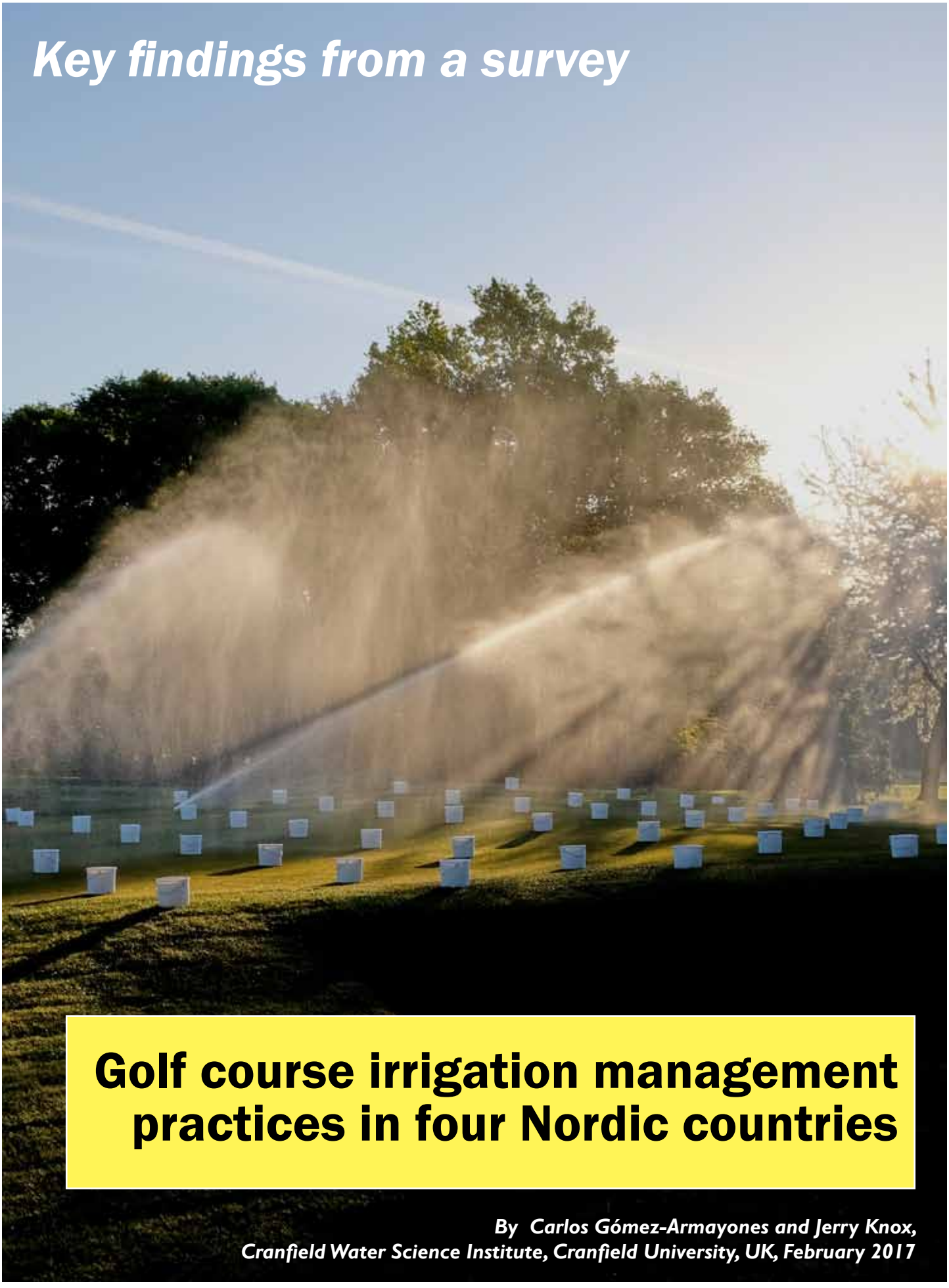
Key findings from a survey



Golf course irrigation management practices in four Nordic countries

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About the project

To achieve and maintain high quality turfgrass standards demanded by players, course management staff have to undertake an intense programme of maintenance activities including mowing, fertilizer and pesticide application, aeration and irrigation.

