EVALUATING THE VIRTUAL WATER TRADE IN THE EGYPTIAN AGRICULTURAL SECTOR IN LIGHT OF THE WATER FOOTPRINT TO ACHIEVE SUSTAINABLE DEVELOPMENT

Submitted By
Gebril Mahjoub Osman Khalil

B.Sc. of Agricultural Sciences (Pomolgy), Faculty of Agriculture, Assiut University, 1981
M. Sc. of Agricultural Sciences (Horticulture), Faculty of Agriculture, Suez Canal University, 1989

A thesis submitted in Partial Fulfillment Of The Requirement for the Doctor of Philosophy Degree In Environmental Sciences

Department of Environmental Agricultural Sciences Institute of Environmental Studies and Research Ain Shams University

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ABSTRACT

EVALUATING THE VIRTUAL WATER TRADE IN THE EGYPTIAN AGRICULTURAL SECTOR IN LIGHT OF THE WATER FOOTPRINT TO ACHIEVE SUSTAINABLE DEVELOPMENT

This study is aiming to evaluate the Virtual Water Trade in the Egyptian Agricultural Sector in light of the Water Footprint to achieve sustainable development

Due to increasing demand for water for development and to face the population growth, the uses of water resources of Egypt became one of the important issues. At the same time the country desire to increase agricultural exports and reduce imports, which requires some sort of balance between the current water stress and the country desires without sacrificing the sustainability of water resources uses. The virtual water and water footprint concept which emerged in the 1990's as indicators on water use in the production of goods and services to assess the Egypt virtual water trade form each of the cereal crops represented in rice, wheat, maize, soybean and vegetable crops represented in potatoes, dry onions, tomatoes, green beans, as well as fruit crops represented in oranges, grapes, dates, bananas, during the period (2001 - 2010). The production figures has been presented including cultivated areas (in 1000 feddan), total production (metric tonnes) and land unit productivity (ton/feddan). The trade volume and values (exports - imports) for each crop was addressed. The virtual water (m$^3$/tonne) and water footprint (m$^3$/year) as well as the water import dependency has been calculated for each crop. The water unit productivity for each crop was figured out (kg/m$^3$) and Egypt water resources and utilization in agriculture production during the study period has been presented.

The results showed that the average cultivated areas as an annual average during 2001-2011 (in 1000 feddan) was for cereal crops as rice 1,491, wheat 2,784, maize 2,052 and soybeans 23. For the vegetable crops
was it was 260 for potatoes, 96 Dry Onion, 58 Green beans and 502 tomatoes. The average fruit crops areas were orange 2,015, grapes 1,320, dates palms 1,224 and bananas 941. The total production data (1000 metric tons) showed: wheat 7,437, maize 6,712, rice 6,072, soybeans 30 and for vegetable crops it was for potatoes 2,758, Dry onions 1,316, green beans 260 and tomatoes 8,073. For fruit crops: oranges 2,015, grape 1,320, dates 1,224 and bananas 941. The average annual volume of virtual water trade in form of the selected crops during the study period (2001-2010) expressed in million m$^3$ was 1,344 million m$^3$ exports versus 13,068 million m$^3$ from import and that the cereal crops exports represents 68% and imports representing 99.85%.

