RW.

Table 2. Comparison of key attributes associated with public acceptance of CO2 storage and geological disposal of radioactive waste.

Subject	Radioactive waste disposal	CO2 storage
Public awareness	Broad public awareness	Minimal public awareness of any aspect of CCS
Public understanding	Generally weak in spite of high awareness	Basic understanding of carbon cycle but minimal to none on CO2 storage itself
Public acceptability of solution	Acceptability poor and greater acceptance not necessarily linked to greater understanding	Linked to climate change and perceived adequacy of other solutions, but still too early to determine.
Demographics	Strong female opposition across time and region	Little evidence of major differences visible at this stage
Timing	Not necessary to address immediately; in most cases deferred for decades	Essential to resolve storage before operation begins because of volume of waste stream
Risk communications	Extensively studied but practice remains weak	Few examples of good practice, poorly studied
Trust in actors	Involves energy industry and government some of least trusted actors in society Eroded by image of 'nuclear priesthood'	Involves energy industry and government, some of least trusted actors in society
Views of grassroots and environmental NGOs	Generally hostile although there has been successful engagement on narrow question of repository siting	Main environmental groups are neutral to moderately positive Some resistance from grassroots groups less concerned with climate change alone
Support for associated energy technology	Support for nuclear power remains divided and this division has continued for decades.	Unabated coal is becoming increasingly unpopular, although there remains support for coal miners in many countries.
CCS: Carbon capture and storage; NGO Non-governmental organization.		

Source Reiner and Nuttall (2011), P311

Reiner and Nuttall (2011) take the view that CO₂ storage problem is likely to be less controversial than RW on account of the need for large number of sites, public familiarity and need to resolve the storage issue in the initial stage itself. de Groot and Steg (2011) point out that acceptability of CO₂ storage may be explained by factors that are influencing the acceptability of RW and these factors are similar. On the other hand although there are similarities between the two, the regulatory and legal regimes are very different (Rossati 2011). Drawing on the lessons learnt from governance of long term RW management Flueler (2012) suggests, inter alia, that 'Settle major issues and harmonize regulations before large actors (states, companies) deploy CCS on a scale of a fait accompli (technically and in terms of generating CO₂ certificates)'. Both the technologies rise ethical issues and according to Brown.

"If it can be shown that the risks from the geological disposal of RW and CO₂ are less problematic than the threat of climate change and that there were no reasonable alternatives to the geological disposal of RW and CO₂ as a way of mitigating the threat of climate change, an ethical justification for the use of these technologies, despite their risks, can be made; however, ethical duties remain to deploy these technologies in a consistent way with other ethical obligations to the maximum degree feasible" (Brown, 2011, P355-356).

Thus while both technologies are controversial CCS may not be so strongly opposed and may gain acceptance as it is perceived as a major solution to climate change. In case of NW/RW the question of serious adverse effects of radiation and its long term consequences, particularly for future generations impact public perception adversely and this is not the case with CO₂. In that sense CO₂ is a known and manageable devil. More over the perception about nuclear energy and RW/NW disposal underwent a sea change after Three Mile Island, Chernobyl and Fukuhsima, while in case of CCS there are no such examples. As the technology is yet to mature and deployed on a large scale it

provides opportunities to build safe guards, develop regulatory and liability regimes and risk governance, and, there by inspire confidence. Familiarity with sources from which CO₂ will be produced is another factor that is in favour of CCS. While these are perceived as obnoxious and polluting, they are not considered as very dangerous when compared to nuclear power. It can also be argued that CCS is a safer alternative than resorting to nuclear power as a solution, in tackling climate change. Hence it can be assumed that while there are similarities between the two CCS is not likely to fare worse in the eyes of public when compared with RW/NW disposal. Although public may not be overtly in favour of CCS, the very absence of a negative perception may work in favour of CCS. But this does not mean that public acceptance of CCS can be taken granted.

Public Engagement, Risk Assessment and Public Acceptance of technology

Over the last few decades the response of the public to technologies has not been uniformly positive and public opposition to technology has played an important role in deciding the fate of some technologies. The nuclear energy which was once perceived as a modern marvel was later perceived as totally undesirable and the changes in perception resulted in slowing down the growth of nuclear energy in some countries while in some progress was stalled. Similarly agricultural biotechnology was responded differently in different countries and the European response has been by and large negative although studies show that Europeans are optimistic about health/medical biotechnology. Understanding the societal responses to emerging technologies, particularly those which are perceived to be risky is important so that the responses can be anticipated. In the last few decades there has been a sea change in viewing public response to and understanding of science and technology. At the risk of over simplification one can state that from a deficit model of public understanding which perceived that the ignorant public needed more understanding of science and technology, today, an approach that favours

public engagement with science and technology is favoured, particularly in emerging technologies like nanotechnology (Sahoo, Anand and Srinivas, 2010).

Acceptance of technology cannot be taken granted and its is a social process and building trust by institutions/agencies that promote the technology is important as it increases the possibility for greater public acceptance. (Stern, et. al., 2009). This means that public engagement is necessary for increasing the understanding by the public as well as enhancing the probability of acceptance by public. But public engagement is not a simple task and measuring its effectiveness is not easy (Pytlikzillig and Tomkins, 2011). Never the less there are no easy options as public engagement can be avoided at the risk of public perception being determined by other factors and actors, particularly NGOs. Hence the challenge lies in effective public engagement rather than trying again and again, top-down approaches to 'educate' the 'ignorant' public and perceive any mistrust or negative response as an indication of lack of knowledge.

This is all the more true in case of CCS. The technology is so new that public awareness is limited while the public has better awareness on climate change, one way or another. This provides an opportunity to engage with the public and at the same time it is also a challenge to promoters and advocates of CCS. To say that their roles have been cut out will not be an exaggeration. Whether they will try this and succeed is an important question that is waiting to be taken up.

Conclusion

In this chapter I have pointed out how the responses to an emerging technology and perceptions about risk and uncertainties are important in shaping its future trajectory. Although this is not unique to CCS, public perception matters more in case of CCS given the estimated increase in its deployment across the globe and the challenge of global climate change. To conclude CCS is an example of an emerging technology whose future

is bound with meeting the challenges of global warming and public acceptance of CCS as a credible and viable solution.

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Chapter 11

Public Perception of Nuclear Power

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Introduction

Right from the 90s there has been international recognition that public opinion is one of the factors that influences acceptance of nuclear power in the energy mix of a country. Many complex factors influence public perception. Many myths cloud realities. One of the methods to influence public perception is to describe these myths and realities with the hope that a discerning audience will identify the facts.

A paper titled “Why is the Public Acceptance so Peculiar only for Nuclear Energy”, by Ohinishi and Tsujimoto (2000) at the 10th International Congress of the International Radiation Protection Association (IRPA-10), highlighted some of the issues. A survey carried out by the researchers covered 2500 persons from two regions of Japan and 350 nuclear researchers from the whole of Japan. The analysis has revealed that the public’s degree of interest in science and technology and the extent of the knowledge

of nuclear energy are quite low, whereas the extent of fear against nuclear technology is extraordinarily high as compared with those of researchers. Moreover the public's nuclear knowledge was found to be considerably negative in its quality.

In spite of the notable records, large segments of society are still concerned about this form of energy. "Lack of understanding and misconceptions contribute to this", first Public Information Forum "Nuclear Power: Communicating for Confidence", in Vienna, conceded (IAEA, 1990).

The attitude of secrecy, a consequence of the association with military added to the concern. Mistrust developed over time in spite of the fact that nuclear power currently provides reliable electric power supply to many countries. Because of this stability in the generation of nuclear power in France, some countries in Europe may be able to walk away confidently from nuclear power.

Grimston (2002), who systematically carried out research on the future of nuclear energy, caricatured nuclear debate as a battle between two diametrically opposed groups, who nonetheless seem to share a large number of features in common.

