

Yemen

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3.5. Yemen

Introduction

1. Status of Biotechnology in Yemen

Biotechnology existed long before there was a special word for it. Many of the principles and some of the techniques involved in biotechnology are ancient. For example, fermentation, in which microbes are used, has been practised for thousands of years to produce beer, wine, cheese, bread and yoghurt. Traditional animal and plant breeding techniques are also a form of pre-industrial or modern biotechnology. Biotechnology defined as “any technique that uses living organisms or substances from those organisms, to make or modify product, to improve plants or animals, or to develop micro-organisms for specific uses”. Therefore, biotechnology involves tools and techniques including those of recombinant DNA technology and it is multidisciplinary contain a variety of natural sciences and molecular biology.

Modern biotechnology is relatively a new issue in many developing countries in the region. In Yemen, it is one of the least developed issues as it is completely new. Consequently, there is poor understanding and little background knowledge on modern biotechnology and associated Genetic Engineering and as well their basic techniques such as Molecular Markers, Marker Assisted Selection, Recombinant DNA techniques, cloning, Transgenic Techniques, Genomics, Proteomics, Bioinformatics and other tools for genomic and proteomic analysis as together with the possible objectives, applications and impacts of these modern sciences on development of various economical sectors. Similarly, knowing the nature and extent of risks come from adopting these sciences in environmental, agricultural and public health sectors is also limited.

However, the risk and negative impacts on biodiversity associated with transfer of Genetically Modified Organisms (GMOs) and use its products is the most issue have been discussed in the report document of the National Biosafety framework (NBF) of Yemen with the acknowledgement of this document in the fact that, there is poor background knowledge in terms of all issues responsible for handling and precautions as well as safety of transgenic organisms transfer and its products.

These deficiencies combined with presence of negative attitudes seeded by the local media that enhance the fear from Biotechnology among policy makers and stakeholders including those working in closely related fields of biotechnology. For many journalists, biotechnology is restricted only on uncontrolled gene manipulation of embryonic cells in Human kind. The media misjudgment on biotechnology and molecular genetics terms is reflected on public attitude as well as negative image in many

policymakers in the country.

In fact, Yemen has many agricultural and environmental problems that increase the importance of biotechnology for Yemen as science and tool that can play an important role in addressing agricultural problems and contribute in agricultural development. For this purposes, there is a great need for adopting biotechnology together with necessarily policies and legislation framework regulating uses and objectives of biotechnology in the country.

Moreover, the actions that would be taken in this regards on different aspects of biotechnology and biosafety framework in Yemen should be developed according to the most important challenges and priorities. On the side of education and research aspects, there is a need to improve education and scientific capacities and technological infrastructure together with more attention given to training issue to those working in all biotechnology fields and particularly to people working in risk management for existing environmental, health, and agricultural systems.

Therefore, Sufficient funds, incentives and facilities need to be provided and strong collaboration between both local and regional related institutions should be established to enhance corporations and mutual benefits exchange that might cover the shortage in mentioned needed facilities. Aiming to further facilitation of that cooperation between the mentioned institutions.

Yemen need to establish a national biotechnology center as central institution for the whole country to coordinate, monitor and enforce biotechnology and associated biosafety issues in all related institutions alongside the country. This center will also help FAO and other international related organizations to achieve their future projects in the country. Policy makers and government officials must be involved in this project to provide sufficient support and to fund the operation of this center. The established center may also help in changing the stakeholders and community negative attitude on biotechnology in collaboration with social authorities to clarify the field of biotechnology as science, tool and industry. This center as it is mentioned before will be the cornerstone for international cooperation toward mutual exchange benefits to ensure fast development of biotechnology knowledge and capacities among the whole region. If we reach this point of development, then we may need to find a way to involve private sector in all issues of biotechnology mentioned before especially the industrial and investigation issues. Then private sector might be encouraged for creation and financing of local private biotechnology enterprises and promote local public research and development.

1.1 Plant biotechnology:

Local Plant Genetic Resources for Food and Agriculture (PGRFA) is the main subject in plant biotechnology in Yemen as many national statistics and reports have confirmed that, local crops varieties such as: wheat, maize, lentil and millet are yield and quality are deteriorating as a result of introducing high yielding varieties as well as extensive use of pesticides and agrochemicals.

The national reports ensured that, the used indigenous breeding methods for selections for new genotypes to improve species productivity and adaptability to different agro-ecosystems were approved to be responsible for crop preservation and improvement in the past and confirm the previous inference by the examples selection processes currently used widely in Tihama, Taiz, Ibb and Lahj in sorghum, and show improvement in seed's color and size with super early maturation and free of pests. It is also mentioned that, inherited knowledge and experience will lead to better understanding of natural resources and consequently better investment for them towards the productivity of various crops, animal and plant species.

