



Dr. Ephraim Nuwamanya
Lecturer / Crop Scientist

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Makerere University, Kampala, Uganda.
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About/Introductory statement

- Experienced researcher and Lecturer of plant physiology and biochemistry with a demonstrated history of working in the agriculture and biotechnology industry.
- Skilled in biochemistry techniques, plant based phenotyping, Near Infrared Spectroscopic techniques, abiotic stress elucidation and management, food sciences and molecular Biology.
- Pioneering scientists for high value products and solutions towards climate effects alleviation such as bioplastics, bioethanol, biodiesel, seedling wraps, and composites long storage foods from local sources.
- Strong community and social services outreach interventions towards mainstreaming developed products such as bioethanol and bioplastics in communities where they are needed.
- An accomplished wide ranging science professional with a Doctor of Philosophy (PhD) focused in Plant physiology (Agriculture) from Makerere University.

Qualifications

PhD in Agriculture, Makerere University, 2016
MSc in Crop Science, Makerere University 2010
MBA-Management, University of Suffolk, 2022
BSc-Science, Makerere University, 2006

Biography

Ephraim Nuwamanya is an academic researcher from various Agricultural Research based organizations including Makerere University Kampala, the National Agricultural Research Organisation and Kyambogo University. Currently employed as a lecturer at the prestigious Makerere University, Ephraim's Research interests span over a range of disciplines with the main ones being plant biochemistry, plant physiology, and crop based product development, laboratory management, and student supervision and training. Through the tenure of his duty, Ephraim has published various works in peer reviewed journals and has contributed to publication of books (4 books) covering a range of topics on sustainability of the agricultural sector. Perhaps the most interesting part of Ephraim's career is his ability to work with teams from other scientific disciplines to achieve specific targets. This includes teams from computer science, robotics and social sciences accounting for about 25% of his scholarly works. These works include artificial intelligence in agriculture, development of high throughput disease detection tools, and working in communities to improve traditional processes and refine them for better production.

Ephraim also has leadership experience having been the lead scientist for the nutrition and bioanalytical laboratory at the National Crops Resources Research Institute (NaCRRI). He has also been the principal investigator of several projects including the Seedling wrap project funded by UK government through Bangor University, the UNCST funded project for starch modification and bioplastic production, the competitive Grants project on biodiesel production and the Mak-RIF funded project on sustainable production of coffee seedling bags.

Other Activities

- Postdoc, crop product phenotyping, Nutritional and BioAnalytical Laboratory, National Crops Resources Research Institute (NaCRRI).
- Consultant (Biochemistry and Environmental social safeguards)
- Visiting Scholar, Kyambogo University Department of biological sciences.
Consultant on Plant biochemistry, Agricultural chemistry.

- Member of the intellectual property management committee of the National Agriculture Research Organisation (NARO) from 2017-2019
- Member of the committee for development and implementation of environmental and social safeguards (ESS) for the East African Agricultural Productivity

Teaching

1. CRS1101: Agricultural Botany and Plant physiology- AGRIC, LUM, HOT, FST
2. CRS 1204: Agronomy and Ecology----- AGRIC, HOT
3. CRS 3109: Crop Physiology----- HOT
4. CRS 4102: Crop Physiology----- AGRIC,
5. CRS 7103: Crop Physiology-----MSC CROP SCIENCE
6. CRS 7211: Advanced plant physiology-----MSC CROP SCIENCE
7. CRS720: Ecophysiology-----MSC CROP SCIENCE

Research

- Lead investigator: Sustainable utilization of used oil based feedstocks and crop waste in reducing soil based plastic pollution arising from seedling wraps funded by Mak-RIF 2022
- Lead investigator: The Seedling Wrap Project funded by UK- government through Bangor University, 2022
- Lead investigator: Modification of cassava starch for of packaging materials, funded by UNCST 2016
- Lead investigator: Alleviating effects of used oil on environment. NARO-CGS grants
- Team member, PEARL cassava project (),Bill and Mellinda Gates under Next generation cassava,
- Team member (CO-PI), RTB Endure Project (Developing cassava shelf life extension technologies), 2014
- Lead biochemistry consultant: The East African Agricultural Productivity Project (EAAP)
- Team member BIO-EARN and BIOINNOVATE project Swedish international development agency, 2007

