Methods

Figure 1

The base map geopackage was downloaded from the GADM v3.6 map database (gadm.org/download_world.html). The latest (1st April 2020) shapefile for global marine protected areas was obtained from protectedplanet.net/marine. The plotted seagrass distribution polygons are based on the latest model of global seagrass distribution (Jayathilake and Costello, 2018). Recent (2017–2020) satellite image screengrabs were taken with Google Earth Pro v7.3.3.7673. Vector data were compiled and plotted using the Mercator map projection (EPSG:3395 WGS 84 / World Mercator) in QGIS v3.8.3 (qgis.org). Pixel data were edited and added in Affinity Designer v1.7.3 (Serif Ltd, serif.com).

Figure 2

In order to perform a comprehensive combinatorial meta-analysis on the effect of seagrass loss on ecosystem services, means, sample sizes (*n*) and standard errors (SE) were extracted from 26 relevant papers (see data files and references). Although studies on seagrass restoration also show clear effects on ecosystem services (Duarte et al., 2013b; Bourque and Fourqurean, 2014; Marbà et al., 2015; McSkimming et al., 2016; Reynolds et al., 2016), these papers were not included. When these descriptive statistics were not explicitly stated, they were extracted from screenshots of plots with Plot Digitizer v2.6.8 (plotdigitizer.sourceforge.net).

Effect sizes with SE and 95% confidence intervals (CI) for each study were then calculated in R (R Core Team, 2019) within the integrated development environment RStudio (RStudio Team, 2019) using the function esc_mean_se of the package esc v0.5.1 (Lüdecke, 2019). The combinatorial meta-analysis, i.e. calculation of overall effect sizes and CI, was performed with the function metagen in meta v4.11-0 (Balduzzi et al., 2019). The forest plot was visualised with the R packages ggplot2 v3.3.0 (Wickham, 2016) and forcats v0.4.0 (Wickham, 2019).

Figure 3

Economic data on private and public profits and costs (see data files) were obtained as outlined below and plotted with ggplot2 v3.3.0 in R. The annual private profits of the tourism and fisheries sectors of Mauritius amount to US $ 913,949,575.5 and US $ 102,472,831, respectively (Statistics Mauritius, 2018). The scuba diving industry on Mauritius has a revenue of US $ 6,314,560.7 yr^{-1} (Vogt, 2001). Because this sum is likely included in the yearly tourist receipts, it was subtracted from tourist revenue, which was therefore estimated to be US $ 907,635,014.8 yr^{-1} excluding scuba diving.

In order to calculate public costs and profits per area of seagrass meadow, 45.5 km^2 (Turner and Klaus, 2005) was used as the total area of Mauritius' seagrass ecosystem. Public costs were calculated on a total ecosystem loss basis. The total cost of seagrass restoration, US $ 383,672 ha^{-1} (Bayraktarov et al., 2016), multiplied by that area equates to US $ 1,745,707,600. The social cost of carbon dioxide (CO_2) that is emitted via seagrass degradation was calculated using the emission estimate of 33333.33 t CO_2 km^{-2} (Pendleton et al., 2012), the social cost of carbon for 2020 of US $ 35.94 per tonne of CO_2 (Nordhaus, 2017) and Mauritius' seagrass area. This yields a value of US $ 54,505,202.27.

Public profits were calculated on an annual ecosystem service basis. Carbon (C) sequestration per unit area was calculated by dividing global sequestration rate of seagrass C, 0.104 Gt C yr^{-1} (Duarte and Krause-Jensen, 2017), by the estimated global extent of seagrass, 600,000 km^2 (Duarte et al., 2013a). The resulting value of 173.33 t C km^{-2} yr^{-1} was then multiplied by the area of Mauritius' seagrass, the conversion factor from mass of C to CO_2 (3.664) (Friedlingstein et al., 2019) and the social cost of CO_2, resulting in a carbon sequestration value of US $ 1,038,516.74 yr^{-1}. This figure likely underestimates the true climate change mitigation value of seagrasses, which are able to counteract ocean acidification (Hendriks et al., 2014) and hypoxia (Giomi et al., 2019) besides sequestering C. Therefore, an alternative calculation was undertaken, where the profit of seagrass climate regulation, US $ 479 ha^{-1} yr^{-1} (Costanza et al., 2014), was multiplied by the area of seagrass. The somewhat less result of US $ 2,179,450 yr^{-1} was used in the final plot. Seagrass nutrient cycling and erosion control values of US $ 26,233 ha^{-1} yr^{-1} and US $ 25,368 ha^{-1} yr^{-1} (Costanza et al., 2014) were multiplied by the seagrass area to arrive at the final estimates of US $ 119,314,650 yr^{-1} and US $ 115,424,400 yr^{-1}, respectively. An alternative calculation of the erosion control ecosystem service involves multiplying the length of Mauritius' coastline, 258 km^2 (Turner and Klaus, 2005), by the average cost of tropical breakwater construction, US $ 34,315 m^{-1} (Ferrario et al., 2014). This equates to US $ 8,853,270,000 but is not as useful as the annual estimate of US $ 115,424,400.