Title: Whole Farm Water Use: A Survey of Northeastern Vegetable Producers
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Key Points

Pre-harvest activities

- The majority of respondents to our survey reported using water for irrigation at least one time in 2017. The predominant irrigation approach among respondents is drip/trickle irrigation, with some respondents reporting use of overhead sprinklers (stationary or traveling).
- The majority of respondents draw from more than one type of water source for irrigation. Deep wells, rivers, and municipal water sources were commonly reported.
- The majority of those respondents who irrigate decided to do so by monitoring crop conditions and/or the feel of the soil.
- Less than half of respondents report testing the quality of water used for irrigation water. The majority of those who do test report testing one time per year. The majority of tests are performed to monitor E. coli presence in irrigation water.

Post-harvest activities

- Most survey respondents wash produce. Respondents use a variety of washing/cooling systems including single, double, and triple wash systems, barrel washers, hydro coolers, and spray systems. There was no single dominant washing system reported by respondents.
- Most respondents who reported washing produce use water drawn from deep wells or municipal systems.
- Most respondents did not report using a sanitizer in their wash water. The majority of those who do use a sanitizer use peroxyacetic acid. The majority of these respondents do not check sanitizer concentration after the initial application.
- The primary method of wash water disposal described by respondents is discharge onto bare ground, often covered by vegetation.

1. Introduction

Produce safety and climate change are two overlapping risks that face vegetable producers in the northeastern United States. Because of recent public health outbreaks (and subsequent litigation) traced back to fresh produce, food safety hazard identification and risk mitigation has become the focus of significant regulatory changes in the United States (FDA 2015). Climate change has been identified as a factor affecting water availability and also increasing microbiological risks in the global produce-supply chain, due in part to an increase of pathogenic bacteria in foods following extreme weather events (Ziska et al. 2016). In the absence of adaptive on-farm management strategies, climate change will likely increase produce safety risks, decrease yield and gross income from specialty crops, and challenge farm viability (Jaykus et al. 2008; Walthall et al. 2012).

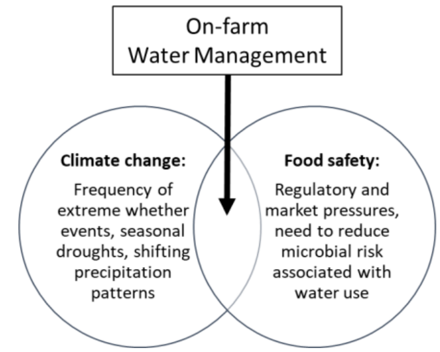

Figure 1: Water management is the common denominator between climate change adaptation and food safety risk mitigation on Northeastern vegetable farms.

Water plays a variety of essential roles on northeastern vegetable farms including irrigation, frost protection, delivery of pesticide and fertilizers, cooling, and washing. In addition to the important role water plays in efficient production systems, it is a key factor in the management of produce safety. An adequate supply of uncontaminated water is critical to the long-term viability of fresh produce farms in this region. Because of climate change and shifting regulatory landscapes, specialty crops producers in the Northeast will likely need to adjust their water management practices, including increases in irrigation areas and rates (McDonald and Girvetz 2013), and careful consideration of irrigation water source and method of application (Liu et al. 2016). The state of water as it leaves the farm is also of increasing importance, as extreme rainfall events can lead to harmful phosphorus and nitrogen contamination of public surface waterways (Buda et al. 2017). In sum, it is likely that current on-farm water management practices will need to change as it becomes increasingly unrealistic to treat water as an inexhaustible, uncontaminated resource.

Currently, little is known about the quality and quantity of the water that specialty crop farms use in the Northeast, the relative importance of different sources of water, and the reliability of these sources under drought or flooding conditions. To address this, we asked vegetable producers in two Northeast states (Vermont and Massachusetts) about their water use practices, including irrigation, vegetable wash water, and water discharge.