- Research interest

Research groups and Centres

1. The NEXTGEN cassava project: <https://www.nextgencassava.org/>
2. The RTB foods project: <https://rtbfoods.cirad.fr/>
3. The makerere university horticulture crops research group
4. The Biocomposites Centre - Bangor University:
<http://www.biocomposites.bangor.ac.uk/>
5. National Agricultural Research Organization (NaCRRI):
<https://naro.go.ug/about-us/paris/nacri/>

Community based work

1. Matovu, M., K. Wanda, A. Bamidele, H. Muyinza, E. Nuwamanya, S. Aceng, P. Nyamutoka et al. "Manual: setting up a packhouse for waxing and relative humidity storage of fresh cassava roots." (2016).
2. Wanda, K., Nuwamanya, E., Matovu, M., Bamidele, A., Abass, A., Muyinza, H., Kaliisa, R., Luna Melendez, J., Pizarro Sanchez, M., Belalcázar, J. and Becerra, L.A., 2015. Training Report: South-South collaboration for strengthening capacities in assessing the postharvest physiological deterioration (PPD) of fresh cassava roots and technologies for shelf-life extension.
3. Waigumba, S.P., Nyamutoka, P., Wanda, K., Abass, A., Kwagala, I., Menya, G., Acheng, S., Nuwamanya, E., Matovu, M., Kaliisa, R. and Muyinza, H., 2016. Technical Report: Market opportunities and value chain analysis of fresh cassava roots in Uganda.
4. Community action research project boosts production of cassava bio-ethanol in Apac- Northern Uganda. rforum.wordpress.com/2018/05/02/community-action-research-project-boosts-production-of-cassava-bio-ethanol-in-apac-northern-uganda/
5. Member of the education department, Kampala Central Seventh Day Adventist church
6. Member of Kajumseter Self help Scheme

Other general contributions to science

1. Potential of biodegradable and compostable alternatives in production of Bioplastics. www.switchafricagreen.org/national-networking-forum-2017
2. Developing an African bio-resource based chemical industry
...[Www.siani.se/video/developing-african-bio-resource-based-chemical-](http://www.siani.se/video/developing-african-bio-resource-based-chemical-)

[industry/](#).

3. Naro Discovers Biodegradable Kaveera From Cassava Chips....[www.newvision.co.ug](#) › new_vision › news › naro-discovers-biodegr.
4. How farmers process fuel from seeds - Daily Monitor .., [Www.monitor.co.ug](#) › Magazines › Farming
5. Naro Encourages Use Of Cooking Oil Into Bio Diesel..... [www.newvision.co.ug](#) › new_vision › news › naro-encourages-cooki...
6. UK- Uganda Bio-Economy event 3-7 June 2019, Bangor ... [london.mofa.go.ug](#) › data › dnews › UK--Uganda-Bio-Economy-eve...

Publications

1. Grace Nalugo, R., Kaweesi, T., Kawooya, R., Nuwamanya, E., Mugisa, C., Namutebi, V., Tumwine, V., Turyahebwa, V. and Tumuhimbise, R., 2022. Physicochemical analysis of Ugandan tea (*Camellia sinensis*) germplasm reveals potential commercial green and black tea varieties. *Journal of Crop Improvement*, pp.1-20.
2. Alamu, E.O., Nuwamanya, E., Cornet, D., Meghar, K., Adesokan, M., Tran, T., Belalcazar, J., Desfontaines, L. and Davrieux, F., 2021. Near-infrared spectroscopy applications for high-throughput phenotyping for cassava and yam: A review. *International journal of food science & technology*, 56(3), pp.1491-1501.
3. Kpoviessi, A.D., Agbahoungba, S., Agoyi, E.E., Nuwamanya, E., Assogbadjo, A.E., Chougourou, D.C. and Adoukonou-Sagbadja, H., 2021. Primary and secondary metabolite compounds in cowpea seeds resistant to the cowpea bruchid [*Callosobruchus maculatus* (F.)] in postharvest storage. *Journal of Stored Products Research*, 93, p.101858.
4. Iragaba, P., Hamba, S., Nuwamanya, E., Kanaabi, M., Nanyonjo, R.A., Mpamire, D., Muhumuza, N., Khakasa, E., Tufan, H.A. and Kawuki, R.S., 2021. Identification of cassava quality attributes preferred by Ugandan users along the food chain. *International Journal of Food Science & Technology*, 56(3), pp.1184-1192.
5. Esuma, W., Ozimati, A., Kulakow, P., Gore, M.A., Wolfe, M.D., Nuwamanya, E.,

