

# A global meta-analysis on the monetary valuation of dryland ecosystem services: The role of socio-economic, environmental and methodological indicators



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## ABSTRACT

Monetary valuation of dryland ecosystem services may help to increase the salience of drylands in decision making. Yet, there is no comprehensive assessment of the indicators that determine the estimated monetary values for dryland ecosystem services (hereafter: dryland value). Having compiled a database consisting of 559 observations from 66 valuation studies in drylands worldwide, this study analyzes the relative importance of local socio-economic, environmental and methodological indicators in explaining the monetary value estimates for nine dryland ecosystem services by means of a multiple regression analysis. By explicitly quantifying the effect sizes of the indicators of dryland value, we shed new light on the driving forces behind monetary valuation of dryland ecosystem services. Our results show that local socio-economic and environmental conditions are marginal in explaining dryland value, indicating that local dryland conditions are not sufficiently captured with current valuation approaches. Simultaneously, we find that methodological factors, including valuation method and study extent, heavily influence dryland value, suggesting that monetary valuation outcomes are largely determined by the selected methodology. This emphasizes the need to improve monetary valuation methods so that they better capture local dryland conditions in order to be able to serve as a meaningful tool for decision making.

## 1. Introduction

Covering about one third of the global land surface, drylands are a critical biome for about one third of the global human population (Fig. 1; Bastin et al., 2017; MA, 2005; Reynolds et al., 2007), who depend on an extensive set of ecosystem services for their wellbeing and livelihood (Boafo et al., 2016; Favretto et al., 2016; MA, 2005). However, because drylands – that are defined by a 0.05–0.65 degree of aridity (Leemans and Kleidon, 2002; UNCCD, 1994) – are typically located in the least developed regions of the world, they have thus far received little attention in public opinion and environmental policy and decision making (Reynolds et al., 2007; Thomas et al., 2012). In recent years, it has been proposed that the estimation of monetary values for

ecosystem services may be a tool to increase the salience of such services in decision making processes (Daily et al., 2009; Fisher et al., 2008). With regard to drylands, such information may, for example, be useful to recently launched initiatives, such as the Land Degradation Neutrality concept adopted by the UNCCD (Orr et al., 2017), the Economics of Land Degradation initiative (ELD, 2015) and the IPBES assessment on land degradation and restoration (IPBES, 2017; Ogennoorth and Faith, 2013). Monetary valuation may, for instance, help to better account for the costs of land degradation and the benefits of sustainable land management in decision making (Quillérou and Thomas, 2012; Turner et al., 2016).

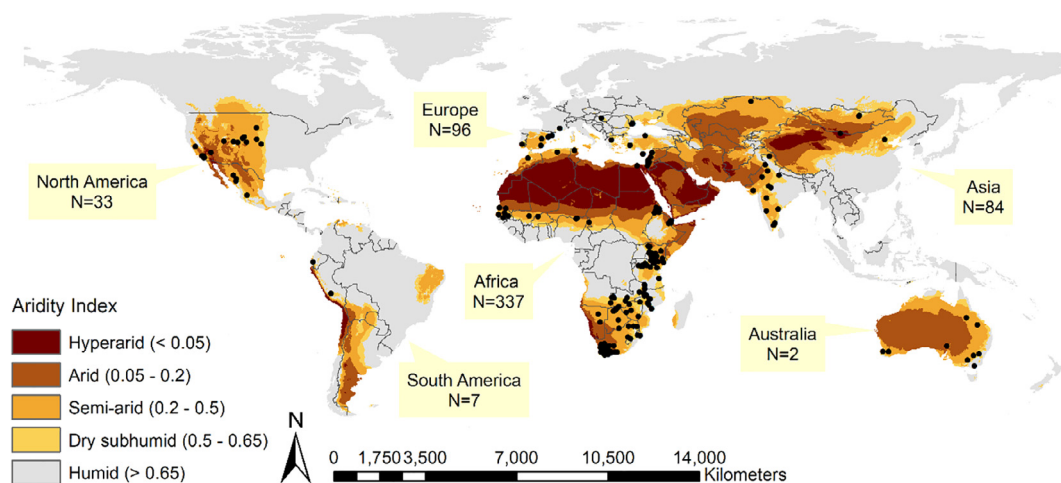
Yet, although monetary valuation of ecosystem services aims to estimate the societal benefits of ecosystem services that accrue to their

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**Fig. 1.** Global map of aridity, indicating arid, semi-arid and dry subhumid land zones (derived from FAO, 2009), which shows the geographical locations of the dryland study sites ( $N = 204$ ) where observations are located that have been summarized in the database of this study ( $N = 559$ ). The number of observations per continent is indicated. The map has a spatial resolution of 10 arc minutes and temporal coverage of 1961–1990.

