

## An Outlook on Jordan Efforts in Conservation of Plant Biodiversity during the First Hundred Years of the Country's Foundation

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### ABSTRACT

Plant biodiversity expresses one of the principal natural resources for all nations as it provides food, medicine, and shelter for all living besides its important role in balancing ecosystems and mitigating climate change. Jordan has paid great attention to its unique heritage of plant biodiversity since the foundation of the country, especially in terms of conservation. Notable conservation efforts have been made by Jordanian governments during the first hundred years of the country's foundation. These efforts were highly fruitful thanks to the unlimited governmental support to all projects related to the conservation of Jordan Flora. So, on the occasion of the first centenary of the country's foundation, this review article was prepared to highlight some of the efforts made by Jordan during the past hundred years to conserve this national wealth of plant biodiversity.

**Keywords:** Conservation, Ex-situ, First centenary, In situ, Jordan, Plant biodiversity

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### INTRODUCTION

Jordan is highly distinguished for its richness in plant biodiversity due to its variable geography and ecology (Oran, 2014). More than plant (2500) species were identified in Jordan, whereas 100 of them were reported as endemic, while 250 species were documented as rare (Al-Eissawi, 1982, 1996). According to the first national report of biodiversity prepared by the General Corporation for the Environment Protection (GCEP, 2001), studying Jordan flora started early as it was mentioned in Flora Orientals,

(Boissier, 1883); Flora of Syria (Post, 1932-1933) in addition to Flora Palestina (Zohary, 1962). Meanwhile, the past thirty years witnessed huge efforts in the collection and documentation of Jordan plant biodiversity. Examples on these efforts are the herbarium collections in the Department of Biological Sciences at the University of Jordan which exceeded 60,000 specimens, in addition to a collection of 10000 specimens at the Herbarium of Department of Biological Sciences at Yarmouk University beside two other collections hosted by the Ministry of Agriculture and National Center of Agricultural Research and Technology Transfer (NCARTT) (GCPE, 2001; NCARTT).

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Plant biodiversity is of immense importance as it is the main source of food for all living, also they are the prominent source of medicine for their remarkable curative powers against microbes due to the action of their active ingredients produced by their cells (Ochoa-Villarreal *et al.*, 2016). Also, plant biodiversity has remarkable contributions in contributing to balancing ecosystems, reducing erosion, mitigating climate change, and providing shelter for animals. Added to all this, being the only source of plant genes necessary for plant improvement and agricultural sustainability.

Unfortunately, Jordanian plant biodiversity has been exposed to dramatic decline due to urbanization, over-collection, overgrazing, and climate change (Al-Eisawi *et al.*, 2000; Oran 2014). This prompted the Jordanian Kingdom to take many important measures during the last century to conserve this important national heritage of plant biodiversity. This review article will highlight some of the Jordanian efforts in conserving plant biodiversity during the first hundred years of the country's founding based on GCPE's first national report on Convention on Biological Diversity (GCPE, 2001), the fourth and fifth national reports on biodiversity in Jordan papered by the Ministry of Environment (MoE, 2009, 2014)), the strategy and action plan report ( MoE, 2015), besides the report prepared by National Center of Agricultural Research and Technology Transfer (NCARTT) on the situation of the plant genetic resources (NCARTT, 2007).

#### **History of Conservation During the Emirate of East Jordan Period (1922-1939)**

Conservation efforts for plant biodiversity started in 1922, as an afforestation project for 23 forests and rangeland was launched, and during the same year, the first unit for forest reservation was established (NCARTT, 2007).

For legislations, East Jordan Emirate had issued the first forest law in 1923, then the general forest law in 1927 was issued and formed the base of recent forest laws which were successful in conserving the woodlands until the first thirties (GCPE, 2001). During the years (1932-1938) all forests

were surveyed, but due to World War II in 1939, Jordan lost many of its natural forests as many of these forests had been cleared to be used for cultivation field crops to counteract famine (GCPE, 2001). However, the year 1939 had witnessed the initiation of the Ministry of Agriculture with a very slight number of technicians.

