# Water productivity is in the eye of the beholder: benchmarking the multiple values produced by water use in the Phoenix metropolitan area

Water Productivity of Phoenix Metropolitan Area Cities

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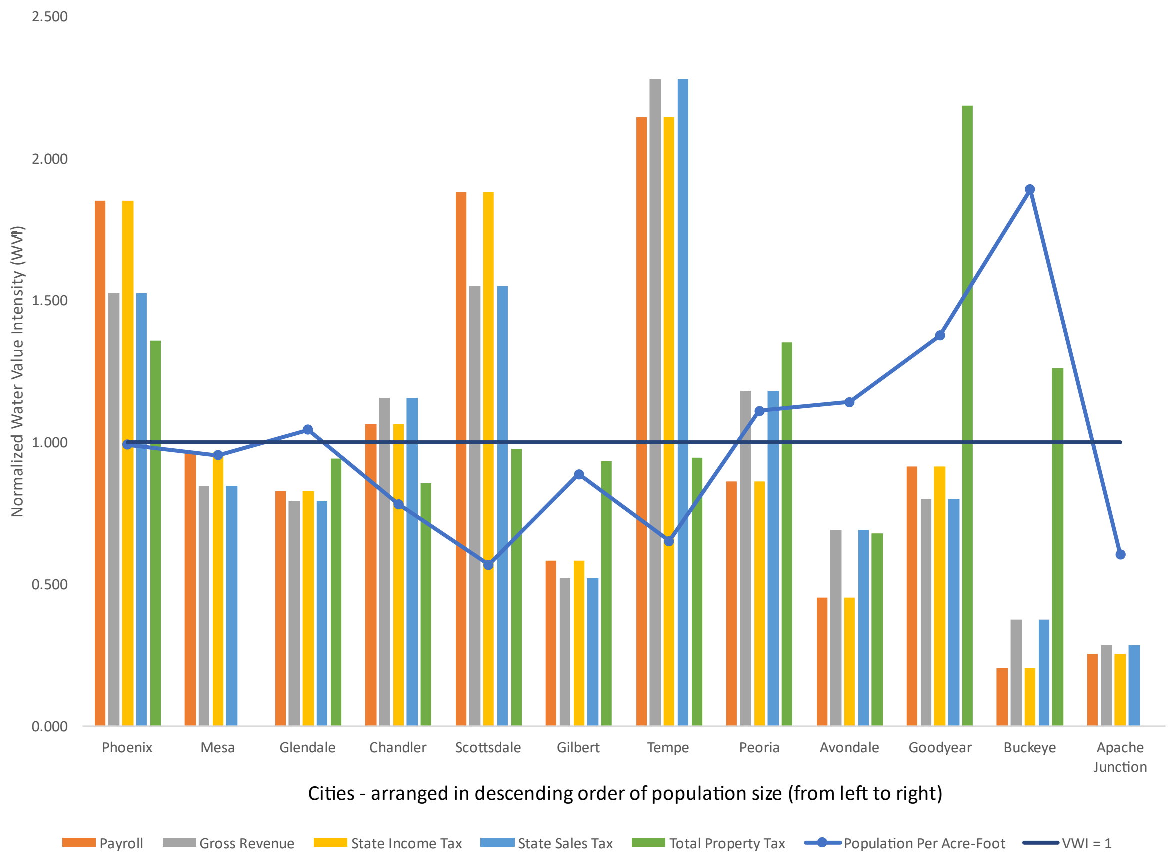
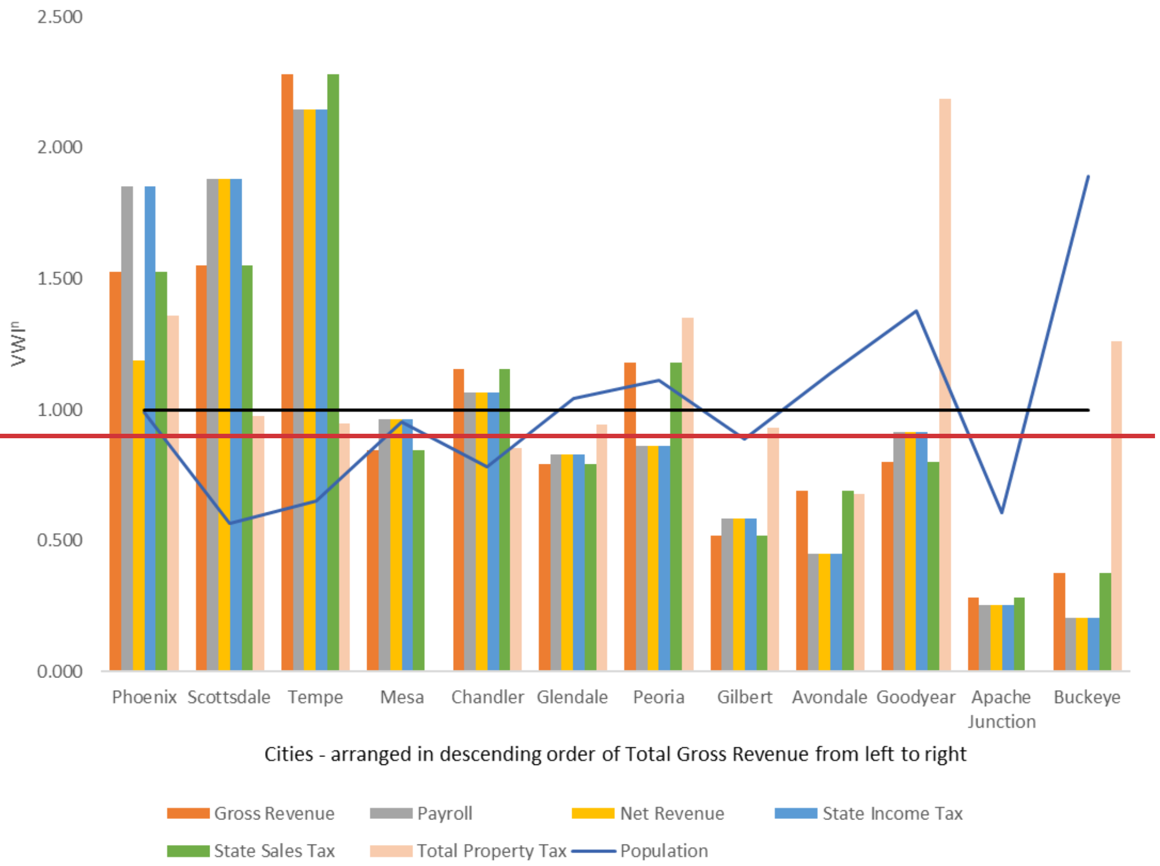
**Abstract.** Water productivity (or efficiency) data informs water policy, zoning and planning along with water allocation decisions under water scarcity pressure. This paper demonstrates that different water productivity metrics lead to different conclusions about who is using water more effectively. In addition to supporting the population's drinking and sanitation needs, water generates many other public and private social, environmental, and economic values. For the group of municipalities comprising the Phoenix Metropolitan Area we compare several water productivity metrics by calculating the Water Value Intensity (WVI) of potable water delivered by the municipality to its residential and non-residential customers. Core cities with more industrial water uses are less productive by the conventional efficiency measure of water used per capita, but core cities generate more tax revenues, business revenues, and payroll revenues per unit of water delivered, achieving a higher water productivity by these measures. We argue that policymakers should consider a more diverse set of socio-economic water productivity measures to ensure that a broader set of values are represented in water allocation policies.

**Graphical Abstract**


Normalized Water Value Intensity (VWIⁿ)
2.500
2.000
1.500
1.000
0.500
0.000
Phoenix
Mesa
Glendale
Chandler
Scottsdale
Gilbert
Tempe
Peoria
Avondale
Goodyear
Buckeye
Apache Junction
Cities - arranged in descending order of population size (from left to right)
Payroll
Gross Revenue
State Income Tax
State Sales Tax
Total Property Tax
Population Per Acre-Foot
VWI = 1


VWIⁿ
2.500
2.000
1.500
1.000
0.500
0.000
Phoenix
Scottsdale
Tempe
Mesa
Chandler
Glendale
Peoria
Gilbert
Avondale
Goodyear
Apache Junction
Buckeye
Cities - arranged in descending order of Total Gross Revenue from left to right
Gross Revenue
Payroll
Net Revenue
State Income Tax
State Sales Tax
Total Property Tax
Population

## 1 Introduction

The coming decades will see major challenges in meeting demands for water in the United States and across the globe (Postel, 1996; Devineni et al., 2015). Apportioning water effectively between agriculture, the world's largest water user and the water use~~demands~~ of industry, energy and urban development will become increasingly important (Hoekstra, 2014; Vörösmarty, 2000; Gleick and Palaniappan, 2010). Reliable metrics are needed for informed decision-making about allocating water sustainably, equitably, and optimally. This is especially true in water-scarce regions like the American Southwest (Tidwell et al., 2012; Wildman and Forde, 2012; Schewe et al., 2014). However, in such regions, there is often a limit to how much water cities can reduce through conservation measures or other demand management policies - a phenomenon known as 'demand hardening'. Even if conservation is still producing water efficiency gains decoupled from growth to date (Richter et al., 2020), demand will eventually harden, so it is in the public's interest to allocate water based on the merit and benefit of use (Howe and Goemans, 2007), however merit and benefit might be defined.