He listed them thus:

1. Both nuclear advocates and opponents believe that major elements of the future are predictable; they are certain about general projections of various energy sources. While the former considers that renewables demonstrably have the practical potential to remain only relatively minor players in world energy supply, the latter assert that renewables demonstrably have the practical potential to dominate world energy supply.
2. Nuclear proponents are absolutely certain about the future role of nuclear power (a major and important one), and

about issues such as nuclear waste (not a difficult technical problem).

Nuclear opponents are absolutely certain about the future role of nuclear power (no role at all), and about issues such as nuclear waste (a technically insoluble problem).

3. Both groups have arrogance born out of belief in infallibility of own analysis.
4. Nuclear advocates believe that the public is irrationally frightened of nuclear power. If only people could be properly educated they would become more pro-nuclear and support the nuclear industry.

According to nuclear opponents, public is irrationally complacent about nuclear power. If only people could be properly educated they would become more anti-nuclear and support anti-nuclear campaigns.

5. Both characterise opponents as either fools or ill-intentioned!
6. Advocates of nuclear power believe that government is not to be trusted to take wise decisions as it is too much influenced by the anti-nuclear media and pressure groups.

Nuclear opponents fear that government can not to be trusted to take wise decisions as it is too much influenced by the nuclear industry and its supporters.

According to Grimston "public opinion" is a very complex issue. Opinion changes dramatically with circumstances. He feels that some of the factors behind the loss of confidence in some developed countries were caused by nuclear industry itself. Cost and time overruns in completing the construction of many nuclear power plants were far higher than projected. These factors remained the same in developing countries According to him, the performance of many plants was disappointing.

This opinion is not true for all countries. For instance in USA, the nuclear fuel share of electricity remained 19 to 20 % from

1990. The average capacity factor remained above 85% from 1999. From 2002, the average capacity factor was over 90%. Companies added 6018 MWe from 1977 simply by up-rating the capacity of operating nuclear power plants. Over 3200 MWe of nuclear power will be added by up-rating from 2011 to 2015. The production cost of nuclear power remained stable from 1996 onwards (just over 2 cents per kWh) from 1996 onwards and lower than coal from 2001 onwards (Nuclear Energy Institute, 2011).

Issues such as management of nuclear waste, nuclear accidents, nuclear proliferation, atomic bomb, nuclear terrorism, biological effects of radiation particularly genetic effects etc are typical subjects of concern.

Management of Radioactive Wastes

Many myths and realities cloud these issues. Identifying these may influence public perception on nuclear power

Radioactive waste stored in glass?

In 1986, Shri O V Vijayan, a literary genius from Kerala wrote an article titled "The Superstitious" in a leading Malayalam weekly. He claimed that he had prolonged arguments with some nuclear scientists on radioactive waste management and believed that scientists are going to keep nuclear waste in glass vessels for thousands of years. According to him, the scientists told him that the glass vessels would not break for 100 or 1000 years. I suspect that the "nuclear scientists" with whom he had discussed the topic did not know the vitrification process - the process in which radioactive waste is added as ingredients to glass thereby making the radioactive material virtually non-leachable. Vitrification is one of the first procedures to handle high level waste

During the end of 1986, Shri V R Krishna Iyer who is known for his strong antinuclear views repeated the same wrong notion about storing radioactive waste in glass vessels at a meeting held

in Mumbai. I responded to several of his criticisms including the one on storing “nuclear waste in glass vessels”. It was difficult to convince him. Apparently, he was against all nuclear reactors. I told him that without operating a research reactor, we cannot have cobalt-60 an essential radioisotope used in the fight against cancer. It appeared that he has no objection to operate such reactors.

Various views and concerns

A review of waste management technologies indicates that it is not an insurmountable problem. The World Nuclear Association, a nuclear advocacy group listed the following views and concerns of general public about radioactive wastes (World Nuclear Association Radioactive Wastes, 2009).

1. The nuclear industry still has no solution to the ‘waste problem’, so cannot expect support for construction of new plants until this is remedied.
2. The transportation of this waste poses an unacceptable risk to people and the environment.
3. Plutonium is the most dangerous material in the world.
4. There is a potential terrorist threat to the large volumes of radioactive wastes currently being stored and the risk that this waste could leak or be dispersed as a result of terrorist action.
5. Nuclear wastes are hazardous for tens of thousands of years. This clearly is unprecedented and poses a huge threat to our future generations.
6. Even if put into a geological repository, the waste might emerge and threaten future generations.
7. Man-made radiation differs from natural radiation.
8. Nobody knows the true costs of waste management. The costs are so high that nuclear power can never be economic.
9. The waste should be disposed of into space.

10. Nuclear waste should be transmuted into harmless materials.

Solutions

WNA has answered these concerns satisfactorily. WNA argues that nuclear industry has actually developed the necessary technologies and implemented most of them. The real issue is to get them acceptable to public.

Safe management practices are implemented or planned for Low-level waste (LLW) and most intermediate-level waste (ILW), which make up 97% of the volume of the waste produced. These are being disposed of securely in near-surface repositories in many countries so as to cause no harm or risk in the long-term. This practice has been carried out for many years in many countries as a matter of routine (IAEA, 1990).

Interim storage facilities currently hold High Level Waste safely. They are relatively small compared to other industrial sectors. Annually, HLW is currently increasing by about 12,000 tonnes worldwide. The waste cools down as its activity lowers by decay. In 40 years, the radioactivity of spent fuel is one thousandth of what it was when it was removed from the reactor. It is still high and needs careful handling. According to WNA, interim storage is a viable option till the quantity of waste accumulated is enough to go for an economic repository.

For disposing high level waste construction of deep geological repositories is accepted universally as a workable solution. Countries such as Sweden, Finland (Grimston,2002) and USA have advanced programmes in progress. USA has a deep geological repository in New Mexico for the disposal of transuranic waste (long-lived Intermediate Level Waste contaminated with military materials such as plutonium).

Every country has realized the importance of public acceptance of the technology. In spite of heroic efforts public

acceptance of the technology is yet to be realized in most of the countries. In USA, the entire programme is mired in political controversy.

Transportation of radioactive waste

WNA has shown that packages that store waste during transportation are designed to ensure shielding from radiation and containment of waste, even under the most extreme accident conditions. Since 1971, there have been more than 20,000 safe shipments of highly radioactive used fuel and high-level wastes (over 50,000 tonnes) over more than 30 million kilometres (about 19 million miles) with no property damage or personal injury, no breach of containment, and very low radiation dose to the personnel involved.

Toxicity of plutonium

Public has a firm belief that plutonium is the most toxic material in the world (Nuclear Energy Institute, 2011). WNA informs the public that gram for gram, toxins such as ricin and some snake venoms and cyanide are significantly more toxic. It may be difficult to change the perception of public on the toxicity of plutonium

Terrorist threat due to nuclear waste

Generally nuclear wastes are stored in secure places in all countries High Level Waste is stored as retained in glass or ceramic matrix. It is very difficult to disperse it by terrorist action. They are very poor choice for “dirty bombs”. If terrorists strike, it will be messy; decontamination is possible; it is expensive but doable. A report released on June 25, 2002 by the National Academy of Sciences, concludes that if a dirty bomb attack were to occur, “the casualty rate would likely be low, and contamination could be detected and removed from the environment, although such cleanup would probably be expensive and time consuming.

Nuclear waste hazardous for thousands of years

Many believe that nuclear wastes are hazardous for tens

of thousands of years. They consider it as unprecedented; they feel that it poses a huge threat to our future generations in the long-term. Many industries produce hazardous waste. The nuclear industry has developed technology that will ensure its hazardous waste can be managed appropriately so as to cause no risk to future generations.

