XJENZA ONLINE

VOLUME 9 ISSUE 1, 2021

The University of Malta Research, Innovation & Development Trust

Malta Chamber of Scientists

Science Journal of the Malta Chamber of Scientists

Editor-in-Chief: Cristiana Sebu

www.xjenza.org

Xjenza Online - Science Journal of the Malta Chamber of Scientists
http://www.xjenza.org

Editorial Board

Editor-in-Chief

Prof. Cristiana Sebu
Department of Mathematics,
University of Malta,
Msida MSD 2080, Malta
Tel.: +356 2340 2466
cristiana.sebu@um.edu.mt

Publication Manager

Prof. Giuseppe Di Giovanni
Department of Physiology and Biochemistry,
University of Malta,
Msida MSD 2080, Malta
Tel.: +356 2340 2776
giuseppe.digiovanni@um.edu.mt

Senior Editors

Dr Sebastiano D'Amico
Department of Geosciences,
University of Malta,
Msida MSD 2080, Malta
Tel. +356 2340 3811
sebastiano.damico@um.edu.mt

Prof. David C. Magri
Department of Chemistry,
University of Malta,
Msida MSD 2080, Malta
Tel.: +356 2340 2276
david.magri@um.edu.mt

Associate Editors

Biological Sciences
Dr Sandro Lanfranco
sandro.lanfranco@um.edu.mt

Cognitive Sciences and Psychology
Prof. Ian Thornton
ian.thornton@um.edu.mt

Computer Sciences and Communication Technologies
Dr Gianluca Valentino
gianluca.valentino@um.edu.mt

Economics and Finance
Dr Ian Cassar
ian.p.cassar@um.edu.mt

Electrical and Control Systems Engineering
Dr Alexandra Bonnici
alexandra.bonnici@um.edu.mt

Health Sciences
Mr Joseph Galea
joseph.f.galea@um.edu.mt

Mechanical, Industrial and Manufacturing Engineering
Dr Pierre Vella
pierre.vella@um.edu.mt

Physics
Dr Lourdes Farrugia
lourdes.farrugia@um.edu.mt

Social Sciences
Prof Godfrey Baldacchino
godfrey.baldacchino@um.edu.mt

Statistics and Operational Research
Prof Liberato Camilleri
liberato.camilleri@um.edu.mt

Advisory Board Members

Prof. Vincenzo Crunelli, Cardiff University, UK — crunelli@cardiff.ac.uk
Prof. David Eisner, Manchester University, UK — eisner@manchester.ac.uk
Prof. Giacomo Rizzolati, University of Parma, Italy — giacomo.rizzolatti@unipr.it
Prof. Charles V. Sammut, University of Malta, Malta — charles.v.sammut@um.edu.mt
Prof. Frank Vella, University of Saskatchewan, Canada — f.vella@sasktel.net
Prof. Angela A. Xuereb Anastasi, University of Malta, Malta — angela.a.xuereb@um.edu.mt

Editorial Board Members

Dr Samantha Austen, Open University, UK — samantha.austen@open.ac.uk
Dr Maurizio Casarrubea, University of Palermo, Italy — maurizio.casarrubea@unipa.it
Dr Maria Cristiana D'Adamo, University of Malta, Malta — cristina.dadamo@um.edu.mt
Dr Katya De Giovanni, University of Malta, Malta — katya.degiovanni@um.edu.mt
Dr Tiziana M. Florio, Univeristy of L'Aquila, Italy — tizianamarilena.florio@univaq.it
Dr Robert Frau, University of Calgiari, Italy — roberto.frau@unica.it
Prof. David Mifsud, University of Malta, Malta — david.a.mifsud@um.edu.mt
Dr Massimo Pierucci, University of Malta, Malta — massimo.pierucci@um.edu.mt

Project Editor

Dr Jackson Levi Said
Department of Physics,
University of Malta,
Msida MSD 2080, Malta
jackson.said@um.edu.mt

Copy Editor

Luke Collins
Mathematics Institute,
University of Warwick,
Coventry, UK
luke@collins.mt

Editorial Assistants

Megan Floyd, Cardiff University, UK
FloydMK@cardiff.ac.uk

Web Administrator

Giovanni Faraone
faraone.g79@gmail.com

Chronological List of Past and Present Editors of Xjenza
The Journal of the Malta Chamber of Scientists