Careful management of freshwater is especially important for the municipalities comprising the Phoenix Metropolitan Statistical Area (Phoenix MSA or PMA), Arizona (Gober et al., 2010; Gober et al 2013; Rushforth and Ruddell, 2015). With a population of 4.9 million, in 2019 Phoenix-Mesa-Chandler is the 10th most populous metropolitan area in the country (US Census Bureau, 2020). Economic growth has been tightly coupled with population growth in the PMA. In 2017 the GDP for the Phoenix MSA was close to $217 billion, having grown by 30% between 2010 and 2018 (US Bureau of Economic Analysis, 2019). Underlying the Phoenix MSA's population growth and economic growth are increasingly scarce water resources.

Studies of water use often employ variations of water footprint analysis to measure water use or water use efficiency (Hoekstra et al., 2011; Hoekstra et al.; 2015; Marston et al. 2018; Paterson et al., 2015; Rushforth and Ruddell, 2018). Water footprints have been calculated for cities in the US (Paterson et al. 2015), and even specifically for cities in Arizona (Bae and Dall'Erba, 2018; Rushforth and Ruddell 2015, 2016; Scott and Pasqualetti, 2010). Water productivity studies have been conducted on industries and products (Marston et al., 2020; Evenson et al. 2018; Maupin et al. 2014; Mayer et al., 2016; Blackhurst et al. 2010; Solley et al. 1983), on the electric power grid (Ruddell et al. 2014), and on Arizona semiconductors (Hubler et al 2012), in addition to the more common study of irrigation agricultural water productivity (Xu et al., 2019; Kinje et al., 2003; Hamdy et al., 2003). Water efficiency benchmark data can help policy makers to develop and implement sound water policy (Berg, 2010). Such benchmarks can help stakeholders to quantify progress towards policy objectives and can help regulators fine-tune efficiency goals (Haider et al., 2016). ~~Because we manage what we measure, it is important to inform policy using appropriate measures for what we value about water use.~~

Per the logic of Embedded Resource Accounting (Rushforth et al. 2013; Ruddell et al. 2014), produced values are accounted for differently by different parties because these parties have different worldviews and decision boundaries by which they account for internal and external costs and benefits. For instance, revenue is mostly valued by business owners, payroll (total salaries) is mostly valued by workers (and is a cost to business owners), taxes are mostly valued by the branch of government collecting the specific tax and by the public beneficiaries of this tax revenue (e.g. state income tax to the state, property tax to the municipality), and population is valued by (presumably) all people – but most especially by democratically elected government officials who set water policy because people vote. There are also many other social, environmental, and economic values produced where water inputs are an input factor (Vardon et al., 2012), including for instance aquatic habitat created by outdoor water use in a desert city, urban heat island mitigation, and federal tax revenue. The return of revenue directly to a water department responsible for its provision is another important type of value needed for fiscal planning and support of water operations (Borrego-Marin et al., 2016), but that kind of revenue is of very narrow interest to a single department of a single municipal government and is discounted by other parties. Because there are many social, environmental, and economic stakeholders with many different sets of interests and values, multiple water use efficiency or productivity benchmarks are appropriate to measure the efficacy of water allocation. Although it should be noted that current study did not include the social, environmental and full economic value of water due to a lack of available data.

The standard residential water efficiency or water sustainability measure for water utilities in the United States is Gallons per Capita per Day (GPCD). Water use efficiency is the reciprocal of the water productivity. Water productivity – also called water value intensity (WVI, Ruddell et al. 2014) is a metric expressing the benefits of water use (in units of the benefit) relative to the costs (in units of water use). The goal of water policy should be to do more social, environmental, and economic good with limited water resources, but not necessarily to use less water but to maximize the value of scarce resource, which may include conservation measures that allow for the future use of water. Shifting to a water productivity (or WVI) perspective puts the emphasis on the values and benefits that are produced, rather than the water that is saved. For example, if we invert the standard GPCD metric, we obtain People per Gallon per Day (PPGD), and this makes it clear that such a metric values supporting additional population using the water resources. It is not incorrect to use an efficiency metric, but we prefer the positive productivity framing to the negative efficiency framing for these reasons.

Comparing multiple water productivity metrics and benchmarks is particularly helpful when there are multiple values and benefits associated with the water use. In this paper we develop a case study comparing multiple water productivity benchmarks for the group of municipalities comprising the Phoenix Metropolitan Area. For these municipalities we compare the water productivity in units of value produced per acre-foot of water delivered. Water productivity metrics in this paper's case study include (1) residential population supported, (2) payroll, (3) gross revenue, (4) state income tax, (5) state sales tax, and (6) total property tax. Other productivity metrics could be used such as the water intensity of land use, or we could add more social and environmental value considerations, but these are beyond the scope of this paper's case study due primarily to a lack of data availability. Our research question is, "What is the comparative water productivity of the municipalities of the Phoenix area, using multiple water productivity measures?"

## 2 Methods

Water that is available to PMA cities is allocated using a complex system of legal water rights and conveyed to the municipalities via large-scale physical infrastructure systems (Jacobs & Megdal, 2004; Holway, 2007). Most PMA municipalities draw water from three main physical water sources: the Colorado River, the Salt-Verde River system, and the large, interconnected groundwater aquifer underlying the metro area. However, while many municipalities have access to all three sources, some municipalities, typically newer ones on the outer edge of the metropolitan area, may not have access to SRP or CAP water (Rushforth et al., 2020).

Within each municipality water is delivered~~allocated~~ to residential~~Residential~~ and non-residential~~Non-Residential~~ uses, which yield residential values (income tax, property tax, population) and non-residential values (payroll, net/gross revenue, sales tax). Of the many municipalities comprising metropolitan Phoenix area, we include twelve in this study (Figure 1): Apache Junction, Avondale, Buckeye, Chandler, Gilbert, Glendale, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, and Tempe. Smaller~~Other smaller~~ and outlying cities (e.g. Litchfield Park, El Mirage, Paradise Valley, Queen Creek, Guadalupe, Surprise, Cave Creek, Fountain Hills) were omitted due to a lack data at the time of analysis.

Water use studies may be based on consumption or withdrawal accounting. However, in this~~This~~ study area water~~uses~~ withdrawal is equal to water consumption, so we have simplified the language to water use, which is defined as the total volume of~~accounting, and specifically~~ water delivered in a municipality less loss and unaccounted (L&U) for water.~~to utility customers, rather than net consumptive use.~~ This is the right choice for most water use studies per the arguments in Ruddell (2018), because city water resources, infrastructures, operating costs, and water rights are measured and priced in units of water volumes ~~withdrawn and~~ delivered, not in terms of net hydrological water balances. We use acre-feet units for this study, not SI units, because acre-feet is the unit of measurement used and understood throughout the water management community in the USA and converting to SI units renders the results more difficult for use in policy applications. Reclaimed water use was not included in this study since it is not delivered~~allocated~~ to municipalities by an external agency ~~(e.g. SRP, CAP, or ADWR in this case),~~ and because it is not withdrawn from the three major hydrological water sources of the region. Also, we do not consider the indirect value of~~Also,~~ reclaimed water because the reclaimed water uses,~~generally is used low economic value or indirect economic value activities~~ such as recreational turf irrigation, make~~making~~ it difficult to measure associated economic value. Additionally,~~And, because~~ reclaimed water~~ use~~ (unlike potable~~raw~~ water~~ deliveries~~) is subject to varied~~inconsistent~~ city and county policies and standards for reporting and accounting, making it is difficult to compare reclaimed water data robustly between municipalities.

This paper's "value intensity" water productivity metrics relate gross value-output to gross water-input, including~~):~~ the residential population supported by potable water deliveries, ~~, along with six different financial metrics:~~ gross revenues, payroll, state sales tax, state income tax, and property taxes. Water productivity could be calculated~~ various ways,~~ using a range of metrics – to include for example, different social and environmental benefits of a city's water use, or the marginal product (instead of gross), or the complete Scope 1+2+3 indirect supply chain water use (instead of Scope 1). Also, these multiple value metrics could be weighted to assign differential importance if appropriate. Because this is the first study of its kind, we calculate a simple set of metrics that are readily computable and straightforward to explain (Table 1), and we weight the metrics equally in the figures for simplicity of visual comparison. Note that payroll and taxes are two components of gross revenue, and as such are not independent from gross revenue.

