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Urban and tourist land use patterns and water consumption: Evidence from Mallorca, Balearic Islands

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ABSTRACT

The island of Mallorca is the main Balearic resort and sustainable water management is a key challenge for the economic and ecological sustainability of tourism as the main economic activity. The critical water supply situation on the island is being exacerbated by the extension of the tourist base to so-called "quality tourism". Since the mid 1990s, low-density residential tourist land uses associated with second homes and more affluent urban dwellers have spread around existing mass tourist urban centres. Increasing water consumption for outdoor uses (gardens, swimming pools) is a direct consequence of this development. Available water consumption data mask the impact of residential tourism on water consumption levels. The objective of the present paper is to compare per capita water consumption in quality tourist, mass tourist and residential urban areas, and to provide quantitative information on the magnitude of water consumption by gardens and swimming pools as water-related leisure structures. The analysis combines water consumption data with a land use geodatabase at the sub-parcel scale, a detailed population inventory, and an estimate of pool water use. The results show that quality tourism produces higher water consumption levels per capita than mass tourism. Garden irrigation is the single main cause of the high water consumption in quality tourist areas and accounts for more than 70% of these areas' total consumption in summer. But even in mass tourist and residential areas, garden irrigation accounts for up to 30% and 20%, respectively, of total water consumption in summer. Individually owned swimming pools cause an additional average water consumption of 22 litres/person/day. The proliferation of swimming pools and lavish 'Atlantic' gardens may turn out as one of the biggest threats to sustainable water management on the island of Mallorca and in other tourist destinations adapting the quality tourist model.

Introduction

At a time when the already critical water supply situation in the Mediterranean is expected to be exacerbated by climate change, mature tourist resorts are extending their tourist base to activities that increase permanent water demand for facilities and leisure structures (golf courses, spas, aquatic parks, swimming pools and irrigated gardens). This is the context and debate to which the present paper contributes a timely case study that highlights the contribution of residential tourism to the increasing water demand in the residential domestic sector. The case study is best put into perspective by reviewing some of the major challenges posed by climate change with respect to the water and tourism issue and by reviewing the developments that have rejuvenated the tourist industry in many Mediterranean resorts in the last two decades. While land use patterns that increase permanent demand for water are spreading, the necessity for more efficient water demand management becomes obvious. This is one of the major challenges posed to land use policy in the immediate future in Mediterranean tourist resorts and urban areas where more disperse settlement patterns evolve.

As a vibrant sector of economic growth in the Mediterranean, tourism becomes a priority issue with regard to sustainable development and climate change mitigation and adaptation. A general concern in the Mediterranean is water availability, and increasing water shortages as a consequence of climate change are expected (Hein et al., 2009; Iglesias et al., 2007; Scott and Becken, 2010). Tourism is one of the development pressures that coincide with the necessity to manage decreasing water resources more efficiently. Many resorts will have to cope with increasing water demand and tourist flows, rising temperatures, and more droughts. The water

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reservoirs are already under pressure and water supply increasingly relies on desalination and reuse of treated water. These developments turn water management into a major challenge for Mediterranean countries and the tourism sector (European Commission, 2009; Hein et al., 2009; Iglesias et al., 2007). Spain in particular is experiencing a tourist and second home boom that increases permanent water demand for facilities and leisure structures, thus the country's tourism sector is increasing its vulnerability to climate change. Paradoxically, this diversification and upgrading of the tourist product and the promotion of off-season tourism are identified as climate change adaptation strategy for the tourism industry (Hein et al., 2009; Iglesias et al., 2007). In economic terms, quality tourism is seen as a strategy for further sustainable growth of "sun and beach" destinations reaching life-cycle maturity (Bardolet and Sheldon, 2008). This discussion shows that at a time when the challenges posed by climate change for the Mediterranean tourism sector are becoming obvious, there are information and knowledge gaps with regard to the impact of tourism on water resources. Water consumption by the tourism sector is not well documented by statistics at present. More complete information on water demand of tourism and its different sub-sectors (second homes, facilities, activities, etc.) is needed by state and local authorities to define priorities for water conservation or demand management programmes. Also, tourism business will benefit from such information in terms of cost savings or risk reduction (European Commission, 2009; Scott and Becken, 2010).

The following discussion focuses on the Balearic island of Mallorca in Spain because this island is presently beginning to experience the problems that many Mediterranean resorts probably will have to face in the near future. Mallorca amply illustrates the transformation of the economy, society, and environment of Mediterranean tourist resorts, including the recent upgrading and diversification of the tourist product observed elsewhere in the western part of the Mediterranean. Moreover, the island exemplifies the need for holistic land use policy and water demand management in the face of the challenges to the supply of water resources for the continued viability of the tourism industry (Essex et al., 2004; Kent et al., 2002).

With a record of attracting more than 4 million tourists annually since 1986, Mallorca is the main Balearic resort and one of the most successful tourist destinations in the Mediterranean. Tourist numbers doubled in the mid 1990s and stabilised at more than 8.4 million visitors annually since 2004 (CITTIB, 2009). The annual average growth rate of 6.7% in tourist numbers between 1960 and 2009 mirrors this development. The major coastal mass tourist resorts on Mallorca were built up in the sixties, during the first international tourist boom, and experienced major demographic and economic growth. These resorts saw twenty years of irrational expansion, based on unbridled construction to the detriment of the seaside, water and other natural resources. A tourism crisis affected the whole Balearic Islands in the late 1980s. Economic developments in the origin countries coincided with rising relative costs of tourist activities and lodging capacity grew faster than tourist demand. In Mallorca, the visitor volume growth rate dropped from 8.3% (1981–1987) to 2% (1988–1992). However, the loss of tourist attractiveness, a drop in tourist consumption, and in the long run a fall in investment was considered to be more severe. The diversification of promotion and provision of high-quality services came into focus. Mallorca was first to embark on the development of a new tourism model that ultimately gave the main Balearic tourism regulations of today the common baselines of "quality of life" through territorial planning and "tourism sustainability" through the provision of appropriate services for demanding customers (Bardolet and Sheldon, 2008; Schmitt, 2007). Since the mid 1990s, the extension of Mallorca's tourist base by the proliferation of second homes, golf courses, and yacht tourism has been marketed under the term "quality tourism". The key drivers for this innovation and the turn from a pioneer of mass tourism to a pioneer of a more diversified tourism model were decrees, policies and programmes that were initiated and implemented by the stakeholders in the Balearic tourism industry. The relevant policies started in the 1990s with planning and zoning and landscape protection, and moved toward controls of further land and coastal development in the 2000s (see Bardolet and Sheldon, 2008, for a detailed chronological overview on tourism land use policies in the Balearics). On the island of Mallorca, the 1991 "Moratorium Law", the 1995 "Regulatory Plan on Tourism Supply" (POOT) and the "New Tourism Law" in 1998 were landmark policy decisions of the Autonomous Community of the Balearic Islands. The 1995 "Quality Plan" was the first global plan to focus strategies and actions on higher quality tourism markets and products. Some authors interpreted this development as a move toward a more sustainable, "quality" type of tourism (Bardolet and Sheldon, 2008), while others highlighted the added environmental strains caused by this new tourist boom (Schmitt and Blàzquez, 2003). The quality tourist model creates additional demands on water supply and quality, thereby exacerbating the island's critical water supply situation. In particular, the growing water consumption in the domestic residential sector has been identified as a critical stressor on the island's scarcest resource. The domestic residential sector has grown as Mallorcan urban residents have become more affluent from the tourist boom and as Mallorca has attracted residential tourists who have built second homes, often with high housing standards (Essex et al., 2004; Kent et al., 2002; Schmitt, 2007; Schmitt and Blàzquez, 2003). The shift to urbanisation and second homes is also reflected by the growth of 14.6% in residential capacity while the tourist accommodation capacity only increased by 2% from 2001 to 2008 (OST, 2010). Urban water consumption on Mallorca increased by 30% from 1998 to 2007 (OST, 2010), when the official resident population grew by 27.7% (IBESTAT, 2010).