2018–
Editor: Cristiana Sebu
Senior Editors: *Sebastiano D'Amico, David Magri*
Associate Editors: *Sandro Lanfranco, Ian Thornton, Gianluca Valentino, Ian Cassar, Alexandra Bonnici, Joseph Galea, Pierre Vella, Lourdes Farrugia, Godfrey Baldacchino, Liberato Camilleri*
Xjenza Online Vol. 9 Iss. 1 - 2021
Xjenza Online Vol. 8 Iss. 2 - 2020
Xjenza Online Vol. 8 Iss. 1 - 2020
Xjenza Online Vol. 7 Iss. 2 - 2019
Xjenza Online Vol. 7 Iss. 1 - 2019
Xjenza Online Vol. 6 Iss. 2 - 2018
Xjenza Online Vol. 6 Iss. 1 - 2018

2013–2017
Editor: Giuseppe Di Giovanni
Associate Editors: *David Magri, Ian Thornton, Ian Cassar, Philip Farrugia, Sebastiano D'Amico, Nicholas Sammut, David Mifsud, Godfrey Baldacchino, Liberato Camilleri, Carmel Cefai*
Xjenza Online Vol. 5 Iss. 2 - 2017
Xjenza Online Vol. 5 SI MNS Proceedings - 2017
Xjenza Online Vol. 5 Iss. 1 - 2017
Xjenza Online Vol. 5 Virtual Issue COST - 2017
Xjenza Online Vol. 4 Iss. 2 - 2016
Xjenza Online Vol. 4 Iss. 1 - 2016
Xjenza Online Vol. 3 Iss. 2 - 2015
Associate Editors: *David Magri, Ian Thornton, Ian Cassar, Philip Farrugia, Sebastiano D'Amico, Nicholas Sammut, Joseph Galea, David Mifsud, Sandro Lanfranco, Mario Valentino, Godfrey Baldacchino, Liberato Camilleri*
Xjenza Online Vol. 3 Iss. 1 - 2015
Xjenza Online Vol. 2 Iss. 2 - 2014
Xjenza Online Vol. 2 Iss. 1 - 2014
Xjenza Online Vol. 1 Iss. 2 - 2013
Xjenza Online Vol. 1 Iss. 1 - 2013

2003–2007
Editors: Joseph N. Grima and Richard Muscat
Xjenza Vol. 12 - 2007
Xjenza Vol. 11 - 2006
Xjenza Vol. 10 - 2005
Xjenza Vol. 9 - 2004
Xjenza Vol. 8 - 2003

1996–2002
Editor: Angela Xuereb
Associate Editor: *Richard Muscat*
Xjenza Vol. 7 - 2002
Xjenza Vol. 6 - 2001
Associate Editors: *Martin Ebejer and Richard Muscat*
Xjenza Vol. 5 - 2000
Xjenza Vol. 4 Iss. 2 - 1999
Xjenza Vol. 4 Iss. 1 - 1999
Associate Editors: *Martin Ebejer, Richard Muscat, and Christian A. Scerri*
Xjenza Vol. 3 Iss. 2 - 1998
Xjenza Vol. 3 Iss. 1 - 1998
Associate Editors: *Martin Ebejer, Richard Muscat, Christian A. Scerri and Emmanuel Sinagra*
Xjenza Vol. 2 Iss. 2 - 1997
Xjenza Vol. 2 Iss. 1 - 1997
Xjenza Vol. 1 Iss. 2 - 1996
Xjenza Vol. 1 Iss. 1 - 1996

Scope of Journal

Xjenza Online is the Science Journal of the Malta Chamber of Scientists and is published in an electronic format. Xjenza Online is a peer-reviewed, open access international journal. The scope of the journal encompasses research articles, original research reports, reviews, short communications and scientific commentaries in the fields of: mathematics, statistics, geology, engineering, computer science, social sciences, natural and earth sciences, technological sciences, linguistics, industrial, nanotechnology, biology, chemistry, physics, zoology, medical studies, electronics and all other applied and theoretical aspect of science.

The first printed issue of the journal was published in 1996 and the last (Vol. 12) in 2007. The publication of Xjenza was then ceased until 2013 when a new editorial board was formed with internationally recognised scientists, and Xjenza was relaunched as an online journal, with two issues being produced every year. One of the aims of Xjenza, besides highlighting the exciting research being performed nationally and internationally by Maltese scholars, is to provide a launching platform into scientific publishing for a wide scope of potential authors, including students and young researchers, into scientific publishing in a peer-reviewed environment.

Instructions for Authors

Xjenza is the Science Journal of the Malta Chamber of Scientists and is published by the Chamber in electronic format on the website: http://www.mcs.org.mt/index.php/xjenza. Xjenza will consider manuscripts for publication on a wide variety of scientific topics in the following categories

1. Research Articles
2. Communications
3. Review Articles
4. Notes
5. Research Reports
6. Commentaries
7. News and Views
8. Invited Articles and Special Issues
9. Errata

Research Articles form the main category of scientific papers submitted to Xjenza. The same standards of scientific content and quality that applies to Communications also apply to Research Articles.