- Egesi, C. and Kawuki, R.S., 2021. Effectiveness of genomic selection for improving provitamin A carotenoid content and associated traits in cassava. *G3*, 11(9), p.jkab160.
6. Nanyonjo, A.R., Kawuki, R.S., Kyazze, F., Esuma, W., Wembabazi, E., Dufour, D., Nuwamanya, E. and Tufan, H., 2021. Assessment of end user traits and physicochemical qualities of cassava flour: a case of Zombo district, Uganda. *International journal of food science & technology*, 56(3), pp.1289-1297.
 7. Nuwamanya, E., Kanaabi, M., Wembabazi, E., Muhumuza, N., Ozimati, A., Esuma, W., Iragaba, P., Angudubo, S., Nanyonjo, A., Tufan, H. and Kawuki, R., 2021. Flour pasting properties define consumer selection decisions for boiled and flour-based cassava food products in Uganda.
 8. ALEXANDER BOMBOM, NUWAMANYA, E., ASIIMWE, P. and EMILIO, O., 2021. CHAPTER FOURTEEN UNLOCKING SORGHUM POTENTIAL TO DRIVE RURAL ECONOMIES IN EASTERN AFRICA 1. *Perspectives on International Research on Science in Africa*, p.207.
 9. Nuwamanya, E., Kanaabi, M. and Alamu, E.O., 2020. NIRS acquisition on fresh cassava roots using the ASD Quality Spec (QST) and relating spectra to root dry matter content by oven method. High-throughput phenotyping protocols (HTPP), WP3.
 10. Nuwamanya, E. and Alamu, E., 2020. NIRS acquisition on fresh matooke fingers using the benchtop NIRS FOSS DS2500 and relating spectra to finger dry matter content by oven method. High-throughput phenotyping protocols (HTPP), WP3.
 11. Nuwamanya, E., Iragaba, P., Kawuki, R.S., Nanyonjo, A.R., Kanaabi, M. and Khakasa, E., 2020. Sensory characterization of boiled cassava. Biophysical characterization of quality traits, WP2.
 12. Owomugisha, G., Mugagga, P.K., Melchert, F., Mwebaze, E., Quinn, J.A. and Biehl, M., 2020, June. A low-cost 3-D printed smartphone add-on spectrometer for diagnosis of crop diseases in field. In *Proceedings of the 3rd ACM SIGCAS Conference on Computing and Sustainable Societies* (pp. 331-332).

13. Aruho, C., Walakira, J.K., Owori-Wadunde, A., Nuwamanya, E., Bugenyi, F., Sserwadda, M., Rutaisire, J. and Borski, R.J., 2020. Growth and survival of Ripon barbel (*Barbus altianalis*) larvae and juveniles fed five experimental diets in captivity. *Aquaculture Reports*, 18, p.100441.
14. Owomugisha, G., Nuwamanya, E., Quinn, J.A., Biehl, M. and Mwebaze, E., 2020, January. Early detection of plant diseases using spectral data. In *Proceedings of the 3rd International Conference on Applications of Intelligent Systems* (pp. 1-6).
15. Ocan, D., Rongrong, Z., Odoch, M., Nuwamanya, E., Ibanda, A.P., Odong, T.L., Lamo, J., Fitzgerald, A.M., Daygon, V.D. and Rubaihayo, P.R., 2020. Volatile organic compound based markers for the aroma trait of rice grain.
16. Bildadi Mlaki, A., Gibson, P., Edema, R., Habineza, J.C., Mwanje, G., Lamo, J. and Nuwamanya, E., 2019. Identification of rice genotypes tolerant to submergence at seedling stage in Uganda.
17. David, O., Rongrong, Z., Martin, O., Michael, K., Angele, P.I., Agnes, A., Bill, W.K., Ephraim, N., Jimmy, L., Melissa, A.F. and Venea, D.D., 2019. Relationship between 2-acetyl-1-pyrroline and aroma in Uganda rice populations with *Oryza* (*barthi*, *glaberrima* and *sativa*) backgrounds. *African Journal of Biotechnology*, 18(31), pp.1016-1024.
18. Ahimbisibwe, M., Banadda, N., Seay, J., Nabuuma, B., Atwijukire, E., Wembabazi, E., & **Nuwamanya, E.** (2019). Influence of Weather and Purity of Plasticizer on Degradation of Cassava Starch Bioplastics in Natural Environmental Conditions. *Journal of Agricultural Chemistry and Environment*, 8(04), 237.
19. **Nuwamanya, E.**, & Atwijukire, E. (2019). Advances in carotenoid increments in storage parts of African staple crops-review. *Journal of Plant Breeding and Crop Science*, 11(3), 68-79.
20. **Nuwamanya, E.**, Acheng, S., Vuzi, P., Muyinza, H., Matovu, M., Atwijukire, E., ... & Adebayo, B. A. (2019). Effectiveness of pruning and waxing in reducing postharvest physiological deterioration in Uganda local cassava varieties. *African Crop Science Journal*, 27(2), 237-251.
21. Atwijukire, E., Hawumba, J. F., Baguma, Y., Wembabazi, E., Esuma, W., Kawuki, R.