beneficiaries (Bateman et al., 2011; Daily et al., 2009; Heal, 2000) and is the most widely used method for ecosystem services valuation up to date (de Groot et al., 2012; Liu et al., 2010), the approach is also widely criticized. Several studies, for instance, suggest that monetary valuation may have difficulty to capture ecosystem dynamics (Farley, 2012; Polasky and Segerson, 2009) and that the researchers' selection of the study scope and methodology have a large influence on the valuation outcome (Martín-López et al., 2014; Schild et al., 2017; Spangenberg and Settele, 2010). For instance, while meta-analyses in other biomes find varying support for the role of socio-economic conditions, they all find evidence of the importance of methodological factors (Brander et al., 2006; De Salvo and Signorello, 2015; Enjolras and Boisson, 2008; Ghermandi et al., 2010; Quintas-Soriano et al., 2016; Salem and Mercer, 2012; Woodward and Wui, 2001). If methodological factors are more important than local conditions with regard to ecosystem properties and socio-economic conditions of beneficiary populations, this suggests that monetary valuation of ecosystem services does not (yet) deliver on its promise.

Despite the critiques, the number of monetary valuation studies has been growing rapidly in the last decades (Liu et al., 2010). This also holds for drylands, although only a few studies explicitly mention that they focus on dryland valuation (Barrow and Mogaka, 2007; Birch et al., 2010; Hein, 2007; O'Farrell et al., 2011). The growing attention for monetary valuation increases the relevance of testing whether such valuation studies do actually capture socio-economic and environmental factors, as they are supposed to do. Drylands are a good case to test this, because their inhabitants are particularly vulnerable to environmental degradation and the associated loss of ecosystem services needed for subsistence (Cowie et al., 2011; Stafford Smith et al., 2009; Verstraete et al., 2009), which should ideally be reflected in the estimated value. As it is difficult to generalize from individual valuation studies alone, amongst others because of their limited geographical focus, the best way to analyze whether the critiques hold is by conducting a meta-analysis, which allows to assess general trends and patterns (Nelson and Kennedy, 2008). To our best knowledge, such a meta-analysis focused on the monetary valuation of dryland ecosystem services has not been carried out so far.

In order to address this research gap, we have identified and compiled valuation studies that estimated the monetary value of ecosystem services in drylands (hereafter: dryland value), resulting in a comprehensive database of dryland value observations. In order to analyze which indicators determine dryland value, we complemented the database with indicators for local socio-economic, environmental and methodological conditions. We hypothesized that local socio-economic

conditions would be relevant, as the welfare of ecosystem service beneficiaries is predominant in determining their values, which may particularly apply for drylands due to the marginalized status of their inhabitants. We also hypothesized that local environmental conditions explain a substantial proportion of the variance in dryland value, because the supply of ecosystem services depends on underlying ecosystem functioning (de Groot et al., 2002), which may be particularly vulnerable to critical degradation thresholds in case of drylands (Verstraete et al., 2009). Lastly, we hypothesized that differentiation in estimate monetary values exists among dryland ecosystem services and dryland ecosystem types, as the dryland biome encompasses a wide range of ecosystems, each having their own distinctive processes and functions.

This meta-analysis contributes to literature on monetary valuation of ecosystem services in three different ways. First, our study is the first that comprehensively analyzes for drylands what indicators determine the estimated monetary values of ecosystem services. Second, while previous studies in other biomes focused mainly on socio-economic and methodological predictors of ecosystem service value estimates and often did not directly address environmental factors (Brander et al., 2006; Ghermandi et al., 2010; Johnston et al., 2005), we include an extensive set of (dryland relevant) environmental indicators in order to investigate to what extent they determine the monetary value estimates for dryland ecosystem services. Third, compared to previous studies in other biomes, this study is the first to explicitly quantify the relative importance (i.e. effect size) of various indicators in determining monetary value estimates for ecosystem services. In addition to these contributions to the literature, our empirical analysis of the drivers of monetary valuation of dryland ecosystem services may also have implications for the meaningfulness of their use in policy making, especially with regard to recent initiatives.

## 2. Methods

### 2.1. Compilation of the dryland value database

To compile a database with observations on dryland value, monetary valuation studies of ecosystem services that were located in drylands were collected using two different approaches: (1) valuation studies that were located in drylands were identified from the TEEB database (van der Ploeg and de Groot, 2010), and (2) valuation studies were collected from a literature search in grey and peer-reviewed literature. For valuation studies that were identified from the TEEB database, all original valuation studies were retrieved. As the number of

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