However, these reports concluded; 1) lack of national breeding programs for the endogenous species. 2) no plan for sustainable use of agro-biodiversity depends. 3) Some genotypes of the endogenous species have excellent unique genetic characterizes. The report reached to the following recommendations:

1. More researches are needed to collect and conserve local genetic materials.
2. Assessment the potent of resources to improve the sustainable use of agro-biodiversity.
3. Improvement of genetic resources depends on research work and selection of breeding method based on sufficient evaluation process.
4. Establishment of genetic resources centers in the Agricultural Research and Extension Authority and in the Faculty of Agriculture of Sana'a is an important step toward genetic resource conservation and assessment in Yemen.

These centers have initiated processes to collect and preserve genetic resources for cereals, vegetables, and other crops in order to study genetic behavior of the collected species and their potential for species improvement.

In spite of the necessity of Modern biotechnology and Molecular Genetics for addressing and solving all the previous mentioned agricultural problems, no report have mentioned these modern techniques as fast and efficient scientific tools in agricultural research contributing in agricultural development if, there are basic facilities and capacities for biotechnology both at the academia and research centers. Moreover, in

the national report there is no indication to the possible use of modern biotechnology and molecular genetics in plant improvement program for population studies as well as fast genome analysis for evaluation assessment of the local varieties as well as the associated causes of the high level of destruction on plant biodiversity and endemic species. This may explain the reason why until this moment, there is no single research have been done in both Academia and Research Centers on plant Molecular Genetics and associated Molecular marker although, these kind of researches are required to evaluate the local Genetic resources in terms of threat, quality, utilization, conservation, restoration or regeneration, etc.

In tissue culture aspect, Faculty of Agriculture at Sana'a University has good lab space as well as good facilities for this technique. However, there is lack of reagents and chemicals needed for running this technique. Moreover, establishment of tissue culture unit in Faculty of Science at Sana'a University is in the progress now. On the other side, initiation tissues culture facilities are available in AREA headquarter laboratory in Dhamar but no reagents are there and no work was carried out in tissues culture there. New tissue culture laboratory, recently, established in Eastern plateau research station (Sayoun) for date palm propagation and another one will be established in Tihama coast research station (Alkadan). The government along with the private sector has recently started a partnership in this field.

Research in this field is restricted on propagation of plant trees that is very difficult to reproduce vegetative. In this type of research there is very good results have been seen in the laboratory of Sana'a University. However, protoplast fusion is the direct issue in tissue culture for GMOs, still absent in country research.

2.2 Animal and veterinary biotechnology:

The situation in animal and veterinary biotechnology is not different from plant, in that, there have not been any breeding research programs and/ or biotechnology research plan to evaluate, characterize and improve local strains, except a single project in chicken improvement at Southern Upland Agricultural Research Station. For example, the introduction of chicken breeds caused large reduction in local strains. Moreover, working on veterinary biotechnology for diseases studies, vaccination and drugs discovery, drug treatments or any other related research topics are beyond the reach even in the near future.

1.3 Microbial/ Industrial biotechnology:

Although the field of Industrial biotechnology is completely absent in Yemen, it can play an important role in economy enhancement if either public or private interest

is taken toward investment in this field. All the local indicators show that, for example, algal biotechnology is one of the most promising issues in Yemen although algal and marine biodiversity haven't been studied in Yemen. Because, investigations of marine algae will provide us valuable products that could even be as important as oil Algal biotechnology has made major advances in the last decades and several algae and algal products. Moreover, the most needed factors for successful of such investigation are existing in Yemen such as, existence of marine commercial algae, open coastal areas for open bond cultivation, stable and high temperature along the year, high light intensity cheap labor costs, etc. (Borowitzka, 1992).

Although, there have been no survey for marine algae, However, many algal cultivars are distributed along the coastal regions in Yemen and have been used by fishers to feed their animals. Red algae are one example of these algae that can be used as rich source for production of commercial iodine and agar. This industry almost spread among eastern regions where the previous required factors are exist.

1.4 Fishing and Algal Biotechnology:

There are several companies working in fishing and fishing cages industry that is combined with algal industry. Although this kind of investigation (growing fish in cages together alga) is representing threat for living organisms in the Yemen sea as it has been reported by Staniford at the European Parliament's Committee on Fisheries public hearing on 'Aquaculture in the European Union: Present Situation and Future Prospects', 1st October 2002, who reported that, "Modern aquaculture practices are largely unsustainable: they consume natural resources at a high rate and, because of their intensity, they are extremely vulnerable to the pollution and disease outbreaks." He added: If sea cage fish farming is to have any long-term future it must be forced to treat its wastes and focus on non-carnivorous species that do not lead to a net deficit in fisheries resources. Closed containment systems may solve the waste and escapes problems but the final fatal flaw lies in feed and food issues. Far from being a panacea for the decline in wild fisheries and the need for healthy food, sea cage fish farming serves only to compound the current crisis.