- S., & **Nuwamanya, E.** (2019). Starch quality traits of improved provitamin A cassava (*Manihot esculenta* Crantz). *Heliyon*, 5(2), e01215.
22. Ulemu, Msiska Mercy, Miesho W. Belay, M. G. Hailay, Kyamanywa Samuel, Rubaihayo Patrick, Odong Thomas, Tukamuhabwa Phinehas, **Nuwamanya Ephraim**, and Nabirye L. Deborah. "Biochemicals associated with *Callosobruchus chinensis* resistance in soybean." *African Journal of Rural Development* 3, no. 3 (2019): 859-868.
23. Elsidig, Mohammed Khalid, **Ephraim Nuwamanya**, Emmanuel Afutu, Wembabazi Enoch, Mwila Natasha, and Siddig Eisa Idris. "Resistance mechanisms of late leaf spot and rosette diseases in drought tolerant groundnut genotypes." *GSC Biological and Pharmaceutical Sciences* 8, no. 1 (2019): 012-027.
24. Iragaba, P., **E. Nuwamanya**, E. Wembabazi, Y. Baguma, D. Dufour, E. D. Earle, R. B. Kerr, H. A. Tufan, M. A. Gore, and R. S. Kawuki. "Estimates for heritability and consumer-validation of a penetrometer method for phenotyping softness of cooked cassava roots." *African Crop Science Journal* 27, no. 2 (2019): 147-163.
25. Mwila, N., T. L. Odong, **E. Nuwamanya**, A. Badji, S. Agbahoungba, P. A. Ibanda, F. Kumi et al. "Gene Action of Cassava Resistance Metabolites to Whitefly (*Bemisia tabaci*)." *Biotechnology Journal International* (2018): 1-16.
26. Mwila, N., **E. Nuwamanya**, T. L. Odong, A. Badji, S. Agbahoungba, P. A. Ibanda, M. Mwala, P. Sohati, S. Kyamanywa, and P. R. Rubaihayo. "Genotype by environment interaction unravels influence on secondary metabolite quality in cassava infested by *bemisia tabaci*." *Journal of Agricultural Science* 10, no. 8 (2018).
27. Mohammed, Khalid Elsidig, Emmanuel Afutu, Thomas L. Odong, David K. Okello, **Ephraim Nuwamanya**, Olupot Grigon, Patrick R. Rubaihayo, and Patrick Okori. "Assessment of Groundnut (*Arachis hypogaea* L.) genotypes for yield and resistance to late leaf spot and rosette diseases." *Journal of Experimental Agriculture International* 21, no. 5 (2018): 1-13.
28. **Nuwamanya E.**, Baguma Y., Atwijukire E, Acheng S, Abidrabo P., Omongo C.A.,

