**PhD Topic:**

"How does cut-and-carry management of temperate pastures compared to grazed pasture alter soil carbon?"

**Host Institute:** Environmental Research Institute

**Supervisor's:** Prof. Louis Schipper, University of Waikato (Chief supervisor)

Dr Aaron Wall, University of Waikato (Co-supervisor)

Dr. Paul Mudge, Landcare Research, Hamilton (Co-supervisor)

**NZ-GRADS Project:**

**Introduction:** Agricultural activities have substantially intensified over the past century, resulting in significant increases in atmospheric concentrations of greenhouse gases (GHGs). GHG emissions from the agricultural industry in New Zealand in 2020 contributed 39,425.5 kt $CO_2$-e, representing 50% of New Zealand's gross GHG emissions in 2020. In New Zealand, about 20% of agricultural land is used as pasture for dairy farming which is also a key component of the national economy. In 2016, New Zealand's export earnings from dairy production totalled $13.6 billion NZD. However, the growth of this dairy industries including pasture harvesting management practice for goat dairy have considerable effects on soil ecosystem, including ability to alter soil carbon (C) stocks with gains or losses of soil C possible potential approaches for managing pastoral lands, including ability to alter soil C are the subject of extensive research. The best methods for managing pastoral lands that boost soil C are the subject of extensive research. The development of mitigation strategies for capture is slowed by a lack of mechanistic understanding of how pastureland management affects soil C in grazed (GZ) and cut-and-carry (CC) pasture management production.

Carbon sequestration in pasture can be determined directly by measuring changes in soil C stocks and indirectly by measuring the net ecosystem carbon balance (NECB) fluxes. Soil C stocks is the measurable component of soil organic matter, which is made up of micro-organisms and decomposing plant and animal material. A change in management practice can cause soil C stocks to either increase or decrease depending on the balance of carbon inputs and outputs (MfE, 2023). When a land management practice decreases soil C stock, $CO_2$, a greenhouse gas is emitted to the atmosphere. When a land management

practice increases the soil C stock, $CO_2$ is removed from the atmosphere. Changes in soil C stocks have a huge implication on soil quality. Reporting this soil C stocks changes is part of tracking greenhouse gas emissions from land management practices.

**Research objectives:** This PhD aims to determine the relative impact of grazed and cut-and-carry (CC) systems by comparing their C stocks to grazed farms using a farm scale replicate soil coring approach. This project will also measure net ecosystem C balance (NECB) in New Zealand cut-and-carry pasture system using the eddy covariance technique. Lastly, I will measure nitrous oxide ($N_2O$) emission from cut-and carry pasture using the static chamber approach in CC. Due to significant spatial heterogeneity in soil, determining changes in soil C can be difficult. The use of standardized sampling procedures, however, enables comparisons of variations in soil C between sites over time, and between management practices. To account for variations in bulk density with treatment and depth, it is crucial that the study use equivalent soil mass calculation to 0.6 m depth. Calculating net carbon balance from cumulative measurements of gaseous inputs and losses, biomass additions and removals, and leaching losses is an alternate method for assessing changes in soil C stocks across annual periods at paddock scale. This method has been used extensively in New Zealand by Schipper et al. (2017); Barnett et al. (2014) and Mudge et al. (2021).