The municipality of Calvià is a paradigmatic example for the new emphasis on quality tourism (Fig. 1). Calvià accounts for 4.4% of the island of Mallorca's surface area and covers 60 km of coastline. The traditional mass tourist base has been extended by attracting residential tourists and the building of second homes. Calvià has a proportion of over 60% second homes and ranks among Santanyí, Alcudia and Andratx as the most attractive coastal municipalities, which is reflected in soaring real estate prices. Increasing water consumption for outdoor uses (gardens, swimming pools) is a direct consequence of this development (Schmitt, 2007).

The influences of similar tourist land use patterns on water demand have been studied in Benidorm and on the Alicante coast (Rico-Amoros et al., 2009). The highest water consumption figures were found in tourist areas with single houses that had gardens and swimming pools. The absence of a pool and a garden results in a two to three times lower mean consumption per household, per capita and in the month of maximum water consumption (Rico-Amoros et al., 2009, p. 499). Mallorca's situation is similar: in addition to mass tourism with its associated infrastructure, seasonal peak of water consumption, and influx of tourists, a more individual tourist landscape with a more residential character has developed. Low-density urbanisation spreads around existing mass tourist centres (Fig. 1). Consequently, water consumption is strongly influenced by water uses for gardens and swimming pools and these water demands create additional water consumption peaks in the season of low rainfall and high evapo-transpiration (Essex et al., 2004). Apart from the high water demand of golf courses and agriculture, this tourist land use pattern contributes to the rising water consumption on Mallorca. However, the magnitude of this contri-

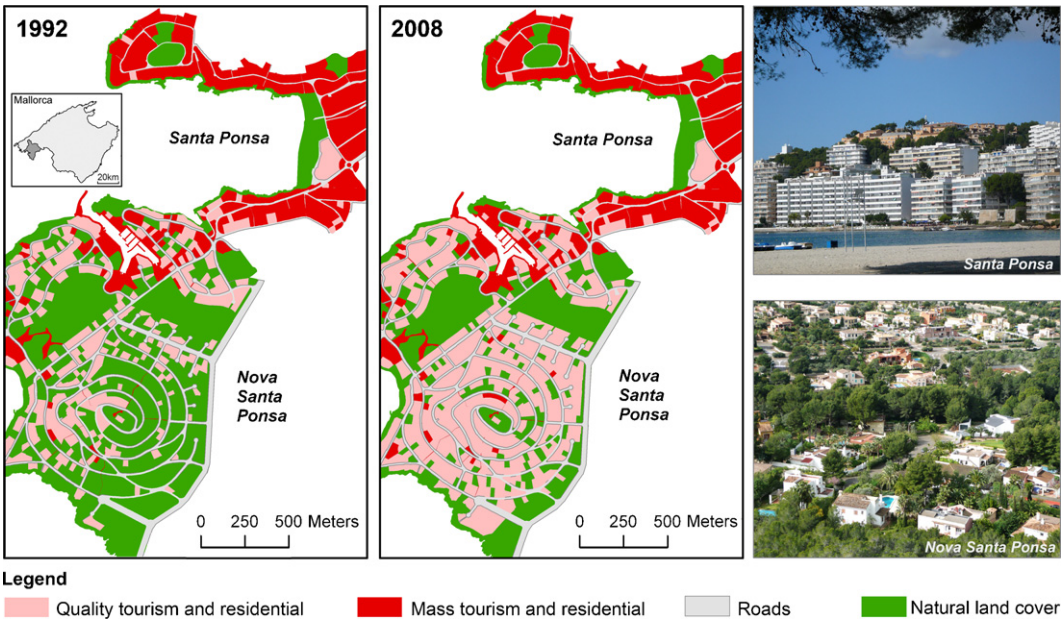

Fig. 1. Land use and land cover changes caused by the spread of residential tourism (Nova Santa Ponsa) around established mass tourist urban centres (Santa Ponsa) in Calvià municipality. Nova Santa Ponsa is a prime example for the real estate boom triggered by quality tourism since the 1990s. In 2008, there were 18 times more private swimming pools in Nova Santa Ponsa and 3.4 times as many houses as in 1995.

bution has not been described in quantitative terms yet, and this paper fills this information gap.

Organisation of the paper

First, the methodology adopted in this study is set in the context of other research approaches to land use and water consumption patterns in order to briefly lay out the objectives and to emphasise the innovative methodology presented here. Second, the case study is introduced by briefly describing Calvià municipality, the most important tourist municipality in the Balearic Islands and one of the Mediterranean's leading tourist resorts. The individual case study areas within the municipality embody the whole range from mass to quality tourist urban form and the related impacts on water consumption. Third, the data collection and data analysis approaches that were applied to compare water consumption levels for different tourist and urban forms and on a per capita basis are described in detail, with a special emphasis on the quality tourism model. Finally, it is concluded that any tourist destination that is to follow the quality tourist development path will exacerbate water demand in the domestic residential sector. Water conservation campaigns and water management on Mallorca should start to address gardens and swimming pools because these leisure structures increase permanent water demand.

Objectives and methodology of the present analysis

At present, there is a lack of data and information on tourist water demand, particularly with respect to the sub-sectors of tourism that have gained importance, like the second home sector in Spain. The main objective of the present analysis is to outline the contribution of non-hotel tourist landscapes to water demand in comparison with conventional mass tourist and residential areas. With climate change as a common challenge to the major tourist destinations in the Mediterranean, the present analysis highlights current developments in the tourism sector that have significant implications for water supply and demand but are hardly addressed in recent land use policies. Other studies in similar contexts and climates use water consumption data per municipality and average estimates for different types of tourist and residential accommodation to analyse the interrelation between tourist land use pattern and water demand (Rico-Amoros et al., 2009). These data and water records from water providers usually require aggregate analysis at census tract or municipality level (Balling et al., 2008; European Commission, 2009). Studies analysing urban water consumption patterns use data obtained in household interviews that are stratified by demographic and socio-economic aspects (Domene and Saurí, 2006; Domene et al., 2005). The present methodology is tailored to contexts where such comprehensive information is difficult to access or collect, or where it has eluded official statistics because informal accommodation for non-hotel, residential tourism has a significant share in urban or tourist land use. Yet, residential tourism and leisure structures can have significant impacts on water resources through high levels of consumption (European Commission, 2009). Therefore, the objective is to overcome the bias of available municipality-level statistics that do not discriminate between the different land use patterns and their respective contribution to water consumption. In municipalities where both residential areas and mass and quality tourism are present or mixed spatially, such discrimination is crucial to identify the share of non-hotel tourism in residential water consumption. The present analysis accounts for this intra-municipal variability of water consumption that is related to land use pattern but masked in per capita data that are aggregated at the municipal level. This approach also circumvents the bias potentially introduced in household surveys carried out in contexts where second homes are widespread and a representative sample may be difficult to achieve. For example, the most detailed available water data for a quality tourist area in the municipality of Palma were aggregated at street level, but the high variability of water consumption levels complicates household sampling. Moreover, many second home owners visit frequently but stay only for a couple of days, which may reduce their availability for interviews in their leisure/vacation time.

The present approach is based on monthly water consumption data for sub-municipal level census districts of Calvià municipality

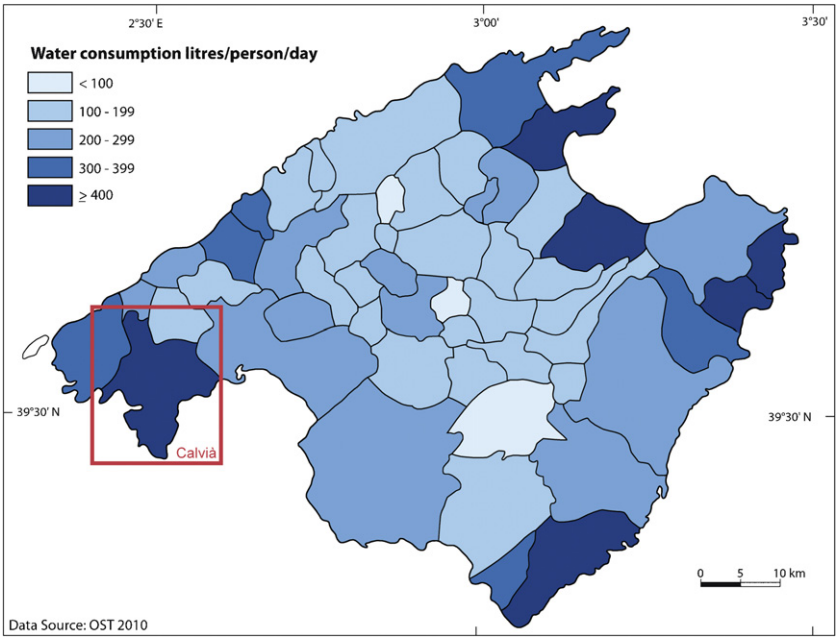

Fig. 2. Per capita water consumption at municipality level in Mallorca (2007).