#### **History of Conservation After Establishment of the Hashemite Kingdom of Jordan (1946)**

The government of Jordan had made many efforts for the maintenance of biodiversity since the establishment of the Kingdom in 1946. For example, in 1966 the government had established The Royal Society for the Conservation of Nature (RSCN) to be responsible for the management of the protected areas and conservation of Jordan's biodiversity. In 1968, a national program for protected areas was launched by the government and RSCN followed by the establishment of the first National Park of Azraq in the same year (GCPE, 2001; MoE, 2009)

Jordan endorsed the Convention on Biological Diversity (CBD) in 1993, which gave Jordan the chance to access international support for its conservation efforts, while in 2003, a strategy and action plan on keeping biodiversity in Jordan were developed were preparing national reports about the condition of biodiversity and conservation efforts was its first liability (GCPE, 2001; MoE, 2009).

MoE fourth a national report on biodiversity status in Jordan (2009) listed several conventions that have been ratified by the government for biodiversity matters like the Convention to Combat Desertification (UN CCD) in 1996 besides the Cartagena Protocol and the Convention of Migratory Species (CMS) in 2000. Also, in the year 2006, the national committee and the Government of Jordan issued the National Agenda document, that described the national strategy and goals of Jordan biodiversity conservation (MoE, 2009, 2014).

#### **Environmental Legislations of Biodiversity**

The Jordanian government had considered conservation of plant biodiversity as one of its major priorities (GOJ)

which was translated into legislation issued for environment protection and conservation of biodiversity.

GCPE's first national report (2001) reported some of these legislations which are quoted as the following:

“- Laws:

- Organization of Cities, Villages and Buildings Law no. 79 of 1966 and regulations.
- Agriculture Law no. 20 of 1973.
- Municipalities Law no. 29 of 1955.
- Organization of Natural Resources Affairs Law no. 17 of 1974.
- Punishments Law no. 16 of 1960.
- Civil Defense Law no. 12 of 1959.
- Environment Protection Law no. 12 of 1995.
- Aqaba Special Economic Zone Law no. 32 of 2000.
- Organization of Natural Resources Affairs Law no. 37 of 1966.
- Public Electricity Law no. 13 of 1991
- Patent Rights Law no. 32 of 1999.
- Crafts and Industries Law no. 16 of 1953 and related regulations.
- Housing Establishment Law no. 27 of 1968.
- Public Health Law no. 21 of 1971.
- Quarries Law no. 8 of 1971.
- Antiquities Law no. 12 of 1976.
- Jordan Authority Law no. 18 of 1977.
- Traffic Law no. 14 of 1984.
- Nuclear Energy & Radiation Protection Law no. 14 of 1987.
- Nuclear Energy and Radiation Protection Law No. 29, 2001.
- Agriculture Law No. 44, 2002.

- Protection law of new varieties No.76, 2002
- Environment Protection Law No. 1, 2003

By-Laws:

- Quarries By-Law no. 7 of 1971.

By-Law of the Protection of Birds and Wildlife and the Regulation of Hunting no. 113 of 1971.

By-Law of the Environmental Protection of Aqaba Special Economical Region no. 21 of 2001.

- Environmental Protection of Aqaba Special Economic Region By-law No. 21, 2001
- Exploitation of Private Forest No. z/12, 2003
- Protection of Wildlife species, their Hunting and Trade Org No. G/34, 2003
- Protection of New Plant Species No. z/45, 2003”

#### **Efforts of Jordanian Government towards conservation of plant biodiversity**

##### **In situ Conservation efforts of plant biodiversity in Jordan**

Jordan (represented by RSCN) had developed a plan for protected areas in 1970, incorporating with the International Union for Conservation of Nature (IUCN) and the World Wild Life Fund (WWF) (MoE, 2009). The plan proposed reviewing 16 in situ conservation sites for biodiversity which represent now ten protected areas that encompass 1,443.5 sq km (MoE, 2009). Currently, in situ conservation places in Jordan that fulfill IUCN requirements for protected sites are those directed by RSCN and the Aqaba Special Economic Zone Authority (ASEZA), while other sites are considered still emerging (MoE, 2009). Today, the Ministry of Environment is in charge of the protected areas which are listed in Table 1.

