

Supplementary Information (SI)

Fostering Responsible Innovation through Stakeholder Engagement: Case Study of North Carolina Sweet potato Stakeholders

Khara Grieger^{1,2*}, Sebastian Zarate^{3,2}, S. Kathleen Barnhill-Dilling², Shelly Hunt⁴, Daniela Jones⁴, Jennifer Kuzma^{5,2}

¹Department of Applied Ecology, North Carolina State University

²Genetic Engineering and Society Center, North Carolina State University

³Department of Forestry and Environmental Resources, North Carolina State University

⁴Department of Biological and Agricultural Engineering, North Carolina State University

⁵School of Public and International Affairs, North Carolina State University

*Correspondence: kdgriege@ncsu.edu

1. Interview Guide for Study Participants

The following interview guide was used by the Sweet-APPS team to conduct individual interviews with sweet potato stakeholders. The interview questions related to three areas of the Sweet-APPS project: 1) Sweet-APPS scanning and imaging technology, 2) User Interface, and 3) Data and User privacy.

Sweet-APPS Scanning and Imaging Technology. The first set of questions relate to the attributes of the diagnostic and sensing platform that we are developing in Sweet-APPS. These include the types of features that may be useful for you as a sweet potato stakeholder in North Carolina.

1. What are some sweet potato production issues or storage problems that you think could be addressed with a new diagnostic sensing and data platform? By “diagnostic sensing and data platform”, we mean an integrated platform that relies on sensing (to detect external and internal features of sweet potatoes) as well as data science and analytic capabilities to help stakeholders make informed management decisions.
2. On a scale from not important to very important, how important do you think it is to estimate sweet potato yields for their:
 - *Shape?*
 - *Size?*
 - *Color?*
 - *Surface defects?*
3. Would you like to elaborate on the importance of any of these or other sweet potato characteristics?
4. Are there *particular attributes or features* you would like to see included in an imaging, diagnosis, and analysis framework?
5. Do you think the platform should classify *pest and pathogen damage*? Why or why not?
6. Do you think the platform should address *chemical or physical indicators of internal produce damage (such as internal necrosis, rot, or insect damage)*? Why or why not?

7. Although this hasn't been developed yet, our team was also thinking of including *deep-tissue quality* that are superior to X-ray scanners, to detect internal metabolites, absorption, and cellular distributions. This perhaps could be explored in next stages of our sensing capabilities. However before going further with our work, we are interested if this would be of interest? Why or why not?
8. Do you think it is important to quantify *environmental factors*, such as temperature, rainfall, soil moisture, pest pressure, when estimating sweet potato yield in the field? Why or why not?
9. Can you rank these *environmental parameters* in order of priority, from most important to least important?
10. Do you think it is useful to have an *estimate of root grades in each bin before sorting*, for example to estimate the US No. 1's per bin? Why or why not?
11. Are there any *other characteristics of storage roots* that are important to quantify? If so, what are they?

User Interface. The next set of questions relate to the attributes of the user interface of the Sweet-APPS platform. A user interface is the means by which you or other users and a computer system interact, such as a computer program, model, or app. With the Sweet-APPS platform, you would be able to classify a sweet potato by taking a picture.

12. We are considering having the diagnostic and sensing platform available for use primarily on a *computer interface*, although we are also exploring options for *connecting to smart phones* too. Do you think it would be useful (for you or other stakeholders) to have the ability to use or connect to a smart phone rather than only using a desktop or laptop computer? Why or why not?
13. We were also envisioning developing the platform in English, however do you think a *Spanish module* would be useful as well? Why or why not?
14. Are there any *other features* on the user interface that you think would be helpful for stakeholders? If so, what are they?

Data and User Privacy. The next and final set of questions relate to aspects of protecting data and user privacy on the Sweet-APPS platform, as our project takes data privacy, protection, and confidentiality very seriously and have put into place numerous mechanisms to safely acquire, use, and store stakeholder-provided data and information. As background, we are planning on using, obtaining, and storing various data types related to growing, packing, and storing sweet potatoes, including i) physical characteristics of sweet potatoes (e.g. shape, size, color, surface defects), ii) field and farm-specific information (e.g. yield per acre, packout weight after storage, input information such as fertilizer and pesticide usage, tillage), iii) environmental parameters or field conditions (e.g. temperature, rainfall, soil moisture, pest pressure), and iv) georeferenced data such as site location. We would like to note that the Sweet-APPS project ensures that user/stakeholder data will be anonymized, de-identified, and names, company names, and other private information like customer lists will never be included.

15. First, we would like to be able to *store data on a cloud* that would be protected by the provider. A "provider" in this case is the cloud data service provider. For this project, we are using Microsoft Azure as the cloud platform, which has standard security practices for keeping stored data secure. *Do you have any questions about storing your data on a cloud? If so, what are they?*

Next, we have a few questions on privacy aspects related to specific data or information types:

16. Do you think it is important to have privacy and data protection regarding sweet potato *shape, size, color, and surface defects* when considering a sweet potato sorting system? Why or why not?
17. Do you think it is important to have privacy and data protection for *environmental parameters*, such as temperature, rainfall, soil moisture, and pest pressure? Why or why not?

