

Tree Plantation Pits in Arid Zones in the Kingdom of Saudi Arabia



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Foreword

Saudi Arabia has recently launched ambitious initiatives and programmes to increase vegetation cover in the country through the rehabilitation, restoration and sustainable management of its natural rangelands, protected areas and natural forests, including the mangrove forests along its coastal areas. The Saudi Green Initiative, a cornerstone of the country's climate and environmental action, has three overarching targets: emissions reduction, afforestation, and land and sea protection. Among its specific targets is the planting of 10 billion trees across the country.

One of the key initiatives contributing to the implementation of the Saudi Green Initiative is the National Greening Program. The programme focuses on utilising the country's wide variety of native plant species for afforestation activities across 13 regions. The programme also aims to build bridges of cooperation between the public, private and non-profit sectors for the preservation of environmental integrity and natural resources in the country.

To achieve the ambitious objectives of the Saudi Green Initiative, national institutions have made substantial investments to enhance the production capacity of existing nurseries and to establish new ones across the country. These facilities are recognised as essential infrastructure for the restoration and rehabilitation of degraded lands, providing the foundation for successful vegetation recovery. In parallel, and consistent with the goals of the National Greening Program, engagement of all relevant non-state actors—including the private sector, community groups, and nonprofit organisations—is encouraged to promote the large-scale propagation of native trees and shrubs. This collaborative approach aims to ensure a sustainable and continuous supply of high-quality seedlings to support the nationwide tree-planting efforts.

This technical document, prepared under the FAO–Saudi Sustainable Rural Agricultural Development (SRAD) Programme, contributes directly to these national objectives. It serves as a practical reference for planners, park managers, and field technicians by offering clear, step-by-step guidance on the design, establishment, and management of tree plantation pits in arid zones. The approach outlined herein is based on field experience and scientific evidence, ensuring that restoration initiatives across Saudi Arabia achieve both ecological and operational effectiveness.

Dr Nizar Hadad
FAO Saudi Arabia Programme Director



Abbreviations

| | |
|-------|--|
| FAO | Food and Agriculture Organization of the United Nations |
| MoEWA | Ministry of Environment, Water and Agriculture (Saudi Arabia) |
| NCVC | National Centre for Vegetation Cover Development and Combating Desertification |
| SLM | Sustainable Land Management |
| SRAD | Sustainable Rural Agricultural Development Programme |
| USD | United States Dollar |

Table of synonyms

| # | Name (RBG KEW 2025) | Synonym |
|---|---------------------------|--|
| 1 | <i>Neltuma juliflora</i> | <i>Prosopis juliflora</i> |
| 2 | <i>Vachellia spp.</i> | <i>Acacia spp.</i> |
| 3 | <i>Vachellia tortilis</i> | <i>Acacia tortilis, Acacia radiana var. tortilis</i> |

Reference is the Royal Botanical Garden KEW, <https://powo.science.kew.org>



1. Description

1.1. General

Tree plantation pits are physical water-harvesting structures designed to retain rainfall runoff for the establishment of trees and shrubs in degraded or desertified areas. Supplemental watering is provided during the initial establishment phase to ensure plant survival. The technique is mainly applied within national parks managed by the National Centre for Vegetation Cover Development and Combating Desertification (NCVC), which has developed and standardised this approach across multiple arid regions of Saudi Arabia.

Plantation Pits are typically located along wadis and smaller channels known as *sheyhib*, where surface runoff naturally concentrates. They are established in blocks ranging from 10 to several hundred metres in length, depending on topography and hydrological features, and may also be found on high plateaux. Many are positioned near terraces and **cross-wadi walls** that enhance infiltration and trap sediments rich in organic matter. Each pit is generally rectangular, measuring about 2 m in length, 1 m in width, and up to 1 m in depth. Spacing between pits varies from 3 m to 10 m, and excavation is carried out mechanically to ensure uniformity and efficiency.



Figure 1. Plantation pits within Thadiq National Park (© Alan Morisey)

Pits are usually dug one year before planting to collect runoff, sediment, and nutrient-rich organic material during the rainy season. During this period, spontaneous colonisation by herbaceous plants improves soil fertility and microclimatic conditions. Once the site is ready, one (occasionally two) seedlings are planted at the centre of each pit with minimal disturbance to existing vegetation. Common species include *Vachellia spp.* (*Acacia, Al Talh*), *Ziziphus spp.* (*As Sidr*), and *Haloxylon spp.* (*Ar Rimth*), all indigenous and well-adapted to arid environments. These trees (over 1.5 m by definition) provide forage, nectar, and shade, while their flowers attract bees that support apiculture. *Ziziphus* honey is particularly valued for its quality and market price, and *Vachellia* honey is also well regarded.