The radioactivity of nuclear wastes decays progressively and has a finite radiotoxic lifetime. A major part of the radioactive species in high level radioactive wastes has a half life of about 30 years. The radioactivity of high-level wastes decays to the level of an equivalent amount of original mined uranium ore in between 1,000 and 10,000 years. Its hazard then depends on its concentration, whereas other industrial wastes (*e.g.* heavy metals such as cadmium and mercury), remain hazardous indefinitely.

Most nuclear wastes are hazardous for only a few tens of years and are routinely disposed in near-surface disposal facilities. Nearly 3% volume of total waste produced is long-lived and highly radioactive and requires isolation from the environment for many thousands of years.

International conventions define what is hazardous in terms of radiation dose, and national regulations limit allowable doses accordingly. Regulatory agencies enforce these regulations. Any hazardous wastes are handled in a way that poses no risk to human health or the environment. Waste is converted into a stable form that is suitable for disposal. In the case of high-level waste, a multi-barrier approach, combining containment and geological disposal, ensures isolation of the waste from people and the environment for thousands of years.

Future impact of wastes from geological repository

Actually, with today's spent fuel or vitrified high-level waste (HLW), extra layers of protection come from the multi-barriers of stable ceramic material, encapsulation, and depth from the biosphere that are designed to prevent any

movement of radioactivity for thousands of years. A stable geological formation, within which the waste will be disposed, also constitutes a highly reliable barrier. Such formations are available.

Scientists and engineers have produced detailed plans for safe underground storage of nuclear waste and some are now operating. Geological repositories for HLW are designed to ensure that harmful radiation would not reach the surface even with severe earthquakes or the passage of time.

Costs of waste management

Producers of radioactive wastes should bear the costs of disposal. Most countries with nuclear power programmes make estimates of the costs of disposal and update these periodically. For low-level waste, the costs are well-known because many facilities have been built and have operated for many years around the world. For high level-waste (HLW), cost estimates are becoming increasingly reliable as projects get closer to implementation.

Based on the estimated total costs of managing nuclear wastes, many countries require that the operators of nuclear power plants set aside funding to cover all costs. Different mechanisms exist in different countries. Although the sum already deposited in dedicated funds are high, the costs of waste management do not drastically increase the price of electricity. Typically the spent fuel management and disposal costs represent about 10% of the total costs involved in producing electricity from a nuclear power plant. Thus, although the absolute costs of waste management are high, they do not render the nuclear fuel cycle uneconomic, because of the high ratio of revenue earned to waste volumes produced.

Waste disposal into space

The option of disposal of waste into space has been examined repeatedly since the 1970s. It is considered very costly.

The method may not be acceptable in view of the safety aspects associated with the risk of launch failure.

Transmutation of nuclear wastes

Transmutation is the process of transforming one radionuclide into another via neutron bombardment in a nuclear reactor or accelerator-driven device. By this method, we can change long-lived actinides and fission products into significantly shorter-lived nuclides. These are radio logically harmless in only a few hundred years.

It is not feasible for all of the wastes produced in the past or to be produced. Transmutation may be able to reduce waste quantities but it will do it only to a certain extent and therefore not eliminate the need for disposal. One of the technical challenges is to isolate each nuclide (partitioning) so that it can then be irradiated, otherwise the process is likely to create as much waste as it destroys! Even if the economics of partitioning and transmutation were favourable, it is likely that the benefits would not compensate for the burden of additional operations required for separating and transmuting only part of the nuclides.

Nuclear Accidents

There were nuclear accidents; one in 1979 at the Three Mile Island in USA and the other in 1986 at Chernobyl in the former Soviet Union and the latest in Fukushima in 2011. International Atomic Energy Agency (IAEA) reviewed the accidents. This led to improvements. No one abandoned nuclear power because of these accidents!

Accidents at Chernobyl and TMI Island had less dramatic effects.

Electric companies connected 50 out of the currently operating 104 nuclear power reactors in USA to the grid since 1979; nineteen of these after 1986. Canadian companies connected all the fourteen operating reactors in Canada to the grid after 1979. Fifty-three out of 59 French reactors came on line after 1979.

The rarest of the rare, simultaneous occurrence of two natural phenomena, a powerful earthquake and a devastating tsunami, led to a serious situation at the Fukushima Atomic Power Station (Fukushima Daiichi). The staff of the Tokyo Power Company (TEPCO) aided by other Japanese personnel is trying to mitigate the effects of the accident. In Fukushima everything which has a potential to go wrong did go wrong eventually. Nuclear technology appears to be on trial now.

On March 31, Xinhua news agency quoted the Japanese National Police Agency's report that the quake and tsunami left 11,417 dead and 16,273 as missing. Nobody died in Fukushima due to radiation exposure. Cost of Fukushima accident is reportedly \$130 billion. The economic losses are pegged at \$239 billion, about 4 % of the Gross Domestic Product.

There was demand for halting the nuclear programme in Germany. Only a year, Germany decided to extend the life of its nuclear power stations it was clearly a political decision. Germans were prepared to pay higher electricity bills in return for ending nuclear energy.

".... there is little doubt that Germany's modern history has combined to produce a deep strain of risk aversion, of caution, and a dislike for surprises, all of which magnify the potential hazards of nuclear energy, producing a perception that is different from that of other major European economies like France or Britain" (Cowell, 2011) NYT quoted commentators.

French nuclear industry will be happy; they have an assured market for nuclear electricity in Germany!!

The Institute of Energy Economic of Japan (IEEJ) estimated that in spite of the expensive accident nuclear power remains competitive; for the past five years the cost of nuclear generation remained stable at around \$0.09 per kilowatt-hour (kWh). During the same period fossil fuel power cost was \$0.12 per

kWh; geothermal power \$ 0.12. The Institute reported that fossil fuel power varied between \$0.12 to \$.016 due to fluctuations in the cost of imported fuel (World Nuclear News Nuclear still cost competitive in Japan, 2011).

Even if compensation of up to \$130 billion for loss or damage from a nuclear accident is taken into account, the cost of electricity generation with nuclear reactors increases to some \$0.11 per kWh (World Nuclear News Nuclear, 2011). Japan which imports 84% of its primary energy has to be pragmatic in its approach to nuclear energy which prior to the accident provided 30 % of its electricity

Biological Effects of Radiation

Radiation is perhaps one of those subjects which have been largely misunderstood, not only by lay persons but sometimes even by highly educated persons. Often, the gap between the conviction and the reality is too wide to be believed. During the course of my professional career, I came across very many incidents and faced situations, which reveal the difference in the mythical perception of people and reality, and how difficult it is to convince people about the myths and the realities of radiation.

The fear about radiation is also shaping the public's perception on nuclear power. Based on the analysis of newspaper clippings from 1991, and on the treatment of the subject by the electronic media, I identified how significant groups of people developed biases against nuclear technology. Allegation of diseases in the villages near Jaduguda, birth defects in the villages near Rajasthan Atomic Power Station (RAPS), blindness and other ailments of cattle near Pokharan site, accidental overexposures of workers at various sites, cattle deaths near Tarapur Atomic Power Station due to leak from the Waste Immobilization Plant (WIP), intake of tritiated water by many workers at Kaiga Generating Station are some of the news stories. Since some of these were accompanied by telling pictures, many persons tend to believe the stories. Each of these have been investigated thoroughly; there were scientific

explanations. Mistaken notions about some of the practices followed in nuclear technology exacerbated the false notions. Undoubtedly these influence public perception on nuclear power.

