Please note: the substantive content of the 2026 NRI Roadmap Survey begins at Question 20 (with prior questions dealing with administrative and other information).

As such all submissions that are published include the responses submitted from Question 20 onwards only.

Q20.

Part 2: Research themes

2.1 NRI comprises the assets, facilities and associated expertise to support leading-edge research and innovation in Australia and is accessible to publicly and privately funded users across Australia and internationally. We are seeking your input on possible directions for future national-level investment - i.e., where the requirements are of such scale and importance that national-level collaboration and coordination are essential.

The 2021 Roadmap used a challenge framework to support NRI planning and investment. With this in mind, consider likely future research trends in the next 5 - 10 years, and with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale and
- describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities.

Q21.

Resources Technology and Critical Minerals Processing

Q22.

Food and Beverage

Agriculture is critical to Australia's food security and economy generating more than 70b$ in export earnings and providing high-quality ingredients for manufacturing. However, the sector is uniquely exposed to climate change as well as changing consumer preferences and environmental regulation. The 2021 Roadmap identified that "phenotyping (backed by data and biocontainment facilities) would support the application of Australia's high-quality fundamental research in genetic engineering and gene editing to crops" to accelerate and improve decision making for sustainable agriculture (e.g. optimising irrigation, fertilizer use, pest management). 2023 funding expanded APPN to national network of nine nodes with greater translation and data capabilities. Additional requirements to meet growing research and industry demand 1. As APPN's seven newly established nodes are still being commissioned, continued investment is needed to fully deliver the projects impact. Investment in improved automation and robotics is also needed to increase the frequency, quality and reliability of crop measurement and to meet growing demand. 2. Expansion to include important missing agro-ecological geographies and institutions is desirable, including the Victorian cropping zones, central Queensland, and the high value cropping mix of Tasmania. 3. As the NDRI process has not been completed at this stage, APPN is operating with a skeleton Data Team, insufficient to organise, package, analyse and share the large complex data sets from the new controlled environment and field equipment. Correct resourcing is critical to deliver crucial insights driving the development of crops better adapted to environmental impact (drought, heat, flooding, etc.) and to fulfill APPN's FAIR data commitments. 4. Dedicated licensed facilities are needed for the expanding field of genetic modification, gene editing and synthetic biology. While adequate controlled environments facilities (greenhouses, climate rooms) are available, field-based facilities are required to bridge from research to farmer's fields. Currently only the heavily booked Rosedale site in South Australia is available to APPN customers. Developing similar facilities in WA and Queensland are needed to cover environmental variation and demand. 5. Finally, the 2021 Roadmap identified research translation infrastructure as critical to drive increased industry investment. The Australian phenotyping community needs further support in the conversion of analysis-ready phenotyping data to usable plant trait outputs that can be integrated into breeding programs and farming system recommendations. Fusion of R&D with commercial offers and commercial accelerators needs to be considered to drive adoption. Non NRI Fit Areas Regional, small-scale and specialised infrastructure that are not integrated into national approaches

Q23.
Medical Products

Q24.
Defence

Q25.
Recycling and Clean Energy

Q26.
Space

Q27.