in the southwest of Mallorca (compare Fig. 1). These high spatial resolution water consumption data were collected by fieldwork and written requests to water providers–the data are not published or disseminated and are usually restricted to internal use. These water consumption data are combined with a very detailed land use and population inventory at the parcel scale. The geographical database encompasses 3450 parcels that are classified as single family residential, multi-residential, tourist apartment or hotel, or non-residential. Each parcel is subdivided into land covers related to water consumption: swimming pool, garden area, and built-up land. This level of spatial detail allows for a very exact, spatially explicit assessment of land use pattern in the study areas. The resulting land use inventory is the basis for a future socio-economic stratification of the area for household interviews to analyse urban water consumption like in the studies of Domene and Saurí (2006) and Domene et al. (2005). The swimming pool inventory is pivotal for the application of a physical model of water losses from swimming pools through evaporation (Hof et al., submitted). The present study analyses the contribution of indoor and outdoor water usage to domestic water consumption in tourist and urban areas distinguished by land use pattern. Urban areas characterised by mass tourism and a high concentration of large hotels are compared to nearby areas that have started to build their tourist base on low-density residential tourism in the vicinity of golf courses and marinas. A residential area not influenced by either type of tourism is used as a reference base for domestic water consumption. The results are valuable input into models explaining water consumption in relation to land use pattern and domestic water demand in tourist resorts that diversify their product. The established consumption model is a useful tool for use in decision-making, defining policies and strategies, and for assessing the impact of future tourism investment projects (compare European Commission, 2009).

Materials and methods

Water consumption is high in all Mallorcan municipalities that include tourist centres. The most recent available data show that actual water consumption exceeds the water demand of 275 litres per person and day (l/p/d) predicted for 2006 (Kent et al., 2002) in all municipalities with coastal tourist resorts. At more than 700 l/p/d (OST, 2010), water consumption is very high in the Calvià municipality in southwest Mallorca (Fig. 2). Quality tourism is expected to contribute significantly to the high per capita water consumption in Calvià, but the spatial distribution and the magnitude of this contribution has not been researched yet. The present study evaluates the land use and water consumption patterns at the sub-municipal level in Calvià. The following sections outline the methods applied to expose the role of quality tourism in domestic water consumption.

The case study areas: a comparison of water consumption in quality tourism, mass tourism and high density residential areas

The municipality of Calvià is often identified as the paradigmatic example of a more diversified tourism development and a new tourism model. Already in 1990, the municipality worked out "The Calvià Plan for Tourist Excellence" in conjunction with the Spanish Ministry for Tourism. Calvià started to concentrate on the substitution of mass tourism for quality tourism and its higher expenditures. In 1999, Calvià passed its Local Agenda 21 which was coined as a sustainable strategy for a tourism destination (Bardolet and Sheldon, 2008; UNEP/MAP-Plan Bleu, 2009). The innovative Local Agenda 21 won Calvià international environmental awards and prizes (Sustainable European City from the European Union in 1997; Good practice for improving the quality of town life from the United Nations in 1998; Green Globe Award from the World Travel and Tourism Council in 1998). The development objectives include the limitation of urban growth and a reduction of water consumption in the residential and tourism sector. Calvià has successfully extended its traditional mass tourist base and this has led to a concentration of 12% yacht berths and 25% of Mallorca's golf courses in the municipality. As a result of the successful attraction of residential tourists, Calvià has a proportion of more than 60% second homes and is characterised by residential resorts, villas and low density residential settlements (Schmitt, 2007). The domestic residential sector has grown substantially in the last two decades: the official residential population in Calvià municipality increased

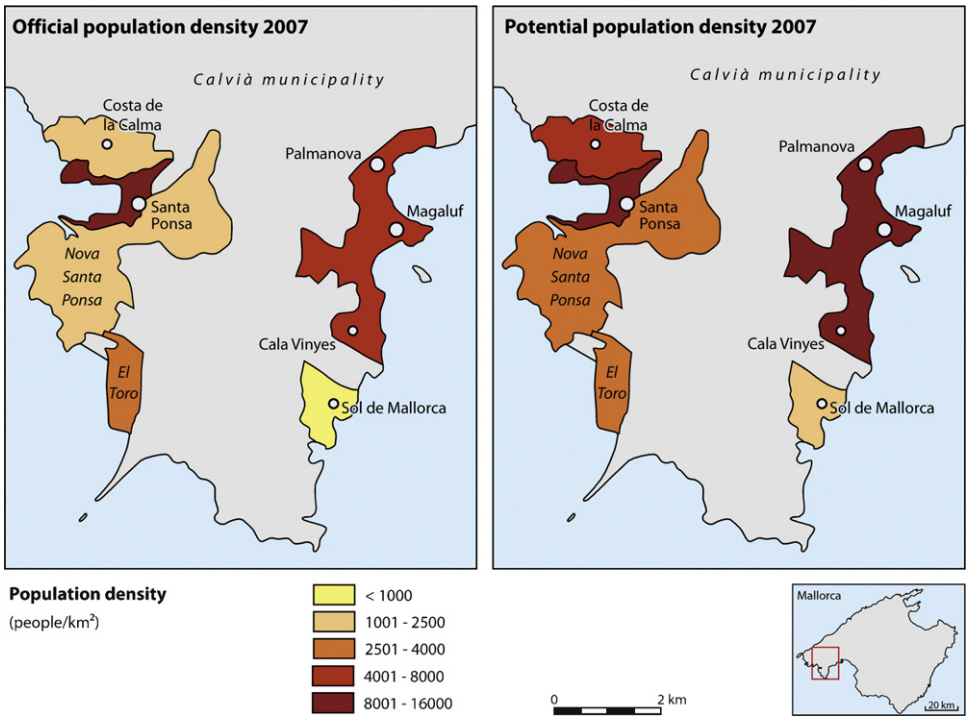

Fig. 3. Location map of the study areas and population density for the official (minimum) and potential (maximum) population. *Data source*: Own calculations with data on official population, tourist hotel and apartment beds provided by Calvià municipal government for the year 2007 (Ajuntament de Calvià, unpublished data) and population inventory data (compare Section "Population and land use inventory at sub-parcel scale").

by 71.5%, while official tourist beds in hotels and apartments grew by only 4.5% between 1994 and 2008.

Due to its maturity, market importance and pioneering development of "quality tourism", Calvià municipality was chosen to illustrate the impacts of different tourist models and associated land use patterns on water consumption (Fig. 3). The spatial configuration of different types of tourist urban models in Calvià municipality is ideal for this research: new low density non-hotel tourist areas have developed next to mature mass tourist urban centres (Fig. 1). Therefore, water consumption data and a detailed land use and population inventory for these spatial entities can be combined to analyse the share of quality tourist structures in residential water consumption. The six study areas represent the whole range from the dense, vertical growth mass tourist urban model to the low density second home quality tourist model with irrigated landscaping (Fig. 3). Nova Santa Ponsa, Costa de la Calma and Sol de Mallorca are quality tourist areas where more than 80% of all parcels are used by single residential houses. The proportion of non-Spanish residents, an indicator of second home ownership, is over 50% here. El Toro is a relatively high density residential area which hosts only one hotel and has a share of 96% single residential houses. Nova Santa Ponsa and Sol de Mallorca are prototypes of high quality residential or non-hotel tourism, characterised by large parcels, of which half is garden area. By comparison, Costa de la Calma is a mix of high quality residential tourism and high density residential areas like in El Toro. In Nova Santa Ponsa and Costa de la Calma, there are a number of flats and apartments in multi-residential houses that are used by tourists and also a couple of hundred hotels beds. However, only 3.3% of the official tourist bed capacity in Calvià municipality (2007) is concentrated in Nova Santa Ponsa, Costa de la Calma and El Toro. The typical high density mass tourist areas are represented by Santa Ponsa and Palmanova/Magaluf/Cala Vinyes, where 24.1% and 16.6%, respectively, of all parcels are used by hotels and tourist apartment complexes that host 68% of the official municipal tourist bed capacity (2007). The resort-like features of villas with private gardens, swimming pools, and the low density residential appearance distinguishes the quality tourist areas from the residential and the mass tourist urban forms (Fig. 1).