Genetic effects of radiation

In 1991, Shri Karan Thapar interviewed me on a popular TV programme “Eye Witness”. It was an entertaining experience. He asked me 40 questions in ten minutes! In the ensuing controversy, I stated the known fact (known to radiobiologists and others who cared to read!) that no genetic effects were found among the thousands of children born to the atomic bomb survivors at Hiroshima and Nagasaki. Thapar, however, unhesitatingly contested my statement as “inexplicable”; he wondered how I did form the impression that no genetic effects were found among the thousands of children of Hiroshima and Nagasaki. He countered. “The opposite is not just a fact, it is the truth” he asserted. That was his perception.

I was not surprised at this scientifically unsupported conviction, as misgivings and myths about effects of radiations have been found to be rampant even amongst technologists, social scientists, physicists, and other highly qualified experts.

While responding to an opinion survey organized by AERB, for the National Academy of Engineering, over 80% of the participants from reputed academic and research institutions in India (IITs at Mumbai, Kanpur, Indian Institute of Science, Bangalore, Roorkee University, Saha Institute of Nuclear Physics, Kolkata, Tata Institute of Social Sciences, Mumbai) stated that genetic effect is a major health effect seen in the children of survivors of atomic bombings contrary to the fact.

An opinion survey, held by me, among 80 specialists attending a programme at the International Centre for Theoretical Physics at Trieste, Italy showed that nearly 30% of the scientists believed in the myth that double-headed monsters were born to the survivors of atomic bombings.

It is virtually impossible to correct such firmly held beliefs.

Radiation deaths due to atomic bombing at Hiroshima and Nagasaki

About 90,000 to 166,000 out of 340,000 to 350,000 estimated population at Hiroshima and 60,000 to 80,000 out of 250,000 to 270,000 persons in Nagasaki died due to the overwhelming force and heat of the blasts as well as high radiation exposures. These occurred shortly or within two to four months after the bombing.

There is evidence that a smaller number of later deaths attributable to radiation exposure occurred over the next few decades. Based on the 1950 census, about 280,000 persons are estimated to have been exposed and survived the bombing. Specialists attribute about 1900 of them suffered from cancer due to excess radiation till 2000. The general impression is that there was a tsunami of cancers among the survivors. In any population with a life expectancy of 70 to 75, about 25% is likely to die of cancer. In a population of size, 280,000 about 70,000 are expected to die of cancer. There is a significant group of survivors living now. A small number of cancers among them will also be due to radiation. The excess incidence of cancer among the exposed A-bomb survivors were identified because scientists carried out a systematic epidemiological study extending over several decades

High radiation levels everywhere

A few years ago an “environmentalist” claimed that he measured high radiation levels at several points in Lucknow. “Radiation levels at some points are higher than those at Chernobyl. The levels at the hostel where the Members of the Legislative Assembly stay are high”, he claimed.

He “measured” higher levels under overhead electric cables and also in the exhaust of cars. The print and electronic media picked up the story. I led a team of scientists to investigate this incident officially.

We found that the Geiger-Mueller counter based instrument he used was defective. It was light sensitive! Once the counter was made light proof by covering the counter by two layers of opaque paper, the radiation levels became normal background levels. Media picked up his version of the story earlier as the report had “the ingredients to stir raw emotions”. We published our version through a press release. The incident generated lot of media interest. The incident has nothing to do with nuclear power; the media frenzy was because the subject was radiation related.

Cattle deaths in Tarapur

Radioactive leak in any nuclear facility makes good copy. A small amount of effluent containing caesium-137 leaked out of a waste immobilization plant located near Tarapur Atomic Power Station. The story kept many reporters and scientists busy for a few days. Scientists identified the leak in a routine survey. Hordes of media persons who landed there went to town with exaggerated stories. The Times of India published the photograph of the skeletal remains of cattle side by side with the story of the “leak”. Cattle death was attributed to radioactivity.

While on a visit to the site, I found that the villagers brought a dead calf and left it at the gate of Tarapur Atomic Power Station. I did not argue with them that radioactivity has nothing to do with the death of the calf. I arranged a post mortem by veterinary surgeons. They scooped up several kilograms of thin polythene sheets from its stomach. Swallowing of carelessly thrown polythene is the major cause for the maximum number of cattle deaths in many parts of India. The viscera of the dead animal at Tarapur did not contain any measurable amount of radioactivity. No newspapers published this part of the radioactive leak story. I spoke to Prof Robert Crease a well known science writer about the incident. He covered it in a feature titled “Horror story that grew legs” in the *Physics World* (Robert Crease, February 2002). I also published the item titled “Bags of trouble” in *New Scientist* (Parthasarathy, 30 October 2004).

Manmade radiation versus from natural radiation

Radiation emitted from manmade radio-nuclides is exactly the same form as radiation emitted from naturally-occurring radioactive materials (namely alpha, beta or gamma radiation). As such, the radiation emitted by naturally-occurring materials cannot be distinguished from radiation produced by materials in the nuclear fuel cycle.

Most elements have a radioactive form (radioisotope) and many of these occur naturally. We are surrounded by naturally-radioactive materials, and are constantly bathed in radiation originating in the rocks and soil, building materials, the sky (space), food and one another. A typical background level of exposure is 2-3 millisieverts per year (mSv/y). Regulations limit extra exposure from man-made radiation due to human activities (other than medicine) to 1 mSv/y for members of the public and average 20 mSv/y for occupational exposure. These levels are very rarely exceeded, though no harm has been shown for levels up to 50 mSv/y. Some people are exposed to lifelong natural background levels which are higher than this (World Nuclear Association Radioactive Wastes, 2009).

A few hundred thousand people live in high natural background radiation areas in many parts of the world. These include Guarapari in Brazil, Yangiang in China, parts of Kerala and Madras in India, and the Nile delta in Egypt, Southwest France among others (UNSCEAR, 2000, Vol. 1 Sources Table 11, p.121). Background radiation levels in some locations in these places are a few hundred to a few thousand times greater than those in normal areas. Similarly a few million people in temperate areas whose dwellings are laced with excessive radon levels are exposed.

In some areas of United Kingdom, persons in 5 per cent of the homes are exposed to doses above 23.7 mSv/year. One per cent of the houses show dose values above 55.8 mSv/year. The highest estimated dose was 320 mSv/year in Cornwall.

Researchers have measured values up to 22,000 Bq per cubic metre. The radon concentration in 500,000 homes in the United Kingdom exceed the 100 Bq per cubic metre (Health Protection Agency, 2010). If we assume that four persons live in a home, two million persons in UK are exposed to a radon concentration of five times the average levels. Researchers have measured radon levels as high as 50,000 Bq per cubic metre in Norway; the maximum concentration measured in Sweden is 85,000Bq per cubic metre 9 UNSCEAR, 2000, Vol. 1 Sources Table 24, p. 13).

The annual dose limit to radiation workers recommended by the International Commission on Radiological Protection is 50 mSv. Many people in New Jersey and Pennsylvania get more radiation from radon in a week than anybody ever got at Three Mile Island. (Nicholls, 1986).

The radiation doses to several hundreds of thousands of persons living in high background radiation areas or in areas of high radon levels will be higher than the average radiation dose to workers in a nuclear power plant. I am not suggesting that just because millions of people are getting exposed to natural radiation, we need not control radioactive releases from nuclear power stations. We must adhere to the stringent dose limits prescribed by the regulatory body in all practices involving radiation sources... The fact that virtually hundreds of thousands of people are exposed to natural radiation without any control is brought out just to place the issue in perspective

The regulatory authorities allow nuclear power plants to release some radioactivity. These are measured to ensure that the releases are within limits prescribed by the regulatory body. The radiation doses to the members of the public due to releases are too small to be measured. Their magnitude is a small fraction of the background radiation present everywhere.

The radiation levels from a nuclear power plant are very small. But if an accident occurs, the doses will be very high.

Emergency plans are in place in case a nuclear accident occurs anywhere.

Safe radiation dose

What is a safe radiation dose? The best answer is "It depends". Though some puritans may argue that there is no safe dose!