## 2.1 Data Sources

This study uses older data from calendar year 2007 due to data availability constraints. The specific variety of data for residential and non-residential water use was no longer collected by the State of Arizona after 2009. We chose 2007 because this is the most recent pre-2009-year coinciding with the publication of the U.S. Census Economic Census.

Residential and non-residential water use data for the PMA's municipalities in this study were obtained from the Arizona Department of Water Resources Imaged Records. Reported water use data for 2007 were used to match US Economic Census data for the same year. Specifically, water use data contained in this report is found in ADWR Notifications on Gallons Per Capita per Day (GPCD) and Lost and Unaccounted (L&U) for Water sent to the individual cities studied in this report (ADWR, 2011a-i). L&U water was incorporated into this study by attributing L&U water proportionately to total water use by residential and non-residential sectors (for an example see Appendix A~~-1~~ and the equation in Appendix B).

Income data were obtained from the U.S. Census Bureau (2009a-f). Property tax data were obtained from the annual budgets from each of the cities in the study (City of Chandler, 2008, 2009; City of Glendale, 2008; City of Goodyear, 2007; City of Mesa, 2008; City of Peoria, 2007; City of Phoenix, 2007; City of Scottsdale, 2008; City of Tempe, 2007; Town of Avondale, 2010; Town of Buckeye, 2007; Town of Gilbert, 2007). Manufacturing, retail, information services, real estate, and professional and technical services data were obtained from the 2007 Economic Census (U.S. Census Bureau, 2009a-f). See Appendix C for the full economic data used in this study.

Water Value Intensities (WVIs) were calculated using the water-volume weighted averages of residential and non-residential sectors (Table D1). Economic values on a water use basis were analysed for several~~six~~ economic categories in the U.S. Economic Census: city-level or town-level income data (Tables D2, D3), city- or town-level manufacturing (Tables D4, D5), city- or town-level retail data (Table D6), city- or town-level information services (Table D7), city- or town-level real estate data (Table D8) and city- or town-level professional and technical services (Table D9).

## 2.2 Simplified Embedded Resource Accounting: ~~or,~~ Point of View Matters in Water Use Accounting

This analysis employs a simplified version of Embedded Resource Accounting (ERA, Ruddell et al. 2014) to associate indirect and direct values with direct (Scope 1) and indirect (Scope 2+3) impacts in an input-output network. In this case there are ~~six~~ direct and local values produced (e.g., Tables D1-D9),~~, one~~ direct impact on the local freshwater stock, and indirect values and impacts are neglected. The water use metrics in this paper are therefore calculated from the point of view of a hypothetical manager of the water resources of the Phoenix metropolitan area (PMA)~~Metropolitan Area~~ who is interested in maximizing a diverse basket of values that are directly associated with water use processes in the PMA. The same hypothetical manager is therefore also disinterested~~ in~~ in indirect value creation and impact such as federal tax revenues or the water impacts of the PMA's supply chains lying outside the area. Everything inside the PMA is "internal" and everything outside the PMA is "external" from this hypothetical manager's point of view. We assert that this point-of-view is historically responsible for water allocation decisions and regulations for the PMA and resembles the point of view of the Governor's office, the regional government, or the Arizona Department of Water Resources, so this is an appropriate choice for this study. Because the worldview of this hypothetical manager encompasses the metro area, ERA defines the resource stock of interest as the total combined annual water deliveries from the Central Arizona Project (2012), Salt River Project (SRP), and groundwater resources to the PMA's major municipalities individually and collectively. If a different point of view is chosen for the accounting, the results will change. For example, the business owners of the City of Tempe internalize revenue-generating value, but not necessarily other values like payroll or taxes benefitting the City of Tempe and its labor force.

The direct water value intensity $WVI_{x,l}$ used here is simply the ratio of the value (*V*) of type (*l*) produced as an output of the municipality's (*x*) collective processes to the input of water (*W*) to the municipality's processes. In other words, $WVI_{x,l}$ is the ratio of value out to water in. $\overline{WVI_l}$ is the mean WVI for value *l* for all municipalities in the area. ${WVI^n}_{x,l}$ has been normalized (*n*) by dividing $WVI_{x,l}$ by the mean $\overline{WVI_l}$, such that municipalities with results above 1 have above-average WVI for that value type. $BWVI_x$ is the basket-weighted water value intensity for municipality *x*; it is the weighted average across all value types for that municipality. In this study, we assume weights of 1 for all value types. From this point of view, all six types of value assessed here are weighted equally. ${BWVI_x}^n$ is the normalized value, like ${WVI^n}_{x,l}$ above.

*WVI*'s may include economic data and measures of economic value, but a *WVI* – or any *VI* – is not a price or a measure of marginal value, product, or cost according to the classical economic Theory of Value, because it does not consider the marginal contribution of the impact on the resource stock to the production of values, or the cost of the resource, or value-added by the process. Since~~Because~~ *VI*'s are not prices or costs, they may not be added together to directly measure the value produced by a process. Rather,~~; rather, a basket (i.e. a range) of~~ *VI*'s should be interpreted as multiple independent benchmarks of the gross productivity of the water use. Per Kumar (2021), we present here as WVI is similar to the water productivity definition based on single factor of production using water use. In other words, WVI is similar to the Partial factor productivity (PFP), which is a ratio of a measure of total output to a measure of a single input category. The two differences are technicalities, and are that (a) WVI could include indirect value production, and (b) WVI makes no attempt to use total productivity and instead is calculated several times using several different and non-commensurable productivities (i.e. values). Gross WVI is a disambiguated metric that is a precise subtype of gross water productivity metric, per the ERA mathematics.

### 2.2 Residential Sector Water Value Intensities

Property taxes were used as a measure for the values produced by residential water use. Primary, secondary, and total levied property taxes by municipalities were considered in this analysis. Calculation of the value intensity of residential water on a per volume use basis is shown in Appendix A.

### 2.3 Non-Residential Sector Water Value Intensities

City-level net and gross revenues and payrolls were used as a measure for the values produced by non-residential water uses such as commercial, industrial, and governmental uses of the city's potable water supplies. City-level state sales tax contributions and income taxes paid to the state were estimated for the non-residential sector using the gross revenue and payroll data, respectively. The state sales tax rate was set at 6.6% and the income tax rate 3.3%, per statutes in effect in Arizona during the study period. From these data, the value intensity of non-residential water uses was calculated for city-level net/gross revenues, payroll, state sales tax contribution, and income taxes paid to the state. Note that income tax is considered a value product of the non-residential sector in this analysis, and taxed payroll is a value product of the business sector, not the residential sector. Net and gross revenue and payroll data were obtained from the US Economic Census. Population data were obtained from the U.S. Census Bureau (2007b). Equations for Revenue, Payroll, and Tax VI's follow. Calculation methods are show in Appendix A.

## 3 Results

In terms of residential population supported per acre-foot of water used (Figure 2), outlying cities such as Buckeye, Goodyear and Avondale are more productive (or efficient) than core cities like Phoenix, Tempe and Scottsdale. However, when economic productivity measures are considered (Figure 3), core cities like Phoenix, Tempe and Scottsdale, dominate the rankings because they produce far more payroll, tax, and business revenue per gallon of water used.

## 4 Discussion

Each city has its own unique water value profile (Table 1) which contribute to its water productivity profile. For example, Chandler is the fourth largest city in the PMA by population, and had the fourth lowest normalized WVI per capita, but its normalized WVI for gross revenue is well above the PMA average (Figure 3). Chandler has a disproportionately large industrial sector dominated by High Value Semiconductor Manufacturing products and services. Previous studies have found this sector produces an unusually large amount of economic value relative to use of water (Hubler et al., 2012). Figure 3 reveals tradeoffs between multiple normalized water productivity objectives. For example, there is a tradeoff between WVI for gross revenue versus WVI for population. The relatively higher business revenue a community generates with its water, the relatively lower population it supports with its water. A detailed study of the Pareto frontiers and tradeoffs between these multiple objectives is beyond the scope of this paper, but such a tradeoff appears to have emerged within the PMA. Despite this, the standard U.S. measure of water efficiency, Gallons per Capita per Day, (GPCD, Evenson et al., 2018), implies that water's value lies entirely in supporting residents and their swimming pools and lawns. When applied in isolation from other metrics for other objectives, this standard measure favors allocating water to bedroom communities. But this comes at a cost of the jobs and tax revenues that the residents of those bedroom communities need for their livelihoods and to pay for their water rights and water infrastructure.