The average unit water productivity of crops expressed in kg/m$^3$ during the period 2001-2010, showed that productivity was higher in vegetable crops, reaching 5.05 for tomatoes, potatoes 4.53, Dry onion 3.64 and 2.26 for green beans. Fruit crops came as the second in the water unit as Bananas 2.15, dates 2.12, and 2.03 for grapes. The cereal crops were the less productive, reaching 1.09 for wheat, 1 for maize, 0.81 for rice and 0.34 for soybeans. The total water footprint calculation for the crops during the period 2001-2010 showed, the average the total water footprint for all selected crops is 38,672 million m$^3$ /year and the share of cereal crops 33,282 million m$^3$ /year (86.06%), and the vegetables 2,532 million m$^3$ /year (6.55%) and fruit crops 2,858 million m$^3$ /year (7.39%). With regard water import dependency, the highest percentage was of soybean crop, 95.96%, wheat 48.15%, maize 40.63%, potatoes 2.65% and the rest of the crops under study were less than 1%. In light of the water footprint, water import dependency, water unit productivity for each crop, it is important to revisit the rice cultivated areas and its export policies which helps in the growth of maize cultivated areas. For both wheat and soybeans, foreign investment out country boarders may be the solution to ensure the continuity of their supplies to Egypt. For vegetable crops it has been found that there are export opportunities and achieve returned without affecting Egypt's water resources for each of the potatoes, dry onions, green beans and tomato crops with more focus on reducing losses in yield and increase water unit productivity as stated in the "sustainable agricultural development strategy towards 2030 to Egypt. As for fruit crops, the results indicated.
that the oranges, grapes, dates exports can continue with the same volumes without impact on the water resources of Egypt with some efforts to increase water unit productivity as well as increased unit area productivity. Although the total water footprint of crop bananas and the water import dependency was not high, but the internal water footprint volume are high compared to other fruit crops and then must reduce export until access to the increase in productivity per unit of water. Generally, the study showed the need to focus on increased water unit productivity and increase land unit productivity of with more efforts to promote the concept "crop per drop"

**Key Words:**

Virtual Water; Water Footprint; Water Import Dependency; Sustainable development; Cereal Crops; Vegetables; Fruit Crops; Rice; Wheat; Maize; Soybean; Potato; Onion; Green Beans; Tomato; Orange; Grape; Dates; Banana
## List of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2. REVIEW OF LITERATURE</td>
<td>4</td>
</tr>
<tr>
<td>2-1 Virtual Water and Water Footprint Related Definitions</td>
<td>4</td>
</tr>
<tr>
<td>2-1-1 Virtual Water</td>
<td>4</td>
</tr>
<tr>
<td>2-1-2 Water Footprint</td>
<td>6</td>
</tr>
<tr>
<td>2-2 The Global Virtual Water Volume Trade</td>
<td>10</td>
</tr>
<tr>
<td>2-3 Egypt's Virtual Water Trade</td>
<td>14</td>
</tr>
<tr>
<td>2-4 Global Water Scarcity – Challenges and efforts</td>
<td>16</td>
</tr>
<tr>
<td>2-5 Environmental Aspects of Virtual Water &amp; Water Footprint</td>
<td>23</td>
</tr>
<tr>
<td>2-6 Water Resources in Egypt and Challenges</td>
<td>26</td>
</tr>
<tr>
<td>3. MATERIALS AND METHODS</td>
<td>34</td>
</tr>
<tr>
<td>3-1 Crops Selected for this Study</td>
<td>34</td>
</tr>
<tr>
<td>3-2 Egypt Production, Productivity and Trade</td>
<td>35</td>
</tr>
<tr>
<td>3-3 Crops Water Requirement (m3/Hectare)</td>
<td>35</td>
</tr>
<tr>
<td>3-4 Crop Productivity (tons/hectare)</td>
<td>36</td>
</tr>
<tr>
<td>3-5 Virtual Water Calculation</td>
<td>36</td>
</tr>
<tr>
<td>3-6 Water use for crop production</td>
<td>37</td>
</tr>
<tr>
<td>3-7 Water Footprint for the Selected Crops</td>
<td>37</td>
</tr>
<tr>
<td>3-8 Water Scarcity and Water Import Dependency</td>
<td>39</td>
</tr>
<tr>
<td>3-9 Virtual Water Economic Figures</td>
<td>39</td>
</tr>
<tr>
<td>4. RESULTS AND DISCUSSION</td>
<td>41</td>
</tr>
<tr>
<td>4-1 Egypt Production Figures</td>
<td>41</td>
</tr>
<tr>
<td>4-1-1 Cultivated Areas Trends</td>
<td>41</td>
</tr>
<tr>
<td>4-1-2 Egypt's Crops Total Production</td>
<td>43</td>
</tr>
<tr>
<td>4-1-3 Egypt's Crops Productivity</td>
<td>45</td>
</tr>
<tr>
<td>4-1-4 Egypt Agricultural Trade (Exports and imports)</td>
<td>47</td>
</tr>
<tr>
<td>4-1-4-1 Imports and Exports Volumes</td>
<td>47</td>
</tr>
<tr>
<td>4-1-4-2 Imports and Exports Values</td>
<td>49</td>
</tr>
<tr>
<td>4-2 Egypt's Virtual Water Volume Trade (Export and Import)</td>
<td>51</td>
</tr>
<tr>
<td>4-2-1 Virtual Water Volume Traded as Field Crops (Cereal)</td>
<td>53</td>
</tr>
</tbody>
</table>
# List of Contents - Continued