Communications are short peer-reviewed research articles (limited to three journal pages) that describe new important results meriting urgent publication. These are often followed by a full Research Article.

Review Articles describe work of interest to the wide community of readers of Xjenza. They should provide an in-depth understanding of significant topics in the sciences and a critical discussion of the existing state of knowledge on a topic based on primary literature sources. Review Articles should not normally exceed 6000 words.Authors are strongly advised to contact the Editorial Board before writing a Review.

Notes are fully referenced, peer-reviewed short articles limited to three journal pages that describe new theories, concepts and developments made by the authors in any branch of science and technology. Notes need not contain results from experimental or simulation work.

Research Reports are extended reports describing research of interest to a wide scientific audience characteristic of Xjenza. Please contact the editor to discuss the suitability of topics for Research Reports.

Commentaries: Upon Editor's invitation, commentaries discuss a paper published in a specific issue and should set the problems addressed by the paper in the wider context of the field. Proposals for Commentaries may be submitted; however, in this case authors should only send an outline of the proposed paper for initial consideration. The contents of the commentaries should follow the following set of rules: 3000 words maximum, title 20 words maximum, references 10 maximum (including the article discussed) and figures/tables 2 maximum.

News and Views: The News section provides a space for articles up to three journal pages in length describing leading developments in any field of science and technology or for reporting items such as conference reports. The Editor reserves the right to modify or reject articles for consideration as News.

Invited Articles and Special Issues: Xjenza regularly publishes Invited Articles and Special Issues that consist of articles written at the invitation of the Editor or another member of the editorial board.

Errata: Xjenza also publishes errata, in which authors correct significant errors of substance in their published manuscripts. The title should read: Erratum: "Original title" by ***, Xjenza, vol. *** (year). Errata should be short and consistent for clarity.

Submission of Manuscripts

Manuscripts should be sent according to the guidelines given hereafter to xjenza@mcs.org.mt.

Referees All manuscripts submitted to Xjenza are peer reviewed. Authors are requested to submit with their manuscript the names and addresses of three referees, preferably from overseas. Every effort will be made to use the recommended reviewers; however the editor reserves the right to also consult other competent reviewers.

Conflict of Interest Authors are expected to disclose any commercial or other types of associations that may pose a conflict of interest in connection to with the submitted manuscript. All funding sources supporting the work, and institutional or corporate affiliations of the authors, should be acknowledged on the title page or at the end of the article.

Policy and Ethics The work presented in the submitted manuscript must have been carried out in compliance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans (`http://www.wma.net/en/30publications/10policies/b3/index.html`); EU Directive 2010/63/EU for animal experiments (`http://ec.europa.eu/environment/chemicals/lab_animals/legislation_en.htm`); Uniform Requirements for manuscripts submitted to Biomedical journals (`http://www.icmje.org`). This must be stated at an appropriate point in the article.

Submission, Declaration and Verification Author(s) must only submit work that has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that is not under consideration for publication elsewhere, that has been approved for publication by all authors, and tacitly or explicitly, by the responsible authorities where the work was carried out, and that, if accepted, will not be published elsewhere in the same form, in English or in any other language, including electronically, without the written consent of the copyright-holder.

Permissions It is the responsibility of the corresponding author of a manuscript to ensure that there is no infringement of copyright when submitting material to Xjenza. In particular, when material is copied from other sources, a written statement is required from both the author and/or publisher giving permission for reproduction. Manuscripts in press, unpublished data and personal communications are discouraged; however, corresponding authors are expected to obtain permission in writing from at least one author of such materials.

Preparation of Manuscripts

Xjenza accepts submissions in MS Word, Libre Office Writer and LaTeX, the latter being the preferred option. Anyone submitting in LaTeX should use the journal template, the latest version of which can be found at `http://github.com/hicklin/Xjenza-Journal-Template`. All the necessary files to run the LaTeX document should be supplied together with the rendered PDF.

If a word processor is used the styling should be kept to a minimum. Bold face and italic fonts, as well as subscript and superscript text may be used as required by the context. Text should be in single-column format and the word processor options should not be used in order to justify text or hyphenate words. Alongside the native format of the word processer, a PDF file, generated by the word processor, must be provided. Furthermore, artwork should be in accordance with the artwork guidelines given below and must be submitted separately from the word processor file. Similarly, the bibliographic data of the cited material should be submitted separately as an Endnote (*.xml), Research Information Systems (*.ris), Zotero Library (zotero.splite) or a BibTeX (*.bib) file.

