D.4.a. Description of the methodology

In the following, we describe our methodology to monitor the progress during the implementation of the plan. Our monitoring system is based on the mandatory and optional indicators presented in the parts D.4.b-d of the application. In accordance with the guidelines of the competition, the indicators are calculated either for the entire **university (U)** and/or for the specific **priority research areas (P)**. Finally, we propose additional indicators to measure the progress in the **emerging fields (E)**.

I.   Definitions

1)   Priority research areas (P)

The priority research areas have been defined and launched based on a tough NCU-wide competition for priority research teams and a research impact analysis using InCites (see Sec.C). Specifically, NCU employees from all faculties and departments were encouraged to propose research projects, which were thoroughly evaluated by external, outstanding experts. The awarded priority research teams distinguish themselves by the preeminent interdisciplinarity of their scope of research. We strongly believe that these "bottom-up" process identified teams that feature great potential for development as well as solid publication records, research activities, and internationalisation. Our selection of priority research teams has been justified by our subsequent analysis of bibliometric indices. The interdisciplinary priority research areas at NCU are the following:

a) **Astrophysics and Astrochemistry**
b) **From Fundamental Optics to Applied Biophotonics**
c) **Dynamics, Mathematical Analysis and Artificial Intelligence**
d) **Towards personalized medicine**
e) **Interacting Minds, Societies, Environments**

We will monitor the progress in research impact within these priority research areas based on the Web of Science database using InCite. The so-called **subject categories** for each area are summarized in the table presented in Sec. C (SWOT). *The interdisciplinary nature of the priority research areas is certified by the identification of 3 to 8 subject categories, which altogether describe their scientific scope.*

2) Emerging fields (E)

Besides priority research areas, we selected so-called "emerging fields". These "emerging fields" are characterized by their significant research impact (InCites) and are, in most cases, formed by research teams that have been highly-ranked in our internal competition

(Sec. C). Furthermore, these fields are not part of the priority research areas in order to keep these areas coherent entities with a well-defined scientific focus. So far, we identified 8 emerging fields in three, broad fields of science. Another 4 fields will be selected in the beginning of 2020. For each of the emerging fields listed below, we define subject categories (again based on Web of Science) that will be used to measure their progress.

Physical Sciences and Engineering

a) Polymer science and multifunctional nanomaterials
   - Polymer science
   - Materials science, multidisciplinary
   - Applied chemistry

b) Automation and control systems
   - Automation and control systems
   - Engineering, multidisciplinary
   - Remote control

c) Soil science, microbiology, agricultural genetics and food quality
   - Soil Science
   - Microbiology
   - Agricultural Engineering
   - Plant Science
   - Food Science and Technology

d) Global environmental changes
   - Geosciences, multidisciplinary
   - Geology
   - Oceanography

Arts, Humanities, and Social Sciences

a) Conservation and restoration of cultural heritage
   - Art
   - Anthrophology

b) Logic and philosophy of science
   - Logic
   - History and philosophy of science

Life Sciences

a) Metabolic civilization diseases
  - Cardiac and cardiovascular systems
  - Endocrinology and metabolism
  - Medical laboratory technology

b) Ecology and biodiversity
  - Ecology
  - Biodiversity conservation
  - Evolutionary biology

II. Lists of indicators for the entire university (U) and the priority research areas (P)

1) List of mandatory indicators (D.4.b)

The following three mandatory indicators and the corresponding number of papers are calculated for the entire university and priority research areas, respectively, for each year from 2013 to 2017 using the Web of Science database and the InCite tool. The corresponding table is shown in Sec. D.4.b.

a) % Articles in Top 10% (U and P)
b) Normalized Citation Impact (U and P)
c) % Articles in International Collaborations (P)

The main challenge is to predict the average value of the indicators in the period 2020–2024. In the following, we will explain our methodology using the data for the priority research area "Dynamics, Mathematical Analysis, and Artificial Intelligence"; the same methodology is applied to the entire university as well as to the remaining priority research areas. The indicators are calculated together for all subject categories listed in the table of Sec. C. for a given area. Specifically for the mathematical area, we selected: *Computer Science, Artificial Intelligence; Computer Science, Software Engineering; Mathematics; Mathematics, Applied; Physics, Mathematical.*