For golf, irrigation not only helps to meet turf water requirements during periods of drought stress or low rainfall, but also helps to maximize turf playability, improve nutrient efficiency, reduce canopy temperature and is an essential component in turf seeding and re-establishment.

Poor or inadequate irrigation management might reduce turf quality, as well as lead to water and energy wastage and groundwater contamination through the leaching of nutrients and pesticides.

Here we summarise the main findings from an industry survey carried out between January and September 2016 regarding irrigation practices on golf courses in four Nordic countries. The aim was to obtain a much clearer and comprehensive understanding of the state of the irrigation system management being adopted by the golf course sector, identifying opportunities for improvement and future research needs.

The survey forms part of a longer-term PhD programme of research currently being supported by STERF and Cranfield University.

Approach

An online questionnaire was designed and sent via email to 885 golf courses identified from internet searches from four Nordic countries including Denmark (186 golf courses), Iceland (65 golf courses), Norway (148 golf courses) and Sweden (486 golf courses).

The questionnaire consisted in 30 closed questions split into four sections: golf course details; irrigation system characteristics; irrigation management; and environmental impacts of Irrigation.

The questionnaires were distributed by email in January 2016, and the results presented here represent aggregate feedback. A response rate of 13% was achieved.

Table 1 Number of questionnaire responses by country and number of holes on golf course

Holes	9	18	27	Other	Total
Denmark	2 (5%)	19 (50%)	11 (29%)	6 (16%)	38
Iceland	9 (45%)	9 (45%)	2 (10%)	-	20
Norway	6 (27%)	12 (55%)	4 (18%)	-	22
Sweden	6 (10%)	34 (54%)	11 (17%)	12 (19%)	63
Total	**23 (16%)**	**74 (52%)**	**28 (20%)**	**18 (12%)**	**143**

Table 2 Average and median in the reported area (m2) on greens, tees and fairways per hole.

Country	Green area (m^2)		Area tees (m^2)		Area fairways (m^2)	
	Average	Median	Average	Median	Average	Median
Denmark	731	722	404	370	11038	6667
Iceland	461	500	264	333	8013	4611
Norway	573	556	392	389	5517	5111
Sweden	606	556	378	370	5257	5556
All countries	**612**	**556**	**372**	**370**	**7296**	**5556**

Key findings

Half (52%) the survey respondents were from 18-hole golf courses; a fifth (20%) reported having 27-holes and the reminder (16%) were 9-hole golf courses. However, the percentage of courses comprising 9-hole and 27-holes varied significantly between individual countries (Table 1).

Each golf course is unique in terms of the different turfed areas that are assigned to individual parts of the course, which may partly explain the considerable variation in reported areas (m^2) on greens, tees and fairways (Table 2). The reported average area per hole was 612 m^2 on greens, 372 m^2 on tees, and 7296 m^2 on fairways. The average total area on 18-course was 1.2 ha on greens, 0.7 ha on tees and 12.6 ha on fairways.

Soil type has an important influence in creating high quality turf coverage. Feedback from survey respondents showed that three quarters (74%) of their golf course greens were built using modified soils, whereas the percentage of courses that used native soils on greens varied between countries, ranging from 31% in Denmark to only 5% in Norway. The dominant use of modified sandy soils for green construction confirms that almost all courses are built over soils that have good drainage but with less water retention than heavier soils, which make them more dependent on irrigation due to lower water holding capacity. Although fairways usually receive lower levels of maintenance compared to greens or tees, these areas are still important given the large overall proportion of a course they represent. Because of the high costs in modifying fairways, they are usually constructed from local soils (93%): 67% over drought tolerant soils (clay/organic soils) and a 26% over drought susceptible soils (sandy soils).