However, this kind of investment has been introduced to Yemen with no previous studied of its impact over benefits. Moreover, the global agricultural scenario has been witnessing a sea change for the last two decades. New issues such as global warming and climate change, new pests & diseases, natural resource depletion and degradation, house hold nutritional security, slowly growing farm profitability, food safety, trade competition etc. have arisen. Therefore, there should be more attention on such invests that might cause drastic effect thousands of times more than what we expect from the GMO effects.

2. Physical facilities dealing with Biotechnology

2.1 Research institutes:

In general multidisciplinary sciences as well as modern fields of science are almost rare in a whole country although, some national and private universities are somehow working in biotechnology research. Major Biotechnology courses are given by the Faculties of Science, Agriculture and Medicine. However, the courses given in modern biotechnology and molecular genetics and other related subjects are limited and base mostly on theoretical issues. The faculties in the previous departments are not equipped with sufficient facilities and equipments. The overall capacities and facilities of above mentioned department in National Universities are not even enough for basic work and assessment. For example, there still no Polymerase Chain Reaction (PCR) unit in some of these faculties. Some institutions on the other hand, have lack of any capacities and facilities for any kind of research especially newly established universities and institutions. On the other hand, some institutions in Yemen such as have some of the previous facilities for basic research in biotechnology (Mostly brought to Yemen through international related agencies). In addition, AREA, recently, supply biotech laboratory in Dhamar by modern equipments like real time PCR, a single mini agarose gel with power supply, a large agarose gel system as well as a PAGE gel and ELISA reader (Baum, 2009)

However, these limited facilities are still either in their packages ore used one time as these institutions limited of national experts and trained technicians who are able to do the basic work of such as GMO's detection and other genetic approaches for any related assessment. In addition, run costs of these facilities are expensive as they can be bought through single agent upon request. For example, the institute of Veterinary in Sana'a has PCR unit with no any other related chemicals and enzymes. Moreover, they never use it for any purpose until this moment. Therefore, there is an urgent need for all local universities, institutions as well as other related governmental agencies to further develop their capacities in infrastructure, training and education as one the first step toward assessment and management of biodiversity and biosafety.

The Ministry of Agriculture and Irrigation through AREA and the National Universities (faculties of science and agriculture) are the key players in modern biotechnology and biosafety. The departments of botany, biochemistry and microbiology of these faculties in addition to other faculties like medicine and environmental sciences in all Yemeni Universities can contribute in modern biotechnology and genetic researches as well as associated the risk assessment and management of GMOs through specialist closely related to DNA Technology.

We can conclude from the previous situation that, the powerful tools provided by speed progress in Biotechnology and associated that can introduce magic solutions for the chronicle problems in Yemeni agricultural, and environmental sectors and to contribute to food security and safety as well as environmental sustainability and conservation still in its emergence. Therefore, there is a need to further develop the capacities and engagement in biodiversity and biosafety in national institutions.

2.2 Research and Academia/ Universities Functional Laboratories:

The main institutions involve in research in Yemen are three:

1. Agricultural Research and Extension Authority is the oldest and the largest in the country,
2. University of Sana'a and
3. University of Aden.

The rest of universities and institutions interest are only in either educational or technical services providers for local communities. The survey summary of the existed national institutions, functional laboratories and related information were modified from the data reported in NBF (2005) and summarized in (Annex 1).

We can conclude from the previous information that, Personnel for Biotechnology, Genetics, Breeding and risk assessment of plant and other organisms are few. As result of this, genetically modified basic knowledge and techniques are rare. Furthermore, no genetically modified crops or microorganism were imported, no facility to produced and poor facilities to detect it exists at any Yemeni institution, but biotech laboratory of AREA could be the first on detecting GMO,s if covered its limitation on equipment and reagents (Annex2).

2.3 Access to consumables, reagents and supplies:

Generally the access to consumable and reagents is difficult and expensive as these materials are not widely used in the country. However, most of the companies dealing with drug importation can supply these reagents upon the request of beneficiaries. For example, the Eppendorf, Fermentas, and Biogen companies have agents in Yemen which is NATCO Company that has the highest reputation in Yemen the most. So, access to consumable and other supplies is not a problem as long as you are ready to pay more and to wait more.

2.4 Access to information:

Generally, Yemeni institutions and other research centers have rare to moderate information accessibility. In this regards, Libraries in Yemen often exist in universities. The local research centers are limiting of these libraries and they some times depend on the libraries of main universities such as Sana'a University and Eden University. However, the current references books are extremely old. For scientific journals, the situation is worse as there are no available journals since 1990. The Ministry of Higher Education and Scientific Research now lunch the National Electronic Library project that will join all Yemeni institutions. The project is still in its progress. The Yemeni Information Center has small library that only provide help to the workers in health sector through several medicinal journals in collaboration with Iran government.

