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Natural or Deliberate Outbreak in Pakistan: How to Prevent or Detect and Trace its Origin: Biosecurity, Surveillance, Forensics

Zabta Khan Shinwari · Ali Talha Khalil · Anwar Nasim

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Abstract Over the last few decades biosecurity and biosafety have emerged as a prominent public health concern due to some high-profile accidents. Effective strategies to deal with the outbreak, whether deliberate or non-deliberate requires a multidisciplinary approach and coordinated decision-making by various state departments such as health, forensics, agriculture, environment, intelligence, law and enforcement, etc. In a dynamic global environment and the overwhelming asymmetric threats from the non-state actors, it is of utmost importance to understand the biosecurity issues and initiate a coordinated global effort to cope with biosecurity and biosafety breaches and develop an as effective response mechanism. An attractive choice for the terrorists, state enemies and non-state actors is the use of biological weapons. An unwanted incident may not only bring chaos to the people, but also can inflict severe economic damage industrially and locally as was in the notorious foot-and-mouth disease outbreak. Because of special geopolitical compulsion, Pakistan is one of the hot spots where special action needs to be taken. The current review focuses on the various approaches, technologies that can be used to alleviate the chances of biosafety and biosecurity incident and emphasizes the role of modern technology that can be used in this regard.

Keywords Biosecurity · Biosafety · Outbreak · Biological weapon

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Z. K. Shinwari · A. T. Khalil (✉)
Department of Biotechnology, Quaid i Azam University, Islamabad, Pakistan
e-mail: talhakhalil.qau@gmail.com

A. Nasim
Pakistan Academy of Sciences, Islamabad, Pakistan

Introduction to Biosecurity

Security and safety are among the fundamental principles that lay the foundation of a prosperous society (Van Tuyll 2013). Pakistan is ranked sixth in terms of population (184.35 million) while in stable circumstances, it is expected to be fifth on the list by 2050 (Pakistan Economic Survey 2012–2013). Hence, any disaster can have a severe impact on the people's life; however, an effective, pre-emptive and well-defined strategy can prevent a significant amount of losses. Because of several notorious accidents biosecurity has emerged as a massive public issue not only for the security analysts, but simultaneously as a research topic for scientists. Technically biosecurity refers to "Technologies, principles and practices that are employed to secure pathogens, toxins and sensitive technologies from unauthorized access, misuse, theft, intentional release or diversion" (World Health Organization 2006). Biosecurity is a broad term covering food security, health security, agricultural security, environmental security, zoonosis, plant pathogens, pests, genetically modified organism's (GMOs), living modified organism (LMOs), alien species (FAO Biosecurity toolkit), etc., and is associated to dual-use technologies which refer to a beneficial research used for malicious purposes (Clevestig 2009). Biosecurity owes the 4Ts phenomena, i.e. biosecurity is specifically related to the transportation, trade, travel and tourism (Waage and Mumford 2008).

Pakistan being an underdeveloped country faces numerous challenges in the global dynamic environment such as population, employment, resources, food, agriculture and health, etc. (Pakistan Vision 2030, 2007), but with planning and management such challenges can be turned into opportunities. Being a frontline state in the war against terrorism, Pakistan has suffered massive losses in the form of manpower and economy. This also makes Pakistan fragile as a bioterrorist attack. Any natural outbreak or deliberate contamination with a biological weapon by non-state actors may have severe consequences. Ensuring the nation's security is the government job, but it cannot happen with the involvement of individual people and civil society (Van Tuyll 2013). Pakistan can be targeted for agriculture, poultries, fisheries, food storage facilities, direct pathogen release, etc. Recent progress in biotechnology and other life sciences poses a dual-use dilemma (Atlas and Dando 2006). There is a possibility of using various biotechnologies to inflict economic chaos. The famous incident of LMOs, foot-and-mouth disease (FMD) in England in 2001 presents awful readings for economists, but also had raised some expensive alarms; although an unintentional outbreak, but causing an economic outcry. The outbreak resulted in the loss of 48 billion US dollars. Meanwhile the FMD in England has given a blue print to the non-state actors (Gewin 2003).

To date, in spite of massive technological advancement globally; our knowledge about the biological warfare is limited. This is rather a greater concern for underdeveloped countries like Pakistan because of the lack of technological capacity to deal with such issues effectively. There is a great need of global partnerships to provide collaborative, multidisciplinary approaches to enhance the biosecurity measures in terms of surveillance, diagnosis and proactive response. In the light of the above discussion, we strongly suggest that Pakistan must come up with concrete preparedness, response plan for biosecurity and biorisk management to ensure the damage control if there is an accident.

"Bioterrorism" Global and Regional Perspectives

Biowarfare tactics are practiced by the state enemies and non-state actors since ancient times to the present day (Dudley and Woodford 2002). The overall spectrum of bioterrorists includes state enemies, criminals, individuals, military ambush or state sponsored event, etc. (Zilinskas and Carus 2000). Historically toxins of plants and fungi, carcasses of animals, infected human corpse, and contaminated blankets have been utilized for bioterrorism (Army Medical Research Institute of Infectious Diseases (US) Staff 2002). The earliest event in records occurred in sixth century, when the Assyrians poisoned wells with rye ergot that leads to the formation of hallucinogenic drugs. Black Death pandemic in 1346 during Kaffa (Ukraine) siege killed about 25 million Europeans in 5 years. In seventeenth century smallpox virus was inoculated in the blankets in French–Indian war (Riedel 2004). Similar tactics were employed in the first World War (WW1). A clandestine operation was carried out by the Germans during WW1 with the intent to spread anthrax cultures to kill cattle and horses (Christopher et al. 1997). Germans are also alleged to have developed glanders, cholera toxins and wheat fungus as biological weapons (Dudley and Woodford 2002). Japan has used anthrax as a biological weapon against China in 1932 and 1945 (Alibek and Handelman 2000; Harris 2002). Rhodesian security forces are also alleged to have spread anthrax to destroy abrogate African cattle during 1978–1980 (Wilson et al. 2000). While Iraq launched official biological weapon proliferation program in 1991, about 25 ballistic missiles and 200 bombs were laden with biological weapons were made intended to cause mass casualties (Zilinskas 1997). In the period of 1999–2001 there were several attempts by Al-Qaida to establish a laboratory for biological weapons by procurement of anthrax spores (CSS Analysis in Security Policy 2007). The famous Bulgarian umbrella or umbrella killing incident is another notorious example bioterrorism. Georgi Markov, a Bulgarian exile, was murdered in a London bus station in 1978 with an umbrella containing ricin. Ricin is a plant-derived noninfectious toxin (Maman and Yehezkelli 2009). Recently in 2013, suspicious letters sent to President Barack Obama and Senator Roger tested positive for ricin (Shea and Gottron 2010). Prior to that ricin-rich mails were sent to another senator Bill in 2004. In a similar bioterrorist event, letters containing anthrax spores were mailed to US senators for notorious purposes in 2001 (Borio et al. 2001). In Pakistan, where the suicide bombings by the terrorists are often targeted towards high-profile personalities like a prime minister or president, the government should overlook the security measures, so that it could prevent attacks of the similar nature.