Table 3 Proportion of golf courses that own an irrigation system and parts of the course irrigated

Country	Irrigation system	Irrigated area				
		Greens	Approach	Tees	Fairways	Rough
Denmark	100 %	100 %	77 %	97 %	17 %	0 %
Iceland	84 %	94 %	11 %	88 %	6 %	6 %
Norway	95 %	100 %	86 %	95 %	60 %	15 %
Sweden	100 %	100 %	90 %	90 %	69 %	6 %
All countries	**97 %**	**99 %**	**75 %**	**92 %**	**47 %**	**6 %**

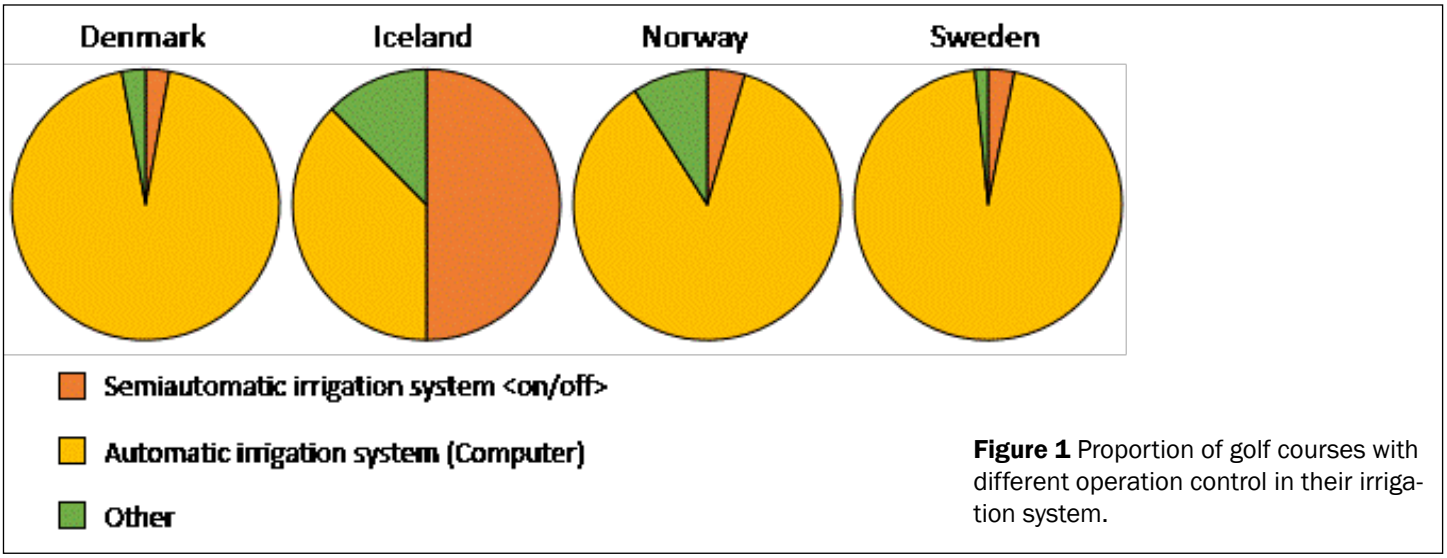

Figure 1 Proportion of golf courses with different operation control in their irrigation system.

Irrigation system characteristics

From courses surveyed, 97% irrigated the greens. This trend was similar for all countries except in Iceland, where 16% courses did not have an irrigation system. The survey also requested information on the different areas irrigated in the course. Almost all (99%) reported that the greens were irrigated; and a slightly smaller proportion for tees (92%) and approaches (75%). Nearly half the courses also irrigate their fairways (47%), although this proportion varied markedly between countries (Table 3).

Only a small minority irrigated the rough (6%). Regarding drainage, 75% of courses reported having artificial drainage systems installed in their courses. Sweden has a very high proportion of courses with artificial drainage (90%), followed by Norway (86%) and Denmark (77%).

The technology used for irrigation plays an important role in improving water efficiency. New technology allows course management staff to control irrigation remotely, recording and monitoring water and energy consumption, enhancing water distribution on the turf, and leading to water and energy savings. In general, most golf courses (87%) control their irrigation using fully automatic systems, i.e., irrigation is operated using a central computer. A minority (9%) operate their irrigation using semi-automatic irrigation systems (manually switching the system on/off) and only 3% use other methods, such as switching on individual sprinklers manually (Figure 1).