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-2-2</td>
<td>Virtual Water Volume Traded as Vegetables Crops</td>
<td>56</td>
</tr>
<tr>
<td>4-2-3</td>
<td>Virtual Water Volume Traded as Fruits Crops</td>
<td>59</td>
</tr>
<tr>
<td>4-2-3</td>
<td>Virtual Water Volume for Domestic Production</td>
<td>62</td>
</tr>
<tr>
<td>4-3</td>
<td>Egypt's Water Resources and Water Utilizations</td>
<td>64</td>
</tr>
<tr>
<td>4-3-1</td>
<td>Egypt's Water Resources Utilization</td>
<td>68</td>
</tr>
<tr>
<td>4-3-2</td>
<td>Egypt's Water Unit Productivity for Domestic Production</td>
<td>71</td>
</tr>
<tr>
<td>4-4</td>
<td>Egypt's Water Footprint for the Selected Crops</td>
<td>73</td>
</tr>
<tr>
<td>4-4-1</td>
<td>Egypt's Water Footprint for Field Crops (Cereal)</td>
<td>76</td>
</tr>
<tr>
<td>4-4-1-1</td>
<td>Rice Water Footprint and Water Value</td>
<td>76</td>
</tr>
<tr>
<td>4-4-1-2</td>
<td>Wheat Water Footprint and Water Value</td>
<td>78</td>
</tr>
<tr>
<td>4-4-1-3</td>
<td>Maize Water Footprint and Water Value</td>
<td>81</td>
</tr>
<tr>
<td>4-4-1-4</td>
<td>Soybeans Water Footprint and Water Value</td>
<td>83</td>
</tr>
<tr>
<td>4-4-2</td>
<td>Egypt's Water Footprint for Vegetables Crops</td>
<td>85</td>
</tr>
<tr>
<td>4-4-2-1</td>
<td>Potatoes Water Footprint and Water Value</td>
<td>85</td>
</tr>
<tr>
<td>4-4-2-2</td>
<td>Dry Onions Water Footprint and Water Value</td>
<td>87</td>
</tr>
<tr>
<td>4-4-2-3</td>
<td>Green Beans Water Footprint and Water Value</td>
<td>89</td>
</tr>
<tr>
<td>4-4-2-4</td>
<td>Tomatoes Water Footprint and Water Value</td>
<td>90</td>
</tr>
<tr>
<td>4-4-3</td>
<td>Egypt's Water Footprint for Fruits Crops</td>
<td>92</td>
</tr>
<tr>
<td>4-4-3-1</td>
<td>Oranges Water Footprint and Water Value</td>
<td>92</td>
</tr>
<tr>
<td>4-4-3-2</td>
<td>Grapes Water Footprint and Water Value</td>
<td>93</td>
</tr>
<tr>
<td>4-4-3-3</td>
<td>Dates Water Footprint and Water Value</td>
<td>95</td>
</tr>
<tr>
<td>4-4-3-4</td>
<td>Bananas Water Footprint and Water Value</td>
<td>96</td>
</tr>
<tr>
<td>5</td>
<td>SUMMARY</td>
<td>98</td>
</tr>
<tr>
<td>5.1</td>
<td>Conclusion</td>
<td>98</td>
</tr>
<tr>
<td>5.2</td>
<td>Recommendations</td>
<td>103</td>
</tr>
<tr>
<td>6</td>
<td>Appendices</td>
<td>105</td>
</tr>
<tr>
<td>7</td>
<td>LIST OF REFERENCES</td>
<td>118</td>
</tr>
<tr>
<td>8</td>
<td>Arabic Summary</td>
<td>106</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Table 3-1</td>
<td>Crops Selected for the Virtual Water Trade Evaluating in Egypt</td>
<td>35</td>
</tr>
<tr>
<td>Table 3-2</td>
<td>USD Exchange Rate to Egyptian Pounds</td>
<td>40</td>
</tr>
<tr>
<td>Table 4-1</td>
<td>Egypt Total Cultivated Area <em>(1000 Feddan)</em></td>
<td>42</td>
</tr>
<tr>
<td>Table 4-2</td>
<td>Egypt Total Production (Million Tonnes)</td>
<td>44</td>
</tr>
<tr>
<td>Table 4-3</td>
<td>Egypt Productivity and Global Rank</td>
<td>46</td>
</tr>
<tr>
<td>Table 4-4</td>
<td>Egypt Trade Volume (Million Tonnes)</td>
<td>48</td>
</tr>
<tr>
<td>Table 4-5</td>
<td>Egypt Trade Values (Million EGP)</td>
<td>49</td>
</tr>
<tr>
<td>Table 4-6</td>
<td>Egypt's Virtual Water Trade Volume Traded <em>(MM³)</em></td>
<td>52</td>
</tr>
<tr>
<td>Table 4-7</td>
<td>Egypt's Virtual Water Volume Traded <em>(MM³)</em> As Field Crops (Cereal)</td>
<td>54</td>
</tr>
<tr>
<td>Table 4-8</td>
<td>Egypt's Virtual Water <em>(MM³)</em> Traded for Each Field Crop (Cereal)</td>
<td>55</td>
</tr>
<tr>
<td>Table 4-9</td>
<td>Egypt's Virtual Water Volume Traded <em>(MM³)</em> As Vegetables Crops</td>
<td>57</td>
</tr>
<tr>
<td>Table 4-10</td>
<td>Egypt's Virtual Water <em>(MM³)</em> Traded for Each Vegetable Crop</td>
<td>58</td>
</tr>
<tr>
<td>Table 4-11</td>
<td>Egypt's Virtual Water Volume Traded <em>(MM³)</em> As Fruits Crops</td>
<td>59</td>
</tr>
<tr>
<td>Table 4-12</td>
<td>Egypt's Virtual Water Traded <em>(MM³)</em> for Each Fruit Crop</td>
<td>61</td>
</tr>
<tr>
<td>Table 4-13</td>
<td>Egypt's Virtual Water Volume for Domestic Production <em>(MM3)</em></td>
<td>63</td>
</tr>
<tr>
<td>Table 4-14</td>
<td>Egypt's Water Resources (Billion Cubic Meter)</td>
<td>65</td>
</tr>
<tr>
<td>Table 4-15</td>
<td>Egypt's Water Share <em>(M³/Capta/Year)</em></td>
<td>66</td>
</tr>
<tr>
<td>Table 4-15b</td>
<td>Egypt's Water Utilizations</td>
<td>69</td>
</tr>
<tr>
<td>Table 4-16</td>
<td>Egypt's Water Unit Productivity <em>(Kg/M³)</em></td>
<td>72</td>
</tr>
<tr>
<td>Table 4-17</td>
<td>Egypt's Average Water Footprint for Crops <em>(Million M³/Year)</em></td>
<td>75</td>
</tr>
</tbody>
</table>
## List of Tables - Continued