Complacency in Biosecurity Measures Can Prove Costly

It is imperative for any government to start thinking critically about the biosecurity measures in order to protect their economies, industry, food, agriculture, livestock and importantly the health of their people. Being complacent and taking biosecurity issues for granted can lead to severe damage. The collapse of Taipei China pig and pork industry in 1997 because of an FMD outbreak illustrates the same. About 50,000 jobs were lost in addition to the loss of 6.9 billion US dollars as a result of the outbreak. Above that the FMD eradication program for the same

outbreak over the span of 3 years cost 15 billion US dollars (Pearson 2000). In 1999 southeastern Asia experienced a slaughter of one million the pigs because of a 3-month prevalence of the Nipah virus. Nipah virus is also the causative agent of severe encephalitis and during the period killed 109 people in Singapore and Malaysia (Dudley and Woodford 2002; Enserink 2000). The unintentional outbreak of FMD in England rather represents an even worst case of economic and industrial collapse because of biological entities. England suffered a loss of two billion US dollars per day and slaughtered 3,900,000 animals in the FMD-hit areas in 2001. The slaughter and disposal of the animals alone in England cost 7.5 billion US dollars. In a similar FMD outbreak in 1967 in England, the direct costs reached up to 260 million US dollars and slaughtering of 442,000 animals (Dudley and Woodford 2002). An outbreak of avian influenza resulted in the loss of 86 million US dollars in Pennsylvania in 1983 (APHIS 1998). An outbreak of swine fever in Holland resulted in the loss of 2.4 billion pounds (Whiting 2003). The substantial growth of fish culture across the world had led to the spread of many parasites of fishes (Hedrick 1996; Hill 2000). Recently, salmon fishing is being threatened by the spread of *Gyrodactylus salaries* (Peeler et al. 2004).

Social Dimensions

Biosecurity and biosafety issues are not only confined to the deliberate or nondeliberate contaminations, but it must be overlooked in rather a broader spectrum. Universities working with pathogenic microorganisms and biological toxins should be provided extensive care to the human resources working in their facility. Not long ago; on 12th February 2010, a senior professor of biology (University of Alabama) went into the meeting of senior faculty and shot six members out which three died (Nature 2012). Here is a lesson for us; what if Amy Bishop Anderson had used a biological weapon/toxin instead of a pistol? Are our research facilities really secured? The interactions of the students and staff are not peaceful, but the social setup and activities and with the aid of psychiatrists we can identify the aberrance in an individual behavior (Nature 2012). People try to find out novel ways of killing (Parker 2014). Considering the weapons, the twentieth century was considered to be the century of physics that ended with the presence of weapons of mass destruction in the states armory. Biology is considered to be the science of the twenty-first century that can have a profound impact on the society, but also demands sustained biosecurity policies (Fidler and Gostin 2008).

In order to conclude the various scenarios presented; a question arises, whether Pakistan is prepared for such events?

Biological Weapons: Darkening the Horizon

As biological weapons posses certain characters like low cost and easy production, easily accessible knowledge of production, less chances of detection because of invisibility (aerosols) and simple logistic requirements, making them a popular choice of non-state actors (Atlas 1998; Rappert 2010) and therefore termed as a poor man's bomb (Livingstone and Douglass 1984). The use of biological weapons is considered as devastating as a nuclear war (Blancou and Pearson 2003). It is estimated that using a Bioweapon/km^2 would cost just one US dollar as compared to conventional weapons which cost about 2,000 US dollars/km^2 (Huxsoll et al. 1988). Pakistan can be targeted with biological weapons on its revenue-generating pillars which are the agricultural resources and livestock (Fig. 1). In addition, biological weapons can be accessed very easily. Pathogens can be isolated from the environment with the help of amateur microbiologists. Bioterrorists can also purchase the bioweapon and use them for notorious purposes. Such bioweapons can be exported to Pakistan very easily through the contractors because Pakistan lacks the technical capacity to deal with such situation. Theologist and ideological goals are not always the cause of terrorism, but they can be used by criminals for blackmailing (Horn 1999).

One of the greatest challenges regarding bioweapons is the use of appropriate dispersal methodology that must be in conformance to the characteristics that bioweapon has. The dispersal can be brought about by using explosive devices, water/food supplies, animals and insects while inanimate objects like medicines, blood and letters can also be used (Fidler and Gostin 2008). In order to have a competitive edge, one industry may use/threat other industries in competition with a biological weapon (Casagrande 2000).