Regarding irrigation uniformity, over half (60%) respondents felt that the system uniformity on their course was ‘adequate’; a quarter (24%) considered that their uniformity was ‘very good’. Only a minority of respondents (2%) reported that the irrigation uniformity was ‘excellent’. To compensate for the detrimental effects of poor

uniformity, the use of soil surfactants is widespread. Most courses in Denmark (90%), Norway (90%) and Sweden (87%) use soil surfactants regularly or occasionally on golf greens. In contrast, in Iceland only half (53%) of courses reported using soil surfactants. The proportion used on fairways was much lower, 73% of respondents reported never using surfactants on fairways.

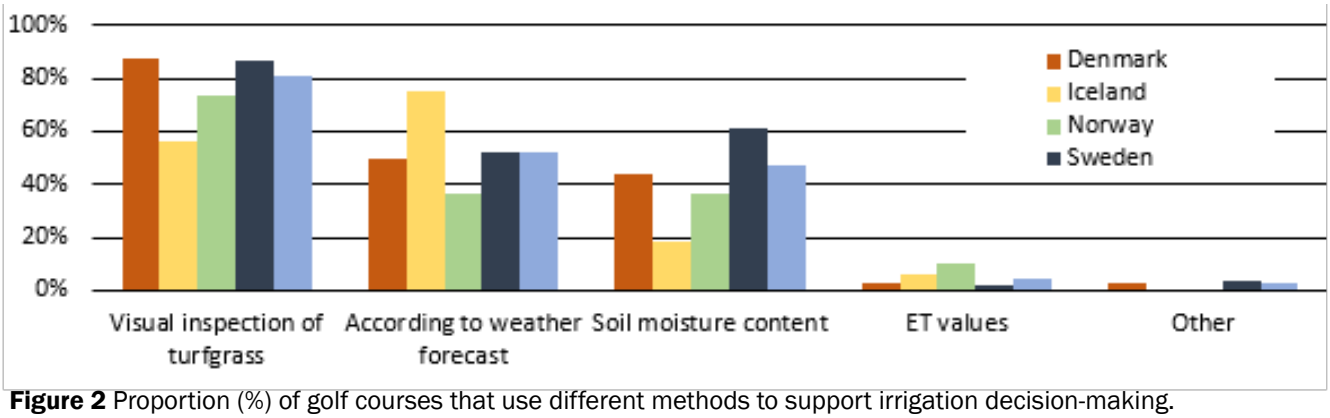

Figure 2 Proportion (%) of golf courses that use different methods to support irrigation decision-making.

Irrigation management

Irrigation efficiency relies not only on the condition of the irrigation system, but also on how irrigation is managed or scheduled. The main factors to be considered in irrigation scheduling are how much and when the water should be applied. Applying just the amount of water helps to maintain a healthy turf while minimising water wastage, groundwater contamination potential risk and other detrimental impacts of excess moisture on turf (disease risk and reduced trafficability). On average, the method most often used to decide when to irrigate is based on turfgrass appearance (81%). The second and third most commonly used methods were weather forecasting (52%) and use of in-situ soil moisture measurements (47%). Only 4% of respondents based their irrigation on evapotranspiration (ET) values (Figure 2).

Irrigation based on visual inspections is widespread but despite achieving good turf quality, may result in excessive water use since the water content in the soil is unknown. On average, only 25% of surveyed courses reported that they knew the field capacity of their soils. This proportion varied between countries: 28% in Denmark, 32% in Iceland, 15% in Norway and 24% in Sweden.

Although the main purpose for irrigating is to replace the turf water use lost through transpiration, irrigation is also used for other reasons. On average, the most common 'other' reasons to water turfgrass include improving turf playability (31%), nutrient uptake (30%) and reducing the turfgrass temperature (28%). Other reported reasons were to wash salts from the soil and to improve turfgrass germination.