Environment and Climate

The NCRIS 2021 Roadmap identified “world leading environmental and climate infrastructure to underpin Australia’s national adaptation strategy” as a Step Change opportunity. While not directly mentioned, agriculture is conducted on some 55% of the Australian land mass (DAFF, 2025) and is thus critical to delivering on this Step Change. While there has been progress in monitoring Green House Gases (GHG) in agriculture (e.g. TERN, CRC for Zero Net Emissions) the focus has been on rangelands and grazing agriculture. Measurement and monitoring in dynamic cropping systems (30% of farms and 10% of the agricultural area) has been limited to date and remains challenging. Recent work by Dr. James Hunt (University of Melbourne and CSIRO) points to a highly complex balance between soil carbon, nitrogen dynamics, crop stubble management and fertilisation practices which drive long term GHG cycles that must be monitored over the same time frame. The measurement of soil carbon, which represents the major long-term pool of carbon in agricultural systems, remains especially difficult. Regarding biodiversity, given that Australia is recognised as a biodiversity loss hotspot whilst agriculture occupies such a sizable proportion of the continent's landmass, there must be specific focus on the monitoring and proactive management of biodiversity in farming landscapes (rather than focused on natural systems only). If we are to address coming biodiversity challenges, we must take up the opportunity represented by effectively managing farming landscapes as harbors of biodiversity. Additional Needs. A strengthened national approach should include; - developing better GHG monitoring methodologies in agriculture inclusive of soil, crop and associated atmosphere. - Establish long term cropping systems reference trials and monitoring these across major agro-ecological zones. - Exploit new UAV and satellite based gaseous sensors and in-situ soil carbon and nitrogen sensors to better and more efficiently monitor these outcomes. - Partnering with TERN and the Atlas of Living Australia to explore the use of the latest a.i. assisted interpretation of camera trap images and acoustic signature to estimate biodiversity levels across farming systems and agro-ecological environments. Non NRI Fit Regional, small-scale and specialised infrastructure that are not integrated into national approaches.

Q28.

Frontier Technologies and Modern Manufacturing

The NCRIS 2021 Road map proposes investments in 8 areas of breakthrough technology, each of which can underpin advances in Modern Manufacturing. • Robotics infrastructure • Nanofabrication infrastructure • Space-related manufacturing infrastructure • Quantum technologies infrastructure • Synthetic biology infrastructure • Omics facilities • Microscopy and advanced imaging facilities • Support for user experience and human-centred design APPN was a direct participant in the Synthetic Biology proposal led by Bioplatforms Australia (BPA) and along with BPA and Therapeutics Innovation Australia is responsible for ‘scale up’ of new innovations in this space. While this will commence in APPN’s indoor controlled environment facilities, eventually these innovations will need to be tested in field conditions, initially in containment facilities licensed by the Office of the Gene Technology Regulator (OGTR). Additional Needs; Synthetic biology, including genetic modification and gene editing offer the opportunity to rapidly boost crops production and sustainability. Research is expected to expand rapidly in the coming 5 to 10 years (the first GM wheat is currently being planted in WA). While adequate controlled environments facilities (greenhouses, climate rooms) are available, field-based facilities are required to bridge from research to farmers’ fields. Currently only the heavily booked Rosedale site in South Australia is available to APPN customers. Developing similar facilities in WA and Queensland are needed to cover environmental variation and demand. Non NRI Fit APPN is not able to comment this area of investment.

Q29.

2.2 The 2024 statement of National Science and Research Priorities (NSRPs) includes outcomes linked to each priority to assist in identifying critical research needed in the next 5 to 10 years.
Consider the priority statements and, with respect to one or more of the 5 priority areas as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or
- not at sufficient scale and describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities, and where relevant, refer to the underpinning outcomes and research identified in the NSRPs document.

Q30.