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-18</td>
<td>Rice Water Footprint</td>
<td>77</td>
</tr>
<tr>
<td>4-19</td>
<td>Wheat Water Footprint</td>
<td>80</td>
</tr>
<tr>
<td>4-20</td>
<td>Maize Water Footprint</td>
<td>82</td>
</tr>
<tr>
<td>4-21</td>
<td>Soybeans Water Footprint</td>
<td>84</td>
</tr>
<tr>
<td>4-22</td>
<td>Potatoes Water Footprint</td>
<td>86</td>
</tr>
<tr>
<td>4-23</td>
<td>Onions Water Footprint</td>
<td>88</td>
</tr>
<tr>
<td>4-24</td>
<td>Green Beans Water Footprint</td>
<td>89</td>
</tr>
<tr>
<td>4-25</td>
<td>Tomatoes Water Footprint</td>
<td>91</td>
</tr>
<tr>
<td>4-26</td>
<td>Oranges Water Footprint</td>
<td>92</td>
</tr>
<tr>
<td>4-27</td>
<td>Grapes Water Footprint</td>
<td>94</td>
</tr>
<tr>
<td>4-28</td>
<td>Dates Water Footprint</td>
<td>95</td>
</tr>
<tr>
<td>4-29</td>
<td>Bananas Water Footprint</td>
<td>97</td>
</tr>
<tr>
<td>5-1</td>
<td>Overall Averages for all Crops Under this Study for the Period: 2001-2010</td>
<td>102</td>
</tr>
</tbody>
</table>
## List of Figures