There is no universally acceptable safe dose. For radiation workers, Atomic Energy Regulatory Board (AERB) wants the annual dose to be "as low as reasonably achievable" (ALARA); also it should not exceed 30 millisievert (mSv) excluding the dose due to natural background radiation and medical exposure, if any. AERB dose limit at 30mSv is lower than 50 mSv prescribed by USA (Sv is a unit of biologically effective dose. One Sv corresponds to a radiation energy absorption of one joule per kg; millisievert is one thousandth of a Sv). I have received about 0.9mSv while recovering a lost radiation source used in industry.

During the Fukushima accident one worker received 106mSv.

For members of the public, the dose limit is one mSv. Pregnant workers may continue to work but the dose to the foetus should not exceed one mSv. In medically justified procedures the following doses in mSv may be considered as safe. Cardiac CT scan 12; angioplasty (a life-saving procedure involving removal of blocks in blood vessels) on an average 400; at times even 1000mSv; treatment of hyperthyroidism, 100,000; radiation treatment of cancer 60,000 mSv to part of the body. In all cases doses must be ALARA without losing medical benefits.

In USA, the dose limit for an astronaut is 250mSv per mission. In an off-site radiation emergency, sheltering and administration of stable iodine may start at a minimum dose of 20 mSv; evacuation is mandated at 100mSv.

The average natural background radiation dose is 2.4mSv annually. In England & Wales, residents of over 100,000 to 200,000 homes are exposed to more than 10mSv annually from radon, a radioactive gas found in nature. The maximum value is more than 100mSv. Millions of persons in countries with temperate weather receive doses ranging from 5 to 10 mSv from radon decay products

Thus, we accept different values of doses as safe and acceptable, depending on circumstances. One need not lose sleep over receiving a few tens of mSv, if the occasion demands it.

ROLE OF MEDIA

Media play a very important role in influencing public perception on any activity. Nuclear power generation is no exception. Smyser (2002), Founder Editor of *"The Oak Ridger"* explained that his collection of cartoons and photos dealing with nuclear technology included ominous-looking faces of a row of cooling towers, a skeleton lording over a series of articles about nuclear wastes, a big-toothed Russian bear made of smoke coming out of a reactor stack, weird-looking vegetables with the headline "Zapped", a caveperson-like figure seemingly prostrate in front of a mean-faced cooling tower and a drawing of a cooling tower with the caption "What If?" (Smyser, 2002). According to him, such graphics were relatively new journalistic phenomena. It is an "artistry to embellish and enhance the news". Smyser felt that "cooling towers are like Richard Nixon's jowls and Jimmy Carter's teeth a graphic artist's dream"

He revealed that generally good nuclear news will appear in page 4 or 5 with relatively smaller font size! Occasionally the font size may be large but the space allotted will be often less prominent. He goes to the extent of saying that there is an antinuclear mindset in the media. "The visual depictions are virtually always threatening and frightening. By and large if any bad news comes it will be spread in detail across top of page 1 in huge headlines. "This is not a matter of partisan bias or anti

nuclear crusading. It reflects a series of routine news judgments, of daily decisions, repeated over the course of several years. It is not conscious intentions but common assumptions that quietly direct news coverage toward dominant perceptions of the news room". Smyser quoted from "*The Media Elite*" by Lichter, Lichter and Rothman. Smyser argues that the role of the media is not to maximize anxiety or to minimize it. In case a radiation accident occurred the media should convey the information as promptly as fully, as accurately, as understandably and as totally in context as possible. In such a role it will minimize anxiety. He gave a few suggestions how scientists and engineers might help the media to play its role better. This will certainly help public to get better perception of nuclear power. My experience of interacting with a few of the most respected representatives of the media highlighted the value of Smyser's suggestions.

Scientists as communicators

Most of the time scientists speak in a language of caution-that too extreme caution. Because of this media or the public is likely to think they are evasive. In addition, use of jargon also comes in the way of effective communication. We cannot blame the media for the handicaps of scientists and engineers. Even if the reporter is keen to listen, many technical people are not equipped to convey information effectively. Public and media are mostly on the same page. Perception on nuclear power conveyed by media is often taken as gospel truth because the counter view is seldom presented.

Smyser suggests that maximum information on the topic should be made available as soon as possible. He is against withholding any information just because of uncertainty, incompleteness or ignorance. He proposes that the speaker may explain that the data are tentative, subject to error, preliminary or even as yet unknown.

Once there was a significant heavy water leak in Madras Atomic Power Station. It took time to rectify the leak. Workers under strict dose control procedures handled it well. The station

management did not explain promptly what was happening. It led to some media hype.

“The public is capable of understanding uncertainty”, Smyser cautioned. If, in a nuclear incident, you may not know how much radioactive material has been released you may say so that is Smyser’s advice. The spokespersons can assure the media that he will convey the information when he knows it with certainty. Honesty and openness pay. Smyser wants the spokesperson to speak in plain language, without jargon. Careful approach will help. One of the difficulties faced by scientists is that their assertions may sound arrogant.

In an eminently readable essay titled “Radiation’s unknown weigh on Japan” the New York Times Columnist Mathew Wald outlined the conceptual difficulties in quantifying biological effects of radiation. In fact the challenges in this field are the most important factor which influences public perception on any practice which involves ionizing radiation. After the Fukushima accident Japanese Government is very much exercised over the dose limits to be prescribed for populations in the vicinity of the stricken nuclear power plant. Fukushima accident led to significant changes in the perception on nuclear power of lay people. What was equally surprising is that a few news papers who were outspoken critics started looking at nuclear power benignly.

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Chapter 12

What is Really Real?

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The world is undergoing severe churning currently, especially in terms of people demanding meaningful participation in public policy. There has been a significant polarization, with many differing and often diametrically opposite views on a range of issues. Thus, for example, there appeared to be a scientific as well as public consensus developing on climate change and consequently a need to at least slow down, if not reverse, climate change. However, there has been a significant push over the past couple of years so that public opinion is changing, and with it the need for public policy to address climate change.

In such a situation, it has become difficult even for interested, but not directly involved, scientists as well as the general public to look at the evidence and make a judgment on what is really real. This presentation deals largely with issues relating to perceptions on nuclear energy, and it examines critically the basis for public fears and reservations against nuclear power.

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There have been several issues recently that have generated substantial public debate, including *Bt* brinjal, nuclear energy, climate change and medical testing and policies. A common theme running through these issues is the connection between society, science (and technology) and public policy involving governments at local, national and international levels.

Although there has generally been some interaction between science and public policy, society has generally been only provided public policy and science, without much direct involvement. However, with growing information available from many sources, there is an increasing questioning from the public towards both science and public policy. This has arisen in part from changes in science activities that have occurred especially over the past century relating to commercial interests, specialization and a checkered track record.

The general public idea of a scientist may be that of a person dedicated to uncovering truth and developing fundamental understanding, with some potential use of the knowledge eventually. However, scientists are also human, with normal human desires for fame and power. There has been an additional factor of wealth coming into this picture, especially over the last sixty years. The potent cocktail of fame, power and fortune has possibly altered scientific activities to such an extent that it may now be driven not just by curiosity but also by financial allure and inducement.

Thus, for example, data show that there has been an increase in industrial support of biomedical research from ~32% in 1980 to 62% in 2000, and a study in 2003 revealed that lead authors of one in three articles held relevant financial interest (Nanjundiah, 2011). This raises an important issue relating to potential conflicts of interest and unbiased scientific investigations. As is well known, studies supported by the tobacco industry were unable to find a link between smoking and lung cancer!

Scientists are still broadly trusted by society. A poll on public attitudes to energy found scientists, environmental protection organizations or consumer associations, and national governments being trusted by 71, 64 and 29% of the people, respectively (oecd-nea.org, 2010).