2. Methods

In 2017, we developed a survey tool which was reviewed by UVM Extension and UMass Extension staff. Five Extension personnel and one farmer tested the survey prior to deployment. IRB Exemption was secured through the University of Vermont (CHRBSS: 18-0199). The survey was executed in UVM Lime, an online platform that allows for branching logic. The target participants were subscribers to the Vermont Vegetable and Berry Growers Association (VVGBA) listserve (608 subscribers, including an estimated 523 farmers) and subscribers to UMass VegNotes Newsletter (2,786 subscribers, including an estimated 1,906 farmers). The estimated number of farmers on both lists was 2,167 individuals. Though we targeted farmers in Vermont and Massachusetts, some subscribers to the VVGBA listserv and the VegNotes Newsletter come from other northeastern states. We addressed potential overlap in subscribers to both lists by creating survey settings that placed cookies once respondents took the survey, disallowing them from taking it again.

The survey was deployed to both the VVGBA listserv and the VegNotes Newsletter recipients three times between November 8, 2017 and January 11, 2018. These surveys were executed without incentives. In addition, we conducted an intercept survey with the same on-line survey instrument at the annual VVGBA members meeting in January, 2018. Participants in the intercept survey were incentivized with a free water test. The survey was closed on February 6, 2018. We collected responses from 155 individuals (26 partial responses, 121 full responses). Using the AAPOR response rate approach 4, which accounts for both partial and full responses (AAPOR 2016), we calculated that the response rate for VVGBA members was 10%, the response rate for VegNotes subscribers was 1%, and the combined response rate was 5%. Because of low response rates, the results that we report from this survey should be interpreted with caution; they are the indicative of survey respondents only, and should not be generalized to the greater population of vegetable producers in the Northeast. Analysis was conducted using IBM SPSS Statistics 24 (IBM 2017).

3. Results

The majority of survey respondents reported growing vegetables (80% of respondents), berries (50%), cover crops (50%), ornamentals (16%), tree fruit (9%), and livestock feed (9%). Seventy-six percent of respondents reported producing products in two or more of the categories listed. Seventy-six percent of respondents were farm owners, while 39% were farm managers and 6% were farm staff. On average, respondents had 19 years of experience working on their current farm, with a standard deviation of 15 years. The majority of respondents were from Vermont (60%) and Massachusetts (24%) (see figure 2).