Figures 1-3 display the development of all three indicators over time. The values are considerably scattered, suggesting to include a longer time span in our model. However, such an analysis lies outside the scope of the current application. In order to correct for the spread, we decided to adopt the fitting function to obtain more realistic results that allow us to highlight the trends. The corrected predictions are, however, still too optimistic and rather risky given the limited time span of the base values and the definitions of the indicators themselves.
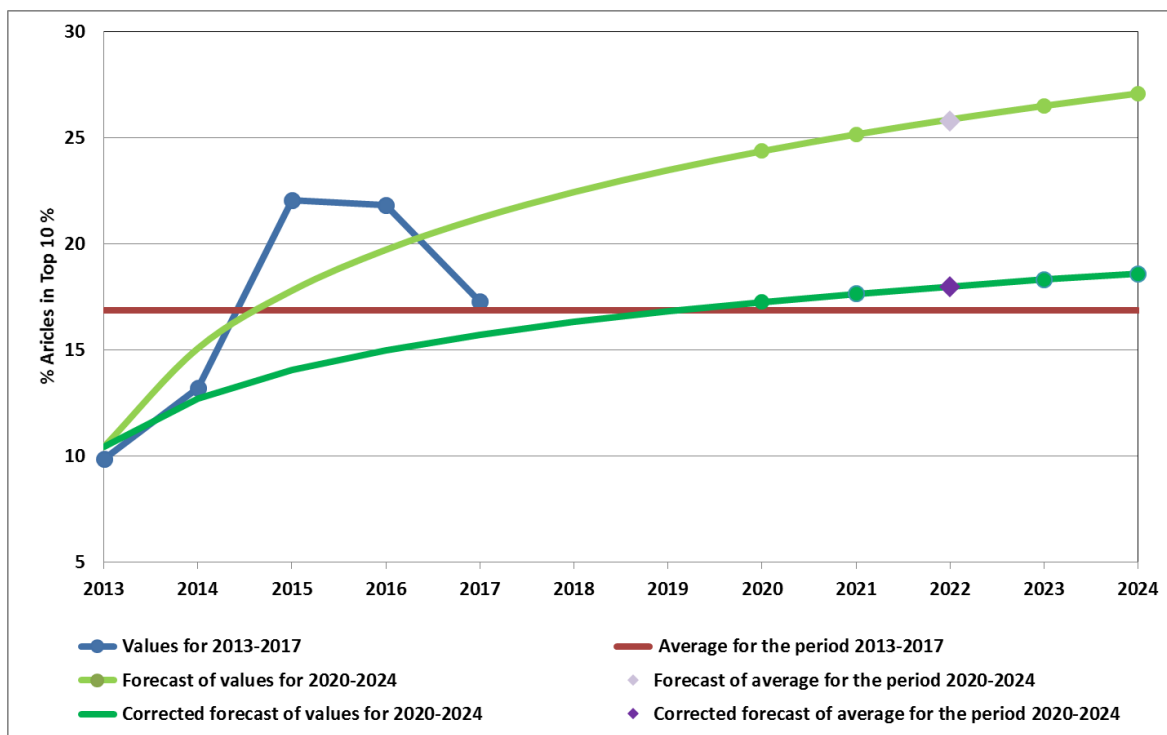