1.2. Water

The technique functions effectively even in hyper-arid zones receiving less or much less than 100 mm of rainfall per year. Supplemental irrigation is, however, essential during the establishment. Each pit is



watered for three years, till roots reach the water table, with 20–100 L applied at each watering, depending on water availability and plant need. Water is drawn from wadi beds and transported by tanker lorry. Gradual percolation encourages roots to reach the groundwater table, after which artificial watering is no longer required.

Although establishment costs are relatively high due to excavation, water transport, and maintenance, the outcomes are highly satisfactory, with strong survival rates and rapid vegetation growth. Landscape transformation becomes visible when large contiguous areas are treated or pit density is high.



Figure 2. Tree plantation pits receiving water from tanker lorry (© Éric Lacroix)

1.3. Design

The technical design was developed by the NCV C park manager, while FAO provided guidance on site selection, spacing, scheduling, fertilisation, and planting under the project *Strengthening MoEWA's Capacity to Implement its Sustainable Rural Agricultural Development (SRAD) Programme* (UTF/SAU/051/SAU, 2019–2025). Funding is shared between the NCV C and local contributors, including donors and volunteers.





Figure 3. Planted pits within Thadiq National Park (© Éric Lacroix)

1.4. Location

The technology was implemented in Thadiq National Park, Riyadh Province (Region), Saudi Arabia — a protected landscape of about 148 km² managed by the National Centre for Vegetation Cover Development and Combating Desertification (NCVC). The representative site selected for documentation lies at 25.1689°N and 45.94174°E. The area was chosen for its accessibility, hydrological potential, and suitability for vegetation recovery. Activities were carried out jointly by NCVC field teams, FAO technical experts, and local volunteers.



Figure 4. Planted pits within Thadiq National Park (© Éric Lacroix)



1.5. Natural Environment

Thadiq National Park lies within the central plateau of Saudi Arabia and has an arid to hyper-arid climate. Average annual rainfall is around 70 mm, occurring mainly from November to April in short, intense storms that generate surface runoff — the key source of water captured by the plantation pits. Summers are extremely hot, with daytime temperatures exceeding 45 °C, while winters are mild, averaging about 20 °C. The climate is classified as a hot desert, with high evaporation (over 3 metres annually) and low humidity (average 10 %).

The landscape consists of gently undulating plateaux intersected by wadis and small wadis (*sheyhib*). Elevation ranges from 100 m to 1,000 m a.s.l., and most plantation sites lie on flat terrain with slopes below 2 %. Soils are shallow (0–20 cm), coarse-textured and sandy, offering good infiltration but limited water retention. Organic-matter content is generally below 1 %, reflecting low biological activity typical of desert ecosystems. The groundwater table lies at depths between 5 m and 50 m. Flooding occasionally occurs after heavy rain but contributes valuable sediment and moisture to the pits.

Vegetation is sparse and dominated by xerophytic shrubs and scattered trees such as *Vachellia tortilis*, *Ziziphus spina-christi*, and *Haloxylon salicornicum*. Habitat diversity is limited by aridity but has improved significantly in rehabilitated areas, where the increased vegetation cover supports pollinators, birds, and small mammals with foxes, wolves, hyenas, honey badger, feral donkeys, stray dogs, wild cats, hedgehogs and rehabilitated gazelles.



Figure 5. Thadiq plateau and wadi system (© Éric Lacroix)



1.6. WOCAT Classification of the Technology


Tree plantation pits are classified under **Sustainable Land Management (SLM)** as a combined **water-harvesting and vegetation-restoration technology**. The system integrates both structural and vegetative measures to reduce land degradation, conserve soil and water, and enhance biodiversity in arid and hyper-arid zones.

The **structural component** consists of excavating rectangular pits (2 × 1 × 1 m) established along wadis and with pit open side located at perpendicular position to the gentle slopes while the excavated soil is heaped on the backward side of the pit to capture runoff, sediments, and organic matter. The **vegetative component** involves planting indigenous trees and shrubs—mainly *Vachellia*, *Ziziphus*, and *Haloxydon*—to stabilise soil, provide shade, and create habitats for pollinators and wildlife. Together, these elements improve infiltration, prevent erosion, and promote natural regeneration.