In this regard, Yemen never got benefits from the donations provided by some international publishers and libraries. For example, there are many publishers as well as international libraries are providing their publication with limited costs and or for free to non-profitable organizations in developing and least developed countries such as, AGORA, Henri and INSAP library.

2.5 Obstacles facing development of Biotechnology:

The main factors affecting the development of modern biotechnology in Yemen are:

1. Limit of qualified human resources.
2. Weakness of institutional capacities.
3. Inadequate financial resources that led to difficulties in providing adequate human and material resources
4. Weak administrative capabilities to administrate the available cadres.
5. Limit of technical and institutional capacities in the lab and in the field.
6. Absence of an appropriate collaboration and coordination and information exchange mechanisms among institutions and concerned agencies.
7. The previous factors are also coupled with other sub factors affecting the psychology and peace mind of cadres such as low salaries, and inadequate resources allocated for their capacity building improvement.

3. Facilities engaged in GMO research and development

Similar to the status of research in Biotechnology, there is no research work on GMOs at the national level and no such crops are produced locally not only in Yemen but also in the whole region except in Egypt where the first genetically modified crop was produced last year. The awareness level is low and presently no authority has been assigned to regulate research and monitor safe utilization and application of GMOs.

Therefore, in order to foster this situation and halt any further biodiversity destruction, a lot of work should be done on the current national ecosystem in order to regulate the utilization and application of Modern Biotechnology and GMO as the need for modern biotechnology together with conventional breeding increases to its upper level to stop the degradation in natural plant populations as well as to help in restoration of the degraded green mountains that seems to be chronically problems in this time.

There is also need for building a database on local varieties and their natural Genetic information that should be taken for granted when decision is made in exportation or creation of related GMOs. Because, germplasm specificities will determine the degree of the negative effect of GM crops genetically near to them. Therefore, there is a need to develop adequate database on national biodiversity to help in formulation suitable precaution policies and legal frameworks. Similarly, there is a need to strengthen technical, institutional, international cooperation, research and social aspects in biotechnology and GMOs. Because, the lack of policy and legislation framework regulating uses and investment in plant natural resources as well as the absence of powerful biotechnological tools, high level of risk on the country fragile ecosystems and its germplasm will increase especially endemic species.

Moreover, the unreasonable high level of fear from GMOs and ignoring the benefits of Genetic and GMO will deprive the country from the benefits of this technology for assessment and evaluation of local genetic resources as well as finding possible solutions for all problems related to agricultural and environmental sectors. Technical capacities and institutional capabilities need to be further improved and public awareness needs to be enhanced.

National Capacity Self-Assessment (NCSA) have develop an excellent category that, classify capacity development efforts into three interconnected levels that involve; 1) Capacity development at the individual level, that rely on harnessing the individual knowledge and developing skills through training in order to change the attitudes and behaviors that raise to increasing of trainee performance in management, motivation,

morale, and accountability and responsibility levels. 2) Capacity development at the institutional level, aim to enhance the functioning capabilities of institutions in terms of tools, guidelines and information management systems. 3) Capacity development at the systemic level, interested in the overall policy, economic, regulatory, and accountability frameworks that will guide both institutions and individuals.

3.1 Ongoing and Planned GMO research and Development efforts:

Yemen is planning to create an integrated system dealing with all of issues related to biotechnology, GMOs and biosafety such as, applications, notifications and authorization, labeling information, and regulations on import and export of GMOs as well as identification and facing emergency situations and PGRFA characterization. Based on this, all applications to import, export, development, handling, field testing and release of GMOs or their products shall be submitted to the institutional biosafety committees (IBCs) identifying or tracking number must be assigned be used to distinguish this application from all others, which in turn shall forward such applications to the secretariat of the NBC to take the necessary and appropriate procedures. All records relating to the applications are stored under the tracking number, which is used to make information readily available to interested parties. The design of this database can facilitate easy information sharing of risk assessment reports and decision documents should provide information on:

- a. Mechanisms for internal safety monitoring;
- b. Safeguards to prevent any unintentional release;
- c. Safeguards to prevent any unintentional trans-boundary movement;
- d. Procedures for post-release treatment and control;
- e. Procedures for immediate notification and emergency response in case of an unintentional release; and
- f. Any other measures that the NBC, in cooperation with the concerned bodies, may require.