Because cities, state government, and economic development organizations want to promote high-quality economic development, and the City of Chandler uses much of its water for this kind of economic activity, allocating more water toward Chandler as compared with a bedroom community would seem to merit consideration based on economic water productivity benchmarks. After all, a bedroom community's residents need the payroll and tax revenues produced by companies in the City of Chandler. But, in turn, those companies employ the workforce that lives in the bedroom communities and depend on that labor for their operations. A residential population cannot be supported without jobs and revenues; both values matter and each supports the other. Therefore, a more diverse set of water productivity benchmarks can help decision makers understand the trade-offs involved in their allocation of water to different kinds of cities and can help policymakers avoid undervaluing the economic allocations of water that are needed to support employment for the residential population. Additionally, the tax base is the major constraint on the ability of a city to finance water rights and water infrastructure to provide adequate water for its residential population. Linking economic and population growth is important. There have been several advocates for the concept of 'wet growth' (Arnold, 2005) and water-conscious land-use planning (Bates, 2012). Water-conscious economic planning and growth can help to promote, protect, and restore water sources, and can prevent growth beyond the limits of water resources (Gober et al. 2010; Larson et al, 2013; Li et al., 2016).

Accurate estimation of the water resources required to "build out" the municipality's zoning and master plan is crucial part of this land use planning process (Gober et al., 2010; Gober et al., 2013; Larson et al, 2013; Li et al., 2016). Once land is allocated to a use (i.e., zoned),~~,~~ the water and land associated with that use cannot be reallocated easily or inexpensively, if at all (Marston and Cai, 2016). In addition, as a municipality continues to grow, it typically approaches the "build-out" stage where further changes become prohibitive due to the scarcity and depletion of land and water resources. Balancing various water productivity values is therefore important in the land use planning process before development occurs.

We present results that focus narrowly on economic water productivity in the PMA as an alternative to GPCD as an efficiency metric, but it is preferable to also include broader economic, environmental, and social dimensions of water productivity. For example, urban tree and shade programs, which are water consumers, may not have high economic water productivity or generate tax revenue, but they do produce demonstrable ecological service benefits such as shade, mitigation of air pollution, flood amelioration, and reduced urban heat island effects. Water planners and decision-makers do not apply equal weighting to their multiple values, so any stakeholder would have their own weights to apply to the multiple-objective decision process that is implied by the use of multiple water productivity metrics. Additionally, combining indirect water use analysis (Rushforth and Ruddell, 2015) with the present paper's multiple value analysis to provide a complete evaluation of the value crated by water use, but it is outside the scope of this work. We think it is important to develop a clear presentation of the multiple-values argument first, and on its own merits, before adding the complexity of indirect value creation from water use.

When broader values like revenue, payroll, and tax benefits are factored into water allocation decisions, different water allocation decisions could emerge. These are political and value-based decisions, not engineering decisions, but such decisions should be more broadly informed with a broader set of water productivity benchmarks.

## 5 Conclusions

This study finds that bedroom communities show higher water productivity based on the standard efficiency benchmark of gallons per capita, but core cities which host large businesses show higher water productivity using a basket of economic values like taxes, payroll, and business revenues. There may be tradeoffs between these competing values produced by water use, and different decision makers bring different points of view and value weighting to that policy discussion. A broader basket of water productivity benchmarks could inform more balanced and equitable water allocation decisions by policymakers.

## Appendices

*Appendix A: Detailed VI Equations*

The ~~Calculation of the~~ VI of residential water ($VI_{Property\ Tax}$) was ~~as~~ measured ~~by property taxes,~~ on a per volume use basis using property taxes~~$VI_{Property\ Tax}$ was taken~~ by dividing the amount of levied property taxes by the municipality's volume of water delivered~~allocated~~ to residential uses. Property~~, property~~ tax data in Appendix C~~,~~ were obtained from the Maricopa County Department of Finance (2007). For some cities,~~);~~ property taxes were reported as zero ~~are~~ due to city-specific policies that restrict the ability of the city to collect property tax.

$$VI_{Property\ Tax} = \frac{\$\ Levied\ Property\ Tax}{Volume_{H_2O}Residential_i\ (ac-ft)}$$

Per capita water use by the residential water use sector of a municipality $VI_{Population}$ is calculated as shown in Equation 13. This metric is included because per-capita equity in water use is currently the primary type of value intensity utilized for water allocation decisions.

$$VI_{Population} = \frac{Population}{Volume_{H_2O},Residential_i\ (ac-ft)}$$

Data in Appendix C were used to calculate~~Calculation of~~ the VIs for net and gross revenue~~revenues~~, payroll, sales tax and income taxes using the following equations~~data shown in Appendix C~~:

$$VI_{Revenues} = \frac{\$Revenues}{Volume_{H_2O}Non-Residential_i\ (ac-ft)}$$

$$VI_{Payroll} = \frac{\$\ Payroll}{Volume_{H_2O}Non-Residential_i\ (ac-ft)}$$

$$VI_{Sales\ Tax} = \frac{\$\ Gross\ Revenues_i \times State\ Sales\ Tax\ Rate}{Volume_{H_2O}Non-Residential_i\ (ac-ft)}$$

$$VI_{Income\ Tax} = \frac{\$\ Payroll_i \times State\ Income\ Tax\ Rate}{Volume_{H_2O}Non-Residential_i\ (ac-ft)}$$

*Appendices B, C, and D: Source Data Tables*

Appendix B: Water Data Tables B1-B3

Appendix C: Tax Data Tables C1

Appendix D: Financial Data Tables D1-D9

**Table B.1. Reported Total Water Demand for PMA Municipalities Included in this Study.**

| City | Demand Category | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Apache Junction** | Total | 10,627 | 10,523 | 11,416 | 10,983 | 10,639 | 11,396 | 11,251 | 11,825 | 11,112 | 11,144 |
| **Avondale** | Total | 5,653 | 7,758 | 9,295 | 10,040 | 11,123 | 9,893 | 13,378 | 14,185 | 13,033 | 13,277 |
| **Buckeye** | Total | 1,094 | 1,049 | 2,434 | 2,601 | 738 | 751 | 3,028 | 4,135 | 4,363 | 4,277 |
| **Chandler** | Total | 48,969 | 53,263 | 55,475 | 55,657 | 55,697 | 58,439 | 61,070 | 64,404 | 63,076 | 60,773 |
| **Gilbert** | Total | 30,438 | 32,800 | 33,984 | 38,047 | 36,596 | 40,190 | 50,515 | 47,915 | 49,085 | 46,239 |
| **Glendale** | Total | 49,472 | 49,773 | 51,193 | 48,707 | 48,828 | 49,242 | 49,740 | 46,849 | 49,586 | 48,133 |
| **Goodyear** | Total | 2,570 | 3,309 | 3,555 | 4,243 | 5,307 | 6,328 | 6,409 | 8,088 | 8,163 | 8,289 |
| **Mesa** | Total | 101,461 | 102,935 | 97,180 | 100,458 | 95,933 | 100,363 | 100,203 | 100,027 | 93,317 | 89,794 |
| **Peoria** | Total | 24,602 | 21,503 | 22,593 | 21,715 | 22,656 | 25,421 | 27,659 | 28,527 | 28,717 | 27,388 |
| **Phoenix** | Total | 332,038 | 340,870 | 346,226 | 329,939 | 337,412 | 314,314 | 331,174 | 321,476 | 304,153 | 305,124 |
| **Scottsdale** | Total | 79,479 | 78,165 | 84,508 | 77,901 | 74,426 | 80,772 | 84,427 | 85,249 | 84,051 | 83,444 |
| **Tempe** | Total | 63,236 | 61,729 | 60,223 | 58,526 | 57,644 | 53,515 | 52,201 | 54,915 | 50,239 | 49,682 |