Fragile Industries of Pakistan

An event of germ warfare or accidental biosecurity lapse can affect the industry directly or indirectly. Being an agricultural country, we may presume about the event had taken place on our agricultural and livestock resources. On an industrial scale, crops are grown on large areas which make it very difficult to monitor. Contamination with infectious pathogen can result in contamination of other crops within a few days. When contaminated stocks are found, they are immediately removed and destroyed and for livestock the entire infected flock or herd needs to be culled. The stock which seems noncontaminated must be confirmed for which one may need diagnostic services from a veterinary doctor or agriculturist. These are costly

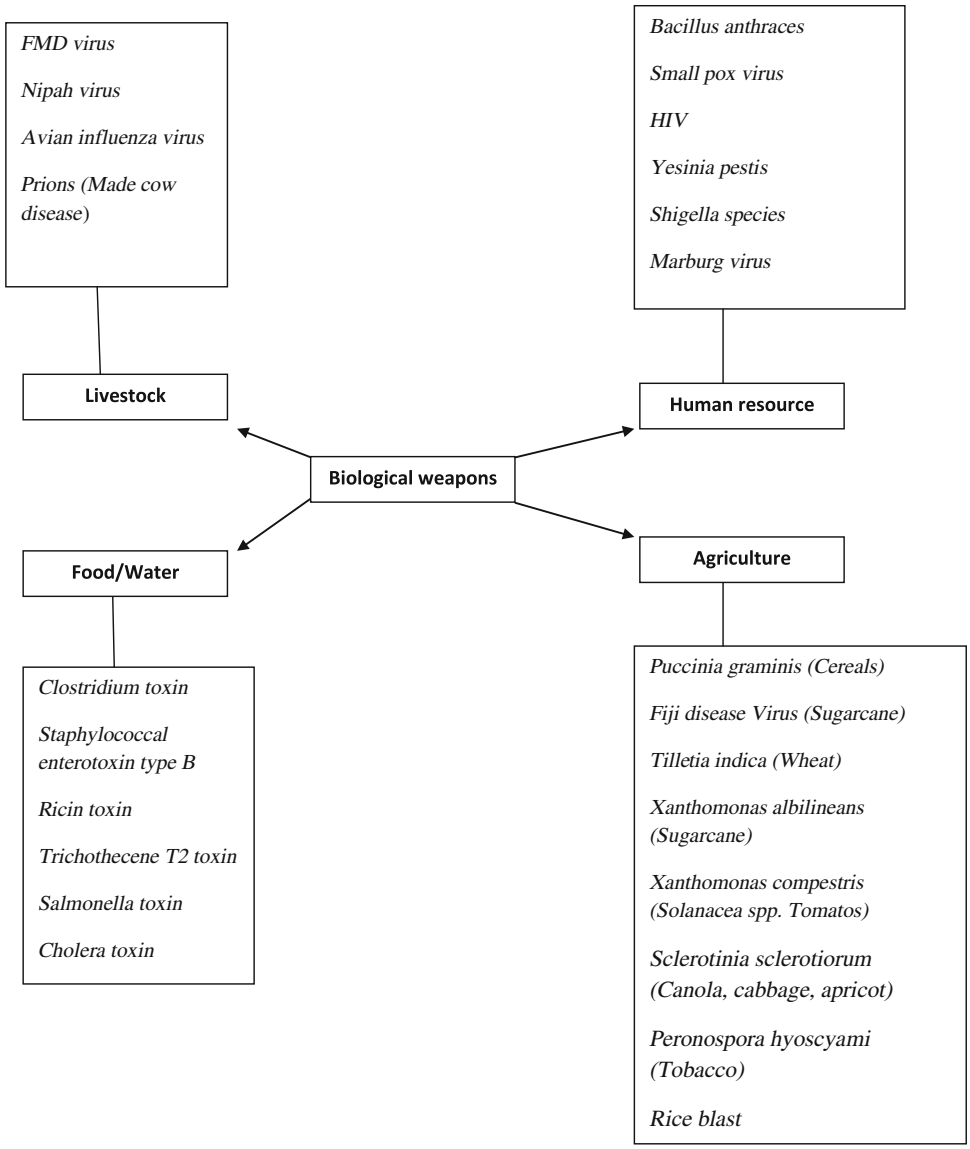

Fig. 1 Some biological weapons and potential targets

procedures that are to be undertaken. Different chemical reagents and chemotherapeutants are needed to alleviate the infection. If there is a fungal infection, expensive fungicides like sterol biosynthesis inhibitors (SBI) and demethylation inhibitors (DMI) will be needed in addition to the human resource (http://www.apsnet.org). Similarly, diagnostic kits, vaccines, antibiotics, veterinarians and doctors will be required. All these are expensive procedures considering an underdeveloped country like Pakistan. Besides this, the particular industry will be defamed which will lead to the loss of consumer trust locally and moreover the export markets will be lost. For safety and security, the Government of Pakistan (GoP) must ensure the International Operating Procedures (ISO 14001) in every industry and take strict actions, plus penalties and penalize the industries that fail to meet the requirements.

Agricultural Sector

Pakistan relies mostly on its agriculture to generate revenue. Agriculture in Pakistan accounts for 21 % of overall gross domestic product (GDP), while absorbing 45 % of the country's human resource and it is estimated that 62 % of people are directly or indirectly involved in agriculture. Livestock also contributes heavily (53.2 %) to the agriculture sector in the form of poultries, fisheries, hatcheries (Economic survey 2009–2010). Dairy farming is considered a popular business in Pakistan. Pakistan is third on the list of top milk producing countries (46,000 liters) and contributes 11.7 % the overall GDP, while 6.5 billion liters of nonprocessed milk is utilized for drinking purposes. In addition, the dairy industry has absorbed about 40 million human resources (The Nation 2013b). The consumption of beef and poultry has also increased in Pakistan over the last

two decades. In the span of just 11 years the poultry consumption has risen by 239 %, i.e. 322 million to 767 million from 2000 to 2010–2011 (Ahmad 2011). All these facts make agriculture *A Soft Belly* of the economy of Pakistan and a potential target for bioterrorism for the state enemies.