**Table 1: List of protected areas in Jordan (MoE, 2009).**

No	Name of Protected Area	Date of Establishment	Area (km <sup>2</sup> )
1	Shomari Wildlife Reserve	1975	21
2	Azraq Wetland Reserve	1978	12
3	Mujeb Biosphere Reserve	1985	212
4	Ajloun Forest Reserve	1987	12
5	Dana Biosphere Reserve	1989	292
6	Wadi Rum World Heritage Site	1997	729
7	Aqaba Marine Park	1997	2.5
8	Dibbin Forest Reserve	2004	8.5
9	Yarmouk Forest Reserve	2010	21
10	Qatar Nature Reserve	2011	110
11	Fifa Nature Reserve	2011	26
Total			1,420

#### **Ex-situ Conservation efforts of plant biodiversity in Jordan**

The updated checklist of vascular plants in Jordan had listed 2565 species, those include Genetic Resources and Crop Wild Relatives (CWR) which comprises vital gene pools of essential crops like wheat, barley, oat, chickpea, lentil, bitter vetch, pea, forages, oil-producing plants, melons, vegetables, fruit crops, dye plants, and medicinal and ornamental plants. Diversity in CWR has elected Jordan to be a major part of the Fertile Crescent for global food security.

#### **The National Center for Agricultural Research and Technology Transfer (NCARTT)**

Jordan had initiated the Genetic Resource Unit (GRU) in 1993 under the umbrella of the NCARTT (NCARTT, 2007). This unit aimed to conserve plant genetic resources from degradation and extinction (NCARTT, 2007). Also, in 2002 NCARTT started the Biodiversity, Genetic Resources and Medicinal Plants program to gather conservation efforts, in

addition to all matters concerning maintainable use of plant biodiversity (NCARTT, 2007).

#### **Seed Bank (NCARTT)**

The Ex-situ conservation in Jordan has been conceded since 1992 by the National Genebank at the National Center for Agricultural Research and Extension (NCARE), conservation tasks include collection, conservation in cold stores and fields, and overall management of PGR and CWR for sustainable utilization. NCARTT established Seed gene bank in 1993 consisting of a 70 m<sup>3</sup> cold store where seeds are stored under mid-term storage conditions of 40°C. Other rooms are prepared to be activated soon for long-term storage (NCARTT, 2007).

Currently, NCARE genebank hosts more than 4671 accessions representing 442 genus and 681 species belonging to 90 vascular plant families. This diversity is conserved under 11 plant categories each needing particular management. The major conservation occurred for wild species and CWR (more than 2058 accession) followed by cereals (882 acc) and legumes (677). On the other hand,

NCARE genebank hosts landraces of crops that have been maintained by Jordanian farmers which considered key genetic material that can be utilized directly for agricultural improvement, among conserved landraces are five local varieties of wheat and two tomato varieties that have been improved by farmers for drought and salinity and other production traits. The genebank has collaborated with biotechnology laboratories of molecular biology and tissue culture wherein vitro conservation and diversity analysis were carried out, particularly for endangered species. Accessions conserved at NCARE genebank are considered a trusted genetic material highly demanded nationally and internationally for various researches like restoration and

rehabilitation, climate change adaptation, ecosystem services, breeding, horticulture improvement, integrating farmers and rural communities in the management process, etc. Accessions are available for exchange according to global treaties and expect to integrate into food security programs. Accessions information is linked to a database where gap analysis is conducted frequently, the information is also required as well as genetic material for conducting strategic research like Jordan conservation strategy for important and economic species. Figure (1) shows the NCARE genebank progress 1994-2017, while plant categories conserved at NCARE seed bank are listed in Figure 2.