**Table B.2. Reported Residential Water Demand for PMA Municipalities Included in this Study.**

| City | Demand Category | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Apache Junction** | Residential | 4,701 | 4,917 | 5,387 | 5,605 | 5,678 | 5,804 | 6,059 | 6,059 | 6,059 | 5,761 |
| **Avondale** | Residential | 4,835 | 5,481 | 6,119 | 6,483 | 7,175 | 7,093 | 8,362 | 8,362 | 8,832 | 8,715 |
| **Buckeye** | Residential | 581 | 604 | 679 | 622 | 599 | 643 | 1,617 | 1,617 | 1,617 | 2,629 |
| **Chandler** | Residential | 27,488 | 29,152 | 31,316 | 31,599 | 32,465 | 33,906 | 35,539 | 36,563 | 34,424 | 34,766 |
| **Gilbert** | Residential | 19,816 | 21,702 | 23,905 | 24,647 | 25,633 | 27,110 | 28,684 | 28,684 | 28,684 | 30,910 |
| **Glendale** | Residential | 35,135 | 34,667 | 36,044 | 34,348 | 34,427 | 33,567 | 34,660 | 34,660 | 34,660 | 31,457 |
| **Goodyear** | Residential | 1,335 | 1,640 | 2,006 | 2,430 | 3,086 | 3,481 | 3,883 | 3,883 | 3,883 | 4,397 |
| **Mesa** | Residential | 64,242 | 65,180 | 67,026 | 65,655 | 65,890 | 63,972 | 65,319 | 65,139 | 65,139 | 60,494 |
| **Peoria** | Residential | 14,400 | 15,208 | 17,077 | 16,925 | 16,962 | 16,224 | 18,981 | 18,981 | 18,981 | 18,819 |
| **Phoenix** | Residential | 208,431 | 205,247 | 209,018 | 201,004 | 200,214 | 195,013 | 202,387 | 202,387 | 202,387 | 188,503 |
| **Scottsdale** | Residential | 49,659 | 49,370 | 52,737 | 51,083 | 46,873 | 54,719 | 57,401 | 57,401 | 57,401 | 56,568 |
| **Tempe** | Residential | 29,814 | 30,826 | 31,884 | 27,593 | 27,368 | 25,989 | 26,208 | 26,208 | 26,209 | 25,024 |

**Table B.3. Reported Non-Residential Water Demand for PMA Municipalities Included in this Study.**

| City | Demand Category | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| Apache Junction | Non-Residential | 5,419 | 5,137 | 5,585 | 5,183 | 4,741 | 5,145 | 5,048 | 5,048 | 5,048 | 4,748 |
| Avondale | Non-Residential | 2,305 | 2,150 | 2,866 | 2,821 | 3,118 | 1,983 | 4,097 | 4,097 | 3,846 | 4,060 |
| Buckeye | Non-Residential | 301 | 188 | 848 | 1,788 | 106 | 110 | 1,270 | 1,270 | 1,270 | 1,482 |
| Chandler | Non-Residential | 18,149 | 19,936 | 20,795 | 20,126 | 19,164 | 20,259 | 22,043 | 23,635 | 23,316 | 21,739 |
| Gilbert | Non-Residential | 6,503 | 8,354 | 8,030 | 9,244 | 9,679 | 9,995 | 11,585 | 11,585 | 11,585 | 11,929 |
| Glendale | Non-Residential | 10,595 | 11,521 | 12,351 | 11,311 | 11,013 | 10,797 | 12,965 | 12,965 | 12,965 | 12,135 |
| Goodyear | Non-Residential | 1,156 | 1,668 | 1,486 | 1,730 | 2,199 | 2,959 | 2,756 | 2,756 | 2,756 | 3,442 |
| Mesa | Non-Residential | 27,053 | 36,579 | 29,500 | 29,028 | 29,252 | 26,898 | 29,373 | 29,373 | 29,373 | 27,340 |
| Peoria | Non-Residential | 4,923 | 4,334 | 3,890 | 3,539 | 4,183 | 5,573 | 7,248 | 7,248 | 7,248 | 7,449 |
| Phoenix | Non-Residential | 102,683 | 102,182 | 105,805 | 100,008 | 101,098 | 106,018 | 109,194 | 109,194 | 109,194 | 102,979 |
| Scottsdale | Non-Residential | 18,730 | 20,071 | 18,740 | 16,140 | 25,392 | 21,305 | 23,725 | 23,725 | 23,725 | 21,274 |
| Tempe | Non-Residential | 27,656 | 26,117 | 24,887 | 25,396 | 25,343 | 23,811 | 24,393 | 24,392 | 24,392 | 22,761 |

**Table C.1. 2007 Payroll and Gross Revenue for PMA Municipalities Included in this Study**

| Economic Characteristics | Tempe | Scottsdale | Phoenix | Peoria | Chandler | Mesa | Goodyear | Glendale | Avondale | Gilbert | Buckeye | Apache Junction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Population | 172,589 | 233,105 | 1,536,632 | 152,795 | 242,522 | 459,742 | 53,654 | 249,455 | 78,043 | 204,904 | 37,678 | 32,901 |
| Payroll ($1000's) | 138,748 | 188,927 | 700,624 | 28,946 | 80,686 | 113,398 | 8,702 | 48,377 | 7,534 | 32,876 | 990 | 3,364 |
| Gross Revenue ($1000's) | 1,658,541 | 1,750,750 | 6,504,679 | 445,974 | 987,115 | 1,121,299 | 85,776 | 521,636 | 129,608 | 330,023 | 20,513 | 42,344 |

**Table C.2. 2007 Tax Data for PMA Municipalities Included in this Study**

| Taxes Collected | Tempe | Scottsdale | Phoenix | Peoria | Chandler | Mesa | Goodyear | Glendale | Avondale | Gilbert | Buckeye | Apache Junction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State Income Tax Paid ($1000's) | 4,440 | 6,046 | 22,420 | 926 | 2,582 | 3,629 | 278 | 1,548 | 241 | 1,052 | 32 | 108 |
| Primary Property Tax Paid ($1000's) | 10,371 | 21,166 | 103,664 | 3,002 | 8,506 | - | 4,172 | 3,888 | 1,796 | - | 2,839 | - |
| Secondary Property Tax Paid ($1000's) | 21,365 | 29,673 | 163,227 | 20,527 | 25,109 | - | 6,633 | 24,669 | 4,087 | 27,258 | 347 | - |
| State Sales Tax Paid ($1000's) | 109,463,701 | 115,549,495 | 429,308,843 | 29,434,280 | 65,149,612 | 74,005,744 | 5,661,210 | 34,427,999 | 8,554,147 | 21,781,503 | 1,353,845 | 2,794,705 |

**Table D.2. Income Data for Municipalities in the Phoenix Active Management Area (Sources: US Census Bureau and AZ Department of Revenue)**

| City | Population | HOUSEHOLD INCOME $ | Average FAGI $ | Per Capita FAGI $ | Average Tax Liability $ | Tax Liability Per Return $ | State Transaction & Priviledge Tax Distributed to Cities $ (2004) | State Sales Tax Per Capita $ | State Transaction and Priviledge Tax Distributed to Cities $ (2011) |
|---|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 32,901 | 46649 | 45569 | 23115 | 1039 | 804 | 2661210 | 81 | 2618154 |
| **Avondale** | 78,043 | 69069 | 45162 | 18332 | 952 | 769 | 3001578 | 38 | 5351475 |
| **Buckeye** | 37,678 | 71177 | 48216 | 18785 | 1010 | 816 | 710766 | 19 | 2112351 |
| **Chandler** | 242,522 | 86333 | 63336 | 29647 | 1670 | 1393 | 14770829 | 61 | 17695102 |
| **Gilbert** | 204,904 | 94151 | 67378 | 28504 | 1703 | 1418 | 9176047 | 45 | 13787266 |
| **Glendale** | 249,455 | 65769 | 48584 | 21643 | 1159 | 919 | 18303410 | 73 | 1843879 |
| **Goodyear** | 53,654 | 87264 | 62050 | 26471 | 1388 | 1157 | 1581887 | 29 | 3661678 |
| **Mesa** | 459,742 | 63739 | 47815 | 21871 | 1141 | 908 | 33254566 | 72 | 34220312 |
| **Peoria** | 152,795 | 78677 | 58290 | 26943 | 1372 | 1126 | 9064543 | 59 | 10673717 |
| **Phoenix** | 1,536,632 | 66661 | 50734 | 22341 | 1382 | 1077 | 110504126 | 72 | 112704366 |
| **Scottsdale** | 233,105 | 106485 | 103539 | 55155 | 3960 | 3100 | 16956076 | 73 | 17843974 |
| **Surprise** | 87,488 | 68704 | 49775 | 25436 | 1014 | 790 | 2580405 | 29 | 6946254 |
| **Tempe** | 172,589 | 66359 | 52168 | 28510 | 1401 | 1148 | 13268827 | 77 | 12656738 |
| **Tolleson** | 6,989 | 41342 | 39084 | 14834 | 807 | 643 | 416070 | 60 | 497422 |