Transitioning to a net zero future

The 2024 NSRP's states that science and research will help Australia "... achieve a net zero economy by 2050, .. and use new technologies, materials and processes to change energy generation and storage, heavy industries and agriculture." The NSRPs suggests research into "solutions for removing carbon dioxide from the atmosphere at scale and for hard-to-abate processes and activities such as agriculture." Agriculture currently accounts for 16.8 % of Australia's emission (DAFF) split roughly equally between plant and animal-based agriculture. As efforts to reduce emissions from the major static energy and transport sectors advance, both the percentage contributions from agriculture, and the pressure to reduce those emissions, will increase. Reducing Agricultural emissions is made difficult due to its highly fragmented and diverse nature and its steady growth in output to meet Australian and regional populations growth. Investment in research and associated research infrastructure must increase to tackle these conflicting realities. Infrastructure can be classified into two broad theme areas; - infrastructure directed to better monitoring across various agricultural systems. - Infrastructure directed to developing solutions via new crop varieties and management approaches to mitigate and adapt agricultural into the future. Additional Needs Better monitoring by; - developing better GHG monitoring methodologies in agriculture inclusive of soil, crop and associated atmosphere. - Establish long term cropping system reference trials and monitoring these across major agro-ecological zones. - Exploit new UAV and satellite based gaseous sensors and in-situ soil carbon and nitrogen sensors to better and more efficiently monitor these outcomes. Better solutions developed by; - Establishing future climate crop modelling facilities. Research on plants in future environments is currently limited to small walk-in/reach-in cabinets which are appropriate for fundamental research only. To observe complex genotype x environment x inter-plant interactions it is necessary grow larger numbers of plants and mimic future climate and field conditions. These facilities should include larger mesocosm style greenhouses with natural soil substrates. Larger real world simulation such as the EucFACE facility at UWS, or the AgFace (https://piccc.org.au/research/AGFACE.html) experiment should also be considered for investment. Such larger facilities are also required for breeding of future ready plant varieties ahead of climate change. - In combination with these facilities, consideration can be given to establishing appropriately licensed containment facilities to allow the testing of future GM, genetic editing and synthetic biology solutions which many believe will be necessary to breed plants at sufficient speed to cope with the rate of climate change. Non NRI fit Regional, small-scale and specialised infrastructure that are not integrated into national approaches.

Q31.

Supporting healthy and thriving communities

Q32.

Elevating Aboriginal and Torres Strait Islanders knowledge systems

The NSRP's specify that ; • The science and research system will evolve to protect and elevate Aboriginal and Torres Strait Islander knowledges. • research that affects or draws from Aboriginal and Torres Strait Islander knowledge and knowledge systems is done in collaboration with Aboriginal and Torres Strait Islander people It then sets out Critical research to include; • incorporating Aboriginal and Torres Strait Islander knowledge into the development and application of critical and emerging technologies, particularly digital and data technologies approaches for protecting and managing Aboriginal and Torres Strait Islander cultural and • intellectual property approaches to preserving language and promoting bilingual education • approaches to climate change adaptation to support regional and remote communities. To achieve the best outcomes, Aboriginal and Torres Strait Islander peoples should guide research. APPN has not to date consulted with the ATSI community regarding the application of plant phenomics research to indigenous knowledge systems. Consultation is a precursor to undertaking any research relevant to indigenous knowledge system, and APPN will take into account relevant reconciliation action plans (RAPS) at our host institutions, and those specific to Agriculture, such as the National Farmer's Federation RAP. Acknowledging the above, plant phenomics services as delivered by APPN can offer the opportunity for indigenous groups to create systematic digital models of various economically and culturally significant plants. This could be linked to genetic characterisation via Genome to Phenome studies (G2P) such as the ongoing OzBarley project Systematic description of such plants can; - protect such knowledge within non-aboriginal legal systems. - improve communication across different language groups. - provide the basis for sustainable economic development of such plants in sustainable ways. Furthermore, phenotyping of such plants within indigenous land management systems, may capture this information - For better understanding of the basis of such systems to benefit the Australian agriculture and community more broadly. - To understand the impact of climate change on such systems. - To work with indigenous communities to adapt systems to new climate realities that we face together as an Australian community. Additional Needs APPN's current physical infrastructure resources are largely sufficient to begin work with indigenous communities. APPN envisages engaging in such communication more actively after 2028. Establishing a G2P program of work, depending on its size, could be a significant undertaking requiring substantial genotyping and phenotyping time and resources. APPN proposes to study further this concept and if appropriate, seek consultation with the ATSI community to structure proposals for the 2028-2033 funding period.

Q33.