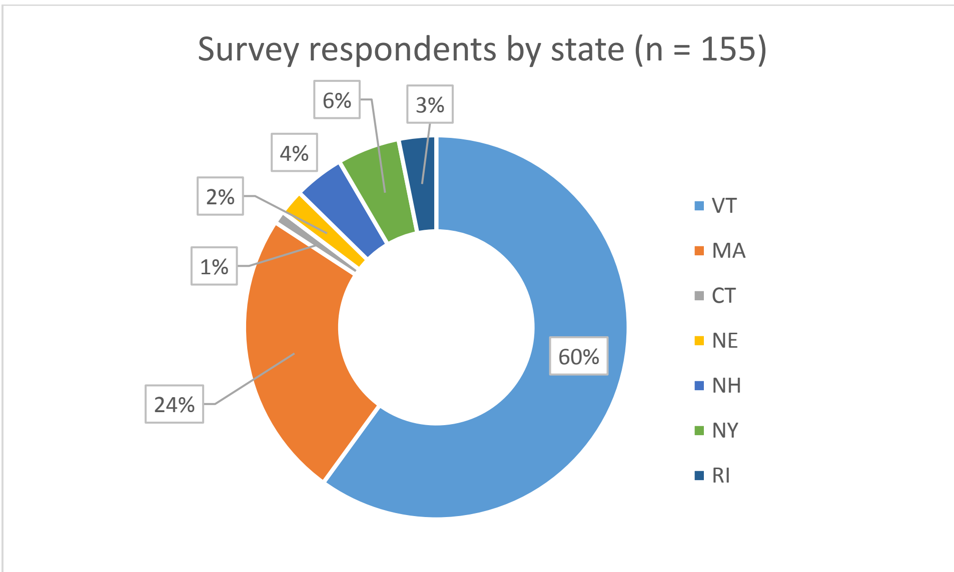

Figure 2: Survey respondents by state

Our sample of respondents reported acreage in production (mean = 26 acres, median = 8 acres) and square feet in high tunnel production (mean = 7,287 sq. ft., median = 2,940 sq. ft.). We asked respondents to report the number of acres irrigated in 2017, (mean = 15 acres, median = 4 acres). All production areas covered by high tunnels were irrigated.

3.1. Irrigation

The majority of respondents (90%) reported irrigating either field acres or high tunnels/greenhouses in 2017. Among those who reported *not* irrigating, 80% reported that they do not have the necessary equipment, and 70% reported that the crops they grow do not require irrigation. No respondents reported that they do not have enough information about irrigation.

Sources of irrigation water reported by survey respondents include deep wells[1] (57% of respondents reported using this source), ponds (33%), municipal sources (25%), shallow wells[2] (20%), rivers (20%), streams or creeks (18%), springs (10%), and cisterns (2%). The majority (54%) of respondents reported using two or more water source types for irrigation purposes, while 33% reported using a single type of source. When asked if they discontinued irrigation because of an insufficient water supply at any point in 2017, the overwhelming majority of respondents (98%) reported that they had not.

The majority of respondents who reported irrigating (94%), reported using drip/trickle irrigation. In addition, 59% reported using non-mobile overhead irrigation systems, and 28% reported using traveling overhead systems. Four respondents reported hand watering, and one respondent reported using a hydroponic system. No respondents indicated use of furrow irrigation, which is more common in western parts of the United States. Sixty-seven percent of respondents reported using two or three of the previously listed irrigation approaches, while 33% reported using a single irrigation approach (see figure 3).

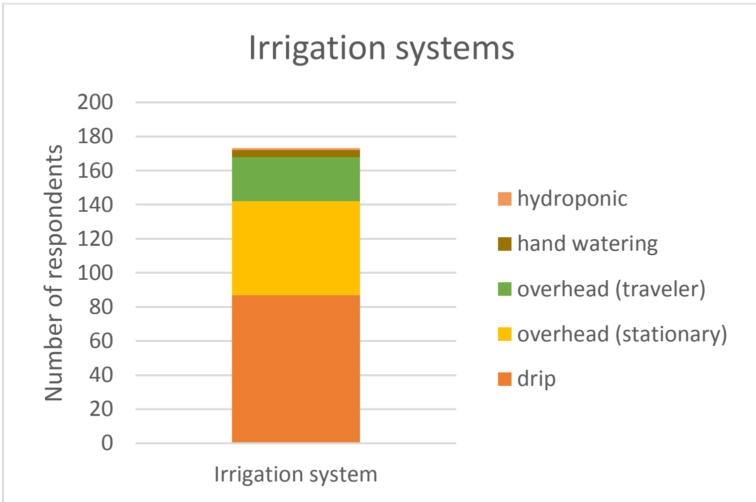

Figure 3: Type of irrigation systems used by respondents (n = 93). Respondents were allowed to select more than one type of watering system.

When asked how they decided when to irrigate, respondents were invited to select as many options as applied to them. The majority of farmers who responded to this question reported that they used crop condition (89% of respondents) and/or the feel of the soil (83%) as their cue to irrigate. Forty-four percent of respondents reported using weather reports, likely related to precipitation forecasts and/or use of overhead irrigation as a method for protecting early season crops (i.e. strawberries) from frost (see figure 4). Most respondents (93%) reported that they did not measure the quantity of water used for irrigation in 2017. Of the few respondents that reported tracking the amount of water used for irrigation, three were located in Vermont, one was located in Massachusetts, and two were located in New Hampshire.