About 50 years ago, medical doctors were treated as demigods. However, with the advent of specialization and super-specialization, increasing awareness of medical malpractices driven by money, a trust deficit developed, so that it is not uncommon now for people to ask for a second opinion in many instances. Science may also be heading in this direction.

Over the past 60 years, there has been a substantial increase in specialization, so that one tends to know more and more of less and less. This has frequently led to attitudes of "Leave it to the experts", or "Daddy knows best," which are no longer acceptable.

The increase in specialization has necessitated collaborations not only within a discipline, but across disciplines; such interactions have been fruitful frequently. In addition, the complex issues being tackled, with the associated infrastructure, has led to scientific publications with numerous co-authors, compared to typically less than five co-authors until relatively recently. Analysis shows that a 1993 paper in the *New England Journal of Medicine* had 972 authors, so that each author effectively contributed two words to the paper (Nanjundiah, 2011). There is an increasing potential danger with specialization and numerous coauthors, that responsibility for publication becomes diffuse, with a chance that collaborators may not fully know the details of the work of their co-authors.

There are at least three important contributors to nuclear fears in the public. First, our common human sensory organs relating to sight, sound, touch, taste and smell cannot be used generally to track nuclear dangers. Second, there are vivid and

horrific images from the nuclear bombing in Hiroshima and Nagasaki, and these memories have been revived by accidents at three mile island, Chernobyl and Fukushima. Third, there is a string of broken promises such as nuclear power becoming “too cheap to meter”, or that all precautions have been taken so that nuclear power is “safe”.

Many governments as well as the nuclear industry label the above nuclear fears as irrational or unfounded. Apart from financial commercial interests and specialization in science, it is appropriate to consider the track record of nuclear power to examine whether public fears about nuclear power are ill-founded.

Nuclear Risks: Defense in depth, passive cooling systems and probabilistic risk assessment are some of the terms encountered when hearing experts discuss nuclear risks. Essentially, the idea is to develop several independent means of mitigating small problems or accidents, so that the overall possibility of a catastrophic accident becomes extremely small. It is unlikely that we will ever be able to account for all “beyond design” events such as the massive earthquake in Fukushima, or human error and bad design in Chernobyl. The third generation nuclear reactors are apparently designed with a risk of failure of one in a million reactor-years (Ramana, thebulletin.org). However, public experience has shown that there have been 5 core meltdowns within a total operation of 15,000 reactor-years since the 1950’s (Chokshi, 2011). Arguments that newer power plants are safe sound hollow when seen in the context of nuclear power plant operators trying to extend the lifetimes of old “less safe” reactors. Furthermore, despite their exhortations on the safety of nuclear power, it is important to note that both governments as well as the nuclear power industry tacitly acknowledge the possibility of a catastrophic nuclear accident: governments try to locate plants away from significant population centers, and the industry tries to limit liability and needs significant government financial support and underwriting.

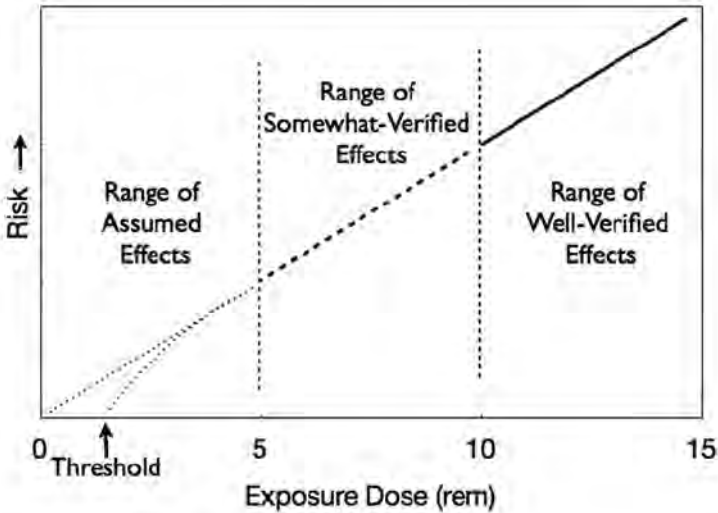


Figure 1. Variation in risk with radiation exposure dose, illustrating the linear no-threshold model as well as a model with a threshold; adapted from (gao.gov).

Scientific uncertainties and implications: It is important to acknowledge and understand uncertainties in science. This is examined in *Figure 1* by considering the changes in risk with radiation dosage (gao.gov). High dosage rates of more than 10 rem are very risky, with the risk increasing linearly with dosage, based on significant evidence from Hiroshima and Nagasaki. At intermediate dosage of 5 to 10 rems, there is limited verification to show that risk continues to be linearly proportional to dosage. At low dosage rates of less than 5 rems, the data are extremely limited and uncertain. A general approach has been to extrapolate the behavior at high dosage all the way down to zero, and this is referred to as the linear no-threshold model. More recently, there has been a significant push to endorse an approach involving a threshold level of radiation, for which there is no risk below the threshold level. This is a topic on which it is difficult to get complete verification of the effects for at-least two reasons: (a) when the risk is small, the increase

in cancers or deaths associated with radiation will be small and this may be well within nominal statistical variations in data, and (b) the presence of natural radiation may obfuscate small effects due to low additional radiation levels. A detailed study by the US National Academy of Sciences committee on Biological Effects of Ionizing Radiation stated (Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2, nap.edu): “The Committee judges that the balance of evidence from epidemiologic, animal and mechanistic studies tend to favor a simple proportionate relationship at low doses between radiation dose and cancer risk,” essentially supporting the linear no-threshold model.

Such uncertainties may have a profound effect on interpretations or estimations.

Thus, for example, estimates of cancer deaths related to the Chernobyl accident vary widely from 62 (unscear.org, 2008) to 4000 (who.int, 2005) to 93,000 (greenpeace.org) to 985,000 (nyas.org)! The first estimate was given recently by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) whereas the second estimate was given by the UN Chernobyl forum and the World Health Organization. The third report came from a study involving 52 scientists commissioned by Greenpeace, and the fourth estimate was from a group of three scientists in Russia and Belarus who collected information from many local sources that were not considered by Western scientists. While differences in methodologies certainly contributed to the vastly different estimates, one of the important factors is consideration for low level radiation. Thus, the estimated low value of 62 deaths from UNSCEAR arose because the committee explicitly noted that they did not consider projections from low level radiation because of unacceptable uncertainties in the predictions (unscear.org, 2008). Clearly, even if the risk is small at low doses, consideration of the very large areas over which there was contamination will lead to large numbers of projected cancers.

There is an additional important point to bear in mind, relating to uncertainties of low level radiation. Eventually, one has to deal with decommissioning and cleaning up sites involved with nuclear activities. Calculations in 1995 revealed that the cost for cleaning up a site in Nevada increases drastically with a reduction in the remnant radiation (gao.gov).

Dealing with Nuclear Accidents: Nuclear accidents have a significant effect on public opinion and perception of nuclear power. Thus, polls conducted before and after a criticality accident in the Tokai Mora uranium mining facility in 1999, with the death of two people, resulted in a change to 53% polled considering nuclear power dangerous after the accident compared to 12% before the accident (oecd-nea.org, 2010). While news about “minor” accidents were not reported widely earlier, so that the impact of such accidents was largely local, the sense of heightened anxiety and wide exposure in media imply that such incidents will be widely disseminated, leading to stiffening of attitudes against nuclear power. Thus, following Fukushima, Germany has decided to close all nuclear power plants by 2020, and Switzerland by 2032. Several other countries are re-evaluating their plans for nuclear power.

There appears now to be a set pattern for officials to deal with nuclear accidents: (a) state that lessons will be learnt, (b) study the nuclear accident, (c) re-examine safety, (d) make changes considered necessary, and (e) declare all plants safe. While such a pattern may be intended to reduce apprehensions about nuclear power, it is necessary to go beyond the above list.