Protecting and restoring Australia's environment

Australia's National Science and Research Priorities (NSRP) highlight the need for research into improved collection, interpretation, sharing of environmental monitoring data, improving prediction of ecosystem and biodiversity conditions, developing new approaches to protecting and restoring biodiversity, developing tools and techniques to collect and analyse environmental data and develop new carbon sources and sinks in soil and vegetation across Australia. As Australian agriculture is conducted on 51% of the continent, it has an important role in both avoiding loss and potential remediation. APPN's national network is well placed to address this priority through: - the use of mobile and fixed field facilities to monitor environmental and biodiversity changes in current systems. - developing new crop types and farming methods that can minimise impact and aid environmental repair via sustainable and regenerative agriculture. Infrastructure can be classified into two broad areas: - infrastructure directed to better monitoring across various agricultural systems. - Infrastructure directed to develop better solutions via new crop varieties and management approaches to lessen ecological impact and where possible regenerate ecosystems. Additional Needs Better monitoring can be achieved by: - growing scientific understanding to develop better monitoring methodologies inclusive of soil, crop and atmosphere. - Establish and monitor long term cropping systems reference trials including monitoring of soil carbon, nutrition and health across major agro-ecological zones. - Partnering with TERN and the Atlas of Living Australia to explore the use of the latest a.i. assisted interpretation of camera trap images and acoustic signature to estimate biodiversity levels across farming systems and agro-ecological environments. Better solutions that can protect and restore our environment can be achieved by: - As mentioned under NSRP #1, establishing future climate crop modeling facilities can accelerate the development and breeding of crops that are better adapted to, and can help mitigate, climate impacts. - An associated benefit will be the direct reduction in environmental impact of such cropping systems due to; o increase nutrient efficiency thus reducing chemical burden and eutrophication risks. o Increase soil carbon storage below ground through stronger root systems. o greater yield reducing the land required per unit of production. - Indirectly, such facility could accelerate the development of completely new crop varieties with reduced environmental footprint, e.g. perennial wheat, wheat grasses. - Finally, it may be possible to utilise such facilities to study and breeding of critical native plants better adapted to future environments to avoid loss of critical reference species in natural systems. Non NRI Infrastructure Regional, small-scale and specialised infrastructure that are not integrated into national approaches.

Q34.

Building a secure and resilient nation

The NSRPs highlight the need to build sovereign economic, societal and food security resilience with specific research focused on "technologies for ... producing food under likely future Australian climate conditions", "predicting, detecting and responding to biosecurity threats and natural disasters...with the objective to "secure ...food production in the face of climate change, weather extremes and biosecurity threats". While Australian agricultural research is world leading, the research workforce is and hampered by inefficient manual and analogue processes. Digital plant phenotyping, backed by automation, robotics and digital infrastructure can make research far more efficient, precise and impactful. Additional Needs: 2023 NCRIS funding expanded APPN to national network of nine nodes, with greater translation and data capabilities, however; 1. As APPN's seven newly established nodes are still being commissioned, continued investment is needed to fully deliver the projects impact. Investment in improved automation and robotics is also needed to increase the frequency, quality and reliability of crop measurement and to meet growing demand. 2. Expansion to include important missing agro-ecological geographies and institutions is desirable, including the Victorian cropping zones, central Queensland and the high value cropping mix of Tasmania. 3. As the NDRI process has not been completed at this stage, APPN is operating with a skeleton Data Team insufficient to organise, package, analyse and share the large complex data sets from the new controlled environment and field equipment. Correct resourcing is critical to deliver crucial insights driving the development of crops better adapted to environmental impact (drought, heat, flooding, etc.) and to fulfill APPN's FAIR data commitments. 4. Dedicated licensed facilities are needed for the expanding field of genetic modification, gene editing and synthetic biology. While adequate controlled environments facilities (greenhouses, climate rooms) are available, field-based facilities are required to bridge from research to farmers' fields. Currently only the heavily booked Rosedale site in South Australia is available to APPN customers. Developing similar facilities in WA and Queensland are needed to cover environmental variation and demand. 5. Finally, the 2021 Roadmap identified research translation infrastructure as critical to drive increased industry investment. The Australian phenotyping community needs further support in the conversion of analysis-ready phenotyping data to usable plant trait outputs that can be integrated into breeding programs and farming system recommendations. Fusion of R&D with commercial offers and commercial accelerators needs to be considered to drive adoption. Investment across these areas will create the world premier integrated phenotyping network capable of accelerated research and delivering impact for Australia's farmers and community.