Food Sector

Deliberate contamination of food resources has been a popular ploy of the bioterrorists. In 1985, 170,000 people were infected as a result of *Salmonella typhimurium* contamination in milk in the United States. In 1984, Rajneesh cult has contaminated the Salad bars in Oregon (CSS Analysis in Security Policy 2007). In 1999, consumption of beef contaminated with prions resulted in death of 120 people while economic damage of 87 billion US dollars (Nestle 2003). Contamination of salad bars with *S. typhimurium* in USA resulted in 751 infections (World Health Organization 2002). Such events occur rather frequently in Pakistan. An important incident occurred in "Raziq Abad police training center" (Karachi) in 2012, in which more than 100 police officers were hospitalized because of eating the contaminated food in the mess (Pakistan Affairs 2012). The event might well be a properly planned attack to take revenge from the Pakistan police in Karachi, working against the criminals, mafia and terrorists. Recently on 7th January 2014, 300 people fell ill due to the consumption of pesticide (malathion) contaminated frozen food stuff in Tokyo. After preliminary investigations, police suspected that the pesticide which is used against aphids was mixed in the plant resulted in tainted products (Tribune 2014). This can be a strategy to sabotage the credibility of Japan largest seafood company *Maruha Nichiro Holdings.* Before this event, seven people died and many were made sick by consumption of cabbage contaminated with *Escherichia coli* in Japan (Tribune 2014).

Beside such intentional modes of contaminations the human fears threats from the non-deliberate mode of contamination. Corn, wheat, potatoes are the 50 % of the world food supply, but recently worrying intrusions have been made in them. *Tilletia indica* is a fungal disease of wheat originated in Asia, but has also appeared in the United States in 1996 (USDA 2004). *Phytophthora infestans* causative agent of the late blight of potato resulted in a famine in the eighteenth century and still prevails in changing virulent forms (Goodwin et al. 1994). In east Africa, another pathogenic fungus *Puccina gramins,* which causes the wheat stem rust has reemerged after years of suppression (Panel 2005).

The described events of food biosecurity lapses are only a few of many, but these events clearly refer biosecurity as a global problem. There is a clear need of a global food biosecurity strategy while taking the poorer and resource-limited counties in consideration. To feed the people of Pakistan with in the coming years is itself a challenge because of the significant reduction in the arable lands and fresh water accompanied by the high birth rates. Besides this, the ever increasing costs of fertilizers and other agricultural chemicals pose a threat to the food security. In the context of climatic changes dealing with these issues becomes even more difficult.

Biotechnology in Pakistan

Pakistan Moving Forward in Biotechnology

Research over the years in Pakistan is considered to be a success story. If the research activities continue in Pakistan at the same pace; the country will jump from rank 43–27 by 2018. There is a 50 % increase (3,939–6,200) over a span of 2 years in the number of research publications. Now Pakistan is publishing more research papers per capita than India. The Ph.D. faculty has increased by 50 % in 2 years in public sector universities. About 10–15 Ph.D. degrees are awarded every week. Ph.D. enrollments have increased by 40 %, while over a period of 2 years the number of M.Phil/MS enrollments has increased by 65 % (The Nation 2013a).

Among the other emerging fields of science, Pakistan has given equal importance to biotechnology in order to produce trained manpower and build the capacity to deal with the requirements of the people. In 2009, Pakistan had 29 centers and institutions for biotechnology, but there are few centers having the capability of producing the GMOs (Tabassum et al. 2012). The research institutes in biotechnology have been increasing rapidly and now there are about 100 institutes, relevant to biotechnology (Fig. 2). Government of Pakistan has also considered biotechnology among the priority area for development in the national commission of science and technology. In 2001, National Commission on Biotechnology was formed to support all biotechnology-related activities. Government of Pakistan has also announced 3.53 million US dollars to put into agricultural biotechnology, medical biotechnology over a period of 5 years since 2009. The first biotechnology-based pharma industry Bago-Ferozsons Biosciences Private Limited (BF biosciences) was also launched with the initial investment of 7.2 million dollars (Aldridge 2009). Above that there are foreign stipends provided for higher education including biotechnology. There are more than 3,000 overseas scholarships granted so far and about 1,200 researchers have come back after the completion of their Ph.D. degrees. Among the returned human resource, 5–7 % are biotechnologist. The life sciences have been given significant importance in the number of supervisors of Ph.D. (Fig. 3).