The technology also delivers **socio-economic benefits** through beekeeping, tourism, and employment opportunities linked to park restoration. It contributes directly to climate-change adaptation and to the objectives of Vision 2030 by increasing vegetation cover and ecosystem resilience.

Full description is available in the **WOCAT Global Database of Sustainable Land Management Technologies**:

https://gcat.wocat.net/en/wocat/technologies/view/technologies_7380/



Tree Plantation Pits in Arid Zones (Saudi Arabia)
Plantation pits

DESCRIPTION
Tree plantation pits are water harvesting structures which capture rainfall runoff for trees and shrubs. They receive supplementary water until seedlings are well established. Species planted are indigenous, and provide both shade and honey.

LOCATION
Location: Thadai National Park, Riyadh Region (Province), Saudi Arabia


Georeference of selected sites
• 45.58176, 25.1659

Spread of the Technology: evenly spread over an area (148.0 km²)

Is a permanently protected area?: Yes

Date of implementation: 2015; less than 10 years ago (recently)

Type of introduction
 through land user's innovation
 as part of a traditional system (> 50 years) during experimental research
 through project's external interventions



حفر زراعة الأشجار في المناطق الجافة (المملكة العربية السعودية)
Plantation pits

الوصف
حفر قري الأشجار هي هياكل لتجميع مياه الأمطار لتلتقط جريان المياه السطحية لمساعدة الأشجار والصحرايات. تلبي هذه الهياكل إضافة مساحة حفر مزارع النباتات مثل: الأوباق المبرومة، حبوب اللؤلؤ، والنمل.

الموقع
الموقع: متنزه تادي الوطني، منطقة الرياض (محافظة)، المملكة العربية السعودية

عدد مواقع تنفيذ التكنولوجيا: تم تحديدها بـ 10 مواقع

المراجع الجغرافي للموقع الجغرافي:
• 45.58176, 25.1659

انتشار التكنولوجيا: منتشرة بالتساوي على مساحة (148.0 كم²)

هل منطقة تنفيذ التكنولوجيا محمية دائمًا؟: نعم

تاريخ التنفيذ: 2015، منذ أقل من 10 سنوات (مؤخرًا)

نوع التنفيذ
 من خلال ابتكار مستخدمي الأراضي
 كجزء من النظام التقليدي (> 50 عامًا) أثناء الأبحاث التجريبية
 من خلال المبادرات الخارجية

Figure 6. Wocat technique: Tree Plantation Pits in English and Arabic.



2. Establishment, Maintenance and Costs

The establishment of **tree plantation pits** involves several coordinated steps over multiple years. Activities are implemented during both dry and wet seasons to ensure optimal timing for excavation, planting, and maintenance. Costs are calculated per hectare, assuming an average density of 100 pits, and are expressed in United States dollars (USD).

2.1. Technical Drawings and Layout

As said, each pit measures about 2 m in length, 1 m in width, and up to 1 m in depth. Spacing between structures varies from 3 m to 10 m, depending on topography and runoff concentration. Pits may be arranged in lines, curves, or clusters following natural terrain contours. Between 100 and 1,100 pits may be established per hectare, although higher densities are rare in practice.

Watering volumes range from 20 to 100 litres per pit at each irrigation event. Water is transported by a tanker lorry (5,000 litres) and distributed manually using hoses. The layout ensures that each pit receives adequate runoff and sediment accumulation during storms and rains.

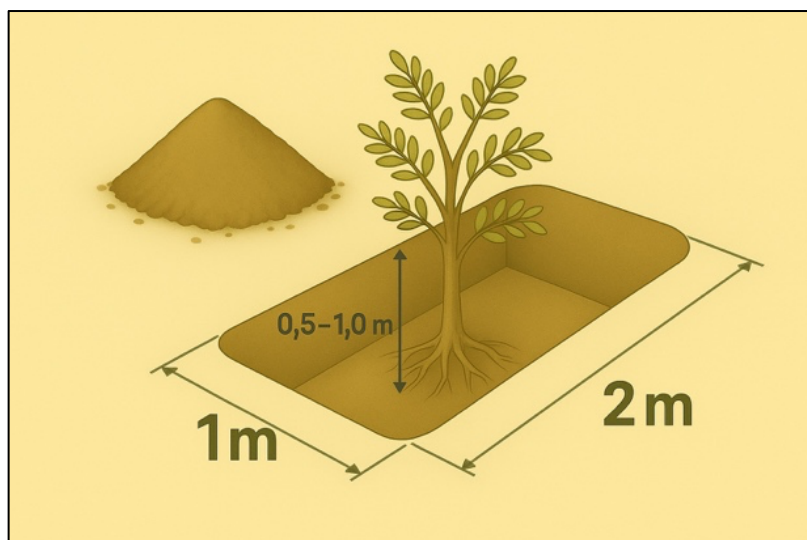


Figure 7. Design of plantation pits (© FAO/É. Lacroix).