Q35.

2.3 The case for a new NRI capability, or enhancements to existing capabilities, typically emerges through advocacy from research communities clustering around rigorously identified needs and goals. Such a concept could respond to a requirement for novel or expanded capacity within a domain, or across domains, and must be such that it could only be made available with national-level investment.

If you have identified such a requirement, briefly describe the need, the proposed infrastructure capability, the medium-term goals, impacted research communities, and the timeframe over which you advocate its establishment. Your response can include links to relevant existing reports.

Digital plant phenotyping, backed by automation, robotics and digital infrastructure can accelerate delivery of solutions to Australia's climate, food security, environmental protection and rural social challenges, including for indigenous knowledge systems. NCRIS recognised this in the 2021 Roadmap and 2023 funding rounds creating an initial national network of human and physical plant phenotyping infrastructure unique in the world. Developments in scientific thinking and sensor capability now offer opportunities to expand and/or focus on important sub-segments to further accelerate impact and delivery. 1) Expansion of Plant to Sensor Facilities: 'Plant to Sensor' phenotyping systems, such as The Plant Accelerator® at the University of Adelaide, provide high capacity 3-dimensional phenotyping of the plants unobtainable by other systems. As there is heavy demand for such systems, replication in other states would add capacity to meet expanding demand. Goal: Expand studies into the phenotype to genotype drivers of crop morphology accelerating new crop variety development and delivery. Impacted Research Communities: Academic researchers, Breeding companies. Timeframe: 2028-2033 2) Specialised plant disease research phenotyping capability: With changing climates and management, crop diseases are growing in number and importance in Australia causing significant losses in yields and threatening food security. Breakthrough plant disease research requires compartmented, climate controlled and quarantine level facilities to cultivate, infect, assess and measure damage. Dedicated field machinery is also needed to avoid cross contamination with other trials. Goal: Address growing endemic and exotic crop disease threats by proactive accelerated phenotyping driven research. Impacted Research Communities: Crop pathologists, Breeding companies, Crop protection companies. Timeframe: 2028 - 2038 3) Enhance satellite-based phenotyping capabilities: The number and resolution of Earth Observation (EO) satellites is rapidly increasing. By 2030, precision may rival some current ground-based sensors, increasing options for space-based phenotyping. Dedicated investment in tasking and acquisition of existing of Australian imagery plus building analytical pipelines will accelerate bridging between different scale. Medium Term Goal: Identify new means to measure crop signatures from space to provide farmers and researchers with new predictive tools and models at dramatically lower cost. Impacted Research Communities: Academic researchers, EO companies, breeding companies, farm advisors, farmers. Timeframe: 2028-2038 4) Expand national root phenotyping capabilities: Roots are fundamental for nutrient, water and carbon storage efficacy yet root phenotyping remains challenging and under-developed. An integrated national root phenotyping facility should be developed by; 1) Expansions of the existing Lysimeter Center at Charles Sturt University (CSU) to include all major national soil types. 2) Expanding the medium scale Rhizobox systems at ANU and 3) Exploit new remote technologies to boost field-based phenotyping. This will create a world-leading facility capable of studying continent-wide soil/plant interactions in a world leading infrastructure. Goal: Accelerate understanding of the link between above and below ground plant phenotypes in near real-world environments, update climate prediction models and strengthen soil management, health and conservation . Impacted Research Communities: Australia wide ag researchers, soil additive companies, fertilizers companies, IPPC researchers, crop modelers, farmers. Timeframe: 2028 – 2038 5) Future climate facilities: To prepare farmer for future climates, it is necessary to mimic future climate and field conditions which can capture complex genotype x environment x inter-plant interactions and grow the larger numbers of plants necessary for breeding. Larger mesocosm greenhouses, including real soil substrates will enable the growth of crop plants in field like environments. Real world simulation facilities such as the EucFACE facility (https://eucface.hieresearch.org/) at UWS, or the AgFace (https://www.piccc.org.au/news/agface-research-news-new-phase) experiment should also be considered for investment. Goal: Breed crops ready for future climates today. Impacted Research Communities: Academic researchers, breeding companies, farmer groups. Timeframe: 2028-2038 6) Monitoring of climate gases in agricultural systems. Green-house gases need to be monitored in Ag systems to confirm research outcomes and meet national reporting requirements. While conducted in extensive grazing environment via TERN and the Zero Net Emissions CRC, monitoring in cropping environment is limited. Based on current understanding, future monitoring must take into account the carbon balance across the crop and atmosphere and soil, as soil is the major long-term store of both carbon and nitrogen. New instrumentation offers ways to do this more efficiently and accurately. Goal: Provide accurate full cycle monitoring of climate gas across major Australian agro-ecological zones and help design management practices with both adapt and mitigate climate change. Impacted Research Communities: Government, Academic researchers, ZNE-CRC, IPPC international researchers. Timeframe: 2028-2050 7) Monitoring of Biodiversity in Agriculture Systems. Biodiversity health in Agriculture systems is increasingly being monitored, both to assess impact, seek mitigations and support remediation efforts. New photographic, acoustic and e-DNA techniques could be used to build monitor status and assess proposed strategies. Goal: To monitor biodiversity in major cropping environments to assess health and develop mitigation and remediation strategies. Impacted Research Communities: Academic, UN, Government Timeframe: 2028-2038