| Figure 2-1 | Contribution of different crops to the total water footprint of crop production | 9 |
| Figure 4-1 | Egypt's Cultivated Areas | 42 |
| Figure 4-2 | Egypt's Crops Production (Million Tonnes) | 45 |
| Figure 4-3 | Egypt and Global Crops Productivity (Tonnes/Feddan) | 46 |
| Figure 4-4 | Egypt's Trade Volume (Million Tonnes) | 48 |
| Figure 4-5 | Egypt's Trade Values (Million EGP) - For Each Crop | 50 |
| Figure 4-6 | Egypt's Trade Values (Million EGP) | 50 |
| Figure 4-7 | Egypt's Virtual Water Trade Volume (MM³) | 52 |
| Figure 4-8 | Egypt's Virtual Water Trade Volume Traded (MM³) as Field Crops (Cereal) | 55 |
| Figure 4-9 | Egypt's Virtual Water Trade Volume Traded (MM³) as Vegetables Crops | 58 |
| Figure 4-10 | Egypt's Virtual Water Trade Volume Traded (MM³) as Fruit Crops | 60 |
| Figure 4-11 | Egypt's Virtual Water Volume (MM³) for Domestic Production | 63 |
| Figure 4-12 | Virtual Water Volume % for Egypt's Domestic Production | 64 |
| Figure 4-13 | Egypt's Water Resources (Percentage: 2001-2010) | 65 |
| Figure 4-14 | Egypt's Water Share (2001-2010) | 66 |
| Figure 4-14b | Egypt's Water Utilizations | 69 |
| Figure 4-15 | Egypt's Water Unit Productivity (Kg/MM³) for the selected crops | 73 |
## List of Figures - Continued