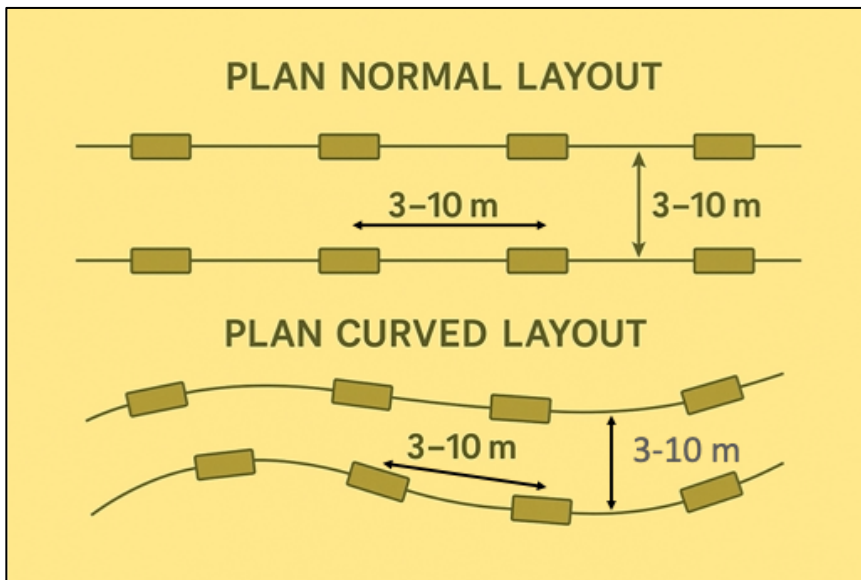


Figure 8. Layout plan of plantation pits (© FAO/É. Lacroix).



Figure 9. Watering system using tanker lorry and hose (© FAO/É. Lacroix).

2.2. Establishment Activities and Costs

Main steps include site identification, marking and staking, mechanical excavation, nursery preparation, planting, and initial watering. Excavation is carried out during the first dry season, and planting follows during the next rainy season.

Average **theoretical** establishment costs can reach of **2,449 USD per hectare**, broken down as follows:

- Labour for planting: 5 worker days at 50 USD/day → 250 USD (90 % borne by land users).
- Labour for watering: 18 worker days at 33 USD/day → 594 USD (90 % borne by land users).
- Excavators for digging pits: 3 hours at 93 USD/hour → 279 USD (90 % borne by land users).
- Watering trucks (5,000 L, 18 rounds over 3 years): 18 units at 47 USD → 846 USD (90 % borne by land users).
- Plant material: 120 seedlings/ha at 4 USD each → 480 USD.



These costs vary according to soil depth, drought severity, and flooding frequency but remain within acceptable limits for national park restoration projects.

2.3. Maintenance Activities and Costs

Maintenance ensures long-term survival and stability of the system. Regular inspections are conducted after major rains or floods to check infiltration efficiency and structural integrity. Seedlings are replaced when necessary during the wet season.

Average **theoretical** maintenance costs are **620 USD per hectare**, including:

- Labour for maintenance, repair, weeding, and replacement: 10 worker days at 50 USD/day → 500 USD (entirely borne by land users).
- Replacement seedlings: 30 at 4 USD each → 120 USD.

Maintenance lasts three years, after which artificial watering is no longer required as roots reach groundwater levels.



3. Impacts

The implementation of tree plantation pits in Thadiq National Park has produced measurable socio-economic, ecological, and climatic benefits within only a few years. The technology restores vegetation, stabilises soil, enhances biodiversity, and strengthens community participation in park management.