Table D.3. Income Data for Municipalities in the Phoenix Active Management Area (Sources: US Census Bureau and AZ Department of Revenue)

| City | State Sales Tax Per Capita $ | Sales Tax per City Area $ | Sales Tax per GPCD $ | Sales Tax per Ac-Ft of Water $ | Distribution of Income Tax as Urban Revenue Sharing $ | Per Capita Urban Revenue Sharing $ | Urban Revenue Sharing per GPCD $ | Urban Revenue Sharing per City Area $ | Urban Revenue Sharing per Ac-Ft of Water $ |
|---|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 79.58 | 74826 | 10287 | 255.58 | 3316127 | 100.79 | 13030 | 94774 | 323.72 |
| **Avondale** | 68.57 | 117357 | 38703 | 441.58 | 6750611 | 86.50 | 48822 | 148040 | 557.03 |
| **Buckeye** | 56.06 | 5629 | 15440 | 364.87 | 2427836 | 64.44 | 17745 | 6470 | 419.36 |
| **Chandler** | 72.96 | 274726 | 108412 | 398.03 | 22468783 | 92.65 | 137659 | 348840 | 505.41 |
| **Gilbert** | 67.29 | 214055 | 71564 | 310.98 | 17280849 | 84.34 | 89697 | 268295 | 389.78 |
| **Glendale** | 7.39 | 30742 | 7448 | 26.58 | 23590446 | 94.57 | 95287 | 393305 | 340.12 |
| **Goodyear** | 68.25 | 19123 | 19754 | 327.83 | 4498039 | 83.83 | 24266 | 23491 | 402.71 |
| **Mesa** | 74.43 | 250790 | 167542 | 324.49 | 43614424 | 94.87 | 213536 | 319637 | 413.57 |
| **Peoria** | 69.86 | 61203 | 35609 | 207.51 | 13445840 | 88.00 | 44857 | 77098 | 261.40 |
| **Phoenix** | 73.35 | 218123 | 515447 | 298.68 | 143647008 | 93.48 | 656962 | 278009 | 380.68 |
| **Scottsdale** | 76.55 | 97020 | 42832 | 163.61 | 22849062 | 98.02 | 54846 | 124234 | 209.50 |
| **Surprise** | 79.40 | 65686 | 92569 | 942.12 | 8591077 | 98.20 | 114488 | 81239 | 1165.21 |
| **Tempe** | 73.33 | 316973 | 34153 | 176.20 | 16137384 | 93.50 | 43545 | 404142 | 224.66 |
| **Tolleson** | 71.17 | 86508 | 5107 | 650.69 | 632468 | 90.49 | 6494 | 109994 | 827.35 |

**Table D.4. Manufacturing Data for Municipalities in the Phoenix Active Management Area (Source: US Census Bureau)**

| City | Population | Manufacturers shipments, 2007 ($1000) | Merchant wholesaler sales, 2007 ($1000) | Retail sales, 2007 ($1000) | Retail Sales Per Capita (2007) $ | Accommodation and food services sales, 2007 ($1000) | Number of establish-ments | Sales ($1,000) |
|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 32,901 | NA | 24707 | 447477 | 13756 | 36282 | 17 | 24707 |
| **Avondale** | 78,043 | 0 | 73438 | 1601272 | 20243 | 94636 | NA | NA |
| **Buckeye** | 37,678 | NA | NA | 215169 | 5676 | 17210 | 9 | NA |
| **Chandler** | 242,522 | 3956031 | 4585919 | 3608290 | 14787 | 500934 | 220 | 4585919 |
| **Gilbert** | 204,904 | 415891 | 649322 | 2079066 | 10063 | 191244 | 147 | 649322 |
| **Glendale** | 249,455 | 912989 | 1013545 | 3627782 | 14457 | 340736 | 135 | 1013545 |
| **Goodyear** | 53,654 | 185496 | NA | 631710 | 11669 | 105052 | 17 | NA |
| **Mesa** | 459,742 | 3072462 | 2037336 | 6294523 | 13669 | 753178 | 301 | 2037336 |
| **Peoria** | 152,795 | 267830 | 251210 | 2340433 | 15135 | 258496 | 56 | 251210 |
| **Phoenix** | 1,536,632 | 16926892 | 23670515 | 21859505 | 14209 | 3644383 | 1946 | 23670515 |
| **Scottsdale** | 233,105 | 4806562 | 3445500 | 6645363 | 28447 | 1314297 | 538 | 3445500 |
| **Surprise** | 87,488 | NA | 20359 | 888224 | 9878 | 115082 | 23 | 20359 |
| **Tempe** | 172,589 | 5877588 | 7286114 | 6172475 | 35768 | 606835 | 511 | 7286114 |
| **Tolleson** | 6,989 | 2128242 | NA | 138737 | 19777 | 17065 | 22 | NA |

**Table D.5. Manufacturing Data for Municipalities in the Phoenix Active Management Area (Source: US Census Bureau)**

| City | Annual payroll ($1,000) | First-quarter payroll ($1,000) | Number of paid employees | Operating expenses ($1,000) | Total inventories, beginning of year ($1,000) | Total inventories, end of year ($1,000) | Sales, receipts, or revenue from administrative records (%) | Sales, receipts, or revenue estimated (%) | Sales Per Establish-ment ($1000) | Payroll Per Establish-ment ($1000) |
|---|---|---|---|---|---|---|---|---|---|---|
| Apache Junction | 1790 | 361 | 66 | 3834 | 3200 | 3582 | 14% | 0% | 1453 | 105 |
| Avondale | NA | NA | NA | NA | NA | NA | 0% | 0% | NA | NA |
| Buckeye | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Chandler | 291766 | 71408 | 4198 | 543461 | 204970 | 206196 | 1% | 3% | 20845 | 1326 |
| Gilbert | 59745 | 14564 | 1450 | 117011 | 49213 | 50744 | 7% | 13% | 4417 | 406 |
| Glendale | 70030 | 16869 | 2079 | 141645 | 127262 | 133548 | 17% | 5% | 7508 | 519 |
| Goodyear | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Mesa | 174055 | 35616 | 3372 | 290320 | 479762 | 476581 | 3% | 9% | 6769 | 578 |
| Peoria | 14834 | 4002 | 368 | 31285 | 16012 | 16168 | 6% | 4% | 4486 | 265 |
| Phoenix | 1650697 | 404324 | 34585 | 2989800 | 1655286 | 1669772 | 4% | 7% | 12164 | 848 |
| Scottsdale | 314307 | 75139 | 5811 | 664083 | 334508 | 361302 | 12% | 14% | 6404 | 584 |
| Surprise | 3461 | 862 | 97 | 5980 | 769 | 918 | 5% | 37% | 885 | 150 |
| Tempe | 722174 | 156112 | 11117 | 1201352 | 468771 | 499405 | 4% | 4% | 14259 | 1413 |
| Tolleson | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

Table D.6. Retail Data for Municipalities in the Phoenix Active Management Area (source: US Census Bureau)

| City | Population | Number of establishments | Sales ($1,000) | Annual payroll ($1,000) | First-quarter payroll ($1,000) | Number of paid employees for pay period including March 12 | Sales, receipts, or revenue from administrative records (%) | Sales, receipts, or revenue estimated (%) |
|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 32,901 | 96 | 447477 | 45386 | 12047 | 2181 | 6% | 8% |
| **Avondale** | 78,043 | NA | NA | NA | NA | NA | 0% | 0% |
| **Buckeye** | 37,678 | 48 | 215169 | 14158 | 2830 | 449 | 10% | 26% |
| **Chandler** | 242,522 | 694 | 3608290 | 353274 | 87134 | 15714 | 2% | 2% |
| **Gilbert** | 204,904 | 441 | 2079066 | 207222 | 48614 | 8466 | 2% | 4% |
| **Glendale** | 249,455 | 714 | 3627782 | 332276 | 83526 | 15566 | 3% | 2% |
| **Goodyear** | 53,654 | 109 | 631710 | 61449 | 16588 | 2955 | 2% | 4% |
| **Mesa** | 459,742 | 1,507 | 6294523 | 653862 | 164729 | 28855 | 6% | 6% |
| **Peoria** | 152,795 | 353 | 2340433 | 216892 | 53154 | 8143 | 5% | 2% |
| **Phoenix** | 1,536,632 | 4,266 | 21859505 | 1913730 | 470361 | 77534 | 7% | 5% |
| **Scottsdale** | 233,105 | 1,378 | 6645363 | 664928 | 163704 | 22923 | 4% | 5% |
| **Surprise** | 87,488 | 147 | 888224 | 85661 | 21606 | 4064 | 2% | 1% |
| **Tempe** | 172,589 | 847 | 6172475 | 447488 | 110713 | 16389 | 4% | 7% |