In regard PGRFA characterization government, has to start to establish capacity building, financial mechanism to apply the modern biotechnology and molecular approaches. Utilization of modern Biotechnological and Molecular genetics approaches for sustainable plants investigation and development through desired characteristic simple and quantitative traits for agro-diversity conservation, displaced areas restoration and forestry improvement for food security under divers> geo-ecological conditions. Application of Molecular Marker Techniques on plant genetic resources characterization, identification and utilization, for plant population studies for: (i) Characterization of genetic structure toward studying the indicators of recent bottlenecks in population size, the ease with which genes are recombined, out-crossing, and the

level of gene flow between populations as well as threat assessment and conservation strategies. (ii) Application of physiological Biochemical and Molecular phylogenetic markers on plant genetic resources characterization, identification and utilization, for wide adaptability to biotic and abiotic stressors such as drought, salinity, pests, diseases nutrient uptake deficiency etc.) under various types of agro-ecosystems (ie. rainfed, irrigated, and dry lands). (iii) Developing of natural multi-purposes plants varieties such as, shrubs or trees for protection of desertification & degradation and restoration of deserts ecosystems and degraded arid lands.

AREA, Faculties of Agriculture in Sana'a and Aden University start strengthening capacity building for the molecular characterization of PGRFA through Rainfed Agriculture and Livestock Project (RALP). The capacity assessment for those agencies which done by Baum (2009) indicated that the molecular characterization of PGRFA could be started in AREA Biotech Lab if the project/ AREA insure the shortage equipments and reagents (Annex 2).

3.2 Possible Gaps affecting GMO Research /Development:

There are a lot of obstacles or gaps facing GMO research and development in Yemen, NBF (2005) summarized some points to overcome these gaps and establishment the GMOs R& D. The suggested points are following:

1. Capacity building in traditional biotechnology is badly needed in Yemen. This should go hand in hand with building the capacities in modern biotechnology.
2. Improving the regional stations through provision of trained experts in modern methods and upgrading the available infrastructure.
3. Establish a national center for biotechnology serving different fields: agricultural, medical and environmental. The national center should be provided with trained staff and infrastructures. This center should be affiliated directly to the ministry of high education and scientific research. The MSc and PhD programs should be organized within the center to activate scientific research and development.
4. Provide scientific data bases in all related fields and activate the role of scientific publication and internet connections.
5. Rehabilitate scientific and research institutions and supply them with modern biotechnology facilities.
6. Formulate a natural scientific research policy.
7. Review the agricultural policies to fulfill the national needs and to eliminate the conflict between the scientists' interest and community needs. These policies should consider the country economy and investors interest, in addition To activating the universities and government institutions roles in related fields of research and development.

8. Review the university curriculum in agriculture and science faculties with emphasis on life sciences and environmental sciences. This could be achieved through, updating the curriculum to cope with needs in technical fields like tissue culture molecular biology to micro-propagate and to characterize biodiversity at molecular level, and to use the modern biotechnology to conserve the endangered species.

4. Biosafety Regulatory Status

The general term of Biosafety is defined in National Biosafety Framework (NBF) report as a concept referring to the need to protect human health and the environment from the possible adverse effects of the products of modern biotechnology, and particularly genetically modified organisms (GMOs). Moreover, the NBF document confirmed the necessity of high level of attention must be paid to biosafety issues which basically linked with the concern in preservation of Yemeni unique biodiversity and carry the responsibilities for economic employment of natural resources potentialities.

This document also acknowledged Yemeni responsibility towards Cartagena Protocol, as well as many other environmental conventions, treaties and protocols, provided that, they will play positive role in resolving the environmental issues such as biosafety. Due to this, Yemen show willingness for any kind of collaboration and cooperation with all countries in the world in terms of biosafety and biodiversity issues such as GMOs, taking into consideration the expected impacts on the bio-ecology of Yemen. Moreover, the document expressed the willingness of Yemen as other developing or under-developed country definitely need to invest in technologies of genetic engineering in order to improve productivity and ensure nutritional needs of our people.

4.1 Status of Biosafety framework in the country:

Ministry of Water and Environment (MWE) through Environment Protection Authority (EPA) is the coordinating agency of NBF project assisted by a National Coordination committee. The NBF document consists of six main parts related discussing several aspects of biosafety framework including (i) Yemeni national international biosafety commitment. (ii) National policies and strategies in biosafety (iii) deals with the future national biosafety by-law intended to be ratified and issued before the end of 2005. (iv) The guidelines on GMO handling and risk management as well as the challenges and constraints in monitoring and enforcement and future plans in GMO issues. (v) Monitoring and enforcement and (vi) The public awareness and participation. For detail see UNEP web site.

4.2 Compliance with International Conventions and Protocols:

Yemen has been involved in many memberships with several international agreements, conventions and protocols:

4.2.1 The Convention on Biological Diversity

The Convention on biological diversity (CBD) launched in 1992 at the United Nations Conference on Environment and Development is a major international forum to managing the Earth's biological resources. Its objectives are: the conservation of biological diversity, the sustainable use of its components; and the equitable sharing of its benefits. Agricultural biodiversity was given a special attention at the Conference of Parties 3 (COP3), held in Buenos Aires in 1996, particularly in the use of relevant genetic resources and genetically modified organisms (GMOs) from biotechnology. The COP3 have decided to establish a program on agricultural biodiversity to "promote the positive effects and mitigate the negative impacts of agricultural practices on biological diversity".