[1] Defined as more than 25' in depth
[2] Defined as less than 25' in depth

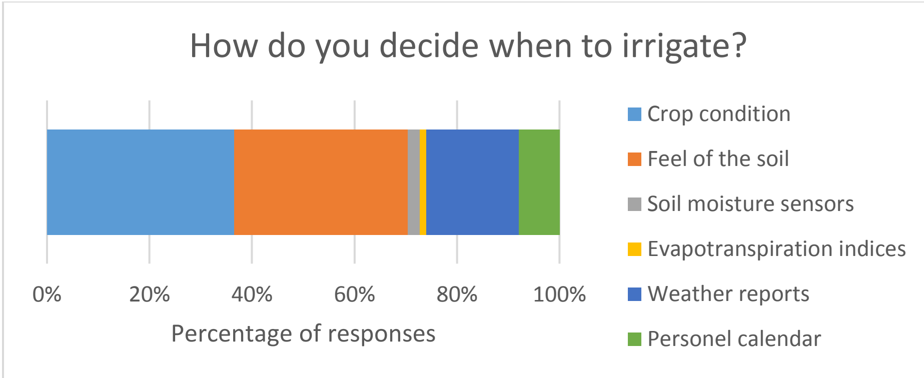

Figure 4: Cues to irrigate reported by survey respondents (n=93). Respondents were allowed to report more than one cue.

3.2. Wash water

Eighty percent of respondents reported that they used water to wash or cool produce in 2017, and 51% reported doing so in winter months (December – March). The majority of respondents drew vegetable wash water from deep wells (59% of respondents), municipal sources (35%), shallow wells (8%) and springs (8%). There was no dominant method used for washing produce, with closely comparable numbers of respondents reporting use of single dunk tanks (19%), double dunk tanks (17%), triple dunk tanks (18%), barrel washers (14%), hydro coolers (13%) and overhead spray systems (20%) (see figure 5). No respondents reported measuring the amount of water used in washing or cooling in 2017. Of the respondents who reported not using water for washing or cooling in 2017, the majority reported that the crops they grew did not require it (70% of respondents), while 20% reported that their buyers do not require product to be washed, and 10% reported that they do not have the equipment or building space for washing or cooling produce. No respondents reported that they did not have enough information about washing and cooling.

