• **Generated an additional 46.9 acres of self-renaturalized areas since 2010.**

The plant cells were intended to serve as seed propagators to colonize the non-vegetated areas within the project boundary and beyond. While the project was only completed in 2010 we thought it would be interesting to attempt an assessment of the growth in vegetated coverage since.

**Methodology**

We used historical satellite imagery embedded in Google Earth to compare the size of the original plant cells with the 2015 vegetation coverage. Eighteen air photos periods are available, covering almost every year between 2001 and 2015. Interestingly, this allows for a comprehensive tracking of the evolution of the project and a simple means of comparison between before and after project site conditions. 2015 air photos were used to draw the outlines of vegetated areas, which were then overlaid on the original CAD construction drawings.

Given the size of the project area, sub zone 3A-3 was selected as a sample area for the calculations. This sub zone is relatively central to the project area and includes 18 cells, one for each of the cell type most commonly found throughout the project. The measured increase in cell area between June 29, 2010 and January 1, 2015 varies between 10.0% and 91.2%. The average growth for the entire sub zone is 40.8%. Interestingly, a comparison of the 2010 air photo with the design plans indicate a 5.9% growth, which either reflects the growth that occurred between the construction itself and the date the air photo was taken or the fact that the cells were not exactly built as per the plans.

Extrapolating from the sub-area's 40.8% propagation rate we estimate the total project increase in cell area since 2010 to be 46.9 acres.

![Figure 5 Example of plant cell growth comparison between design documents and 2015 air photo](Sources: plan, MTP; air photo, Google Earth and DigitalGlobe 2015)
Figure 6. Cell growth in sub-area 3A-3 between 2010 (in green, top left) and 2015 (in red, top right). (Sources: plan, MTP, air photo; Google Earth and DigitalGlobe 2010-2015)
**Limitations**

The resolution of the air photos makes it difficult to distinguish clearly the edges of the plant cells or to distinguish plant cells from adjacent humid areas that show as a darker color. The dimensional distortion inherent in overlaying air photos with CAD construction drawings also required an imperfect scaling operation, which further reduces the reliability of the plant cell edge configuration. This was not an issue when comparing Google Earth air photos from different periods. Finally, the limited number of air photos available required us to compare cell conditions at different periods of the year (June 2010 and January 2015), which would presumably affect plant condition and, as a result, the clarity of cell edges.

Furthermore, due to the size of the site and time constraints we used a representative sample area to extrapolate propagation growth for the entire wadi bed. This does not account for the possibility of significant dispersion variations in certain areas of the riverbed. Again, ground-truthing would be required to establish the precision of the calculated plant cell growth rate.

- **Supports a diverse fauna with 15 bird species, 9 fish species, 3 mollusc species, 2 amphibian species, and 3 reptile species inventoried since 2009.**


### Birds

Bittern, Egret, Mallard duck, Heron, Long-beaked bird sp. (unidentified), Moorhen, Black-necked stilt, Woodpecker, Eagle, Sea gull, Mynah, House sparrow, Spotted dove, Pigeon, Kingfisher

### Fish
Tilapia, African Jewelfish (Cichlid), Molly (Sailfin & Balck-spotted), Gambusia (Mosquito fish), African and Sucker Mouth catfish, Koi Carp, Suckermouth Catfish

Mollusks
Melanoide snail, Ram Horn snail, Asian clam

Amphibians
Frog sp., Turtle sp.

Reptiles
Common house gecko, Arabian spiny-tailed lizard, water snake

Insects
Grasshopper, Dragonfly, Honey bee


Limitations

The evidence remains anecdotal and limited to photographic records from the consultant and ADA personnel. No mammals were included in the inventory. Furthermore, many species observed are non-native and / or considered invasive (i.e. the house sparrow, the koi carp) and as such cannot serve as indicators of a healthy ecosystem.

• Sequesters 89,144.9 pounds of carbon annually (327,161.8 pounds in carbon dioxide equivalent).