Figure 1. Percent of Articles in Top 10% for the priority research area "Dynamics, Mathematical Analysis and Artificial Intelligence". The blue dots show the indicator values for 2013-2017 according to the Web of Science database calculated using the *subject categories* defined in the table in Sec. C. The horizontal red line illustrates the average of the blue datapoints. The light green curve shows the least-square best fitting to the 5 datapoints using a fitting function of the form y = a ln(x) + b. For the dark green curve, the a-coefficient has been modified and corrected so that the expected values are more realistic. The violet diamonds show the average values of the indicators for 2020-2024 for each of the green curves.
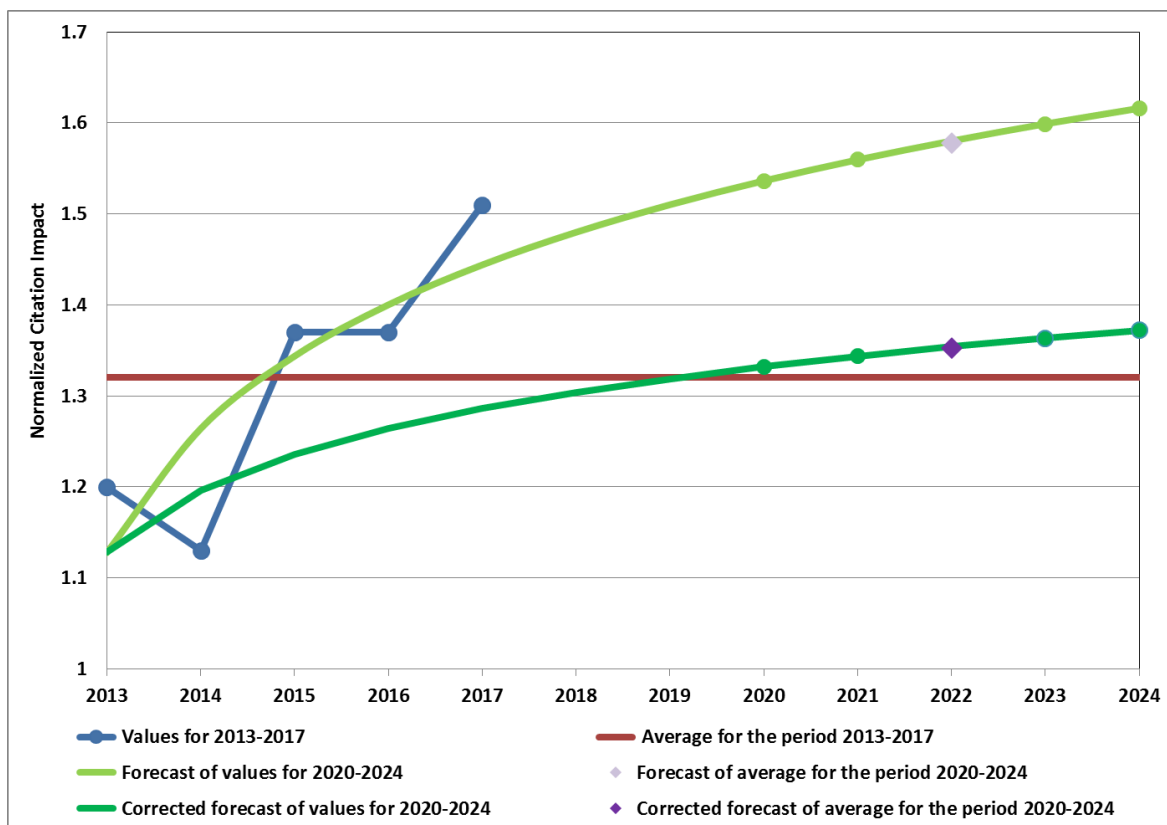