18. Do you think it is important to have privacy and data protection for *production practices or inputs* such as application of fertilizers, pesticides, harvest time, or other factors? Why or why not?
19. Do you think it is important to have privacy and data protection on any sweet potato *licensed algorithms* generated by this project and developed by the NC State Sweet-APPS team? Why or why not?

Next, our team would also like to be able to *aggregate data and information* in order to help improve our models to make predictions. This would mean that a user/stakeholder would provide their raw, individual data that would then be aggregated or combined with other relevant users/stakeholders across the NC sweet potato supply chain by the Sweet-APPS team in order to improve its overall utility for sweet potato stakeholders. Keep in mind that the Sweet-APPS project ensures that user/stakeholder data will be anonymized, de-identified, and all identifying characteristics, including names, company names, and/or customers will never be included. We have a few questions about how you feel about aggregating data and information on the Sweet-APPS platform, with the goal of ultimately improving our data analytic capabilities that will, in turn, help stakeholders make informed decisions based on these data.

20. Do you have any *questions or concerns about de-identifying and aggregating your data and information* with others stakeholders? If yes, what are they?
21. On a scale from not at all comfortable to completely comfortable, *how comfortable are you with sharing your data* with other stakeholders?
22. Are there certain data points or pieces of information that you are *most concerned* about sharing? If so, what are they? Keep in mind that these are de-identified and anonymized data.
23. Are there certain data points or pieces of information that you are *least concerned* about sharing? If so, what are they?
24. We are also exploring an option of *stakeholders being able to only share output analytics* with other stakeholders rather than sharing their own, raw data. Would that be of interest to you? Why or why not?
25. *Who are you most concerned about* in regard to accessing your data? Why?
26. Are there any *other issues* or thoughts that we haven't discussed that you think will be important in regard to improving your profitability, or any topics related to data, privacy, and users? If so, what are they?

2. Results from Stakeholder Interviews

Table S1. Stakeholder participant views of Sweet-APPS sweet potato features and attributes according to perceived importance or value. Values shown in both total number and percentage of total participants across stakeholder groups.

	No. of stakeholder participants	1. Size		2. Shape		3. Color		4. Surface defects		5. Internal defects		6. Deep tissue	
Stakeholder group		n	%	n	%	n	%	n	%	n	%	n	%
Growers with packing lines	9	9	100 %	9	100 %	7	78 %	9	100 %	5	56 %	0	0 %
Growers without packing lines	6	6	100 %	6	100 %	6	100 %	5	83 %	1	17 %	0	0 %
Industry and leadership	10	10	100 %	10	100 %	10	100 %	10	100 %	6	60 %	3	30 %
Supply chain stakeholders	4	4	100 %	3	75 %	3	75 %	4	100 %	3	75 %	2	50 %
Total	29	29	100 %	28	97 %	26	90 %	28	97 %	15	52 %	5	17 %

Table S2. Stakeholder participant views of Sweet-APPS environmental parameter and user interface features and attributes according to perceived importance or value. Values shown in both total number and percentage of total participants across stakeholder groups.

	No. of stakeholder participants	7. Rain fall		8. Soil moisture		9. Pest pressure		10. Temperature		11. Prod. Practices		12. Smart phone		13. Spanish	
Stakeholder group		n	%	n	%	n	%	n	%	n	%	n	%	n	%
Growers with packing lines	9	7	78 %	9	100 %	8	89 %	9	100 %	3	33 %	9	100 %	8	89 %
Growers without packing lines	6	6	100 %	5	83 %	5	83 %	6	100 %	3	50 %	6	100 %	6	100 %
Industry and leadership	10	8	80 %	7	70 %	8	80 %	7	70 %	2	20 %	10	100 %	7	70 %
Supply chain stakeholders	4	4	100 %	4	100 %	3	75 %	4	100 %	2	50 %	4	100 %	3	75 %
Total	29	25	86 %	25	86 %	24	83 %	26	90 %	10	34 %	29	100%	24	83 %

Table S3. Stakeholder participant views of data and privacy protection relevant for Sweet-APPS platform. Values shown in both total number and percentage of total participants across stakeholder groups.

	No. of stakeholder participants	14. DP - SP key attributes		15. DP - Environ parameters		16. DP - Prod. practices		17. DP - Algorithm		18. DP - Aggr. data		19. DP - Comfort sharing		20. DP - Concerned access	
Stakeholder groups		n	%	n	%	n	%	n	%	n	%	n	%	n	%
Growers with packing lines	9	6	67	3	33	5	56	1	11	0	0	6	67	7	78
Growers without packing lines	6	3	50	2	33	4	67	0	0	0	0	4	67	4	67
Industry and leadership	10	9	90	6	60	9	90	3	30	3	30	3	30	8	80
Supply chain stakeholders	4	2	50	1	25	2	50	1	25	1	25	3	75	3	75
Total	29	20	69%	12	41%	20	69%	5	17%	4	14%	16	55%	22	76%