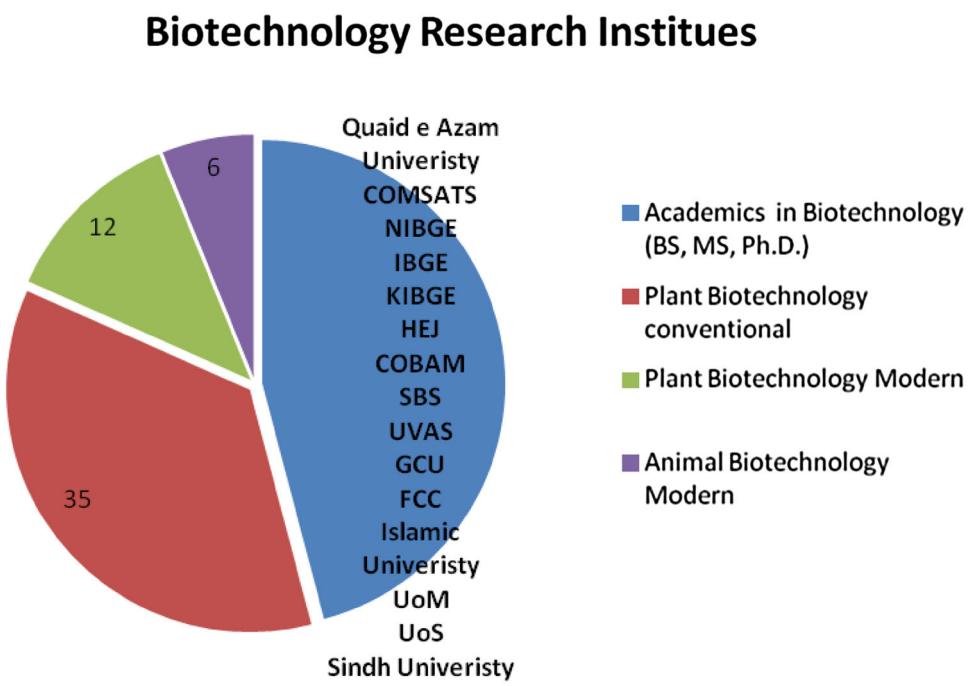

Fig. 2 Biotechnology research and major institutes in Pakistan

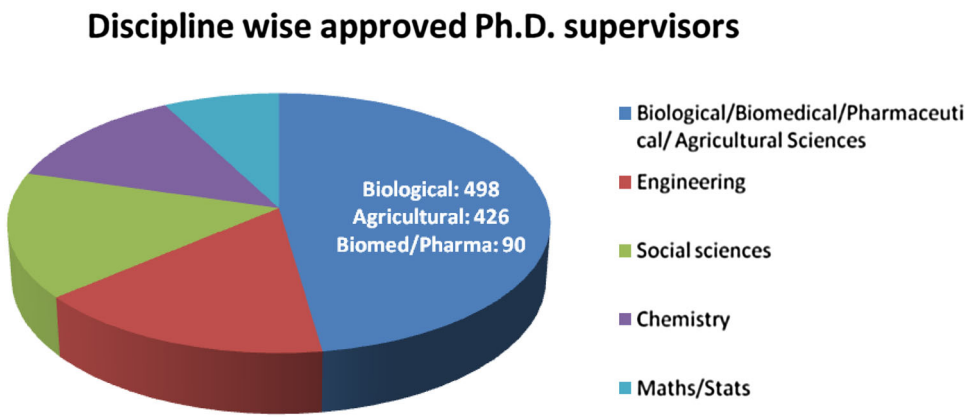

Fig. 3 Discipline-wise approved supervisors in Pakistan

Dual Use of Biotechnology

The life sciences have enjoyed a massive turn around because of molecular biology, genetics and biotechnology over the last 50 years. Numerous biotechnologies have fueled these benefits to society, but also have raised some alarms about the dual use of biotechnology. During the last few years, the dual use research has become a sparked debate (Selgelid 2010). Technically dual use means research, science or technology that can be used for good as well as bad purposes (National Research Council 2004). Biotechnology represents a Dual-Use Dilemma because many biotechnologies have the potential to be misused (National Research Council 2004). Dual-use concerns of biotechnology are raised because of a series of dangerous experiments conducted by the scientist. Creation of the mouse pox vaccine-resistant super strain by genetic manipulation (Jackson et al. 2001), synthesizing the polio virus from the scratch (Cello et al. 2002), synthesis of the Spanish flu virus (Tumpey et al. 2005) and synthetic biology indicate dual use.

GMOs in Pakistan

Genetic engineering is considered as a solution to the yield deficits, enhancing the nutritional profiles, abiotic and biotic stress tolerance in plants; however, there is uncertainty about the impact of GMOs on the human and environmental health and also whether these products will provide a sustainable solution to food problems (Gilbert 2013; Ibrahim et al. 2013a, b). The GMOs are considered extremely dangerous by some authors as compared to other war-based hostile nuclear technologies and the existing armory (Henderson 1999). Genetic alterations of traditional

Table 1 Different centers working on GM crops in Pakistan

Major center	Crops	Biocontainment facility	Location
National Institute of Biotechnology and Genetic Engineering	Cotton, rice, wheat, potato, sugarcane, tomato, chili	Yes	Faisalabad (Punjab)
Center of Excellence in Molecular Biology	Cotton, rice, chicken pea	Yes	Lahore (Punjab)
National Agricultural Research Council	Cotton, rice, wheat, ground nut, chicken pea	Yes	Islamabad
Institute of Biotechnology and Genetic Engineering	Brassica	No	Peshawar
Quaid e Azam University	Soya bean, potato	No	Islamabad
Forman Christian College	Ground nut	Small	Lahore
School of Biological sciences	Sugarcane	No	Lahore

bioweapons could augment their virulence and antibiotic resistance several folds. Such experiments have already been tried in the past by the bioweaponeers of Soviet (Hart 2006). The notorious mouse pox experiment conducted by the Aussie researchers in 2001 depicts the danger that GMOs exhibit. In order to produce contraceptive vaccines, when the genetically modified mouse pox virus was injected, the mice died with a lethality rate of 60 %, which is far greater than the use of non-GM mouse pox virus. A much severer controversy raged when the same experiment was repeated by the researchers of the United States on cow pox virus because cowpox virus has the tendency to infect humans (Fidler and Gostin 2008).

In terms of GM crops, most research in Pakistan is performed on cotton and rice in which have already been modified for abiotic stresses like salt resistance and biotic stresses like bacterial, viral and insect resistance along with qualitative traits (Tabassum et al. 2012). Research on GM crops and the institutes involved in Pakistan are enlisted in Table 1. Numerous GM varieties of cotton and corn from different multinationals like Monsanto, Bayer crop, Nath seed, Silver land, Syngenta and Dupont-pioneer are pending for approval from the National Biosafety Commission (NBC). Pakistan is included in the list of mega biotech countries that grows GM crops on 50,000 or more hectares. Pakistan is the eighth largest GM area in the world (James 2009). There are many questions associated with the use of GM crops, such as: are GM crops inherently safe or dangerous from human and environmental perspectives? Costs and benefits associated with GM crops? Biosafety of GMOs and irreversible modification in the environment by the use of GM crops (Makoni et al. 2006).

Pakistan Preparedness

Pakistan is fragile to bioterrorist activities because of the current outdated system of agriculture, food and livestock management. There is a lack of basic infrastructure, technology and scientific and legislative capacity to deal with the issue of biosecurity in order to ensure the sustainable food production. Flexible infrastructure is needed to be developed which will allow consistent review and improvement of the virtually nonexistent system of crop and livestock protection. Being a resource-limited country, Pakistan has tried its best to ensure the biosafety and biosecurity measures are in place. This section describes the efforts of government towards achieving biosecurity of Pakistan.