Looking historically at the development of nuclear power plants (see, for example, an excellent 1992 BBC documentary (bbc.co.uk, 2011) entitled “A is for atom”), it is clear that Governments and the nuclear industry have always claimed that nuclear power is safe, even when they had some contrary indications. While such approaches may be ascribed to the cold war era until the 1990s, when nuclear power was closely linked

with nuclear bombs, it is surprising to note that this legacy continues even now. Thus, the UK government decided to play down the Fukushima accident, with a coordinated public relations strategy together with nuclear companies (guardian.co.uk, 2011). After Fukushima, a leaked recent study for the Russian president revealed that the Russian reactors were grievously under-prepared for natural and man-made disasters ranging from floods to fires to earthquakes to plain negligence; meanwhile, Russians declared their plants safe (bellona.org, 2011).

Coming to the situation in India, which followed the pattern described above, there have been two recent reports which cause confusion. First, around Sept 20 it was reported that India was awaiting a final report on French nuclear reactors, dealing with issues raised by Fukushima; orders would be finalized only after Indian authorities examined the report critically (thehindu.com). Within a week, there was another report from the nuclear establishment claiming that the Jaitapur plant would be completed, although with some delay (economictimes.indiatimes.com). This reveals the difficult predicament of the nuclear establishment in riding two generally incompatible horses: on the one hand, they need to reassure the public that safety will not be compromised, but on the other hand they want to keep foreign vendors happy that the deals will go through, with a delay. The two statements also appear to suggest that an evaluation of the report will not be open-ended, as the decision to go ahead has already been made.

Making public policy “scientifically”: Frequently, in dealing with complex issues, claims are made that the decisions should be made scientifically. However, when there are many parameters involved with complex issues, it becomes clear that values guide the relative significance of the different parameters. Take a simple example of buying a car: usually this involves a trade-off between cost and performance, with different people choosing different trade-offs depending on their inclinations.

With complex issues, such as nuclear power or Bt brinjal, there is a need to make multiple trade-offs, so that the overall analysis is based on the judgment of the relative importance of the various factors. Therefore, one needs to always keep in mind: who pays the costs and who reaps the benefits, as these are usually two different sets of people. Thus, for example, is it reasonable to have asked local villagers near Tarapur nuclear power plants to give up their land and possibly their livelihoods so that air-conditioned malls in Mumbai can operate comfortably; while, at the same time, the deprived villages in the vicinity of the power plants continue to suffer about 8 hours of power shutdown everyday (lokraj.org.in)?

Human Development and Consumption: Over the last several decades, there has been a substantial push for economic growth worldwide, and the term GDP (gross domestic product) has become common usage. The term GDP has become conflated with development, and also consumption, with many suggestions of a correlation between GDP and energy consumption. About two decades ago, a human development index (HDI) was developed in recognition that life expectancy together with literacy and education also contributed to human development, apart from economic growth (hdr.undp.org, 2010); HDI varies between ~0.3 and 0.95, with higher values being desirable (thewatt.com). *Figure 2* shows the variation in HDI with per capita energy consumption for 60 countries. There are several other figures with different energy factors and units, but the general trend of a saturation is still maintained.

Such approaches have an important bearing on nuclear power, as energy planning is based on presumed growth of GDP over the next two to four decades; clearly, assumed linkages between GDP growth and energy consumption drive current policies for power production. The data in *Figure 2* indicate broadly that there is a saturation in HDI of ~0.9 to 0.95 around a per-capita energy consumption of 2,400 kg oil equivalent (kgo e), so that an energy consumption of 2,400 kgo

e may be a desirable number. There are at least two important problems with this approach. (a) First, HDI is based on a mixture of contribution of some factors; limitations to the approach include the consideration of only a few factors relating to human development, and also the mathematical procedure adopted to come up with a single number. Indeed, the factors included in calculating HDI were modified last year, and the new approach gives HDI values that are lower than the older procedure. (b) Second, *Figure 2* suggests that India would need to increase energy consumption by a factor of ~ 5 to increase its HDI from ~ 0.62 to ~ 0.9 . However, the data also shows that there are countries with ~ 600 kgo e energy consumption having an HDI of ~ 0.8 to 0.82 . This analysis suggests that an energy consumption increase of less than a factor of ~ 2 could suffice in obtaining a high HDI of 0.8 to 0.85 .¹ Essentially, the vertical spread of the data at any energy consumption could be termed the elasticity of HDI, representing conditions where an increase in HDI is not related to an increase in energy consumption; for example, at the vertical line of $2,400$ kgo e, HDI varies from ~ 0.68 to 0.92 . Extending the figure to consider all countries, instead of only 60, will probably lead to an increase in elasticity. It is interesting to note also that further increase in energy consumption beyond $2,400$ kgo e does not lead to any significant increase in HDI; while Hong Kong and USA have a similar HDI of ~ 0.93 , USA consumes almost three times as much of energy per capita as does Hong Kong.

An increase in energy consumption by a factor of ~ 2 for India to get to an HDI of ~ 0.8 to 0.85 would lead to drastically different plan for power generation compared to one involving an increase in consumption by a factor of ~ 5 ; this may also reduce the justification for nuclear power plants. It is also important to bear in mind that projections beyond a couple of decades may be

¹ The equitable distribution of the available energy is an important but different matter. Energy policies are frequently justified as necessary to provide electricity to the rural areas, although this is likely to be a minor factor in the overall energy consumption.

meaningless in the current technological climate with frequent new developments and possibilities for significant paradigm changes.

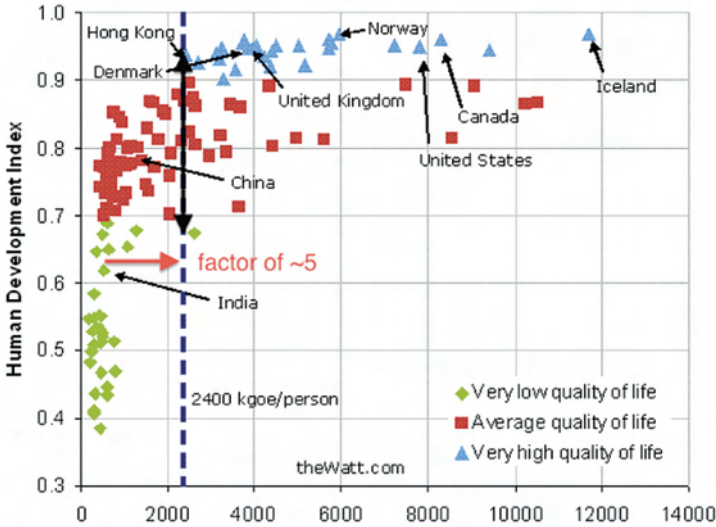


Figure 2. Variation in Human Development Index (HDI) with energy consumption showing a plateau in HDI (thewatt.com). The horizontal orange arrow suggests incorrectly that India will need to increase its energy consumption by a factor of ~ 5 ; the vertical black arrow at an energy consumption of 2400 kgo e/person reflects the elasticity in HDI, suggesting the possibility of an increase in HDI without any increase in energy consumption.

Alternatives to Nuclear Power: If nuclear power is not considered seriously due to the perceived risks and the lack of public acceptability, it is necessary to examine alternatives. It is appropriate to first utilize existing energy resources optimally. Currently, nuclear energy contributes $\sim 3\%$ of the total energy needs, and even with a substantial expansion over the next two decades, it is projected to contribute only 6% to India's energy needs (planningcommission.nic.in). India's current transmission and distribution losses for electricity are more than $\sim 25\%$ compared to values of ~ 5 to 10% globally. Clearly, a decrease in

such losses towards global levels will lead to substantial energy becoming available. Conservation of energy and enhanced energy efficiency can also increase available energy effectively. Note that dire consequences of large-scale power outages in Japan following Fukushima did not materialize, with a focussed effort towards energy conservation and efficiency.