Collection of water consumption and population data at sub-municipal spatial level

For the individual study areas, monthly domestic water consumption data (2007) were collected from public and private water companies. Population data for 2007 (official census data, official tourist numbers) were provided by the Calvià municipal government (Ajuntament de Calvià, unpublished data). The private water company ATERCA S.A. (Aguas del Término de Calvià) delivered figures on monthly water consumption by domestic end users in Santa Ponsa, Nova Santa Ponsa, Costa de la Calma and El Toro for 2005–2007 (unpublished data). The municipal water company Calvià 2000 S.A. provided figures on monthly water consumption by domestic end users in Sol de Mallorca and Palmanova/Magaluf/Cala Vinyes for 2005–2007 (unpublished data). All water data exclude the loss in the water supply network, the water consumption of commercial users and golf courses, and therefore the results presented here apply to water consumption in the domestic residential sector.

Population and land use inventory at sub-parcel scale

A land use database was built from digital cadastre data and by visual interpretation of high resolution digital colour orthophotos (year 2006, geometric resolution 50 cm/pixel), and on-screen digitizing (Dirección General de Catastro, 2010; IDEIB, 2010). Pool area, garden area, and built-up area (sealed surfaces and buildings) were mapped using the geographic information system ArcGIS™ by subdividing land parcels into these land use types at a scale of 1:600. For every parcel with tourist use declared in the online

cadastre (Dirección General de Catastro, 2010), the numbers of official tourist beds in hotels and apartments as listed by the Calvià municipal government for the year 2007 (Ajuntament de Calvià, unpublished data) were recorded in the database. Accommodation capacity in second homes is 119% of official tourist accommodation capacity (Ajuntament de Calvià, 2006). Therefore, the number of apartments is a proxy of tourist beds in non-declared units and was recorded by querying the online cadastre data to estimate the additional number of tourists in these units. The number of residential houses and the number of flats in multi-residential houses was queried for all residential parcels (Dirección General de Catastro, 2010), and recorded in the database. With this geodatabase structure and content, the relevant land use types for water consumption outdoors (garden area and pool area) and the relevant population numbers for indoor water consumption (number of inhabitants and tourist beds) can be determined per parcel and for different tourist and residential housing types.

To account for the impact of tourists, two scenarios are presented. First, a calculation for the official population which represents a minimum population (Fig. 3):

Official population = official census data + ((hotel beds + apartments beds) × monthly capacity utilization factor).

Second, a calculation where the potential population represents a maximum population, reflecting the maximum residential population plus tourists in second homes and tourists in non-declared units (Fig. 3):

Potential population = ((no. of apartments + no. of flats + no. of single residential houses) × average household size) + ((hotel beds + apartments beds) × monthly capacity utilization factor).

Average household size is according to INE (2009b) and the capacity utilization factor includes the monthly percentage of open hotels and tourist apartments and their utilization factor according to CITTIB (2009). The resulting water consumption figures are compared with findings from other studies in similar climates and contexts (Domene and Saurí, 2006; Domene et al., 2005; Loh and Coghlan, 2003; Rico-Amoros et al., 2009; Syme et al., 2004).

Water consumption figures per capita and per area unit

In order to demonstrate the differences in water consumption between mass tourist, quality tourist and residential areas, the monthly water consumption figures are combined with the population inventory of the study areas to compare the per capita water consumption profiles for the month of maximum water consumption (July) and the annual average consumption in litres per person per day (l/p/d). All calculations refer to the year 2007. The results are presented and compared for the official (minimum) and potential (maximum) population scenario to emphasize the impact of tourists in the study areas which are differentiated by land use pattern.

Comparing actual water consumption data to municipal estimates for consumption by tourists and in different housing types

The municipality of Calvià publishes facts and figures on public environmental concerns like water consumption per resident and per tourist per day. The following estimates were derived from these sources: 400 l/p/d in single residential houses with pool and garden, 200 l/p/d in flats and apartments and 270 l/p/d per tourist bed occupied in hotels or apartments (Ajuntament de Calvià, 2006). These values are combined with the population and land use inventory of the study areas to compare the monthly water consumption to be expected from these estimates with the actual monthly water consumption in the study areas. The capacity utilization factor of hotels and tourist apartments is taken into consideration to account for the variable component of tourist water demand that is directly linked to the occupation rate.

Estimation of indoor and outdoor water consumption and per capita water consumption for different types of domestic water uses

Other studies in similar climates and contexts have shown that analyses of domestic water consumption have to take three variables into account for a model explaining patterns: per capita consumption indoors (dependent on household size, seasonality of inhabitancy and capacity utilization of tourist accommodation), and outdoor water consumption for garden irrigation and swimming pool maintenance (Domene et al., 2005; Rico-Amoros et al., 2009; Syme et al., 2004). There is evidence that outdoor water uses cause large variations in water consumption, while indoor water consumption is fairly stable across income categories, seasonal variations, socio-economic groups, and housing types (single or multi-residential). Water consumption for garden irrigation, for topping up the swimming pool, and evaporation of water from the swimming pool are constant water uses that are independent of the number of persons per household. Single houses with substantial outdoor uses are major water consumers and their consumption pattern is influenced by season and has a positive correlation with garden size and swimming pool ownership. Garden irrigation induces substantial increases in summer water consumption particularly in low-density housing areas with lavish and green gardens with turf grass and other water-demanding plants (Balling et al., 2008; Domene and Saurí, 2006; Loh and Coghlan, 2003; March and Saurí, 2009; Syme et al., 2004).

These studies were conducted in urban residential areas and are based on extensive water meter and/or questionnaire data, and household surveys. The present approach takes the findings of these urban studies into consideration and presents an innovative solution for accounting water consumption to certain types of outdoor usage (garden, outdoor swimming pool) in contexts where non-hotel, residential tourism in second homes has a significant share in land use and water consumption. The methodology is applicable to study areas that do not meet the data requirements needed to stratify for household survey samples. The focus is on the relation between different urban and tourist land use patterns and water consumption, comparing the quality tourist to the mass tourist and the residential urban form. The following sections outline the methodology to determine each of the variables for the domestic water consumption analysis. The spatial grain of the analysis is the sub-municipal census district level. At this high spatial resolution, the model couples water consumption data and land use inventory data (pools, gardens) with population data and a physical model of pool water evaporation rates. This approach circumvents the reliance on extensive water meter data, which are missing for Mallorca because water meters are the exception, not the rule. Only since the year 2000, the installation of water meters is obligatory in new buildings.

Pool water

To resolve one variable in the model, the water losses by evaporation from open air swimming pools are quantified to assess the amount of water used outdoors independent of the other variables. Coupled with indoor water use, this is an important factor for the distinction between the contribution of pool and garden maintenance to total outdoor water use. The approach follows the logic that once the pool is filled and in use, the water loss from evaporation has the main influence on the total water consumption for running a pool. The estimation of water losses by evaporation from swimming pools is a function of pool area and derived by a simpli-

fied calculation of the net heat input by radiation and convection. The average quantities evaporated per m^2 per day over the year for a swimming pool in Mallorca correspond to a daily loss of 5 litres of water/(m^2 day) and an annual water loss of 1.83 m^3/m^2/a. An average pool (6.2 m by 6.2 m and 1.5 m deep) loses about 70 m^3 of water per year by evaporation, which is 122% of its filling capacity (Hof et al., submitted). According to residential pool service companies, a total change of water normally takes place every year (personal communication, Juergen Schmidtke, Fincasitters Company, Mallorca, July 2010). To account for the contribution of pool filling water to total water use, one complete fill of all pools in each study area is included in the monthly estimate of water consumed for the maintenance of swimming pools:

$$w_{\text{Pool}} = \dot{n}_{\text{average}} * a_{\text{Pool}} * \text{days} + a_{\text{Pool}} * \text{average pool depth} * \frac{1000}{12}$$

where w_{Pool}: sum of pool water evaporation loss and filling of pools [litres per month]; $\dot{n}_{\text{average}}$: average water quantity evaporated by a swimming pool in Mallorca [litres per square meter per day]; a_{Pool}: pool area [square meters].