Compared to other activities, irrigation does not constitute a major component of maintenance budgets. When irrigation, fertilization, pesticides and other maintenance activities (mowing, sowing, aeration) were compared, budget

Table 4 Reported costs for irrigation expenditure on energy, water, maintenance and consultancy services

Activity	Denmark	Iceland	Norway	Sweden
Energy	20%	11%	19%	24%
Water	44%	25%	12%	17%
Spares/Maintenance	36%	64%	68%	57%
Consultancy	0%	0%	2%	2%
Ave. expense 9 hole (EUR)	2,011	1,721	2,095	1,728
Ave. expense 18 hole (EUR)	7,080	2,928	7,572	10,178
Ave. expense 27 hole (EUR)	9,294	2,459	13,615	9,192

allocations for irrigation varied between 3 and 8%. When respondents were asked about the composition of irrigation costs (Table 4), on average, 36 to 68% of costs were allocated to spares and maintenance, 13 to 41% on water consumption and 11 to 23% on energy. However, respondents reported that it was very difficult to accurately estimate costs for each component of golf course operation and management.

Regarding metering the volumes of water consumed, there were large differences reported between individual countries. In Denmark a very high proportion (89%) of courses record water consumption in contrast to 13% in Iceland, 25% in Norway and 45% in Sweden.

Environmental impacts of irrigation

In general, the survey responses indicated that irrigation was not considered to be an activity that produced significant negative impacts on the environment. Overall, three quarters (73%) of respondents disagreed with the view that water use was an environmental issue on golf courses. This proportion was higher in Norway (90%) and Sweden (84%), although a majority of respondents (74%) also agreed that overirrigation may lead to more pests and therefore greater reliance on pesticides treatments. Survey participants were also asked to rate to what extent irrigation and maintenance activities in golf impact on the environment. The general perception was that these activities generate little or no negative environmental impact. Finally, respondents were asked to choose two actions they would carry out to reduce water requirements on their course (Figure 3).

On average, 54% would improve the irrigation uniformity in their system, and 49% considered that less water could be used by adopting better scheduling strategies. However, this option varied markedly between countries. The option that was considered least attractive was to install new infrastructure to reduce water leakage (29%).

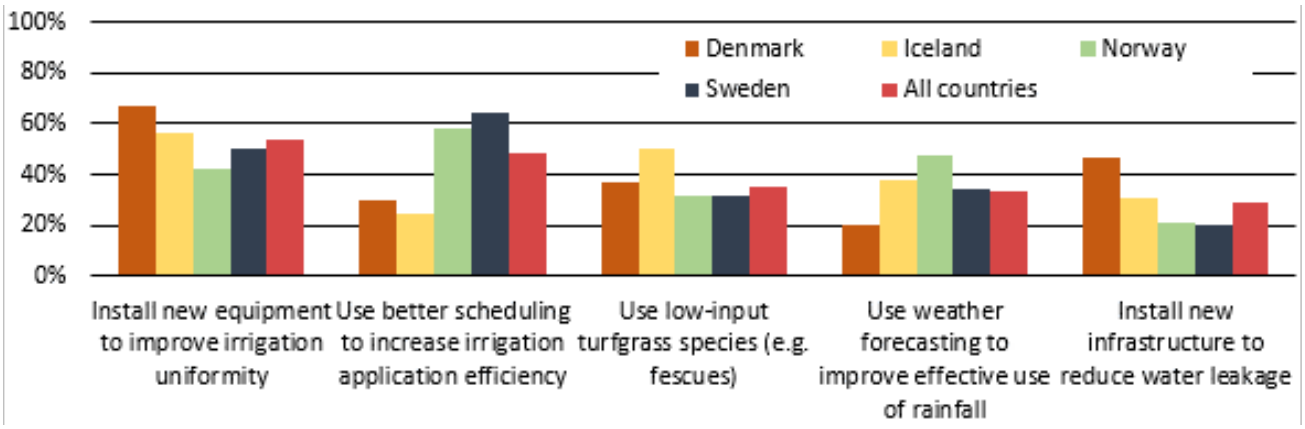

Figure 3 Measures considered most appropriate to reduce water needs in golf

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