Global Conventions and Treaties

Biological and Toxin Weapon Convention

In order to prevent the spread of germ warfare, various treaties have been signed. The most important of them is the biological toxin and weapon convention. The biological and toxin weapons convention (BTWC) is an international consensus to curtail the use of pathogenic microorganisms as biological weapons (http://www.idsa.in). Pakistan is signatory of the BTWC since 1972 and participates actively in the review conferences of the BTWC. After Pakistan nuclear tests in 1998, there were sanctions imposed by the US government not only at the nuclear facilities, but also the major biological research centers [BIS (Bureau of Industry and Security) 1998] which were lifted in 2001, because there were no evidence related to the offensive biological weapons program (Jane's CBRN assessments 2012). Pakistan during the review conferences of the BTWC has urged the non-signatory states to sign the treaty and favored the transport of biological entities only for peaceful purposes (Basit 2001). Pakistan being a signatory of the BTWC, it is compulsory to stay in conformance with different articles of the BTWC.

United Nations Security Council

Being a nonpermanent member of United Nations Security Council Pakistan has obligatory responsibilities to work for the peace and international security. In 2004, United

Nation Security Council adopted "The Resolution 1540" unopposed, which refers to the nonproliferation of nuclear, biological and chemical weapons (United Nations 2004) and refrain from supporting the countries involved.

World Trade Organization and Sanitary and Phytosanitary Agreement

Pakistan has been member state of World Trade Organization (WTO) since 1995 (http://www.wto.org). The clauses in the WTO related to the biosecurity has mostly stemmed from the agreement on the application of sanitary and phytosanitary measures (Roberts et al. 2013). The sanitary and phytosanitary agreement places restrictions on the import of plants, animals or any product derived from them if the purpose is the introduction of animal or plant pests.

Convention of Biological Diversity and Cartagena Protocol on Biosafety

Pakistan was among the 155 signatories of convention of biological diversity (CBD) in 1992. Pakistan has adopted fierce biological diversity conservation plans since 1992 and constructed global plans for the sustainable and global development in terms of environment protection. Under the CBD, there is an agreement among the party nations called Cartagena Protocol on Biosafety, which is an international treaty for the movement of LMOs between the countries (http://www.cbd.int/). In 2003, the Cartagena protocol entered into force. The Cartagena protocol is an important agreement to eliminate the adverse effects of the LMOs and allow the sustained and effective use of biological resources by safe and secure transboundary movements of LMO (Roberts et al. 2013).

Legislative Efforts by GoP

Although there are many legislative measures taken which are somehow related to biosecurity, they do not specifically deal with the biosecurity issues of Pakistan. There is extravagant need for the biosecurity act in Pakistan. In order to develop the science and technology in a legal framework, Pakistan has come up with certain laws, guidelines for sustained development of its resources. Important laws relevant to biosecurity are discussed here in a brief.

Environmental Protection Act

Environmental protection act (1997) is regulated by the environmental protection agency (EPA) that works under the Ministry of Climate Change This act basically involves the conservation, improvements, protection and promotion of a sustained development. Besides controlling the pollution, this act is also based on the hazardous substances in the environment (http://www.environment.gov.pk/). Under the act, EPA is empowered to perform environment impact assessment and initial environment examinations in the onwards projects. With the consensus now Pakistan has a National Environmental Policy. This act establishes a chain between many government administrative bodies. At the top of his hierarchy, there is a Pakistan Environment Protection Council, which brings about amendments if required in the National environmental policy. The EPA-Pakistan makes sure the implementation of the act and also has the investigatory powers (search warrants) and can seize the property if disobeyed.

National Biosafety Centre

Under the Sect. 31 of the environmental protection act, Pakistan has constituted the National Biosafety Committee that operates in the National Biosafety Centre. Pakistan biosafety rules were notified in 2005. There are three levels of administrative bodies regarding NBC. The federal committees include the first tier National Biosafety Committee and the second tier Technical advisory committee while the third level includes the Biosafety committees working within different institutes across Pakistan (Roberts et al. 2013; http://www.environment.gov.pk/).

Export Control Act

The legislation on the Export control act is in place since 23rd September 2004. This act is a major step moving forward in terms of peaceful coexistence in the world. This act is based on the strengthening the regulation of the exports of sensitive technologies, materials and goods, biological and nuclear weapons etc. According to the act, any offense can lead to the imprisonment of up to 14 years and can be penalized for five million rupees or both penalties can be announced for the culprits (IAEA Information Circular 2004).

Strategic Export Control Division

After the Export Control Act in 2004, Pakistan has also constituted the strategic export control division (SECDIV) in 2007 that works under the Ministry of Foreign Affairs. SECDIV is also responsible for the implementation, Environmental Protection Act 2004. The export control list that is subjected to regulations under the environmental protection act is periodically reviewed by the members of SECDIV. The export control list (updated 2011) mentions about 51 human pathogens, 19 biologically derived toxins,

17 animal pathogens, 13 plant pathogens which are subjected to strict export hurdles.

BioRisk Analysis

"Risk" is referred as the probability of harmful consequences and expected deaths due to the interaction between natural or human mediated hazards (Khan 2007). To cut short, risk is chance of harm from a hazardous activity. In Pakistan, the concept of disaster management is solely restricted to providing the relief to the affected people. Risk assessment, risk management and risk communication are the integral part of Risk analysis (Manning et al. 2005). Risk assessment represents the understanding of potential dangers and hazards and the possible consequences; risk management represents the systematic reviews of policies regarding risk assessment while risk communication is the effective exchange of experience, opinions between assessors and managers of risk (Hathaway 1993). Various state departments and concerned ministries must prepare procedures for risk management and disaster risk reduction, which will cover the potential risk identification, risk control measures, periodic review of these measures and ensuring the implementation. General principles of risk assessment in the Cartagena protocol are:

- "The assessment of risks must be carried in scientifically sound and transparent way for which the international guidelines made by international organizations can be used" (Annex 3, Paragraph 3).
- "Risks that are associated with LMOs should be considered in the context of risk associated with non-modified recipients in the likely parental receiving environment" (Annex 3, Paragraph 5).
- "Depending on the particular LMO, risk assessments should be performed on case by case basis" (Annex 3, Paragraph 6).