- and Alicai T (2017). Cassava brown streak disease effects on leaf metabolites and pigment accumulation. ACSJ, Vol. 25, No. 1, pp. 1 - 10
29. **Nuwamanya E.**, Baguma Y., Atwijukire E., Acheng S., & Alicai T. (2015). Effect of cassava brown streak disease (CBSD) on cassava (*Manihot esculenta* Crantz) root storage components, starch quantities and starch quality properties. IJPPB, 7(2), 12-22.
 30. **Nuwamanya, E.**, Rubaihayo, P. R., Mpairwe D, Osiru D, Baguma, Y., & Hawumba, J. Utility of biomarkers in selection for hydrothermal stress tolerance in cassava IJACS/2015/8-2/235-248
 31. **Nuwamanya E.**, Rubaihayo P.R., Hawumba J.F., Kawuki R. & Baguma Y (2015). Analysis of phenotypic responses influencing leaf growth rate and harvest parameters in cassava (*Manihot esculenta* Crantz) under hydrothermal stress. JPBCS, 7(6), 185-202.
 32. **Nuwamanya, E.**, Rubaihayo, P. R., Mukasa, S., Kyamanywa, S., Hawumba, J. & Baguma, Y. (2014). Influence of spectral properties on cassava leaf development and metabolism. AJB, 13(7), 834-843.
 33. **Nuwamanya, E.**, Rubaihayo, P. R., Mukasa, S., Kyamanywa, S., Hawumba, J. F., & Baguma, Y. (2014). Biochemical and secondary metabolites changes under moisture and temperature stress in cassava (*Manihot esculenta* Crantz). AJB, 13(31), 3173-3186.
 34. **Nuwamanya Ephraim**, Robert S. Kawuki, Anton. Bua, Linley Chiwona-karlton, and Yona Baguma; (2011). Utilisation of non food parts of cassava (*Manihot esculenta* crantz) for production of bio-ethanol and biofuels. AMBIO-SPRINGER, DOI10.1007/s13280-011-0183-z
 35. **Nuwamanya Ephraim**, Yona Baguma, Enoch Wembabazi; A comparative analysis of market starches of root, tuber and cereal crops based on their amylose amylopectin properties. AJB pp. 12018-12030,
 36. Mufumbo R, Baguma Y, Kashub S, **Nuwamanya E**, Rubaihayo P, Mukasa S, Hamaker B and Kyamanywa S (2011). Functional properties of starches on the East African Market. African Journal of Food Science Vol. 5(10), pp. 594-602

37. Mufumbo R, Baguma Y, Kashub S, **Nuwamanya E**, Rubaihayo P, Mukasa S, Hamaker B and Kyamanywa S (2011) Amylopectin molecular structure and functional properties of starch from three Ugandan cassava varieties. JPBCS. 3(9), pp. 195-202.
38. Kawuki R. S, Pariyo A., Amuge T., **Nuwamanya E.**, Ssemakula G., Tumwesigye S., Bua A., Baguma Y., Omongo C., Alicai T. and Orone J (2011). A breeding scheme for local adoption of cassava (*Manihot esculenta* Crantz). JPBCS Vol. 3(7). pp. 120-130,
39. **Nuwamanya E.**, Baguma Y., Emmambux N., Kawuki R.S. and Rubaihayo P. R. (2010). Crystalline and pasting properties of starch are influenced by its molecular properties. AJFS 4(1) pp. 008-015, January, 2010
40. **Nuwamanya E.**, Baguma Y., Emmambux N., Taylor J. and Rubaihayo P.R. (2010). Physicochemical and functional characteristics of starch from Ugandan cassava varieties and their progenies. Journal of Plant Breeding and Crop Science Vol. 2(1). pp. 001-011, 2010
41. **Nuwamanya E.**, Baguma Y., Kawuki R. S. and Rubaihayo P.R. (2009). Quantification of starch physicochemical properties in a cassava F1 segregating population. African Crop Science Journal, Vol. 16, No. 3, pp 191-202

BOOKS

1. **Ephraim Nuwamanya**. 2010. Assessment of cassava root starch characteristics in half sib populations derived from a polycross between elite cassava introductions and Ugandan local varieties. A thesis submitted to The Post Graduate School at Makerere University Kampala
2. **Nuwamanya Ephraim**, Yona Baguma and Patrick R. Rubaihayo (2010). Descriptive and comparative analysis of cassava starches: Descriptive and comparative analysis of starches from cassava varieties in East Africa. LAP LAMBERT Academic Publishing, ISBN-10: 3838389182, ISBN-13: 978-383838918
3. **Ephraim Nuwamanya**. 2015. Mechanisms of Tolerance to Hydrothermal stress in cassava (*Manihot Esculenta* Crantz). A thesis submitted to The Post Graduate School at Makerere University Kampala

CONTRIBUTIONS TO BOOKS

1. **Nuwamanya, Ephraim**, Yona Baguma, and ME Chrissie Rey. "An African perspective: developing an African bioresource-based industry—the case for cassava." In *Creating Sustainable Bioeconomies*, pp. 135-147. Routledge, 2016.