The government of Yemen ratified the CBD in 1995. The National Biodiversity Strategy and Action Plan for Yemen (NBSAPY) were prepared in 2005 as a first step toward the enhancement of the biodiversity components, including agricultural biodiversity.

4.2.2 Cartagena Protocol on Biosafety:

The Cabinet approved the Cartagena protocol on biosafety in 2005. The protocol has been presented to the Parliament for approval. A Presidential Decree No 64 for 2005 has been issued by the President stipulating the acceptance of Cartagena Protocol on Biosafety. The protocol is focusing in particular on the trans-boundary movement of GMOs, the protocol requires Parties to ensure that the development, handling, transport, use, transfer, and release of GMOs are undertaken in a way that prevents or reduces the risks to biological diversity and to human health. The adoption of this protocol leading to release the first legal document on Biosafety, which indicated for:

a. National Biosafety Committee (NBC):

There is a National Coordination Committee consists of members representing several Institutions, agencies and stakeholders groups:

1. The Minister of Environment: Chairman;
2. The Chairman of the General Environment Protection Authority: Vice Chairman;
3. The deputy Minister of the Ministry of Environment Member;
4. Representative of the ministry of Industry and Trade: Member;
5. Representative of the Ministry of Public Health and Population: Member;
6. Representative of the Ministry of Agriculture and Irrigation (AREA): Member;
7. Representative of the Ministry of Fishery Wealth: Member;
8. Representative of the Ministry of Defense: Member;
9. Representative of the Ministry of Interior: Member;
10. Representative of the Ministry of Higher Education and Scientific research: Member;
11. Representative of the Authority of Customs: Member;
12. Representative of the Yemen Authority of Specifications and measurements: Member;
13. Representative of the Union of Industrial and Commerce Chambers: Member;
14. Representative of the Consumer Protection Society: Member;
15. Legal adviser: Member;
16. Four specialized experts in agriculture, science, medicine, and marine sciences, selected for institutions and universities by the Minister upon the proposal of the chairman of the General Environment Protection Authority Members and
17. The Biosafety Project Coordinator (the NBC secretary). Member

The coordination committee is responsible for nominating the biosafety projects team when necessary. Usually members of these projects are consisting of available national consultant and experts with background knowledge related to the issue under discussion.

b. Institutional Biosafety Committees(IBCs):

The Presidential Decree indicated to establishment of institutional biosafety committees at concerned bodies (IBCs) which are represented in the NBC. Such IBCs shall be chaired by the NBC member of each concerned body. These shall have the following duties under delegation from the NBC:

- Receiving applications and requests;
- Processing such applications and requests;
- Reviewing risk assessment provided by applicants;
- Forwarding reports concerning applications, risk assessment and attached documents to NBC;

- Deciding on samples for field test and research;
- Implementing other duties prescribed by legislation of the concerned body;
- Submitting regular reports on mandated issues;
- Any other duties assigned to it by NBC.

c. The Scientific Committee (SC):

The decree indicated that, the Scientific Committee (SC) shall be formulated by a Ministerial resolution. The members of the SC shall not be less than nine members as follows: 1) A representative for each of the Agriculture College, Science College, Medical College, and Marine Sciences college of the recognized Yemeni universities, as well as the Agricultural Research and Extension Authority; and 2) Other members of the SC shall be chosen on the basis of scientific degree, qualification, and experience and in accordance with the specific conditions and terms contained in the executive ordinance regulating the works and activities of the NBC. Furthermore, the SC shall exercise the following duties:

- To undertake risk assessment in order to evaluate the benefits and risks resulting from the use of GMOs and their effects on the environment and society. In case of issuing a license after undertaking the probable risk assessment, the committee must carry out periodical review of the safety measures and standards that are followed to ensure that sufficient safety policies are followed. Therefore, the SC shall be responsible for undertaking risk assessment and to approve the issuing of licenses to conduct such experiments and their applications.
- To review or carry out the risk assessment and management submitted by the applicant.
- To review the procedures of risk assessment and management and to provide suggestions for modifying them.
- To undertake periodical assessment for the instructions and guidelines related biosafety and to review any decisions in the light of the latest developments related to import and export activities and/ or the local utilization and use of GMOs and their products in the Republic of Yemen.
- To monitor and control the activities of handling, transport, and the local utilization use of GMOs and their products in the Republic of Yemen and to ensure that the implementation and execution of appropriate procedures regarding such activities are fully and safely applied.
- To submit recommendations regarding the procedures of the contained use and the restrictions to be contained in the license and its duration as well as the mechanism of submitting reports and control procedures.