**Table D.7. Real Estate Data for Municipalities in the Phoenix Active Management Area (source: US Census Bureau)**

| City | Population | Number of establish-ments | Revenue ($1,000) | Annual payroll ($1,000) | First-quarter payroll ($1,000) | Number of paid employees | Sales, receipts, or revenue from administrative records (%) | Sales, receipts, or revenue estimated (%) |
|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 32,901 | 42 | 23469 | 3822 | 1024 | 123 | 12% | 11% |
| **Avondale** | 78,043 | NA | NA | NA | NA | NA | NA | NA |
| **Buckeye** | 37,678 | 15 | 46949 | 2305 | 637 | 58 | 2% | 0% |
| **Chandler** | 242,522 | 301 | 227950 | 37680 | 10260 | 1171 | 13% | 11% |
| **Gilbert** | 204,904 | 307 | 185181 | 34687 | 8767 | 1003 | 11% | 8% |
| **Glendale** | 249,455 | 250 | 202866 | 30910 | 7560 | 1208 | 11% | 16% |
| **Goodyear** | 53,654 | 61 | 33695 | 5577 | 1201 | 166 | 23% | 20% |
| **Mesa** | 459,742 | 594 | 524907 | 80140 | 20491 | 2834 | 15% | 13% |
| **Peoria** | 152,795 | 152 | 114499 | 25124 | 6266 | 710 | 11% | 12% |
| **Phoenix** | 1,536,632 | 2227 | 3261013 | 746350 | 185769 | 17353 | 11% | 12% |
| **Scottsdale** | 233,105 | 1102 | 1992041 | 335830 | 85047 | 5637 | 9% | 8% |
| **Surprise** | 87,488 | 55 | 48095 | 6761 | 1653 | 445 | 6% | 6% |
| **Tempe** | 172,589 | 451 | 768874 | 138486 | 32144 | 3423 | 9% | 9% |
| **Tolleson** | 6,989 | 3 | 1068 | 370 | 77 | 12 | 39% | 0% |

Table D.8. Information Services Data for Municipalities in the Phoenix Active Management Area (source: US Census Bureau)

| City | Population | Number of establishments | Receipts ($1,000) | Annual payroll ($1,000) | First-quarter payroll ($1,000) | Number of paid employees for pay period including March 12 | Sales, receipts, or revenue from administrative records (%)?? | Sales, receipts, or revenue estimated (%)?? |
|---|---|---|---|---|---|---|---|---|
| Apache Junction | 32,901 | 6 | N | 1996 | 492 | 50 | N | N |
| Avondale | 78,043 | NA | N | NA | NA | NA | N | N |
| Buckeye | 37,678 | 5 | N | 933 | 214 | 18 | N | N |
| Chandler | 242,522 | 77 | N | 104599 | 31878 | 2125 | N | N |
| Gilbert | 204,904 | 41 | N | 26622 | 6502 | 454 | N | N |
| Glendale | 249,455 | 40 | N | 22578 | 5956 | 520 | N | N |
| Goodyear | 53,654 | 8 | N | D | D | b | N | N |
| Mesa | 459,742 | 120 | N | 149666 | 39598 | 3006 | N | N |
| Peoria | 152,795 | 26 | N | 9088 | 2390 | 252 | N | N |
| Phoenix | 1,536,632 | 694 | N | 1347304 | 347914 | 21256 | N | N |
| Scottsdale | 233,105 | 249 | N | 541288 | 134269 | 6725 | N | N |
| Surprise | 87,488 | 7 | N | 1593 | 482 | 30 | N | N |
| Tempe | 172,589 | 162 | N | 209756 | 54879 | 4157 | N | N |
| Tolleson | 6,989 | 5 | N | D | D | a | N | N |

**Table D.9. Professional and Technical Services Data for Municipalities in the Phoenix Active Management Area (source: US Census Bureau)**

| City | Population | Number of establish-ments | Receipts/Revenue ($1,000) | Expenses ($1,000) | Annual payroll ($1,000) | First-quarter payroll ($1,000) | Number of paid employees for pay period including March 12 | Sales, receipts, or revenue from administrative records | Sales, receipts, or revenue estimated (%) | Annual Payroll Per Establish-ment $ |
|---|---|---|---|---|---|---|---|---|---|---|
| Apache Junction | 32901 | 30 | 9679 | N | 2722 | 687 | 122 | 30% | 21% | 91 |
| Avondale | 78043 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Buckeye | 37678 | 22 | 22110 | N | 7136 | 1884 | 149 | 2% | 12% | 324 |
| Chandler | 242522 | 610 | 373941 | N | 490947 | 126119 | 7138 | 37% | 18% | 805 |
| Gilbert | 204904 | 463 | 412515 | N | 152162 | 34923 | 3538 | 16% | 6% | 329 |
| Glendale | 249455 | 303 | NA | N | NA | NA | NA | NA | NA | NA |
| Goodyear | 53654 | 67 | 36598 | N | 15146 | 3501 | 355 | 16% | 18% | 226 |
| Mesa | 459742 | 1084 | 709255 | N | 302360 | 69800 | 7120 | 26% | 14% | 279 |
| Peoria | 152795 | 219 | 79141 | N | 27921 | 6860 | 702 | 33% | 8% | 127 |
| Phoenix | 1536632 | 5055 | 7158437 | N | 2947465 | 671593 | 46810 | 15% | 7% | 583 |
| Scottsdale | 233105 | 1972 | 3573147 | N | 1158253 | 272299 | 17313 | 15% | 6% | 587 |
| Surprise | 87488 | 83 | 27484 | N | 11120 | 3024 | 437 | 20% | 22% | 134 |
| Tempe | 172589 | 1005 | 1321432 | N | 606044 | 152654 | 10930 | 15% | 8% | 603 |
| Tolleson | 6989 | 2 | NA | N | NA | NA | NA | NA | NA | NA |

**Data Availability**

The data used in this study is publicly sourced and reproduced in the paper's appendices.

**Author Contributions**

BR designed the study and led the writing. RR carried out data collection and calculations and helped with the writing. DH edited and rewrote the manuscript, including preparation of the results.

**Competing interests**

The authors declare that they have no conflict of interest. BR and RR disclose that they were paid consultants to the City of Chandler, Arizona in 2012.

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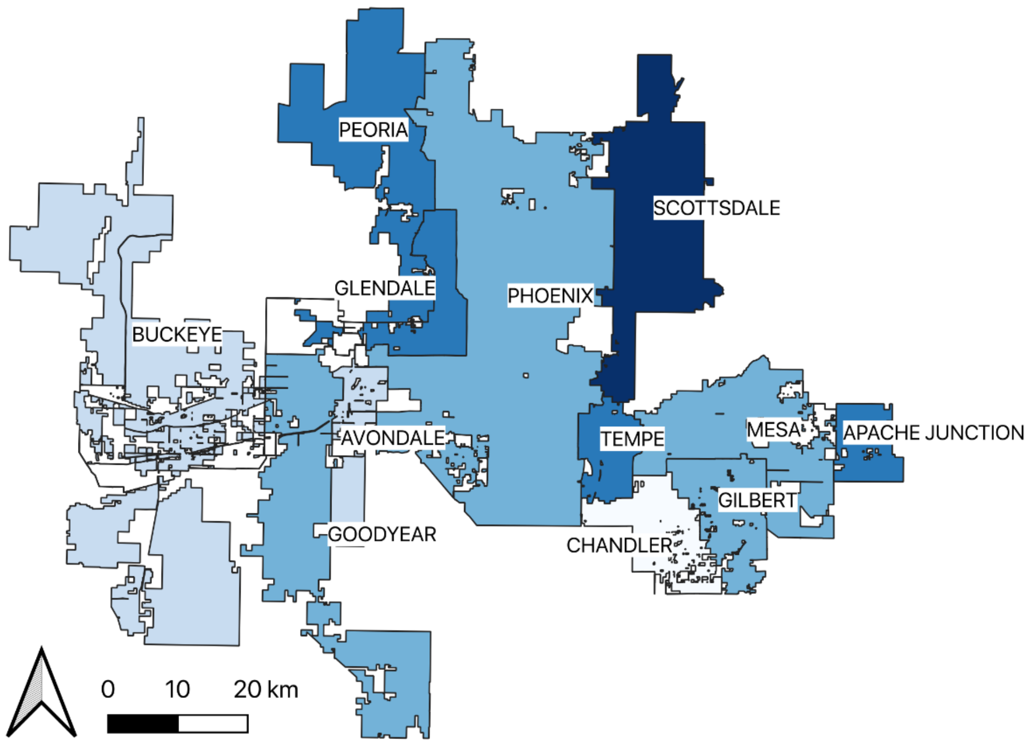