CONFERENCE PROCEEDINGS

2. Owomugisha, Godliver, **Ephraim Nuwamanya**, John A. Quinn, Michael Biehl, and Ernest Mwebaze. "Early detection of plant diseases using spectral data." In *Proceedings of the 3rd International Conference on Applications of Intelligent Systems*, pp. 1-6. 2020.
3. Mwila, N., Rubaihayo, S., Kyamanywa, S., Odong, T., **Nuwamanya, E.**, & Mwala, M. (2016). Evaluation of biochemical components as a mechanism of cassava resistance to whitefly infestation in Uganda. *Regional Universities Forum for Capacity Building in Agriculture*.
4. Aruho, C., Wadunde, O., **Nuwamanya, E.**, Bugenyi, F., Borski, R. J., & Rutaisire, J. (2018). Growth and survival of *Barbus altianalis* larvae and juveniles in captivity. *BSC (Botany and Zoology), PGDE (Biology), MSc.(Zoology), PDPPM (Project management)*, 172.

LOCAL CONFERENCES

1. Potential of biodegradable and compostable alternatives in production of Bioplastics. www.switchafricagreen.org national-networking-forum-2017
2. Developing phenotyping procedures and utilization of Near Infra red Spectroscopy in cassava breeding. Poster Presented at Nextgen Cassava meeting, Kampala, 2019.
3. Successes in developing cassava with high Vitamin A content. Poster presented at the ISTRC meeting, Cali Colombia, 2019.
4. Analysis of compositional changes after cassava flour fermentation for cyanogenic varieties of cassava in Uganda. Poster presented at Cassava GCP-21 meeting , Cotonou, 2018

OUTREACH

1. Matovu, M., K. Wanda, A. Bamidele, H. Muyinza, **E. Nuwamanya**, S. Aceng, P. Nyamutoka et al. "Manual: setting up a packhouse for waxing and relative humidity storage of fresh cassava roots." (2016).

2. Wanda, K., **Nuwamanya, E.**, Matovu, M., Bamidele, A., Abass, A., Muyinza, H., Kaliisa, R., Luna Melendez, J., Pizarro Sanchez, M., Belalcázar, J. and Becerra, L.A., 2015. Training Report: South-South collaboration for strengthening capacities in assessing the postharvest physiological deterioration (PPD) of fresh cassava roots and technologies for shelf-life extension.
3. Waigumba, S.P., Nyamutoka, P., Wanda, K., Abass, A., Kwagala, I., Menya, G., Acheng, S., **Nuwamanya, E.**, Matovu, M., Kaliisa, R. and Muyinza, H., 2016. Technical Report: Market opportunities and value chain analysis of fresh cassava roots in Uganda.
4. Community action research project boosts production of cassava bio-ethanol in Apac- Northern Uganda. rforum.wordpress.com/2018/05/02/community-action-research-project-boosts-production-of-cassava-bio-ethanol-in-apac-northern-uganda/

GENERAL CONTRIBUTIONS TO SCIENCE

7. Potential of biodegradable and compostable alternatives in production of Bioplastics. www.switchafricagreen.org › national-networking-forum-2017
8. Developing an African bio-resource based chemical industry ...[Www.siani.se/video/developing-african-bio-resource-based-chemical-industry/](http://www.siani.se/video/developing-african-bio-resource-based-chemical-industry/).
9. Naro Discovers Biodegradable Kaveera From Cassava Chips....www.newvision.co.ug › new_vision › news › naro-discovers-biodegr.
10. How farmers process fuel from seeds - Daily Monitor .., [Www.monitor.co.ug](http://www.monitor.co.ug) › Magazines › Farming
11. Naro Encourages Use Of Cooking Oil Into Bio Diesel..... www.newvision.co.ug › new_vision › news › naro-encourages-cooki...
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Videos

<https://www.youtube.com/watch?v=S2L8NuQPOXE>

<https://www.siani.se/video/developing-african-bio-resource-based-chemical-industry/>

<https://www.youtube.com/watch?v=vjFUQfBryLA>

<https://www.youtube.com/watch?v=ANQMLBKlyg>