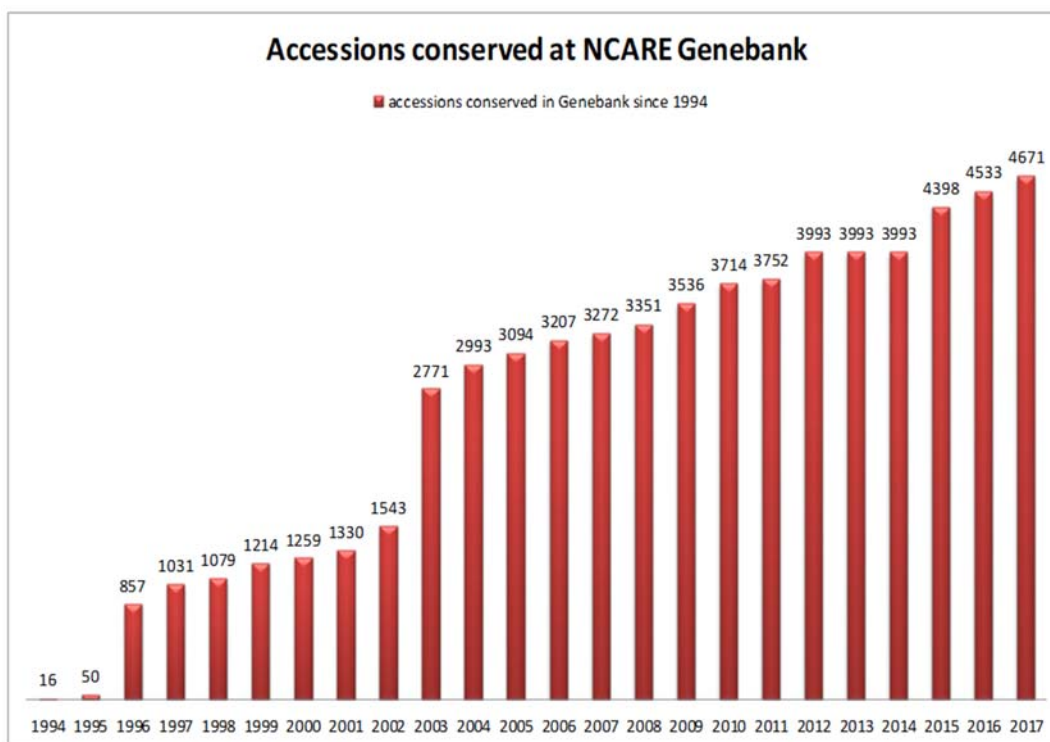


Figure (1 ): NCARE genebank progress 1994-2017 (NCARE, 2017)

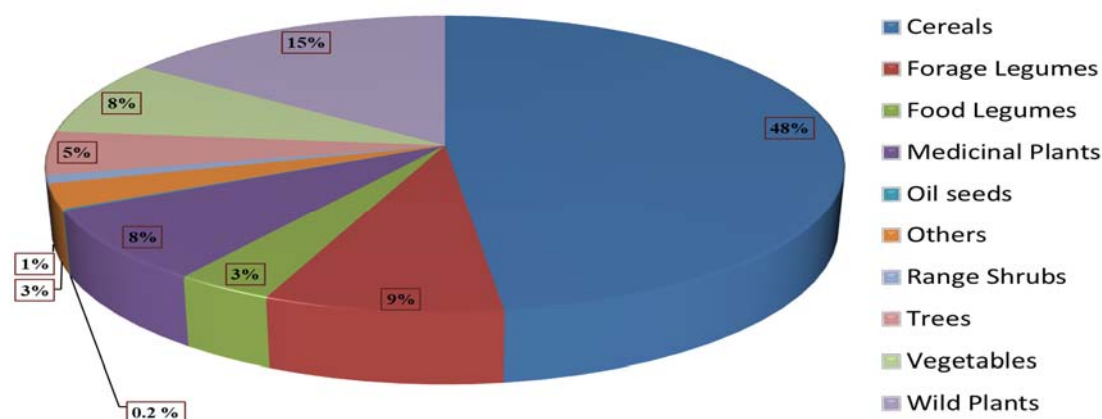


Figure (2): Plant categories conserved at the seed bank (NCARE, 2017)