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-16</td>
<td>Egypt's Average Water Footprint for Crops (Million M^3/Year)</td>
<td>75</td>
</tr>
<tr>
<td>4-17</td>
<td>Rice Water Footprint</td>
<td>78</td>
</tr>
<tr>
<td>4-18</td>
<td>Wheat Water Footprint</td>
<td>81</td>
</tr>
<tr>
<td>4-19</td>
<td>Maize Water Footprint</td>
<td>83</td>
</tr>
<tr>
<td>4-20</td>
<td>Soybeans Water Footprint</td>
<td>85</td>
</tr>
<tr>
<td>4-21</td>
<td>Potatoes Water Footprint</td>
<td>86</td>
</tr>
<tr>
<td>4-22</td>
<td>Onions Water Footprint</td>
<td>88</td>
</tr>
<tr>
<td>4-23</td>
<td>Green Beans Water Footprint</td>
<td>90</td>
</tr>
<tr>
<td>4-24</td>
<td>Tomatoes Water Footprint</td>
<td>91</td>
</tr>
<tr>
<td>4-25</td>
<td>Oranges Water Footprint</td>
<td>93</td>
</tr>
<tr>
<td>4-26</td>
<td>Grapes Water Footprint</td>
<td>94</td>
</tr>
<tr>
<td>4-27</td>
<td>Dates Water Footprint</td>
<td>96</td>
</tr>
<tr>
<td>4-28</td>
<td>Bananas Water Footprint</td>
<td>97</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>Percentage</td>
<td></td>
</tr>
<tr>
<td>AHDR</td>
<td>Aswan High Dam Reservoir</td>
<td></td>
</tr>
<tr>
<td>ASL</td>
<td>Above Sea Level</td>
<td></td>
</tr>
<tr>
<td>Avg.</td>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>AWU</td>
<td>Agricultural Water Use</td>
<td></td>
</tr>
<tr>
<td>BCM</td>
<td>Billion Cubic Meters</td>
<td></td>
</tr>
<tr>
<td>bm3</td>
<td>Billion Cubic Meters</td>
<td></td>
</tr>
<tr>
<td>CAPMAS</td>
<td>The Central Agency for Public Mobilization and Statistics in Egypt</td>
<td></td>
</tr>
<tr>
<td>CWP</td>
<td>Crop Water Productivity</td>
<td></td>
</tr>
<tr>
<td>CWR</td>
<td>Crop Water Requirements</td>
<td></td>
</tr>
<tr>
<td>CWU</td>
<td>Crop Water Use</td>
<td></td>
</tr>
<tr>
<td>DWU</td>
<td>Domestic Water Use</td>
<td></td>
</tr>
<tr>
<td>EFP</td>
<td>Environmental Footprint</td>
<td></td>
</tr>
<tr>
<td>EGP</td>
<td>Egyptian Pound</td>
<td></td>
</tr>
<tr>
<td>et. al</td>
<td>and Others</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>European Commission</td>
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</tr>
<tr>
<td>EWFP</td>
<td>External Water Footprint</td>
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</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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</tr>
<tr>
<td>Feddan</td>
<td>Land area measure used in Egypt (1 Feddan = 4200 square meters). (1 Feddan = 0.42 ha). (1 Hectare = 2.38 Feddans</td>
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</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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</tr>
<tr>
<td>Gm3/yr</td>
<td>Billion Cubic Meters per year</td>
<td></td>
</tr>
<tr>
<td>GVWE</td>
<td>Gross Virtual Water Export</td>
<td></td>
</tr>
<tr>
<td>GVWI</td>
<td>Gross Virtual Water Import</td>
<td></td>
</tr>
<tr>
<td>ha</td>
<td>Hectare, an international land area measure (1 ha = 10000 square meters)</td>
<td></td>
</tr>
<tr>
<td>IWFP</td>
<td>Internal Water Footprint</td>
<td></td>
</tr>
<tr>
<td>IWMl</td>
<td>International Water Management Institute</td>
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<tr>
<td>IWU</td>
<td>Industrial Water Use</td>
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### List of List of Units and Abbreviations - Continued

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Kg.</td>
<td>Kilogram</td>
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<tr>
<td>M3/Yr/Cap</td>
<td>Cubic Meter per Year per Capita</td>
</tr>
<tr>
<td>MEGP</td>
<td>Million Egyptian Pound</td>
</tr>
<tr>
<td>MOALR</td>
<td>Ministry of Agriculture and Land Reclamation, Egypt</td>
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<tr>
<td>MWRI</td>
<td>Ministry of Water Resources and Irrigation</td>
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<tr>
<td>NVWI</td>
<td>Net Virtual Water Import</td>
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<tr>
<td>SWERI</td>
<td>Soil, Water, and Environment Research Institute</td>
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<tr>
<td>Tone</td>
<td>metric tonnes (1 Tone = 1000 Kilogram)</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>USFOREX</td>
<td>United States Foreign Exchange Services</td>
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<tr>
<td>VW</td>
<td>Virtual Water</td>
</tr>
<tr>
<td>VWEV</td>
<td>Virtual Water Import Volume</td>
</tr>
<tr>
<td>VWIV</td>
<td>Virtual Water Export Volume</td>
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<tr>
<td>VWV</td>
<td>Virtual Water Volume</td>
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<tr>
<td>WF</td>
<td>Water Footprint</td>
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<td>WID</td>
<td>Water Import Dependency</td>
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<td>WS</td>
<td>Water Scarcity</td>
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<td>WTO</td>
<td>World Trade Organization</td>
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