The monthly water consumed for the maintenance of swimming pools is divided up for the official and potential population, respectively, to compare differences in water consumption that are caused by the different land use patterns. More specifically, it is of interest to estimate the impact of increased private swimming pool ownership on water consumption, comparing mass and quality tourist areas and El Toro as reference base for residential areas.

Indoor water use

The calculation of indoor water consumption differentiates between tourist hotel and apartment beds on the hand and residential houses on the other hand. The total water consumed indoors is calculated in detail as the sum of water consumed per tourist bed occupied and consumed indoors in apartments, flats and single residential houses. The monthly calculations for the official and potential population take the average household size and tourist capacity utilization into account (compare Section "Population and land use inventory at sub-parcel scale"). Similar studies in the Mediterranean determined the daily indoor water consumption per capita at 142 l/p/d (Rico-Amoros et al., 2009), which is close to the average per capita consumption of 136 l/p/d in the Balearic Islands in 2007 (INE, 2009a). Since water consumption from pools is estimated separately, the value of 142 l/p/d for indoor water use of single and multiresidential houses is used in accordance with the mean daily consumption for permanently occupied single residential houses with minimum garden and no pool (see Rico-Amoros et al., 2009, p. 499). The average consumption figures per bed occupied across different hotel categories are obtained from Rico-Amoros et al. (2009, p. 496), while indoor consumption for apartment beds equals that of single residential houses without garden or swimming pool (142 l/p/d).

Garden irrigation

The amount of water available for garden irrigation is derived by deducting the total amount of water consumed indoors for the official and potential population, respectively, and the pool water use from the total water consumed in the respective month. The resulting amount is divided by the total garden area, resulting in an estimate of garden irrigation per square meter:

$$w_{\text{Garden Summer Detailed}} = \frac{(w_{\text{Total}} - w_{\text{Indoor Detailed}}) - w_{\text{Pool}}}{a_{\text{Garden}}}$$

where $w_{\text{Garden Summer Detailed}}$: estimate of water used for garden irrigation [litres per square meter per day]; w_{Total}: total amount of water consumed by domestic end users [litres per month]; $w_{\text{Indoor Detailed}}$: total indoor water use [litres per month]; w_{Pool}: sum of pool water evaporation loss and filling of pools [litres per month]; a_{Garden}: total garden area [square meters].

In combination, the estimates of indoor consumption, pool water use and garden irrigation result in an estimate of water consumption by use type for each study area.

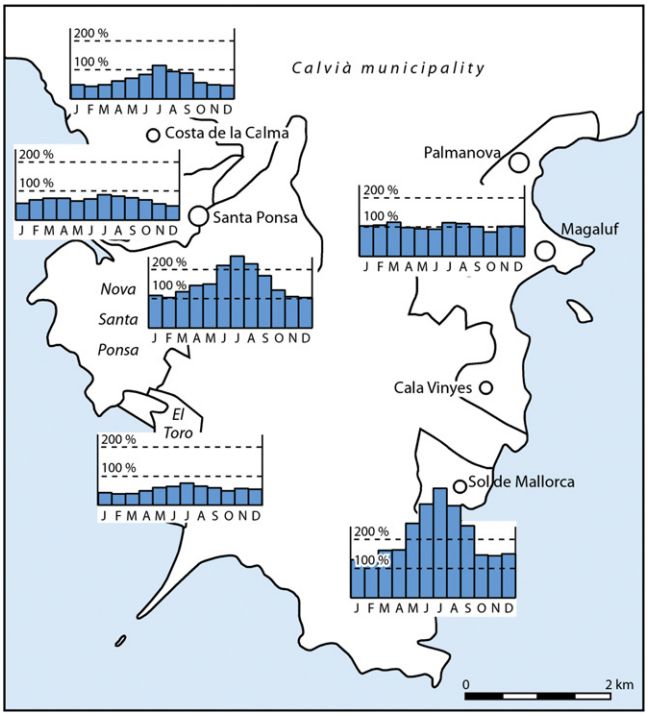

Fig. 4. Comparison of actual water consumption (2007) with water consumption calculated according to municipal water consumption estimates for housing types and tourist beds (100%) in 2007. *Data source*: Own calculations with population inventory (compare Section "Comparing actual water consumption data to municipal estimates for consumption by tourists and in different housing types"), water consumption data by ATERCA S.A. and Calvià 2000 S.A., and consumption estimates by Ajuntament de Calvià (2006).

Results and discussion

Comparison of actual water consumption and municipal estimates

The most detailed information published by Calvià municipality on per capita water consumption for tourists and different housing types was combined with the population and land use inventory to compare the monthly water consumption to be expected from these estimates with the actual monthly water consumption in the study areas (compare Section "Comparing actual water consumption data to municipal estimates for consumption by tourists and in different housing types"). The results show that while these estimates are the basis for official water demand planning, they cannot explain the actual water consumption patterns. The actual consumption in quality tourist areas Nova Santa Ponsa and Sol de Mallorca exceeds the estimates by more than 150% in the summer months from June to September (Fig. 4). Over the whole year, the estimates meet the actual consumption only in Palmanova/Magaluf/Cala Vinyes. Even in summer, the actual monthly consumption of mass tourist Santa Ponsa, the high density residential area El Toro, and the more mixed area Costa de la Calma is lower than the estimates. In contrast, the estimates drastically underrate the actual summer water consumption of quality tourist

Table 1
Land use and water consumption patterns in the study areas (2007).

Urban form	Santa Ponsa Mass tourism	Palmanova/Magaluf/Cala Vinyes Mass tourism	Nova Santa Ponsa Quality tourism and residential	Sol de Mallorca Quality tourism	Costa de la Calma Quality tourism and residential	El Toro Residential
Area [ha]	85	357	502	100	170	87
Built-up area [%]	76	51	46	31	43	61
Garden area [%]	15	13	18	25	23	21
Pool area [%]	1.1	1.0	0.9	0.7	1.0	0.9
Percentage of single residential parcels	32	51	88	90	89	96
Level of swimming pool ownership (single residential)	40	48	77	100	42	37
Annual water consumption [hm^3]	0.88	2.98	1.80	0.27	0.40	0.17
Pool water use [%]	3.5	4.2	7.7	9.2	13.3	15.2
Garden irrigation [%]	28.9	54.1	73.9	78.8	60.2	9.1
Indoor[a] [%]	67.7	41.7	18.4	12.0	26.5	75.7
Water consumption per capita[a] [l/p/d]	210	341	771	1181	536	188
Pool water use	7.3	14.5	59.4	108.2	71.1	28.5
Garden irrigation	60.6	184.2	569.8	930.9	322.5	17.1
Indoor	142	142	142	142	142	142

[a] Calculations for the official population in 2007 (see Section "Population and land use inventory at sub-parcel scale" for details): The census population for each study area plus the official tourist hotel and apartments beds (Ajuntament de Calvià, unpublished data); taking into consideration the tourist capacity utilization factor according to CITTIB (2009). *Data source*: Own calculations, water consumption data by ATERCA S.A. and Calvià 2000 S.A.

areas. These results clearly show that a more explicit consideration of water consumed by garden irrigation should be taken into account in combination with a detailed population inventory and water consumption estimates by housing type. This argument is supported by the findings on land use and water consumption patterns and actual per capita water consumption in the study areas, as outlined in the following section.

Land use patterns and water consumption in the case study areas in comparison

The spatially explicit results on land use and water consumption patterns at the sub-municipal level highlight interrelations between land use and water consumption that are indiscernible in municipal water consumption figures (Table 1). Compared to the mass tourist and residential urban form, the quality tourist urban form is characterised by a low proportion of built-up land, a predominance of single residential houses with private gardens and a high level of swimming pool ownership. The per capita water consumption for the officially registered residents is 2.9–3.5 times higher than in the residential and mass tourist areas. Based on the calculations outlined in the previous sections, garden irrigation is the single main outdoor use contributing to the high water consumption in the quality tourist areas, and the contribution of swimming pool maintenance is higher than estimated in other studies (compare Loh and Coghlan, 2003; Vidal et al., 2010). The significant influence of single residential houses on water consumption is also reflected here. This housing type is associated with permanent residents and second homes and the sprawl of new low density urban natures in the form of lavish green gardens and swimming pools seen elsewhere in southern European cities (compare Domene and Saurí, 2006).