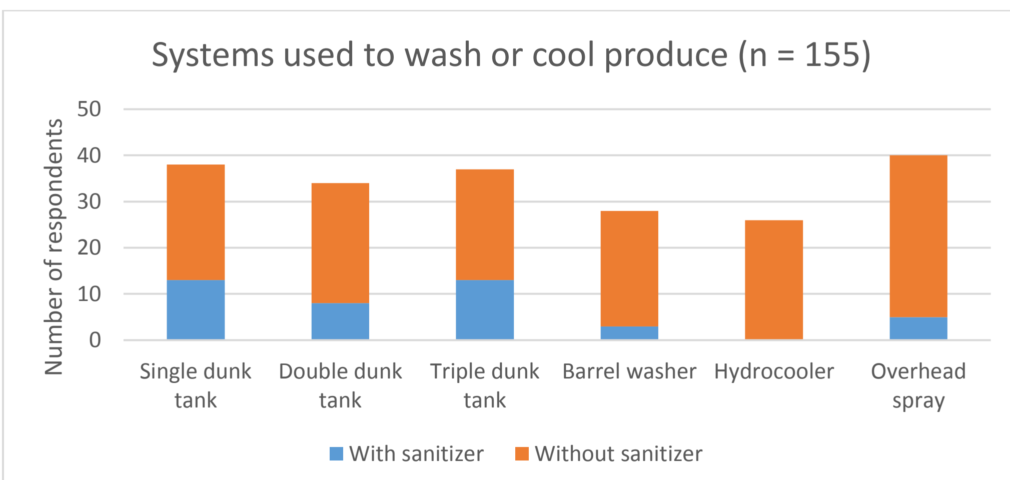

Figure 5: Washing and cooling systems reported by survey respondents

Respondents who reported adding sanitizer to their wash water used the following: 32% of respondents used peroxyacetic acid (brand names include Sanidate, Tsuamni, VigorOx) and 5% used a chlorine-based sanitizer. Sixty-five percent of respondents reported not using a sanitizer in their wash water. Those who reported using sanitizer were asked if they checked for sanitizer concentration at any time in 2017. Twenty-one percent reported that they had checked using produce-specific test strips and 4% reported checking using pH test strips, but the majority (64%) reported not checking for sanitizer concentration. Twenty-nine percent of those respondents who used sanitizers reported checking concentration levels at every wash (29%), daily (29%), weekly (14%), monthly (14%), or once a year (14%).

Reasons given for not using sanitizer are described in figure 6. The predominant reason given for not using sanitizer was *I don't think I need it* (75% of responses to this question.) Write in responses shed light on the diversity of reasons why growers may feel that they don't need to use sanitizer: one respondent reported installing a ultraviolet light system, another reported that they draw water from a municipal system, and a third reported they have not had any problems in the past. Yet another respondent cited research by the University of Vermont Extension showed that triple washing provides sufficient protection from E. coli contamination (Blevins and Grubinger 2015).

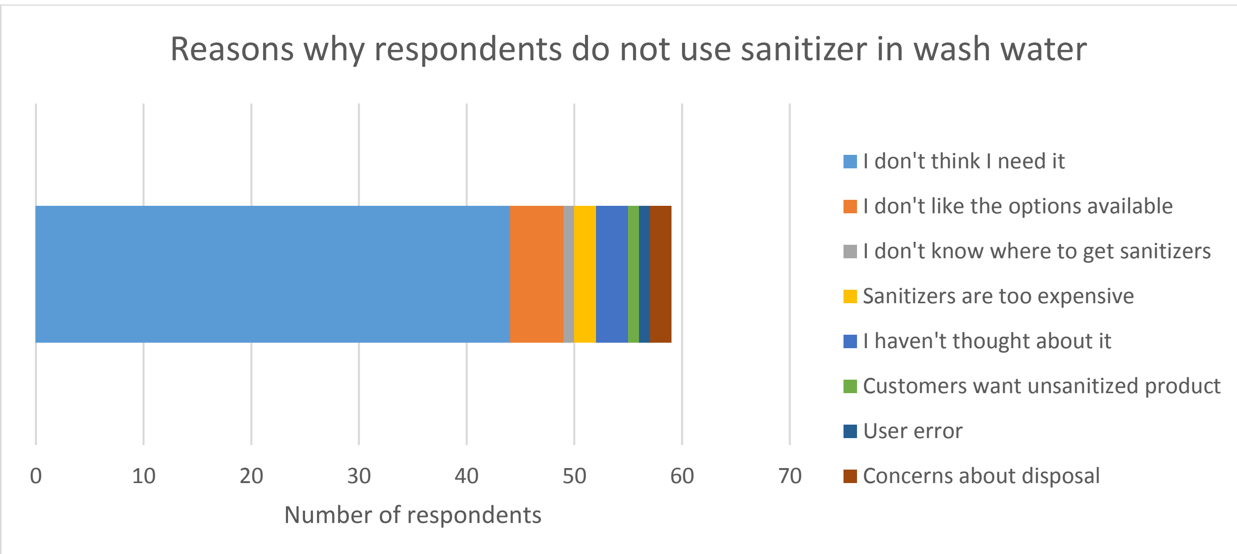

Figure 6: Respondent reported reasons for not using sanitizer in wash water (n = 155)

3.3. Water quality

Forty-four percent of respondents reported testing the quality of their irrigation water, with the majority of these testing once per year (78% of respondents). Respondents that do not test the quality of their irrigation water provided a variety of reasons why they do not do so: 64% reported that their water source was low risk (e.g. groundwater), 35% reported that their customers do not require water tests, 23% reported that they did not have enough information about water testing, 11% reported that water testing was too expensive, and 6% reported that they didn't know where to send water tests. Additionally, six respondents reported that they draw water from a municipal source, and the municipality conducts the water tests on their behalf. Of respondents who report testing their irrigation water, the majority (90%) report testing for E. Coli, 12% report testing for nitrate contamination, 12% for heavy metal contamination, and 7% for biological or chemical agents.