Figure 2. Normalized Citation Impact for the priority research area "Dynamics, Mathematical Analysis and Artificial Intelligence". Similar symbols and colors are used as in Figure 1.

These indicators are rather sensitive to external factors that lie beyond our area of influence, e.g., the number of citations by authors/papers not affiliated with NCU. Nonetheless, the most important trend is that *the number of citations increases slowly with time.* Depending on the discipline, a bulk of citations is reached within 1 to 5 years. Note that mathematics is rather slow in this respect. Thus, the indicators that will be monitored annually will not immediately respond to the rise of articles in Q1 journals published within each subject category.

The fundamental principle of economics - *the law of diminishing returns* - may affect the above predictions. Therefore, we decided to alter the slope (a) of the adopted function to predict new, more realistic trends. These values are reported in the tables in Sec. D.4.b. and will be used to monitor and assess the progress. We should emphasize, however, that *we aspire to follow the more ambitious trends (light green curve)*, which may become realistic if the impact of other factors, like improving the quality of university governance, will quickly bear fruit.
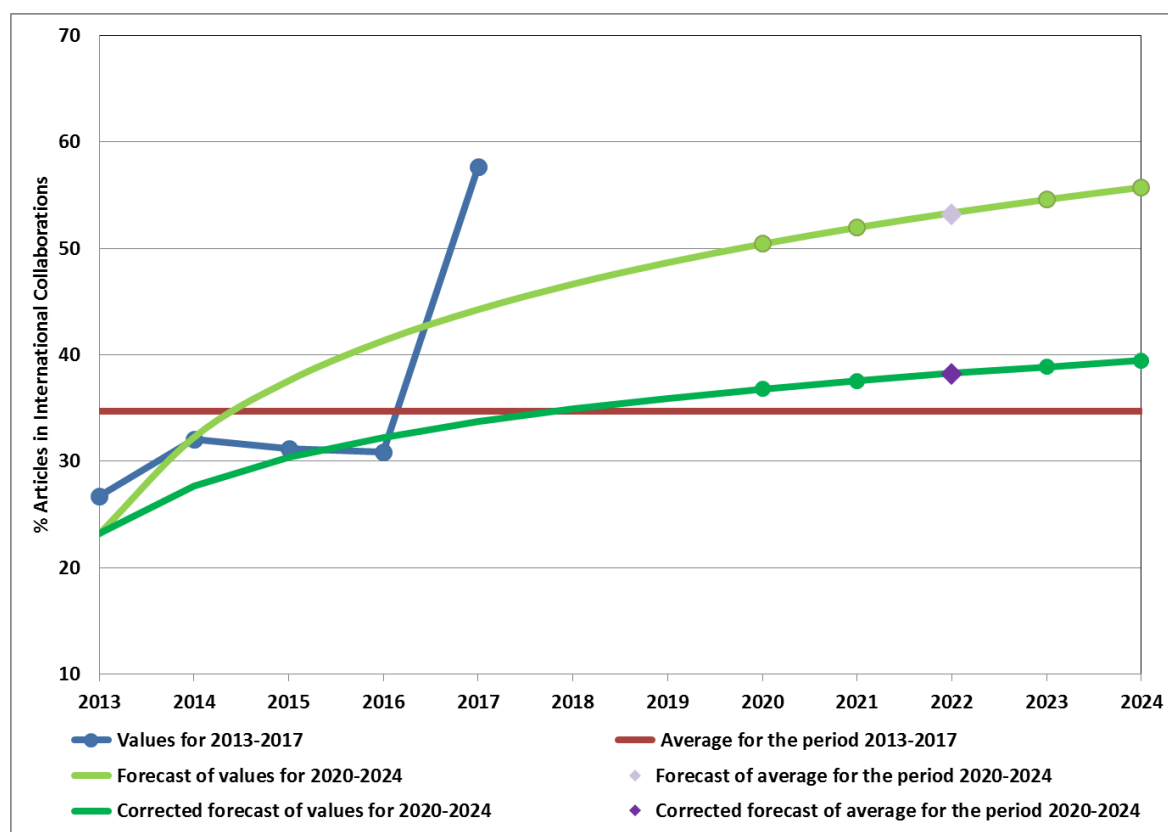

Figure 3. Percent of articles in international collaboration for the priority research area "Dynamics, Mathematical Analysis and Artificial Intelligence". Similar symbols and colors are used as in Figure 1.

Additional mandatory indicators include:
d) Scholarly Books of Prestigious Publishers (P)
e) International Research Grants (P)
f) Staff Policy Openness (U)
g) Student-to-Staff Ratio (U)

The table in Sec.D. lists all scholarly books for the priority research area "Interacting Minds, Societies, Environments" emerging from humanities and social sciences. Although we provided international research grants for all priority research areas, the specified limit in the number of characters does not allow us to include a complete list. Thus, we focus on research grants with exceptionally strong international dimension. We should empha-size that several grants that have been awarded by Polish funding agencies are executed in collaboration with international institutions (e.g., Foundation for Polish Science - FNP; National Science Center - NCN; National Center for Research and Development - NCBiR).

The remaining two indicators are obtained from the POL-on system maintained by the Polish Ministry of Science and Higher Education and calculated for the entire university. The indicator values related to staff policy openness and student-to-staff ratio are given for December 31, 2018.