The per capita analysis of water consumption patterns at the sub-municipal level shows the temporal effect of tourist influx for the mass tourist areas and the impact of garden irrigation in the quality tourist areas (Table 2). Although all hotels and tourist apartments are open in July and have a high occupancy rate (97%), per capita water consumption is consistently higher in July, both for the official and the potential population (Table 2). The variation between the study areas is considerable. The extremely high level of water consumption in July in quality tourist areas is caused by outdoor water use as outlined below. Even in January, the month of minimum water consumption, the per capita water consumption in both quality tourist areas Nova Santa Ponsa and Sol de Mallorca is close to the average consumption estimate of 700 l/p/d for Calvià municipality (compare Section "Materials and methods"). This could indicate that in Nova Santa Ponsa and Sol de Mallorca the potential population estimate matches the actual situation closely as it better reflects the ambient population in undeclared tourist units taken into account in the detailed population inventory. The estimates of per capita water consumption in quality tourist areas compare to 590 l/person/day for single houses with gardens and swimming pool in the month of maximum consumption and an annual average of 452 l/person/day observed in the study on the Alicante coast (Rico-Amoros et al., 2009). In the Barcelona study, Domene et al. (2005) observed 248 l/p/d and 459.2 l/p/d during the summer months for low income and high income groups, respectively. With a lower level of pool ownership and smaller gardens, the annual average in Santa Ponsa, Costa de la Calma and El Toro is close to the 150 l/person/day described for single permanently occupied houses with minimum gardens and no pool (Rico-Amoros et al., 2009).

In areas in Mallorca where mass tourism is more dominant, the per capita water consumption ranges from 570 to 793 l/p/d if only the resident population is accounted for (OST, 2010). These per capita data are aggregated at the municipal level and are highly biased because they mingle the water consumption in neighbouring residential, mass tourist and quality tourist areas. For example, the presence of tourist zones doubles the per capita consumption of local inhabitants in urban areas in the Alcudia Bay and Sa Pobla Plain, where more than 50% of the municipal water uses are related to tourism. The mean consumption is 560 l/p/d if only the resident population is accounted for and 307 l/p/d considering the equivalent mean tourism population (Tamoh et al., 2008, p. 134). While this average estimate of 307 l/p/d falls in the range of results presented here for mass tourist areas (Table 1), the innovative approach taken here clearly has added value as it delivers spatially explicit and per capita water consumption information for the different types of urban form that are present in tourist municipalities (Tables 1 and 2).

Coupled with irrigated gardens, a high level of swimming pool ownership is correlated with high water consumption, but the actual relationship between garden area, swimming pool area and water consumption in tourist areas is relatively under researched.

Table 2
Water consumption per capita in the study areas (2007).

	January – official population	January – potential population	July – official population	July – potential population	Annual average – official population	Annual average – potential population
	Litres per person per day					
Santa Ponsa	174.0	114.5	247.5	199.5	203.2	151.5
Palmanova/Magaluf/Cala Vinyes	401.7[a]	221.9	348.6	280.2	347.0	236.0
Nova Santa Ponsa	570.9	259.8	1192.0	582.8	758.0	360.7
Sol de Mallorca	726.5	309.4	2082.3	886.8	1177.8	501.6
Costa de la Calma	447.3	111.7	790.5	256.5	518.9	152.4
El Toro	145.3	125.8	257.1	224.0	186.6	162.1

[a] The figures for Palmanova/Magaluf/Cala Vinyes in January are higher than what would be expected from the population estimate. Possibly the official population is underrating the occupancy rate both in January and July. *Data source*: Own calculations, water consumption data by ATERCA S.A. and Calvià 2000 S.A.

The land use database reveals the different land use patterns of the study areas (Table 1). The results for the per capita garden and swimming pool area vary considerably between quality and mass tourist areas (Fig. 5). Nova Santa Ponsa and Sol de Mallorca represent the proliferation of gardens and pools as residential resort features, even if the per capita results for the potential population are compared. Since El Toro is almost exclusively residential, the differences between the official and the potential population scenario are minimal compared to Costa de la Calma, where many undeclared tourists units exist that influence the potential population value. The high density mass tourist land use pattern of Santa Ponsa and Palmanova/Magaluf/Cala Vinyes is reflected in a comparatively low garden and pool area per capita (Table 1, Fig. 5).

Despite the fact that, next to gardens, swimming pools are often referred to as problematic outdoor use in water consumption studies (Domene and Saurí, 2006; Schmitt, 2007), quantifying the magnitude of pool water consumption has received little attention. In the Mallorca case study areas, pools cover 12.4 ha and the proportion of pool area to the study area ranges from 0.7% to 1.1%, with 60% of the pool area concentrated in the quality tourist areas. The monthly and annual estimates of the water consumption from pools are a function of pool area and the per capita estimates of pool water use follow the pattern of pool area per capita (Fig. 5). Consistent with the findings of other studies (Domene and Saurí, 2006; Loh and Coghlan, 2003; Vidal et al., 2010), the presence of a swimming pool causes additional water demands, especially when the proportion of single residential houses and swimming pool ownership is higher (Table 1). On an annual basis and for the potential population, the per capita pool water consumption is 5.5 l/p/d and 10.4 l/p/d in Santa Ponsa and Palmanova/Magaluf/Cala Vinyes, respectively. By comparison, the per capita pool water consumptions of 28.1 l/p/d, 20.5 l/p/d and 24.8 l/p/d in Nova Santa Ponsa, Costa de la Calma and El Toro, respectively, reflect the impact of growing levels of affluence (swimming pools) on water consumption. Sol de Mallorca is an extreme, with a per capita pool area of 4.4 m^2 and a per capita pool water consumption of 46.1 l/p/d. Vidal et al. (2010) estimated an additional water consumption by swimming pools of 57 l/p/d when considering only the population with

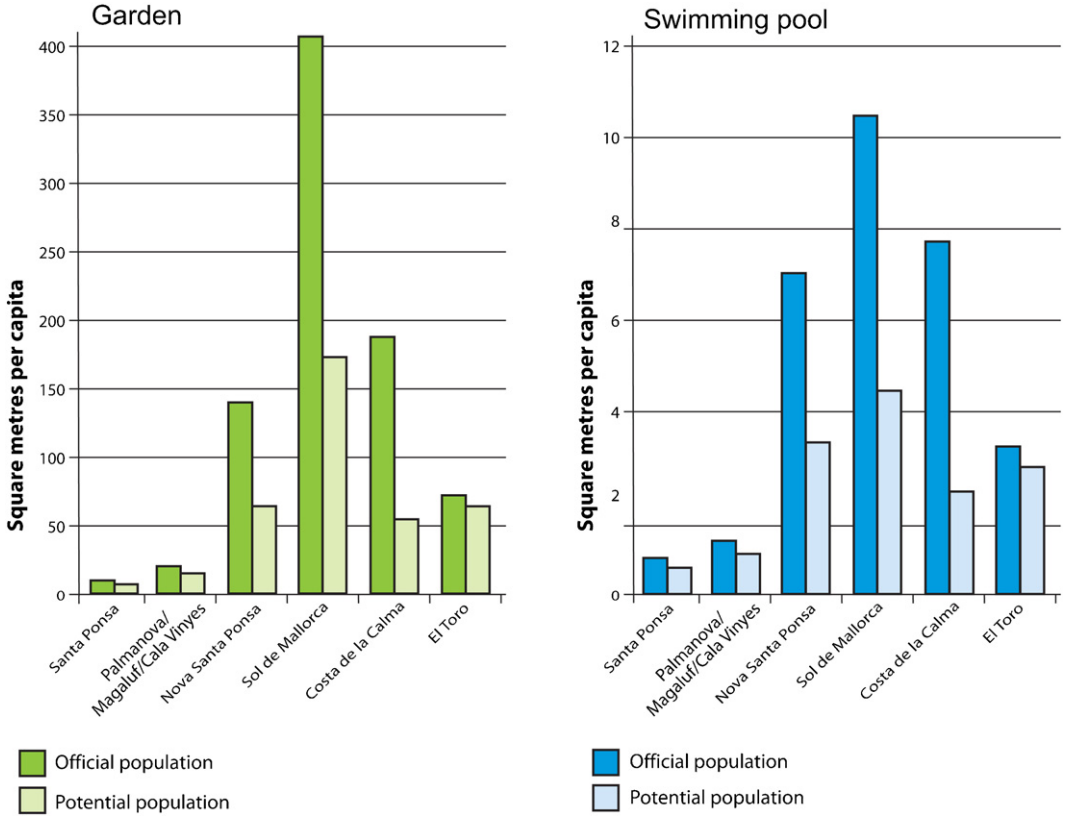

Fig. 5. Pool and garden area per capita in comparison for the official and potential population (year 2007). *Data source*: Own calculations.