### ***Herbarium (NCARTT)***

NCARTT National Herbarium safeguards a collection of 3070 herbarium specimens which are currently updated in terms of infrastructure and technology as specimens are examined by NCARTT incorporation with d KEW Garden (UK) (NCARTT, 2007). NCARTT had signed with the Millennium Seed Bank Project (MSBP) in 2001 to conserve and duplicate seeds and herbarium specimens of Jordan flora in seed banks and herbariums of both NCARTT and MSBP (NCARTT, 2007).

#### **Conservation Studies and projects conducted under the umbrella of NCARTT**

The following studies and projects are quoted from the NCARTT report on the state of plant genetic resources (2007):

“• Promotion, preservation, and utilization of herbal and medicinal plants of Jordan (2004- 2008) GEF project.

- Collection, characterization, maintaining, and estimating genetic relationships of *Pistacia* wild germplasm in Jordan. (2001-2003).

- Evaluation, characterization, and seed multiplication of cereals accessions conserved in NCARTT Gene Bank. (2000- 2003).

- Characterization of cereals accessions collected and conserved in the gene bank at NCARTT, studying the genetic diversity of these accessions, and identification of promising accessions that process certain characters with the emphasis on salt and/or drought tolerance characterization of all accessions at the gene level using DNA fingerprinting techniques.

- A booklet was issued (2003) to highlight the annual activities of the plant genetic resources unit at NCARTT and to inform researchers in the national institutes about the availability of particular species at NCARTT/PGRU as seeds and herbarium specimens. The booklet includes information about collected members of 43 Genera under 24 families among which some species registered in the list of the survey of economic plants from arid and semiarid lands (SEPASAL)

- Study of genetic diversity in 34 accessions of Okra and 50 Eggplant landraces in Jordan (1999)

- Study on Importance of wild germplasm of *Amygdalus* Almond and Apple species (2004), local geographical distribution, morphological variability between prevailing species and conservation status of the plant resource.”

#### **Ex-situ Conservation efforts of Ministry of Agriculture**

Ministry of Agriculture had established a seed center at the Department of Forestry consisted four units that store seeds of 70 species, in addition to mid-term storage rooms that conserve forest trees and pastoral shrubs genetic resources especially indigenous and threatened species (NCARTT, 2007).

#### **Ex-situ conservation efforts of The Jordanian Universities**

##### **Herbariums**

Yarmouk University hosts a collection of 20000 specimens of Jordan Flora. Also, the Department of Biology at the University of Jordan has a herbarium collection of 60,000 species collected from different sites of Jordan. Al-Bayt University had also established a herbarium in 1994 that hosts specimens of Jordan biodiversity including plant seed specimens.

##### **In vitro propagation of wild and medicinal plants**

Jordan has different types of wild medicinal and aromatic perennial herbal shrubs that are distributed from north to south of Jordan. Most of these plant species are very remarkable and have limited distribution in different parts of