3.1. Socio-economic and Cultural Impacts

Vegetation recovery has increased shade, reduced sand movement, and improved the visual and recreational quality of the park. Employment opportunities arise during excavation, planting, and maintenance phases, while beekeeping, linked to *Ziziphus* and *Vachellia* species, provides valuable supplementary income. The growing attractiveness of the park stimulates ecotourism and awareness of vegetation restoration. Community volunteers, families, and visitors increasingly engage in conservation activities, reinforcing local ownership and environmental pride.

3.2. Ecological Impacts

Tree plantation pits effectively enhance soil moisture, reduce erosion, and promote groundwater recharge by capturing and infiltrating runoff. Vegetation cover has increased significantly, with higher density of trees and shrubs contributing to carbon sequestration and local climate regulation. Improved microclimatic conditions favour pollinators, birds, and small and big mammals, while new habitats develop along rehabilitated wadis and terraces. The system also moderates flood and drought effects by slowing runoff and retaining water and sediments.

3.3. Off-site Impacts

Positive off-site effects include improved groundwater availability, reduced downstream flooding, and lower sedimentation in adjacent areas. The technology thus benefits not only protected zones but also surrounding agricultural and residential lands.

3.4. Cost-Benefit and Climate Response

Although the initial establishment of tree plantation pits involves relatively high costs (depending on the real costs of operations) due to excavation, water transport, and maintenance, the long-term economic and environmental returns are highly positive. Once the pits are constructed and the trees established, maintenance costs remain low and survival rates exceed expectations. Over time, the benefits in soil stability, vegetation growth, and ecosystem services outweigh the investment.

From an economic perspective, restored vegetation provides direct income opportunities through apiculture, local employment, and nature-based tourism. The improved landscape also supports indirect benefits such as erosion control, groundwater recharge, and flood mitigation, which contribute to reduced infrastructure damage and enhanced local well-being and reduce dust allergies.

From a climatic perspective, the system increases resilience to temperature extremes, irregular rainfall, and flash floods. The pits harvest and store runoff, reducing drought stress while stabilising microclimatic conditions in vegetated areas. The additional biomass and soil organic matter enhance carbon sequestration and contribute to Saudi Arabia's Vision 2030 objectives for land degradation neutrality and climate adaptation.

The **tree plantation pit system** thus represents a cost-effective, climate-resilient solution that links economic value with ecological restoration and long-term sustainability.



4. Adoption and Lessons Learnt

The tree plantation pits technology has evolved from a pilot initiative into a standard management practice within Thadiq National Park and other protected areas managed by the NCVC. Its proven performance and visible environmental results have encouraged replication across the Riyadh Region, where several hundred thousand new pits are now established annually.

4.1. Adoption and Replication

Adoption is steadily increasing among national parks and local institutions, supported by the NCVC and FAO through the SRAD Programme. There is an expanding number of land users and institutions adopting it independently. High initial costs remain the main limitation, but results demonstrate strong long-term returns, prompting inclusion of this method in regional long-term restoration strategies.

4.2. Strengths

Land users and managers view the technology as highly effective for restoring degraded lands, improving landscape aesthetics, and enhancing long-term biodiversity quality (flora and fauna). It creates visible “green corridors” that attract wildlife and visitors and foster ecotourism. Technically, it is robust, adaptable to various soils and rainfall conditions, and easily replicable with mechanical support and basic training.

4.3. Weaknesses and Risks

The principal constraints are the cost of heavy machinery, labour, and water transport during the establishment phase. The technique also depends on fuel availability and must be monitored to avoid overwatering or structural damage after intense rainfall. These risks are manageable with proper supervision and maintenance planning.

4.4. Key Lessons

Experience shows the importance of early planning, correct site selection, and phased watering schedules to reduce costs and maximise survival. Continuous monitoring and adaptive management ensure resilience under changing climatic conditions. Integration of apiculture, tourism, and community involvement increases sustainability beyond ecological restoration alone.

The tree plantation pit system is now recognised as one of the most effective large-scale approaches for combating desertification and promoting sustainable land management in Saudi Arabia’s arid and hyper-arid zones.



5. References and Acknowledgements

All reference links verified on 21 September 2025.

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National Centre for Vegetation Cover Development and Combating Desertification (NCVC):

<https://ncvc.gov.sa>

Royal Botanic Gardens, Kew: <https://powo.science.kew.org>

WOCAT Global Database

Full description available online:

https://qcat.wocat.net/en/wocat/technologies/view/technologies_7380/

Video documentation: <https://player.vimeo.com/video/1026092452>

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