Meanwhile, 49% of respondent reported testing the quality of water used for vegetable washing or cooling purposes. Those who did not test wash water cited the following reasons: customers do not require it (36%), the producer did not think they had enough information about water testing (10%), the producer doesn't know where to send samples (5%), and water tests are too expensive (5%). Additional write-in responses by producers included that they drew water from municipal sources (17 respondents), or the water was from a well (4 respondents). Of respondents who report testing their wash water, all (100%) reported testing for E. Coli, while 18% report testing for nitrate contamination, 10% for heavy metal contamination, and 7% for biological or chemical agents. Seventy-six percent reported never receiving a negative test result from a water test. For those who have received unsatisfactory test results, 16% reported treating the water source, 3% reported ceasing use of the water source, 3% reported doing nothing, and 1 individual reported taking another sample from a different tap.

Preventing backflow into irrigation systems is one approach that growers can take to stop contamination before it happens. Among those respondents who reported irrigating field crops, 23% reported that all systems were equipped with backflow prevention devices, 9% reported that some systems were equipped, and 22% reported that no backflow prevention devices were installed. Among those who reported irrigating in high tunnels or greenhouses, 26% reported that all systems were equipped with backflow prevention devices, 12% reported that some systems were equipped, and 15% reported that no backflow prevention devices were installed (see figure 7).

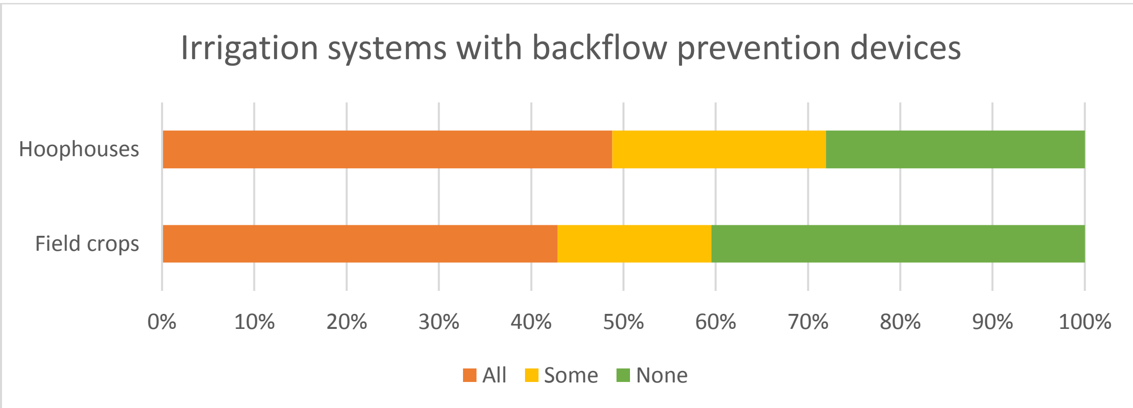

Figure 7: Prevalence of backflow prevention devices used by survey respondents in field crop and hoop house irrigation systems (n = 155)

The predominant method for disposing of water used for washing and/or cooling is by releasing the water onto bare ground mostly covered by vegetation (63% of respondents), or onto bare ground covered by sand, gravel, or silt (24%), or onto a non-porous surface (5%). Alternatively, respondents reported disposing of wash or cooling water using a leach field (18% of respondents). Respondents reported other disposal methods not listed in the survey options including a concrete tank that empties into a dry well tank (1 respondent), a settling pond (1 respondent), and an underground gravel field (1 respondent). A minority of respondents reported releasing water into a ditch or directly into surface water (4%).