- To propose the formulation of permanent or temporary sub-committees of special nature of the concerned bodies.
- To perform any other tasks to be assigned by the NBC.

d. Regulatory Approvals:

The NBF and Presidential Decree illustrated the scientific methods for risk assessment and risk management which adopted from Cartagena Protocol and related documents of FAO and OECD. However, until now no single assessment is done due to the limitation of capacity building on GMOs detection. Therefore, the committees mentioned above are stagnant.

5. Capacities for GMO Detection

Regarding to capacities on GMO detection, it is very important to develop National Projects, which focus on the preparation of implementation of a National Biosafety Framework including regulatory, administration and decision making systems, and create active mechanisms for public participation and information. Here are some of valid or modified activities cited from NBF (2005):

- Gathering of necessary information concerning the use of modern biotechnology, existing legislation on biotechnology and/or biosafety;
- Activating and establishing Committees such as: National/Institutional Biosafety Committees, Scientific Committees, GM Advisory Committee, Review Committee, and GMO Approval Committee to enforce the Regulation;
- Training Biosafety Committees at both institutional and national levels to conduct scientifically sound biosafety reviews, etc;
- Developing National Biosafety Database and linkages to the Biosafety Clearing House;
- Drafting legal instruments as Guidelines for implementing the Regulation;
- Sharing experience on the organization and risk assessment and risk management with other countries, which are in a more advanced stage of implementation and enforcing biosafety regulations;
- Cooperating with other countries and international organizations in developing relevant educational, public awareness programs and intensive training on advance molecular biology.

Table 1: Summary of existence national institutions and functional laboratories and relate and information on; Year established, Mandate, Laboratories infrastructure/ equipment/ capacity, Funding sources, Human resources/Staffing/ Categories, Capacity building plans/strategy.

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
Agricultural Research and Extension Authority	1950s	8 Regional Stations + 5 National Centers	Conducting applied research to solve farmers problems in agriculture (crop + live-stock)	Ph.D 71 MSc. 87 BSc. 219 Distributed at the HQ and the branches	New lab facilities initiated for Biotechnology Tissue culture and Molecular	Research >85%, Education and Social Services	National and international fund (USD...)	Nil-rare Except 2-7 technical reports
			Crop and resource management research Socioeconomic research	62 Ph D (19 + 13)	Ordinary lab. Facilities No DNA manipulation facilities. Poor library No field station facilities	Education > 85 %, Research and Social Services		5-6
University of Sana'a	1970	Faculty of Science	Academic institution engaged in academic training in life sciences	91 Ph D	Traditional teaching laboratories suffering from lack of chemicals and reagents	Education > 80%, Research and Social Services	National	2-4
			Academic institution engaged in academic training in agricultural sciences		Tissue culture Lab. Storage facilities Facilities for Genetic mapping Research farm	In situ and ex situ conservation Collection of Genetic Resources material	(0.1-0.2 USD)	Nil
		Faculty of Agriculture	Collection & preservation of Genetic Resources	1 Ph D 2 MSc 7 BSc	Basic facilities in the plant quarantine lab.+Virus detection lab. Biological control lab. Pesticides residual effect (to be established)	Implementation of Research, and Technical services	National and international fund (USD...)	Nil
Ministry of Agriculture & Irrigation	1962	General Dep. Plant Protection	Protecting plants and controlling ag. Pests . Plant Protection Campaigns Plant quarantine	2 Ph D 29 MSc 132 BSc				

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
Ministry of Agriculture & Irrigation	1962	Central Veterinary Laboratory	Monitoring outbreaks of animal diseases Diagnosis of animal diseases Routine analysis of feed Campaigns against animal diseases	3 MSc 10 BSc 14 trained technicians	Well equipped laboratory Animal cell culture facilities	Animal vet Service oriented activities.	National and international fund (USD...)	Rare
University of Aden	1970	Faculty of Education Department of Life Science	Education Faculty engaged in academic training	13 Ph D 14 MSc	No facilities available in Biotechnology or Microbiology Library is outdated	Research, Education and Social Services		1-3
		Department of Chemistry	Academic degree training	11 Ph D	Poor lab facilities = outdated library	Research, Education and Social Services		
		Faculty of agriculture	Teaching and Academic degree training No Training in Biotechnology	44 Ph D in different disciplines	Teaching labs with ordinary facilities No facilities for Biotechnology training Outdated Library		National	
University of Taiz	1995	Faculty of Science Dep. Microbiology+ Dep. Life Sciences	Teaching and Academic degree training No Training in Biotechnology	5 Ph D (microbiology) 6 Ph D (Life Sciences)	Poor facilities	Research, Education and Social Services		Nil
		Center for Environmental Studies	Under establishment	2 Ph D	No lab. facilities yet available	Research and Studies	National	Nil
University of Hadhramout	1995	Faculty of Sciences	Teaching and Academic degree training No Training in Biotechnology	8 PhD and 3 13PhD, 4MSc	No lab. facilities	Research, Education and Social Services	National	Nil

