Chapter 7
Experts' Opinions on the Use of NDVI for Land Degradation Assessment

Methodological issues were raised by Wessels (2009) regarding the GLADA assessment, chiefly the interpretation of RUE outside arid and semiarid regions, growing season differences between the northern and southern hemisphere and their implications for calendar year summations of NPP, and issues of scale in the interpretation of AVHRR NDVI vs. MODIS NPP relationships. He also maintained that the RESTREND technique provided a more dependable alternative. In response, Dent et al. (2009) clarified that RUE was not being used as an indicator of land condition but simply to separate NDVI trends caused by drought in those areas where biomass potential is directly related to rainfall, essentially drylands. Regarding seasonal differences in growing season between the northern and southern hemispheres, there was no difference in the long-term trends when the hydrological year was used for the southern hemisphere. And, finally, the RESTREND approach was also applied to the GLADA data and showed no significant difference with the RUE-adjusted NDVI approach; the choice of the RUE-adjusted NDVI was made on account of its simplicity and amenability to economic evaluation (Dent et al. 2009).

7.1 NDVI: Rainfall Proportionality, an Important Consideration

Methodological weaknesses that might seem to question the applications of RUE in the Bai et al. (2008) study (as with many studies in this area) have to do with the lack of consideration given to the effect of lack of proportionality in the use and interpretation of RUE (computed from NDVI-derived NPP) as a proxy for identifying areas of land degradation. The theoretical basis for RUE assumes proportionality between NPP (as indicated by NDVI) and rainfall (Le Houerou 1984), meaning that a fixed ratio (RUE) exists despite changes in rainfall over time. NDVI and rainfall should intercept at zero to meet this assumption of proportionality with changes in the

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rainfall (Dardel et al. 2014; Fensholt and Rasmussen 2011; Verón et al. 2005). The theoretical assumption of proportionality is important in understanding the functioning of the relationship between these two variables (rainfall and NDVI). Recent studies have shed light on the importance of considering proportionality in the use of RUE derived from relationship between NPP (derived from NDVI) and rainfall (Dardel et al. 2014; Fensholt and Rasmussen 2011). The practical application of the relationship between NDVI and rainfall does not lead to generally robust results characterized by proportionality between variables. One of the main reasons for this lack of robustness is that NDVI is never zero—NDVI is always slightly positive, even on bare soils (Verón et al. 2005; Fensholt and Rasmussen 2011). The assumption of a linear relationship between NDVI and rainfall will also not to be applicable in cases where vegetation growth requires a certain threshold of rainfall (Dardel et al. 2014), which is the case in many areas of the tropical savannah with a distinct rainy and dry season. The result in both cases (either on bare soils or in places where a threshold of rainfall is required for vegetation growth to be triggered) is that a linear relation between NDVI and rainfall might exist but no proportionality. This means that RUE is in fact not able to normalize vegetation productivity for varying rainfall and consequently RUE calculated in this case is sensitive to changes in rainfall over both space (since it will artificially trend to infinity values (Dardel et al. 2014)) and time (Fensholt and Rasmussen 2011; Fensholt et al. 2013). The result of the RUE dependency on rainfall in a time-series analysis will be that "*significant trends will emerge if rainfall undergoes temporal changes within this range of values*" (Dardel et al. 2014; Fensholt and Rasmussen 2011; Fensholt et al. 2013). If overlooking this fundamental inefficiency of RUE to normalize for rainfall changes in the case where proportionality between variables is absent, the direct use of RUE for trend analysis (or indirect use when masking out pixels due to a certain trend in RUE) may lead to misleading interpretations. So as not to include cases with such artificial trends simply reflecting a change in the rainfall regime rather than land degradation, Fensholt and Rasmussen (2011) restricted their analysis of trends in Sahelian rain-use efficiency to using only cases: (1) where no per-pixel temporal correlation between annual RUE and rainfall was found; and (2) where estimates of growing season ΣNDVI and annual rainfall correlation were statistically significant ($p < 0.05$).

7.2 Building on the GLADA Assessment

Recent studies have used different approaches to assess land degradation at different scales, some using the GLADA methodology at different scales. Bajocco et al. (2012) summed NDVI values on a pixel basis recorded for each year between 2000 and 2002 and computed the mean annual ΣNDVI as a surrogate for the total annual biomass production of the Mediterranean region. Le et al. (2014) used the long-term trend of interannual mean NDVI over the period 1982–2006 to delineate land degradation hotspots but cautioned that the use of proxies is subject to uncertainties which need to be understood and addressed. De Jong et al. (2011a) made use of the

GIMMS NDVI data to analyze global greening and browning, using three approaches: a linear model corrected for seasonality, a seasonal nonparametric model, and analyzing the time series according to vegetation development stages rather than calendar days. The trends found using the linear model approach corrected for seasonality were very close to those identified by Bai et al. (2008) applying a linear model to yearly mean values, but there was a substantial difference in results from the different models—a cautionary reminder of the importance of putting results within the context of the methods applied and of providing adequate metadata to aid interpretation and understanding of the results. de Jong et al. (2011a, b, c) also used the Harmonic Analysis of NDVI Time Series (HANTS) algorithm to remove residual cloud effects by applying Fourier analysis, complemented by detection of outliers that were replaced by a filtered value. Comparison of global NDVI trends using the HANTS-reconstructed data with the original GIMMS data shows no measurable difference—so GLADA is unaffected by cloud cover. Chinese researchers have made use of the GIMMS database and the GLADA methodology for several countrywide studies. In the process, some new indices were developed, such as the sensitivity index—the degree of reaction of NDVI to rainfall change in specific rainfall regions (see Annexes 3 and 4).

Nkonya et al. (2011) used the first difference econometric approach in studying the global extent of land degradation and its human dimensions. NDVI trends were used to represent land degradation or improvement, and the NDVI-derived global land cover change was overlain with poverty distribution to better understand the connection between land degradation and poverty. The study found consistencies with Bai et al. (2008) in the relationship between severe poverty and decrease in the NDVI in some but not all parts of Africa. In a rigorous analysis of greenness in semiarid areas, worldwide, using AVHRR GIMMS data from 1981 to 2007, Fensholt et al. (2012) found that semiarid areas are, on average, greening, but similar increases in greenness over the study period may have broadly different explanations and cautioned against general assertions of ongoing land degradation in semiarid regions.