Q36.

Part 3: Industry perspectives

This section is seeking input specifically from industry-based respondents. Other respondents can skip this section.

Recommendation 6 of the 2021 Roadmap related to improvements in industry engagement with NRI. To complement work on this topic that has occurred since then, we are seeking additional advice on NRI requirements as perceived by current or potential industry-based users.

Q37.

3.1 Have you (or your organisation) interreacted with or used Australia's NRI?

- (●) Yes
- ( ) No

Q38.

3.2 If so, please briefly outline the NRI capabilities you (or your organisation) have interacted with or used. Do not limit your response to NCRIS capabilities.

Q39.

3.3 Please indicate your (one or more) primary reasons for interacting with NRI:

- [ ] For expertise or advice
- [ ] Access to research resources or products
- [ ] Access to equipment for research
- [ ] Access to equipment for operational reasons
- [ ] Help in translating research
- [ ] Access to data
- [ ] Support for clinical trials
- [ ] Other (please specify)

Q40.

3.4 If you answered no, please indicate your (one or more) primary reasons:

This question was not displayed to the respondent.

Q41.

Part 4: Other comments

4.1 Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

The 2026 Roadmap will build on the 2021 roadmap, defining future investment in existing NCRI infrastructure and potentially adding further infrastructure. APPN received a major boost to funding in 2023, moving from 3 to 9 Nodes. Given initial delays in funding announcements, and further administrative delays at newinstitutions, most nodes are currently still in the set-up phase, purchasing and commissioning equipment and establishing APPN-wide operating protocols. Crop research and plant breeding is by nature a long-term process, often taking 5 to 10 years to deliver new solutions. Accordingly, it is critical that operational funding is maintained, and minimum equipment renewal is allowed for. Security of funding will further allow; - To attract and develop the highly skilled staff necessary to operate and deliver outputs. - To develop techniques appropriate for Australia’s unique climate and needs. - To attract significant industry and commercial partnership. This first of a kind infrastructure network is drawing significant interest and we can expect strong use over time, however this is dependent on surety about continued base funding.