Recommendations

Technological and scientific capacity building can be a way forward towards risk mitigation of biological hazards. In this section, we present certain suggestions that can be useful in the risk mitigation.

National Biosecurity Centre

In order to cope with the demanding issues of biological security, there is a great need for a biosecurity center in Pakistan in order to coordinate all the related ministries (health, agriculture, livestock, environment) and the related departments. Eminent scientists, technocrats, politicians, security and threat analyst should be the integral part of the biosecurity centre will ensure the development of policies and legislation biorisk management. In addition to the biosecurity center, preference should also be given to the construction of zoopathological and phytopathological departments. An electronic disease reporting system and geographical information system need to be developed that can trace out the locality of new pathogenic strains. These departments will work in collaboration with the different societies such as the Pakistan Botanical Society, Pakistan Academy of Sciences, PASTIC, etc., to initiate funding in the area of mutual interest and produce well-equipped knowledge-based human resource.

Public Awareness and Training

Although the local farmers in Pakistan can deal with the some diseases, they fail to cope with exotic pathogens. Therefore, farmers, agriculturists and veterinarians need advanced training to deal with any foreign pathogen (Elbers and Knutsson 2013). Workshops and seminars on the topic of contagious crop/animal diseases, prevention and response strategies to bioterrorism, livestock management, etc., will increase the understanding of the complex issues of biosecurity. Such imitative or raising the awareness levels of young scientists, teachers, researchers about biosecurity. Biosafety and dual-use technologies has already been taken by the Department of Biotechnology, Quaid e Azam University, Islamabad, which is involved in an international project with Landau Network-Centro Volta and Sandia National laboratories. Along side, Police and Rangers who are responsible for the security must also be trained in this regard.

Diagnostics

Until now most the diagnostic in terms of animal or plant diseases is performed in research institutes. There is a great need for corporate investments to increase the capability so that they could detect a biological weapon. The infrastructure of these labs should support cooperative extension, that is, they should be electronically connected to the rest of the disease-control laboratories at national and international levels. In addition, the veterinary clinics should be properly distributed in the remote areas. All the diagnostic facilities need to be electronically connected.

Environmental Monitoring and Epidemiological Surveillance

An early detection and warning system can be very useful for the damage control. Monitoring the crop fields or herds

is indeed a difficult task because it is impossible to check each and every plant or animal in the stock. Mostly biological weapons are used as aerosols, which are colorless, odorless, tasteless preparations making them invisible to unaided eye (Hawley and Eitzen 2001). A professional surveillance system is needs to be adopted at the borders to prevent any chances of smuggling across the borders. Our technology of immediate pathogen detection in the environment is primitive. There is a great need to develop automated remote sensing capabilities. Of late, partial success has been achieved in the development of those technologies that can detect pathogen in environment like TWOBIAS (two-stage rapid biological surveillance and alarm system) biological surveillance (http://twobias.com).

Quarantine Procedures for the Transport Materials

Strict actions relevant to the quarantine procedures need to be adopted at transport avenues. The infected material must be isolated from the rest of the stock after the initial indications. Any nonindicated movement or shipment of the crop (GM and non-GM) or animals should be immediately stopped and if the stock is cleared from the quarantine department only then should be allowed for further transport. Destroying the contaminated stock should be the first priority. Increased border security should also be initiated.

Advanced Transport Technology

The advanced transport system (ATS) can be very useful in reducing the threats associated with the shipments and transport of infected goods, animals or plants. This transport technology is characterized by utilizing the microchips having stored information about the transport materials. ATS can be helpful in tracking down the pathogen and preventing the transport of infectious materials from place to place.

Hindering the Biological Weapon Acquisition

Various resources can be used by the non-state actors to obtain a bioweapons for their malicious purposes. Direct enrichment from the natural resources, purchasing the pathogen culture, by forcing a research facility, blackmailing, state biodefence and biological weapons programs and also can acquire the capability of genetic engineering a microorganism to be used a biological weapon using an internet recipe. There is also a possibility of the insiders of the biodefence institute to abuse their work and get access to the sensitive bioweapons or provide information to the non-state actors (Barletta 2002; Choffnes 2002; Ebright and Connell 2002). Such incident has already happened in 1981 in the United States where the spores of *Bacillus anthracis* were obtained from the military biodefence facility, and the same were used in mailing the anthrax spore-rich letters (Regalado and Fields 2002). Access control to the pathogen can certainly be an effective ploy to decrease the risk because when the access denial from a pathogen for the non-state actors will negate the chances of any accident. Off late, there was an attempt to steal the pathogens from the biodefence lab in Kazakhstan; the mission failed due to physical security measures (CNN 2002).

Response Mechanism to Bioterrorism and Role of National Disaster Management Authority

Any event related to biosecurity and biosafety lapses can lead to multiple ways, thus making the response to an event a bit tricky (Elbers and Knutsson 2013). Such nefarious acts might be deliberate announced one's or deliberate un announced one. Similarly, these can be accidental. In different cases the first responders in the event will be different (Elbers and Knutsson 2013). Therefore, the prevention of bioterrorism needs rapid and effective diagnostic arsenal, multi-dimensional approach and proactive legislation. There is significant need for vaccination of animals against diseases like FMD. For animals that act as a reservoir for the human pathogens, vaccination will reduce the chances of zoonosis. Government should consider certain precautionary measures such as the stockpiling of vaccines, antibiotics and diagnostic kits so that they could be available if they were needed. In addition, biodefence research (looking for vaccines, drugs and therapeutics against biological weapons) should be given priority in the country. Certain Agrochemicals like pesticides, insecticides, fungicides, etc. should also be stocked for as per precautions. The focus should be directed towards the proper action plan to deal with an outbreak. The response to bioterrorist attack is complex in the country like Pakistan.