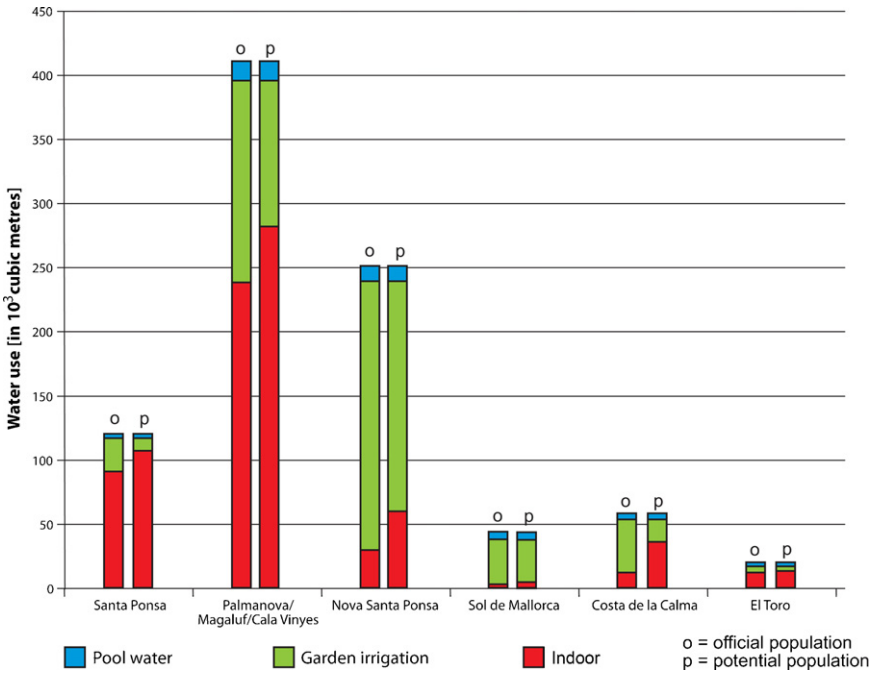

Fig. 6. Estimated water consumption by usage type in the month of maximum water consumption (July) – assumption of official and potential population (2007). *Data source*: Own calculations.

access to swimming pools. For all study areas in Calvià, the average is 22.6 l/p/d and only the annual average pool water consumption of quality tourist areas in Nova Santa Ponsa and Sol de Mallorca compare to the 37.9 l/p/d caused by the presence of a swimming pool as estimated from the whole sample of 532 households in the Metropolitan Region of Barcelona (Domene and Saurí, 2006). However, the estimate on pool water use is conservative as it does not take into account water losses from filtering, leakage, overflows, emptying, or water withdrawal by pool users, for example.

Estimates for indoor and outdoor water consumption and per capita water consumption for different types of domestic water uses

The estimate of domestic water consumption by use type for each study area shows the magnitude and a profile of water consumption in mass tourist areas compared to quality tourist and residential areas (Fig. 6). In accordance with findings of other studies the results show that gardens are the single main cause for outdoor water consumption. Especially the increase of gardens planted with turf grass and species not adapted to the local climate is extremely important for rising domestic water consumption (Domene and Saurí, 2006; Domene et al., 2005). Even if the maximum, the official population is assumed, garden irrigation contributes more than 70% to water use in the quality tourist areas Nova Santa Ponsa and Sol de Mallorca (Fig. 6). This is considerably higher than the average of 45% contribution of garden irrigation to total water consumption of households with comparable garden designs in the Barcelona study (Domene et al., 2005). The underlying estimates of water consumption for garden irrigation in July range between 0.7 l/(m^2 day) in El Toro and 6.4 l/(m^2 day) in Nova Santa Ponsa. By comparison, Domene et al. (2005) reported an average for garden irrigation in summer of 2.7 l/(m^2 day) for gardens planted mainly with Mediterranean shrub species and 4.4 l/(m^2 day) for gardens with high proportions of turf grass and other water demanding species. The contribution of pool water use to water consumption in July is highest in El Toro (14.5%) and lowest in Santa Ponsa (2.9%), while the average is around 7.7% in the quality tourist areas. These results are higher than the 2.8% observed in the Australian study (Loh and Coghlan, 2003) and show that the rising level of swimming pool ownership observed especially in quality tourist areas on Mallorca in the last 20 years poses additional demands on water supply. While garden irrigation is the main cause for the high per capita water consumption in the quality tourist areas, the key determinant appears to be the type of garden design (especially involving water-demanding plants) rather than garden area (compare also Domene and Saurí, 2006; Domene et al., 2005; Loh and Coghlan, 2003). While Santa Ponsa and Palmanova/Magaluf/Cala Vinyes have similar proportions of garden area (Table 1) the contribution of garden irrigation is much higher in Palmanova/Magaluf/Cala Vinyes and Nova Santa Ponsa (Fig. 6). Likewise, the proportion of garden area in Sol de Mallorca, Costa de la Calma and El Toro is quite similar (Table 1), yet the contribution of garden irrigation to total water consumption in El Toro is only 26% (official population) and 18% for the potential population scenario (Fig. 6). The results presented here on land and water consumption patterns, per capita consumption patterns (Tables 1 and 2) and the allocation patterns of water consumption at sub-municipal level (Figs. 5 and 6) show that private gardens and particularly 'Atlantic' gardens as positional goods, and the high proportion of single residential houses in quality tourist areas increase water consumption in the residential domestic sector (compare Domene and Saurí, 2006).

Conclusions

The spread of low density residential areas is the outcome of urban sprawl and the proliferation of non-hotel tourism in Mallorca and in an increasing number of municipalities on the Spanish Mediterranean coast. The present study adds evidence on water consumption patterns to the findings of other studies that have demonstrated the impact of land use pattern on water demand in such contexts and climates. Low density tourist areas consume more water per capita than high density residential or mass tourist

areas, especially for outdoor uses of water. The increasing level of ownership of swimming pools and the preference for lavish gardens with turf grass instead of Mediterranean garden plants is the main factor driving this high water consumption. Besides drastic differences in total pool area, variability in garden design and probably garden irrigation practices are causing enormous differences in water consumption of tourist landscapes differentiated by land use pattern. Understanding the share of private irrigated gardens with swimming pools in residential water budgets is a first step toward designing water conservation policies focused on reducing outdoor water use and targeting neighbourhoods where outdoor use is high.

The approach presented here shows that if average indoor water consumption, population data and household sizes are known for a certain area, the total number and surface area of swimming pools can be combined with average per capita indoor consumption and the total water loss by pool evaporation to deduct an estimate of water used for garden irrigation, as the single main outdoor use contributing to domestic water consumption. The results do not necessarily reflect a close estimate of the actual individual household water consumption, but as outlined above, both the estimates on per capita water consumption and the differences between quality, mass tourist, and residential areas are in the order of magnitude of observations in other studies. This spatial approach presents land use pattern as an explanatory variable in domestic water consumption analyses. The approach is transferable to areas for which pool and garden area can be easily inventoried from remote sensing data and combined with population data and water consumption figures. Compared to a representative sample household survey, important assumptions and generalisations have to be made with respect to indoor water consumption. Data on household size, occupancy rate and tourist capacity utilisation are important to obtain results for indoor water consumption. The methodology applied takes the empirical findings on the influencing factors for indoor and outdoor water consumption into consideration (compare Loh and Coghlan, 2003; Syme et al., 2004). In addition, the present analysis relies on statistical data collected with high temporal resolution for tourist numbers, occupancy rate and capacity utilisation in the official tourist sector. Due to the significant share of second homes, the generalised assumptions on indoor consumption are most problematic in quality tourist areas. More complete data on household size and temporal aspects of occupancy in second homes as well as on differences in garden design are desirable, but may be very difficult to obtain if an adequate sample size is required. Several factors like the absence of extensive water meter data and the sensitive issue of second homes and environmental impact of quality tourism hamper the feasibility of such a study design on Mallorca.