NCU is strongly committed to encourage staff policy openness. As the very first university in Poland, we obtained the **HR Excellence in Research** award in 2015. This award en-couraged us to implement the regulations of the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers to create the best possible envi-ronment for researchers and to support their training, mobility, and career development (see https://www.umk.pl/en/university/excellence-in-research/). Since 2015, we are pro-moting positive changes in various HR-related aspects. Specifically, we adhere to the "Open, Transparent and Merit-Based Recruitment of Researchers OTM-R", which is con-nected to the indicator related to staff policy openness. Therefore, we expect openness to gradually grow achieving a value of 20 in 2025.

As a research university, we are committed to further decrease the student-to-staff ratio to optimize the amount of time our scientists can spend on educating and nurturing the younger generation of researchers. According to the Ministry, the student-to-staff ratio cannot exceed a value of 10 for research universities. Currently, NCU features a student-to-staff ratio of 10.22. Taking into account the declining trend of enrolled students over the past 5 years, we predict a the student-to-staff ratio of 9.8 in 2025.

2) List of optional indicators (D.4.c)

We select the following optional indicators for monitoring and evaluation.
a) Normalized Citation Impact for Internationally Co-authored Articles (P)
b) % of International Doctoral Students (U)
c) Doctoral Students' Articles in Q1 Journals (U)
d) Number of inventions protected by foreign patents (U)
e) Revenues from commercialisation (U)
f) Foreign accreditations

The selection was motivated by our strategic plan for development (Sec. D). The main goal of NCU is to increase the level of internationalisation, which can be unambiguously measured by (a) the number of publications resulting from international collaborations and their impact and (b) the percentage of international doctoral students. An increase in the quality of education, especially at the doctoral level, will simultaneously accrue the number of publications in Q1 journals (c). Since the quality of education can be assessed by means of foreign accreditations, we will certainly apply for additional ones (f). Such measures will help us to raise our visibility abroad and attract more international students. Finally, our objectives are closely related to innovations. We will measure the increase in entrepreneurship at NCU using the number of inventions protected by foreign patents (d) and revenues from commercialisations (e).

The normalized citation impact has been calculated using the InCite database. The predicted average value for the time period of 2020-2024 are calculated in the same manner as the mandatory indicators (a-c).

The percentage of international doctoral students is calculated using the POL-on database. Specifically, the predicted value is determined based on the trends between 2013 and 2017 using the same approach as for the mandatory indicators. We expect that this number will increase more rapidly due to the launch of our new, interdisciplinary PhD schools. Nonetheless, the exact dynamics of this process is difficult to anticipate.

The doctoral students' articles in Q1 Journals are defined as Q1 articles featuring at least one PhD student affiliated with NCU as co-author. We calculated the numbers of such Q1 articles in 2013-2017 and, according to the trend, we anticipate the average of 72 articles in 2020-2024.

The remaining indicators have been collected internally at NCU.

3) List of indicators determined by NCU (D.4.d)

We define the following indicators to monitor and evaluate the progress in the objectives 4-6 presented in the plan (Sec. D).

a) The number of young scientists in priority research teams at NCU (objectives related to the professional development of the academic staff - part 4)

In 2019, NCU initiated a unique contest for research teams to promote cross-disciplinary research activities. The applications were evaluated by external, distinguished scientists. We will organise similar contests in the future to promote young scientists as group members and leaders of such priority research teams.

b) The number of administrative staff members in the international and grant offices (objectives related to the quality of university governance - part 5)

The number of administrative staff members in key offices strongly affects the quality of the support offered to scientists. We intend to increase the number of administrative staff responsible for internationalisation and research grants, which are critical for the development of NCU.

c) The number of staff members and students who completed the TRIZ training to develop skills useful for innovations (other objectives - part 6)

This indicator will be monitored annually with the goal to reach 100 participants who successfully completed the TRIZ training. We are planning to train 40 candidates until the interim evaluation.

4) Indicators to monitor emerging fields

We are planning to monitor the progress of the emerging fields using the same indicators as for the priority research areas. In addition, we will monitor:
- % Articles in Q1 journals (E)
- % Articles in Q2 journals (E)
- Number of articles in Q1 journals (E)
- Number of articles in Q2 journals (E)

Through the directed support of NCU, the emerging fields should reach the same level of excellence and international collaboration as present in the priority research areas. At the same time, we will acknowledge their need to first build a capacity of top quality papers simultaneously reducing the percentage of papers in low-impact-factor journals.