The first responders in the event if it is an infectious pathogen of humans will be the paramedics, doctors, social workers, while in case of agricultural bioterrorism and livestock protection, then the respondents will be various agriculturists and veterinarians, etc. The agility of the first responders holds the key to recovery and can mitigate the risk (CSS Analysis in Security Policy 2007). They mostly have the first hand experience of the event. It is necessary for the government to train the farmers, poultry keepers, dairy farmers, etc., about the various ways to protect themselves as well as their resources. Short courses and diplomas in the subject of risk management should be made mandatory for the law and enforcement to cope effectively with any associated risks. Free entry seminars for farmers, dairy and poultry keepers, etc., can be very helpful in this regard.

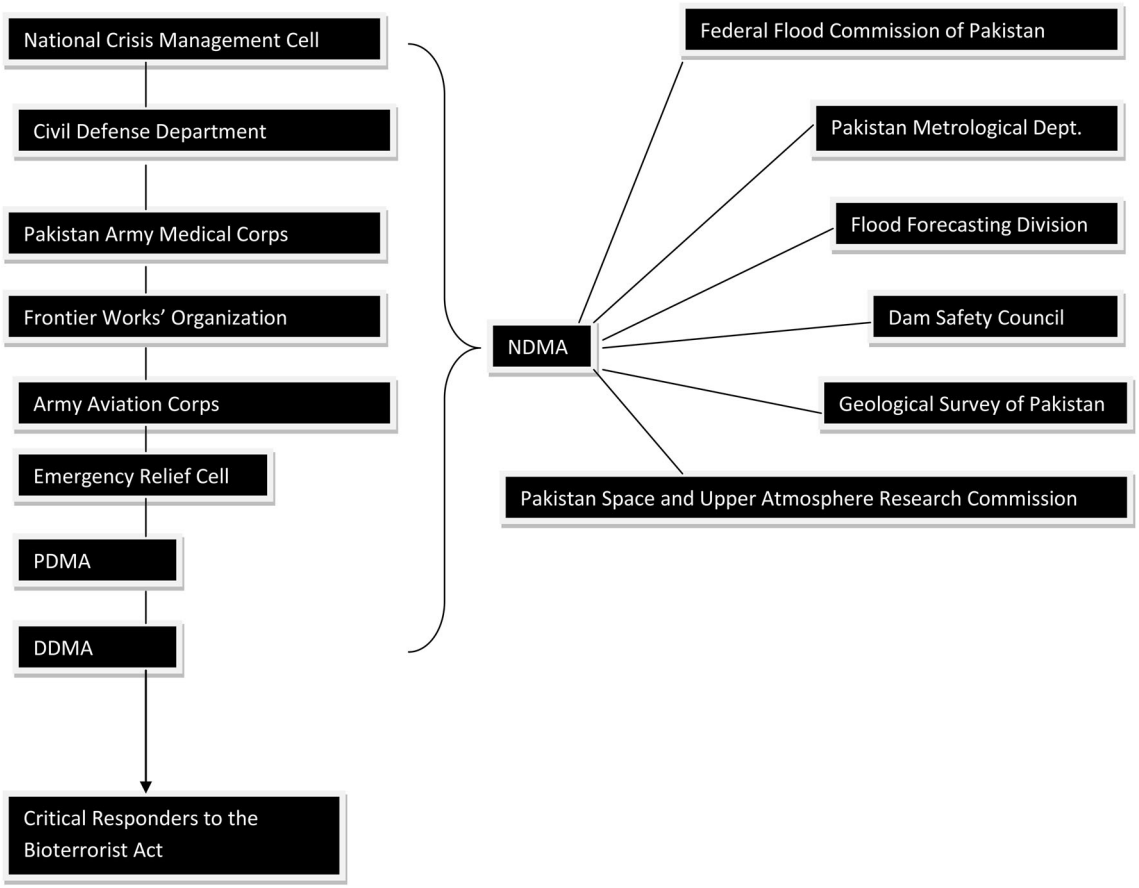

Fig. 4 Interdepartmental role of NDMA

National Disaster Management Authority

Under the chairmanship of the Prime minister, National Disaster Management Authority (NDMA) was constituted after the earthquake of 2005 and can be considered as second responders in the event. NDMA is an independent disaster/hazard control authority that should have proper emergency response plans and risk control measures. The organizational structure of NDMA can be explained in three hierarchal tiers. The first tier includes the National Disaster Management Council that lay down the policy principles and laws for NDMA. Administratively NDMA directs the second tier that is Provincial Disaster Management Authority, possessed by all of the five provinces in Pakistan (Khyber Pukhtonkhwa, Punjab, Sindh, Balochistan and Gilgit Baltistan). The third hierarchal tier includes the District Disaster Management Authority that directs the disaster management at the very place where the event has happened. In order to cope with the disasters, the NDMA works with other federal and provincial departments for the risk mitigation (Fig. 4). All the activities are controlled under the interior ministry through National Crisis Management Cell. If there is an accident, NDMA should come up with the human resources, risk-mitigation plans and subsequently perform environmental cleanups. NDMA should allocate a certain proportion of their budget to perform all their activities with undue pauses. At the same time, the government needs to allocate a sufficient biodefence budget to prevent any incident. Government should ensure the commitment of research institutes and labs to the biological weapon and toxin convention.

Conclusion

Since 2001, Pakistan has moved forward in the global movement against terrorism and therefore on the hit list of various terrorist organizations that are in pursuance to harm Pakistan. There is a prevailing threat for Pakistan from the terrorists of potential harm. One cannot exclude the option of using biological weapons against Pakistan by the non-state actors and terrorists. In a scenario like that, biosecurity measures should not be taken for granted.

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