Jordan. Some of these species are now considered endangered plant species and also as they are endemic to Jordan which gives these plants a distinguished situation. Furthermore; they have novel medicinal powers due to their constituents of remarkable essential oils which had been used in folk medicine for ages (Taifour, and EL-Oqlah, 2014 and, 2016). In vitro propagation means are considered as one of rapid propagation and virus-free method. In vitro propagation has been applied widely by academics and researchers in Jordanian universities to propagate different medicinal plant species in Jordan such as *Paronychia argentea* (Alenizi *et al.*, 2020) and wild germander (*Teucrium polium* L.) (Al- Qudah *et al.*, 2011). Also, many wild medicinal plants were in vitro propagated then re-cultivated in the wilds; like *Solanum nigrum* (AL- Kiyam *et al.*, 2019); *Ammi visnaga* (L.) Al-Saleh *et al.*, 2019); *Peganum harmala* L (Zatimeh *et al.*, 2017); *Achillea fragrantissima* (Younis *et al.*, 2015); *Silybum marianum* (Al Hawmdah *et al.*, 2014); *Capparis spinosa* (Al-Mahmoud *et al.*, 2012) and many more.

So, it is clear that Jordanian Universities had a great contribution to the field of plant tissue culture and conservation via the micropropagation technique. This was due to the continuous support of the Jordanian government for scientific research and Jordanian Universities. Besides that; the encouragement of the Jordanian government to the institutions and researchers to introduce modern technologies to conserve the plant genetic resources in Jordan.

#### **In vitro conservation of wild and endangered plant species**

Jordan universities have made huge and fruitful efforts for the conservation of many wild plants that are native to Jordan, especially those exposed to threats of extinction. Research and postgraduate projects that aimed for the conservation of Jordan flora were generously funded by the Deanships of Scientific Research. The in vitro conservation techniques adopted by these projects were either mid-term

conservation techniques (slow-growth, conservation using osmotic agents, minimal growth medium, Absciscic Acid, and cold storage) or long-term storage (Cryopreservation).

Examples of Jordanian wild plants that were successfully conserved thanks to the efforts of the academics, researchers, and postgraduate students are: date palm, bitter almond, black iris, wild pear, sour orange, grapevine, Shih, wild mint, yarrow, spiked thyme *Moringa* and many more

(Shibli *et al.* 2005; Shibli *et al.*, 1999; Shibli, 2000; Tahtamouni, *et al.*, 2001, Al-Ababneh *et al.*, 2002; Shatnawi *et al.*, 2011; Sharaf *et al.*, 2012; Al-Baba *et al.*, 2015; Younes *et al.*, 2015; Tahtamouni *et al.*, 2016; Al- Ruwaiei *et al.*, 2017).

In vitro conservation methods applied by the Jordanian academics and researchers have offered a strong and multi-package of techniques that do so well when other conservation methods are not feasible, especially in cases of endangered, rare, and threatened plant species. For example, wild pear (*Pyrus syriaca*) was preserved at ultra-low temperature by Tahtamouni and Shibli in 1999 where cryopreservation technique was newly introduced to Jordan. Also, micropropagation was used for plant propagation and conservation of the national flower of Jordan's black iris (*Iris nigricans*) via somatic embryogenesis (Shibli and Ajlouni, 2000).

Slow growth conservation using osmotic agents was also applied for the conservation of many wild plants in Jordan as a midterm conservation technique. For example, Bitter almond (*Amygdalus communis* L.) was successfully conserved in 1999 by slow growth techniques using sucrose, mannitol, and sorbitol (Shibli *et al.*, 1999).

Cryopreservation which is the most reliable tool for the long-term storage of plant germplasms) was also used for the long-term conservation of many endangered species (Shibli *et al.*, 2006). Cryopreservation stands for the storage of plant parts or cells under the cryogenic temperature of (-196 °C) (Al- Ruwaiei *et al.*, 2017). Cryopreservation is superior to most other conservation approaches as it's simple and applicable to a wide range of genotypes in addition to its

minimal maintenance requirements and contamination risks (Tahtamouni *et al.*, 2017; Younis 2012). In Jordan, most cryopreservation research conducted in the universities had focused on how to make the different procedures for cryopreservation, like encapsulation-dehydration, vitrification, encapsulation-vitrification, and droplet vitrification applicable to various plant species of Jordan flora (Shibli and Al-Juboory, 2000; Al-Ababneh *et al.*, 2002).