Water is a critical resource for the sustainability of tourism as the island's principal economic activity. Therefore, the hydrogeological, climatic and socio-economic conditions related to water resources and the water consumption of agriculture and the mass tourist sector have received much attention. Unanimously, the mismatch between water demand and water supply on Mallorca was highlighted (Essex et al., 2004; Kent et al., 2002). The present results point to the fact that the aesthetically pleasant quality tourist model which Mallorca is pioneering may pose an additional and serious threat to sustainable water management on the island. There are approaches to improve water management on the whole island. In implementing the EU Water Framework Directive, extensive analyses on water availability, quality, cost, and protection of water resources were carried out (Conselleria de Medi Ambient, 2004), but without specifying tangible measures to reduce water consumption. The island government's action programme for the Hydrological Plan of the Balearics (Conselleria de Medi Ambient, 2008) is aimed mainly on infrastructural measures to improve the water supply. However, package 12 of the action programme sets aside over 1 million Euro for stakeholder-oriented communication of water saving measures. This is the basis for recommendations for the reduction of daily water consumption by residents on a voluntary basis and the already published communication strategy for a campaign on sustainable water use (Conselleria de Medi Ambient i Mobilitat, 2010). The advocated measures to reduce water consumption mainly focus on indoor water use. For the reduction of outdoor water use, the covering of swimming pools and the collection of rainwater is recommended. The increased reuse of water in agriculture and for the maintenance of golf courses is called for. In sum, the current Mallorcan environmental policies do hardly reflect the necessity of improved management of outdoor water consumption and strict conservation measures are not envisaged. While the island has significant vulnerabilities to climate change, this challenge is rarely reflected in sustainable tourism policy and planning documents as being an important tourism issue (compare Dodds and Kelman, 2008). Water relevant policies still adhere to the hydraulic paradigm and focus mainly on water supply enhancement, rather than water demand management.

The review above shows that current water policy does not pay much attention to water consumption by outdoor uses. It is difficult to say how water conservation and management measures might be implemented. While the present results and other studies clearly show that more efficient water management may be a determining factor for the long-term viability of tourism (Essex et al., 2004; Kent et al., 2002), it is difficult to judge the political leeway for more strict measures or policies. Water prices on Mallorca vary strongly, depending on the municipality and on the water providers. With an average of 1.58 Euro/m^3, the Balearic water price in 2007 was the second highest in Spain, topped only by the Canary Islands (INE, 2009a). Compared to the rest of Spain, the average of 2 Euros/m^3 in Calvià municipality is the highest water price nationwide. The municipal rate system is graduated to consumption levels and incurs a maximum of 2.50 Euros/m^3 in the high consumption band (Ajuntament de Calvià, 2010). Price mechanisms probably would not make a difference in water demand because when dealing with water-related outdoor activities like garden irrigation or use of swimming pools, price-elasticity of the demand approaches (March and Saurí, 2009). The fate of a previous policy instrument underpins the difficult political climate on the island of Mallorca when it comes to taxing for environmental purposes. The most significant initiative for the use of economic instruments in the shift from mass tourism to more sustainable tourism was an eco-tax decided by the Autonomous Community of the Balearic Islands in 2000. Depending on lodging standard, the eco-tax was set to range from 0.25 to 2 Euro per tourist night spent. The purpose of the eco-tax was to promote environmental protection, with extra resources for environmental policy, building clearance and the conservation of natural and cultural value. However, water conservation was not at all an objective of the eco-tax. The eco-tax was in effect from March 2002 to March 2003 and was withdrawn by the newly elected Autonomous Community government, not least because it was highly unpopular with stakeholders and it had met fierce opposition from local hoteliers and international tour operators.

Water conservation campaigns in the municipality of Calvià already address garden planting and irrigation tentatively (compare Ajuntament de Calvià, 2008). However, the results presented here show that gardens and swimming pools are an important issue for water management on Mallorca and conservation measures should start to address this issue more explicitly. For gardens, the use of more Mediterranean species and adequate irrigation technology should be encouraged, and for swimming pools, the

use of pool covers and more extensive reuse of water are strongly advisable.

The Calvià Local Agenda 21 was adopted in 1999 and defined a number of objectives for the sustainable use of freshwater. The Calvià municipality set itself a target to reduce, by 2007, the amount of water consumed by 20%, thus reaching the consumption level of the year 1997 (10 hm^3). Without that target and the action taken (e.g. improvement of the pipeline network, reuse of water, installation of water meters and water-saving technology, consulting teams for citizens and tourists) it was assumed that consumption would rise to 17 hm^3, an increase of 70% in water consumption for the period 1995–2007. The real consumption figure for 2007 was 12.1 hm^3, which was above the target but well below the forecast. The achievement of the water consumption goal set in the Local Agenda 21 would have required a 7% reduction in water consumption per capita by 2001, reaching a consumption of 121 litres/inhabitant/day and a reduction of 10% (117 litres/inhabitant/day) by 2007. For tourists, a reduction by 10% of the water consumed per tourist, achieving a consumption of 141 litres/tourist/day by 2001 and of 15% (134 litres/tourist/day) by 2007 would have been required (Stefano, 2004). At more than 700 l/p/d (OST, 2010) reported as municipal-level water consumption figure and between 162 l/p/d (residential), 152 l/p/d (mass tourism), and 502 l/p/d (quality tourism) (compare Section "Estimates for indoor and outdoor water consumption and per capita water consumption for different types of domestic water uses"), current per capita water consumption is much higher than these targets of the Calvià Local Agenda 21.

In the face of climate change, the sustainability of the new urbanised seaside is a further important question. Studies that have already modelled the vulnerability of urban water consumption to climate change suggest adaptation and mitigation strategies that apply to Mallorca, too, given the similarities of land use and consumption patterns. In arid urban contexts in the United States it was shown that the sensitivity to climate change is positively correlated with water-intensive urban natures characterised by irrigated landscaping, a high percentage of single residential houses with private swimming pools, and high income levels (Balling and Cubaque, 2009; Balling et al., 2008). It is expected that there will be a climate-induced increase in residential water consumption in the immediate future. This development calls for a shift from current policies that emphasize the indoor water use while ignoring the very important share of outdoor consumption to overall residential water consumption. These studies suggests that limits on parcel size, the number of swimming pools, and restrictions on outdoor water use would lower climate sensitivity and make the city more resilient to temperature increase as a consequence of climate change. There is a need for adequate water demand management policies and market-oriented approaches, such as conservation-oriented pricing. However, making price incentives effective, targeting the more affluent water users, requires metering and a pricing scheme that achieves a conservation potential in outdoor uses without translating the burden to essential uses and residential households that use considerable lower amounts of water anyway (compare Balling and Cubaque, 2009; March and Saurí, 2009). These arguments are underpinned by the results presented here that clearly show the significant contribution of second home tourism to high water consumption levels, while per capita water consumption in the residential and mass tourist areas is much lower anyway. Water conservation measures in Calvià municipality would have to target second home owners and affluent urban dwellers as key players in residential water consumption. The recommendations for urban development that advocate a more dense urban form and water conservation policies that impose restrictions on irrigated landscaping are equally recommendable in the Balearic context (compare Balling and Cubaque, 2009; Balling et al., 2008).

The issue of water supply and demand in urban and tourist areas is a pressing problem to be addressed by land use policy in the Mediterranean in the immediate future. The results presented here clearly show that planning authorities and other stakeholders in the tourism sector should take the water issue into account when defining future tourism policies and strategies. A sustainable water demand management is likely to become a decisive factor determining the long-term viability of mass and quality tourism on the island of Mallorca.

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