**Significance of Research:** In 2019, New Zealand passed a zero-carbon act which sets a target for all greenhouse gases except for biogenic methane from agriculture to reach net zero by 2050 (Ministry for the Environment, 2019). Commitment by New Zealand government to reduce GHG emissions by 30% below 2005 levels by 2030 (MfE, 2020) is already a priority. Parting to meet this target is to evaluate soil C dynamic via soil C stocks and net ecosystem C balance in CC management system on farm scale, which is eminent for New Zealand, and to '4 per 1000' global initiatives. Increasing soil C stocks in pasture soils drawing down $CO_2$ concentration in the atmosphere offer a way to reduce greenhouse gas emissions. Soil C can change as a result of agricultural pastureland management. This research will assist guide global greenhouse gas (GHG) reduction plans by assessing the implications in grazed and cut-and-carry pasture systems. For soil C stocks inventory, quantifying soil C stocks in pasture with different managements including cut-and-carry and grazed pastures is important. The C sink potential of soils has prompted much interest in identifying mechanisms that lead to increases in soil C as a mitigation strategy for emissions reduction. In New Zealand, dairy industry has experienced significant expansion during past quarter-century (Wall et al., 2019). Pastural management activities can have a significant impact on soil C stocks, but net C exchange is poorly understood. Therefore, there is an urgent need to determine the impacts of

different pastural management practices (GZ & CC) on soil C losses or gain. The study will also provide research-based evidence data that enhance proper grazing management decisions to improve and encourage C gain and avoid loss of C.

**Impact of the project in reducing GHG emissions:** This study will improve our understanding on how pasture removal in cut-and carry pasture management systems and associated grazed pasture management practices affect soil carbon stocks, net ecosystem carbon balance and $N_2O$ emissions. Such knowledge will provide quantitative relationship at farm scales of how soil C can be maintained or increased. This is through the direct soil field measurement via replicate core sampling approach, close chamber analysis method and field measurement through net ecosystem C balance (NECB) methodology. By examining the impact of pasture removal on measured net carbon balances, this research study will contribute to the advancement of the net ecosystem carbon balance technique. Data from the study can contribute to the testing and validation of models. This allows further scenario testing geared at reducing GHG emissions from pastureland management practice in New Zealand while considering productivity of the system. Additional contributions will likely include improved understanding of importance of dung returns and other C fluxes in carbon cycling when comparing soil C in grazed and cut-and-carry pasture management system, particularly as to the fate of carbon following transfer from one system to another.

Policy makers will benefit from the proposed research, as present GHG inventories lack sufficient data on losses or increases in $CO_2$, $N_2O$, and soil C stock resulting from pasture management practices in cut-and-carry pasture systems. As a result, further incorporation of information regarding the effects of cut-and-carry and grazed pasture management production in the study will be significant to inform future GHG mitigation option.

**My motivation:** To be academically competent, I need to undertake research study; this will give me up-to-date tools and knowledge needed for my future career in teaching and research. It is after a good deal of self-motivation and evaluation that I have decided to pursue this project topic leading to a doctorate, considering the positive contribution of the research topic on agriculture greenhouse gas emission reduction. This decision followed carefully after considering my academic background, the areas of my interest, the host institute and supervisor's research trajectory and my ultimate professional ambition, which is to pursue a research career as a teaching faculty member in future.

However, there are two reasons why I believe that graduate study in a reputed institute and university, such as Environmental Research Institute, The University of Waikato, is important for a person aspiring

for a research career. Firstly, working for a thesis under the guidance of an expert whose work can serve as a model is the most effective method of transforming a student or upcoming scientist into a largely independent researcher making significant original contributions in Environmental Science. Secondly, the emphasis of graduate study on intensive and independent study of a specialized area is an ideal way of making a student capable of reaching the frontiers of knowledge in a subfield quickly and keeping abreast of the latest development.

## Myself and future hope

**Henry Obiahu Ota** is a native of Ebonyi State in Southeastern Nigeria. Henry Ota is currently undertaking a PhD under the supervision of Louis Schipper and Aaron Wall with project topic focusing on "How does cut-and-carry management of temperate pastures compared to grazed pasture alter soil carbon?". His research trajectory/interests span across biogeochemical processes and operation in soils, land management and land use practice changes, soil carbon stocks, and greenhouse gas emission monitoring in agricultural components. His future hope is geared towards choosing a research or related academic job or a position with a greater emphasis on teaching (postdoc) to further expand his research repertoire.

## Favourite quote…

"*Until you get to the end of the tunnel, you cannot see light*"