Methodology

The method used for calculating carbon sequestration for trees planted in the Wadi Hanifah project was based on the U.S. Department of Energy’s 1998 Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings. This method calculates carbon sequestration by multiplying specific coefficients associated with the number of trees planted, tree age, tree survival rate, planted tree size (bound and burlap or containers), and the annual sequestration rate of tree species of a certain age (see Figure 9). Using a timeframe of 6 years from the original planting date (2008), we determined carbon sequestration figures associated with the urban forest of the project (e.g. the trees planted within the zones identified in Figure 1).
Limitations of Methodology

The international arid desert location of the project made the use of American online calculators such as i-Tree or the National Tree Benefit Calculator impractical. Calculation coefficients relevant to Saudi Arabia could not be obtained so survival rate and annual sequestration coefficients of Saudi tree species were established using comparative American species (in terms of physical characteristics and growth pattern), using the USDE database. Growth rates for each individual species were obtained for the following sources:

<table>
<thead>
<tr>
<th>Species name</th>
<th>Tree Type (H or C)</th>
<th>Growth Rate</th>
<th>Tree Age</th>
<th>Number of Trees Planted</th>
<th>Survival Factor</th>
<th>Number of Surviving Trees</th>
<th>Annual Sequestration Rate</th>
<th>Carbon Sequestered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia gerradi</td>
<td>H</td>
<td>S, Moderate, Fast</td>
<td>6</td>
<td>3,884</td>
<td>0.639</td>
<td>2,482</td>
<td>7.1</td>
<td>17,621.3</td>
</tr>
<tr>
<td>Acacia nilotica</td>
<td>H</td>
<td>M</td>
<td>6</td>
<td>4,460</td>
<td>0.639</td>
<td>2,850</td>
<td>7.1</td>
<td>20,234.6</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>H</td>
<td>S</td>
<td>6</td>
<td>11,521</td>
<td>0.639</td>
<td>7,362</td>
<td>3.7</td>
<td>27,239.1</td>
</tr>
<tr>
<td>Phoenix dactylifera</td>
<td>H</td>
<td>S</td>
<td>6</td>
<td>4,634</td>
<td>0.639</td>
<td>2,961</td>
<td>3.7</td>
<td>10,956.2</td>
</tr>
<tr>
<td>Tamarix aphylla</td>
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<td>M</td>
<td>6</td>
<td>420</td>
<td>0.639</td>
<td>268</td>
<td>7.1</td>
<td>1,905.5</td>
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<tr>
<td>Tamarix nilotica</td>
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<td>M</td>
<td>6</td>
<td>1,774</td>
<td>0.639</td>
<td>1,134</td>
<td>7.1</td>
<td>8,048.5</td>
</tr>
<tr>
<td>Zizyphus phoebe-christi</td>
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<td>S</td>
<td>6</td>
<td>1,328</td>
<td>0.639</td>
<td>849</td>
<td>3.7</td>
<td>3,119.8</td>
</tr>
</tbody>
</table>

Total Pounds of Carbon Sequestered: 89,164.9
Total Pounds of Equivalent CO2 Sequestered x 3.67: 327,161.82
Equivalent CO2 Sequestered in Short Tons / 2000: 163.58

Figure 9. Carbon sequestration modeling assumptions.
As we were unable to access accurate local air pollution levels, we were also unable to delve into a more elaborate methodology for a more precise carbon sequestration figure for the planted trees in the project. Also, this method does not account for the carbon sequestration achieved by other plant species.
Figure 10. Example of survival factors and annual carbon sequestration rates for common urban trees used to extrapolate values for Saudi species. Source: U.S Department of Energy’s 1998 Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings. Page

- Reduces municipal/potable water consumption by using 92.5 million gallons per day of bioremediated urban wastewater for park amenities and irrigation.