3.4. Water related concerns

Respondents reported concerns surrounding a variety of water-related topics (see figure 8). Among the topics we inquired about, producers were most concerned about irrigation-related issues, including (1) aligning irrigation quantity and timing to best meet crop needs (83% reported being very concerned or concerned about this topic), (2) water conservation in irrigation (80%), and (3) irrigation practices to protect produce safety (77%). Respondents were also concerned about wash water quality to protect produce safety (75%), and labor/time management in pre-harvest activities (77%). Topics of lowest concern among survey respondents were wash water discharge (59% of respondents reported being very concerned or concerned about this topic), and conserving water in post-harvest activities (e.g. washing or cooling produce) (67%).

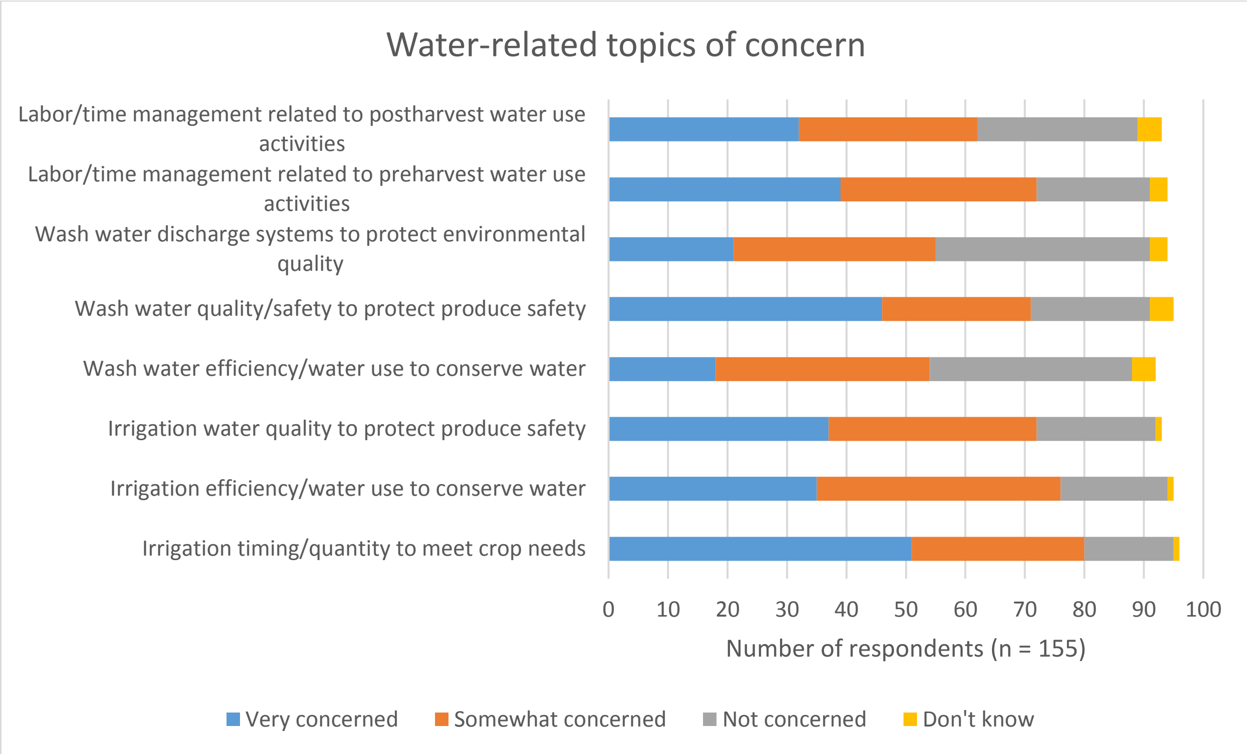

Figure 8: Level of concern reported by respondents related to different water-use topics

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