Institutions	Year Established	(Branch)	Mandate	Staff Laboratory & library	Facilities	Proposed Mission	Available Yearly Fund (USD)	# Published papers yearly/ Scientist
		Faculty of Environmental and marine Sciences	Teaching and Academic degree training No Training in Biotechnology	5 PhD and 2 MSc	Some lab. facilities	Research, Education and Social Services	National	Nil
		Faculty of Marine Science	Teaching and Academic degree training No Training in Biotechnology	13 PhD, 11 MSc + Staff hired from Sana>a University + Arab expatriate staff	Limited lab facilities so far	Research, Education and Social Services		Nil
University of Hudaida	1995	Faculty of Medicine	Teaching and Academic degree training No Training in Biotechnology	14 Ph D + Staff hired from Sana>a University + Arab expatriate staff	Limited facilities inherited from a previous vet institute	Research, Education and Social Services	national	
University of Dhamar		Faculty of Agriculture + Veterinary Science	Teaching and Academic degree training No Training in Biotechnology	16 Ph D + staff hired from Sana>a University + Arab expatriate Staff	Limited facilities inherited from a previous vet institute	Academic degree training (BSc)	Not yet	Nil
University of Ibb	1996	Faculty of Science	Teaching and Academic degree training No Training in Biotechnology	12 PhD, 11 MSc	No lab. facilities yet available	Academic degree training (BSc)	Not yet	Nil
		Faculty of Agriculture	Teaching and Academic degree training No Training in Biotechnology	8 PhD and 6 MSc	No lab. facilities yet available			Nil
Private Sectors: Access to information YASAD	2006		Research & Training	8 PhD + 6MSc + 14 BSc	Limited	Research & Training		Not yet
Private Sectors: YAPB	2007		Research & Training	7 PhD +12 MSc + 23 BSc	Limited	Research & Training		Not yet

Table 2: Equipments required for AREA laboratory quantity and estimate price US\$.

Item	Qty	Unit Price	Total Price
Thermal cycler with block for 0.2 ml tubes, 96 wells	1	4500	4500
Transilluminator	1	3000	3000
PAGE gel system	2	4000	8000
Power supply (channels 4)	1	3000	3000
Compact microcentrifuge with adaptors for 0.5 ml and 0.2 tubes	1	1500	1500
Stirrer, hotplate	1	600	600
UPS, Stabilizer, 3000 Ambers	1	2500	2500
A3 scanner	1	1500	1500
Microwave	1	1000	1000
Heat block with blocks for 0.2 ml, 0.5 ml and 1.5 ml tubes	1	1500	1500
Stand alone gel documentation system	1	1500	1500
Medium size horizontal electrophoresis unit, complete	1	600	600
Power supply for the electrophoresis unit	1	800	800
Shaking water bath, 20 – 24 liter	1	3000	3000
Micropipette 0.5 – 10 µl	2	250	700
Micropipette 10 – 100 µl	2	350	700
Micropipette 100 – 1000 µl	2	350	700
Shaker large size	1	3000	3000

Source: modified from Baum (2009).

Table 3: Reagents required for AREA biotech lab for in country training.

Reagents	Qty	Reagents	Qty
Ethanol absolute (100 or 96%) (mol bio grade) 1 L	3	CTAB (cetyltrimethylammonium bromide), 500g	1
Isopropanol, 1 L	1	Taq DNA polymerase, 10000 units	6
Chloroform, 1L	3	DNA marker (100 pb DNA Ladder (250 µl))	6
Phenol solution	2	Beta-mecraptoethanol (14 Mm), 100 ml	1
Isoamyl alcohol, 1L	2	Xylene cyanole, 10 ml	6
Hydrochloride acid (HCL) Concentrate, 1L	1	Mineral oil, 100 ml	1
Sodium hydroxide, 1000 gm	1	Bromophenol blue loading solution (3 x 1m)	6
Glycerol, 100 ml	2	dNTP's (10mM each)	5
Tris-base (Tris 500 g)	6	Tris-borate-EDTA buffer 10X concentrate 10 L	1
Ethylenediamine tetracetic acid (Na2-EDTA), 500 g	1	Tris-EDTA buffer 100-Con, 1000 ml	2
Ethidium bromide, 100 g	1	Parafilm	6
Bromophenol blue dye, 100g	1	AFLP, SSR, ...etc primers	
Ethidium Bromide (10mg/ml), 10ml	1	Chemicals for silver staining kit plus components	
Boric acid EDTA, Na2 Salt, 1000g	1	Others reagents used for GMO's detection ?????	

Source: modified from Baum (2009).