- Reduces the average temperature in public parks by XXX degrees relative to adjacent urban areas

[Awaiting data from the Arriyadh Development Authority.]
Social benefits [Incomplete. Awaiting data from the Arriyadh Development Authority.]

• Attracts 200,000 visitors per week.

• Increased per capita open space allocation in Riyadh by XXX%.

• Re-established the social, cultural, and recreational significance of the wadi for Riyadh residents.
  
  • Increase in recreational and interpretative uses: Tracking data availability from security services. Also, we may be able to obtain data on sanitary block usage. Awaiting data from the Arriyadh Development Authority (ADA).
  
  • Increased educational use: Listing the number of school visits by different levels and any post-secondary programs, which study aspects of the Wadi Hanifah project. Awaiting data from the Arriyadh Development Authority (ADA).
  
  • Increased social and cultural significance: looking at how to track the increase of project-related posts in social media.

Methodology (draft)

The Wadi Hanifah has been voted number 11 of 37 things to do in Riyadh by Trip Advisor reviewers - ahead of all other public open spaces in Riyadh. Of 86 reviewers, 62 rated the river park corridor as "very good" or "excellent".
Figure 11. Trip Advisor ranking of Wadi Hanifah as a visitor destination. Source: [http://www.tripadvisor.ca/Attraction_Review-g293995-d2646179-Reviews-Wadi_Hanifah-Riyadh_RiyadhProvince.html](http://www.tripadvisor.ca/Attraction_Review-g293995-d2646179-Reviews-Wadi_Hanifah-Riyadh_RiyadhProvince.html), Retrieved August 6, 2015.

Search functions embedded in three social media platforms – Facebook, Instagram, and Twitter – were used to track the number of posts for variations of Wadi Hanifah between 2009 and 2015.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>FACEBOOK &quot;WADI HANIFAH&quot;</td>
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<td>N/A</td>
<td>N/A</td>
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<td>21</td>
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<td>N/A</td>
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<td>N/A</td>
<td>260</td>
<td>74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Wadi Hanifah - Riyadh&quot;</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>17</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>TWITTER &quot;WADI HANIFAH&quot;</td>
<td>2</td>
<td>8</td>
<td>25</td>
<td>62</td>
<td>24</td>
<td>25</td>
<td>14</td>
</tr>
</tbody>
</table>

Figure 12. Mentions of Wadi Hanifah in selected social media platforms

Limitations (draft)

The numbers of posts generated are impossibly low, especially given that a Google search of "Wadi Hanifah" returns 146,000 hits, "Wadi Hanifah blog" 28,800 hits, and "Wadi Hanifah picture" 69,700 hits. This may reflect filtering and management restrictions within each of the social media platform. We are looking at alternative methods of tracking posts, including resorting to a third party firm specializing in social media analytics. We are also considering expanding the search to other platforms, such as Flickr and seeking assistance to conduct similar searches in Arabic.
• Promotes environmental awareness through daily visual exposure to XXX commuters and XXX park users.

[Awaiting data from the Arriyadh Development Authority.]

Economic [Incomplete. Awaiting data from the Arriyadh Development Authority.]

• Increased property values along the wadi ten-fold.


• Reduces flood-related expenditures on infrastructure maintenance and repair

Cost recovery analysis of flood damage before and after the projects construction. Awaiting data from the Arriyadh Development Authority (ADA).

*Methodology*

Analysing pre and post-design expenditures related to flooding damage. Data from the ADA for 2008 floods and 2012+.

*Limitations*

• Increased local nursery production and sales of native plants by XXX

• Created ___ jobs during construction and ____ full time positions for ongoing maintenance

*Methodology*

Analysing data collected from the ADA regarding the size of local work force during construction as well as the number of full time positions in the parks and Bioremediation Facility.

*Limitations*
Does not account for other employment created by the Wadi Hanifah project i.e. vendors and secondary merchants who sell goods within the WH network

**Cost Comparison**

[To complete]

**Works Cited**