Many types of research were conducted using the different cryopreservation techniques for the long-term storage of many plant species of Jordan. For example, Shibli (2000) succeeded in conserving the black iris (*Iris nigricans*) somatic embryos using the encapsulation-dehydration method. Also, cryopreservation of 'Nabali' olive (*Olea Europea*) was successfully achieved using encapsulation-dehydration and encapsulation-verification methods (Shibli and Al-Juboory, 2000). Moreover, encapsulation-dehydration and verification were applied for long-term conservation of wild-type rootstocks such as wild pear (*Pyrus syriaca*) (Tahtamouni and Shibli, 1999) and sour orange (*Citrus aurantium*) (Al-Ababneh *et al.*, 2002).

So, all these efforts have made Jordan one of the pioneer countries in the region that had dealt with new techniques for the protection of plant biodiversity.

### **Ex-situ conservation efforts of The Royal Botanic Garden (RBG)**

The Royal Botanic Garden (RBG) was established in Jordan for the conservation of plants that are native to Jordan's Environment. RBG has many tasks RBG such as publishing and updating the checklist of the flora of Jordan and Red List of Jordan flora, development plans of the national herbarium, seed bank in addition to ensuring conservation of native Jordan flora especially those endangered (Moe, 2014, 2015).

Currently, more than 580 species are protected at the Royal Botanic Garden campus at Tal Al-Rumman in addition to wild plants growing outside its surroundings.



Moreover, RBG has started its National Virtual Herbarium (NVH) in 2012 which provides free online access to plant collection specimens that exceed 2,600 botanical species of Jordan supported by data provided by the other herbaria of Jordan.

#### **Jordan Future Vision for its Biodiversity by 2050**

At the beginning of the second millennium, Jordan started a national dialogue with stakeholders involved in biodiversity. This dialogue came up with several vision statements that hopefully will be filled by the year 2050. One of these vision statements was: "By 2050, the biodiversity of Jordan is valued for its national heritage vitality, conserved

for the well-being and enjoyment of people, and sustainably used for the benefits of current and future generations" (MoE, 2009). And after a hundred years since the establishment of the Hashemite Kingdom of Jordan, and based on the tremendous efforts that have been carried out to preserve plant biodiversity in Jordan, we can confirm that Jordan will not spare any effort to achieve this vision by continuing the tireless work that the kingdom has practiced since its establishment in partnership with its people and loyal friends.

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## نظرة عامة لجهود الأردن في الحفاظ على التنوع البيولوجي النباتي خلال المائة عام الأولى من تأسيس البلاد

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### الملخص

يعبر التنوع البيولوجي النباتي عن أحد أهم الموارد الطبيعية لجميع الأمم، إذ يوفر الغذاء والدواء والمأوى لجميع الأحياء إلى جانب دوره المهم في موازنة النظم البيئية والتخفيف من تغير المناخ، وأولت الأردن اهتماماً كبيراً لتراثها الفريد من التنوع البيولوجي النباتي منذ تأسيس الدولة، خاصة من حيث الحفاظ. وبذلت الحكومات الأردنية جهوداً ملحوظة للحفاظ على البيئة خلال المائة عام الأولى من تأسيس البلاد، وكانت هذه الجهود مثمرة للغاية بفضل الدعم الحكومي غير المحدود لجميع المشاريع المتعلقة بالحفاظ على نباتات الأردن. لذلك، وبمناسبة الذكرى المئوية الأولى لتأسيس البلاد، تم إعداد هذه المقالة لتسليط الضوء على بعض الجهود التي بذلها الأردن خلال المائة عام الماضية للحفاظ على هذه الثروة الوطنية من التنوع البيولوجي النباتي.

**الكلمات الدالة:** الحفاظ، خارج الموقع، الذكرى المئوية الأولى، داخل الموقع، الأردن، التنوع البيولوجي النباتي.

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