**Figure 1. Map of the Phoenix metropolitan statistical area (PMA) showing the member municipalities.**

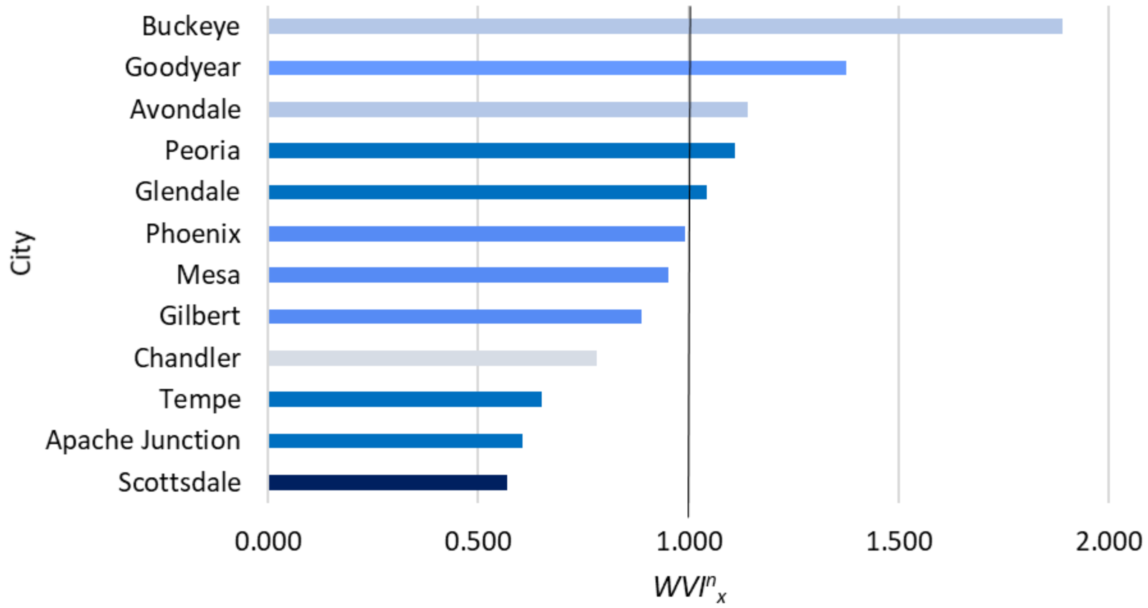


**Figure 2. PMA municipalities x listed in order of their relative $WVI^n_x$ for residential population supported. The PMA's mean value is 1. Outlying bedroom communities like Buckeye, Goodyear, and Avondale score above average on the traditional per-capita basis of water use benchmarking (cities are color-coded to correspond with Figure 1).**

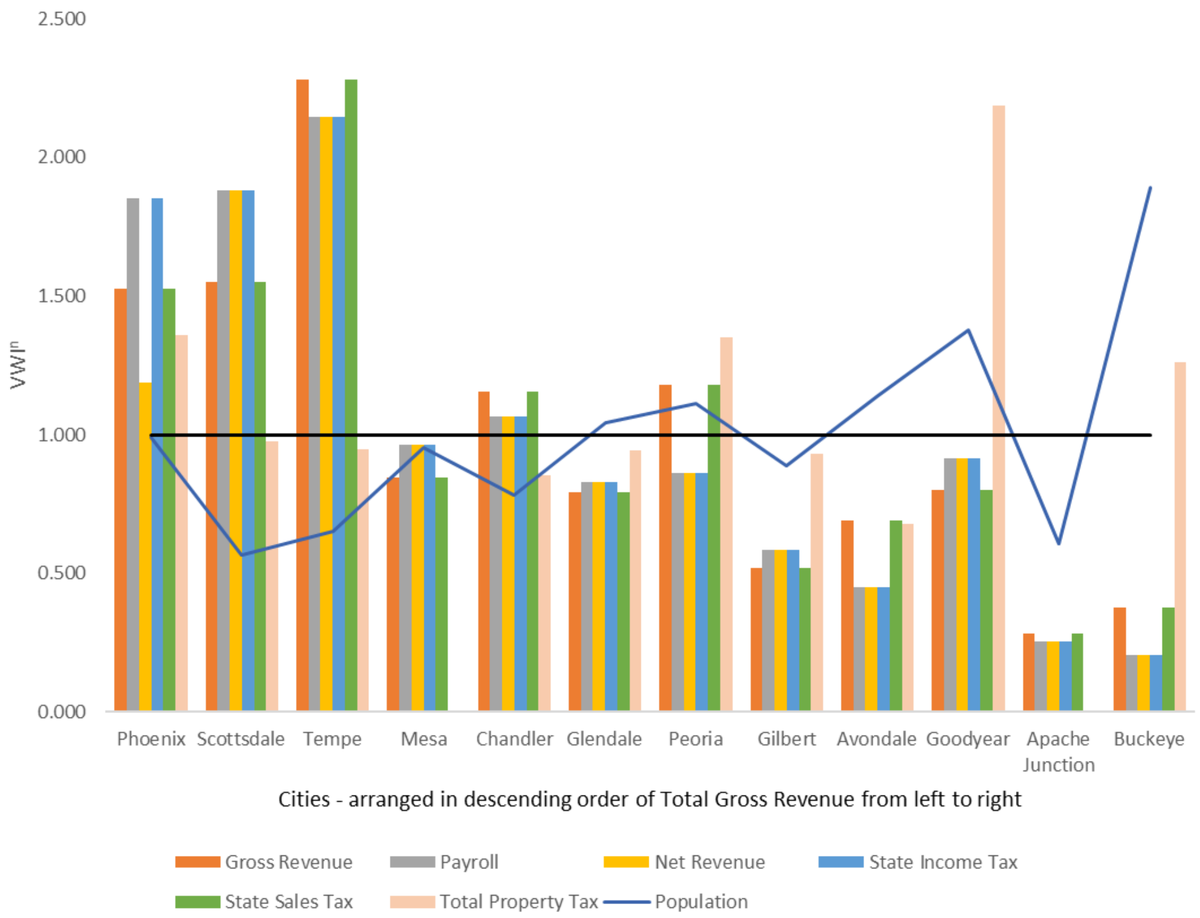


**Figure 3. *$WVI^n$* for economic value types (colored bars) and population value type (blue line) for each PMA municipality. The PMA's mean value is 1 (black). Municipalities are arranged in order of decreasing tax revenues from left to right. This ranking also corresponds approximately with geographic distance from the overall urban center of Phoenix, and to size of population and economic GDP. Core municipalities like Tempe, Scottsdale, and Phoenix score above average on an economic basis of water use benchmarking, but below average on a population basis of population supported, demonstrating some degree of tradeoff between these productivity objectives.**

**Table 1. General Characteristics of Cities in the Phoenix Metropolitan Statistical Area (*no reclaimed water)**

| City | Population | Area ($km^2$) | Density (pop $km^{-2}$) | Payroll ($x1000) | Gross Revenue ($x1000) | Total Property Tax ($x1000) | Income Tax ($x1000) | Sales Tax ($x1000) | Total Water Use* (ac-ft) | Acre Feet Per $Km^2$ of City | Acre Feet Per Person Per $Km^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Apache Junction** | 32,901 | 91 | 362 | 3,364 | 42,344 | NA | 108 | 2,795 | 10,244 | 759 | 28 |
| **Avondale** | 78,043 | 119 | 656 | 7,534 | 129,608 | 5,883 | 241 | 8,554 | 12,119 | 689 | 18 |
| **Buckeye** | 37,678 | 971 | 39 | 990 | 20,512 | 3,186 | 32 | 1,354 | 4,989 | 34 | 129 |
| **Chandler** | 242,522 | 166 | 1460 | 80,685 | 987,115 | 33,616 | 2,582 | 64,150 | 23,501 | 945 | 16 |
| **Gilbert** | 204,904 | 166 | 1234 | 32,876 | 330,022 | 22,258 | 1,052 | 21,782 | 44,335 | 1,782 | 36 |
| **Glendale** | 249,455 | 155 | 1609 | 48.376 | 521,636 | 28,557 | 1,548 | 34,428 | 69,359 | 2,994 | 44 |
| **Goodyear** | 53,654 | 495 | 108 | 8,702 | 85,775 | 10,805 | 278 | 5,661 | 11,169 | 150 | 104 |
| **Mesa** | 459,742 | 352 | 1306 | 133,398 | 1,121,299 | NA | 3,628 | 74,006 | 105,459 | 2002 | 80 |
| **Peoria** | 152,795 | 451 | 339 | 28,945 | 445,973 | 23,529 | 926 | 29,434 | 51,437 | 764 | 153 |
| **Phoenix** | 1,536,632 | 1339 | 1148 | 700,624 | 6,504,679 | 266,891 | 22,420 | 429,809 | 377,341 | 1,891 | 329 |
| **Scottsdale** | 233,105 | 477 | 489 | 188,927 | 1,750,749 | 50,838 | 6,046 | 115,549 | 109,065 | 1,536 | 223 |
| **Tempe** | 172,589 | 104 | 1660 | 138,748 | 1,658,540 | 31,736 | 4,439 | 109,463 | 70,907 | 4,600 | 41 |