Nuclear power has generally been considered to be cheaper than renewable energy from sources such as solar. However, this may largely have been a result of some creative accounting. As noted elsewhere, even in the '50s and '60s, British nuclear proponents had cooked up data to show that nuclear power was at that time cheaper than coal power (bbc.co.uk, 2011). With unusual candor, the British energy Secretary Huhne noted recently that nuclear power has been amongst the most costly failure of British policy-making, with payments of £2 billion per year being made currently for power that was used decades ago; surprisingly, he supports new nuclear power stations without *any* public subsidies (independent.co.uk) A very recent study has shown that solar energy will be cheaper than nuclear energy in two locations where nuclear plants are being considered in USA (ucsusa.org). Furthermore, there have been frequent time and cost over-runs in upcoming power plants, which would also favor alternative renewable energy sources. It is relevant to note that renewable power projects may also need to deal with issues relating to availability of land and other factors, for large solar farms as an example.

Closing Comments

It is clear that the linkages between society, science and public policy need to be reworked, so that society becomes intimately involved with both science and public policy, as shown in Figure 3. Questioning of science by the public does not warrant an anti-science label, just as societal desire for partnership and involvement in public policy should not be seen as being anti-constitutional. Gone are the days when leading authorities in Science or Public Policy can declare truths and directions for society to follow.

While scientific expertise is essential in providing some answers and directions for the future, it is clear that society wants to be, and needs to be, involved in shaping public policies that may entail scientific issues.

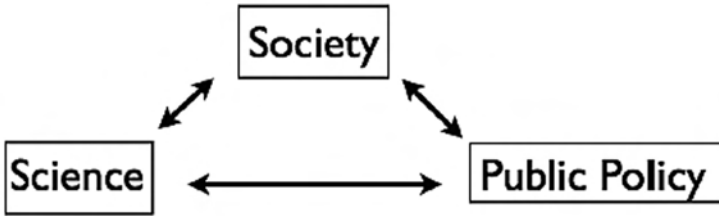


Figure 3. Illustration of desirable inter linkages between society, science and public policy.

There is sufficient information available to understand public apprehensions regarding nuclear power; open communication from nuclear bodies is essential, but it may not be sufficient to bridge the trust deficit. Plans for massive nuclear power installations based on projections for over four decades are not merited, as the projections may not be valid. Furthermore, there are sufficient alternatives available to generate the needed energy.

Governments and the nuclear power industry must desist from “proclaiming safe” (in opposition to “crying wolf”), as they only increase public anxiety and mistrust when the next nuclear accident happens. Comparisons of the safety of nuclear power plants with crossing a road in urban India or flying on a plane are insensitive at best, as the public appears to recognize that what is important is the *potential* for acute and chronic damage in case of a catastrophic nuclear accident. It is ironical that the conditional support for the nuclear renaissance arising from a more serious perceived threat of climate change is likely to be reduced, as corporations unwilling to have a longer term perspective of global warming have pushed an agenda to sow confusion about climate change.

Finally, we all have our individual perceptions of risks, and on an individual basis we pay the price when reality differs from our perception. However, public policy must take into account the larger societally perceived risks, especially in a large densely populated country like India, without much hope of moving large populations in case of a serious accident. Allaying public fears and concerns is likely to be difficult, in view of the trust deficit arising from historical and contemporaneous approaches by the nuclear industry.

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DISCUSSION

Prof. Parthasarathy: There are many fears associated with the nuclear industry: radiation, proliferation, accidents etc. Though many industries produce hazardous waste, nuclear industry faces the brunt of protests. This is despite the development of technology in the nuclear field. This fear has all the more increased with the accident at Fukushima. Radiation is a subject that has been misunderstood not only by lay persons but even by the highly educated. Thus the nuclear regulatory body has a responsibility to communicate credibly and be more open.

Due to constant communication journalists who were exposed to a lot of information after the Fukushima incident have helped few outspoken critics to look at nuclear power benignly. Thus with constant communication, pro-nuclear enthusiasts may find it a bit easier to change the perception of lay public on nuclear power.

Prof. Atul Choksi: Scientists are human and fallible. They have vested interests. Hence nuclear risk and uncertainty is not really known. Thus the concerns of the public are valid.

Dr Chidambaran Iyer

Part III

PANEL DISCUSSION

**CONCLUSIONS AND
RECOMMENDATIONS**

Chapter 13

Summary of the Panel Discussion

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NIAS has organized this very innovative and timely Brainstorming Workshop on Public Risk Perception. This is a serious problem which has appeared time and again worldwide as a conflict between developments based on modern technology on the one hand, and the possible hazards introduced by those technologies on the other. In India such concerns have arisen in different contexts ---our nuclear reactor programs, genetically modified crops and even hazards of using cell-phones. All these examples carry the common feature that individual members of the public (including most of its intelligentsia as well) cannot, on their own, assess the risks attendant to these complex technologies and have to make a less than fully informed assessment of the level of risk and compare it with the benefits.

The problem of Public Risk Perception has many dimensions to it, starting from the philosophical social, psychological, political and of course technical. This Workshop has been fortunate in having presentations by experts on each of these aspects. Issues discussed, among others, included the distortions caused by

“Blinkers” in theoretical frameworks used in analyzing the problem, the knowledge discrepancy between experts and the lay man and the increasingly dominant role of the media. The sessions were also devoted to a clear pedagogical explanation of possible hazards associated with specific examples like nuclear energy, GM crops and cell-phone hazards.

The Concluding Panel Discussion was devoted to using the insights generated by all these talks to evolving a methodology of public debate on risk perception, assessment and intervention. To provide a framework for the discussion, the session began with enumerating what would be, at the conceptual level, the logical steps needed to achieve this goal. These were:

1. First the experts from different interest groups must get together to ascertain and agree on the facts. These experts would NOT decide policy or choose between alternatives -- only bring out the technical facts accompanying any given choice. Unless there is some level of agreement on FACTS between experts, the public will be prey to exaggerations and rumour.
2. Having come to an agreement the experts must educate apex policy makers and opinion makers, including bipartisan, parliamentary committees, media and NGOs representing different affected parties.
3. These opinion makers then have to hammer out a compromise policy taking into account technical, economic and “political acceptability ” factors
4. They then will have to decide whether to continue with project, or abandon it, or delay it.
5. Having come to some consensus, the opinion and policy makers must convey a uniform and distilled message to the public. This last part will be very difficult. Ways have to be found to communicate down to the affected public through the local political machinery, district collectors, ground level government officials

6. All this has to be done well before any agitation starts. Investment and action in that project must be postponed till this is done.

It is self evident that this sequence of steps is not totally realistic. For this system to work everyone down the chain has to be honest. They should not accept a viewpoint behind closed doors and then turn their backs on it outside for political expediency. Irrational and pre-conceived notions by the public have to be removed without at the same time minimizing any of their genuine concerns.

In the real world we live, these ideal pre-requisites don't exist. So these different steps and stages will get intermixed and not follow the above logical sequence at all. Indeed several participants in the room pointed out a variety of ways in which these different steps will get intermingled, with each step not waiting for the earlier ones to finish. The purpose of starting out by listing the idealized steps is only to benchmark what is needed, so that one can as close to them as possible.

Some important recommendations made were:

1. Experts must keep in touch with the public regularly and gain their confidence.
2. There must be flow of ideas not just from the experts "down" to the public but just as importantly from the public to the experts bringing out the problems at the ground level.
3. The experts' discussion should not merely be on the technological aspects but equally on social and cultural implications.