Article Structure

A manuscript for publication in Xjenza will typicall have the following components: Title page, Abstract, Keywords, Abbreviations, Introduction, Materials and Methods, Results, Discussion, Conclusions, Appendices and References.

The manuscript will be divided into clearly defined and numbered sections. Each numbered subsection should have a brief heading. Each heading should appear on its own separate line. Subsections should be used as much as possible when cross-referencing text, i.e. refer to the subsection by the section number.

Title page

- The title should be concise yet informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- Author names and affiliations. Indicate the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript number immediately after each author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address.
- Corresponding author. Clearly indicate who will handle correspondence at all stages of refereeing and publication, including post-publication. Ensure that telephone and fax numbers (with country and area code) are provided in addition to the e-mail address and complete postal address. Contact details must be kept up to date by the corresponding author.
- Present/permanent address. If an author has changed the address since the work described, this can be indicated as a footnote to the author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Abstract A concise and factual abstract is required of up to about 250 words. The abstract should state briefly the background and purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, references and non-standard abbreviations should be avoided. If essential, these must be defined at first mention in the abstract itself.

Abbreviations Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention as well as in the footnote and should be used consistently throughout the text.

Introduction State the objectives of the work and provide an adequate background, avoid a detailed literature survey or a summary of the results.

Materials and Methods Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Results Results should be clear and concise. Numbered/tabulated information and/or figures should also be included.

Discussion This should explore the significance of the results of the work, yet not repeat them. Avoid extensive citations and discussion of published literature. A combined section of Results and Discussion is often appropriate.

Conclusions The main conclusions based on results of the study may be presented in a short Conclusions section. This may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Acknowledgements Collate acknowledgements in a separate section at the end of the article before the references. Do not include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided assistance during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Units Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI. Anyone using LaTeX should use the package siunitx in all cases.

Footnotes Footnotes should be used sparingly. Number them consecutively throughout the article, using superscript Arabic numbers. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes by a superscript number in the text and list the footnotes separately at the end of the article. Do not include footnotes in the Reference list.

Table Footnotes Indicate each footnote in a table with a superscript lower case letter.

Artwork Electronic artwork general instructions:

- Make sure you use uniform lettering and sizing of your original artwork.
- Save text in illustrations as 'graphics' or enclose the font.
- Only use the following fonts in your illustrations: Arial, Courier, Times, Symbol or Computer Modern Roman, the latter is preferred.
- Number the illustrations according to their sequence in the text.
- Name your artwork files as 'fig$x$' or 'tab$x$' where x corresponds to the sequence number in your document.
- Provide captions to illustrations separately.
- Produce images near to the desired size of the printed version or grater.
- Make sure that the artwork has no margins and borders.

- Submit each figure as a separate file.

Formats Regardless of the application used, when your electronic artwork is finalised its file format should be one of the following (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):

- PDF or SVG: Vector drawings. Embed the font or save the text as 'graphics'.
- JPEG or PNG: Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
- JPEG or PNG: Bitmapped line drawings: use a minimum of 1000 dpi.
- JPEG or PNG: Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.

Where possible use a vector format for your artwork (PDF or SVG). If this is not possible, supply files that have and adequate resolution.

Colour Artwork Make sure that color artwork files are in an acceptable format (JPEG, PNG, PDF or SVG) and have the correct resolution.

Figure Captions Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (not on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum, but explain all symbols and abbreviations used.

Tables Number tables consecutively in accordance with their appearance in the text. Place footnotes to tables below the table body and indicate them with superscript lowercase letters. Avoid vertical rules. Be moderate with the use of tables and ensure that the data presented in tables do not duplicate results described elsewhere in the article. Large tables should be submitted in CSV format.

Citations and References Reference and citation styles for manuscripts submitted to Xjenza should be in accordance to the APA v6 style.

Citation in text References to cited literature in the text should be given in the form of an author's surname and the year of publication of the paper with the addition of a letter for references to several publications of the author in the same year. For further information regarding multiple authors consult the APA v6 guidelines. Citations may be made directly

Kramer et al. (2010) have recently shown ...

or parenthetically

as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999).

Groups of references should be listed first alphabetically, then chronologically. When writing in LaTeX use `\textcite{}` and `\parencite{}` for the respective cases mentioned.

The reference section Every reference cited in the text should also be present in the reference list (and vice versa). The reference list should also be supplied as an Endnote (*.xml), Research Information Systems (*.ris), Zotero Library (zotero.splite) or a BiBTeX (*.bib) file. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

References should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication. Consult the APA v6 guidelines for multiple authors. Below are some examples of referencing different bibliographic material.

Reference to a Journal Publication:

Agree, E. M. and Freedman, V. A. (2011). A Quality-of-Life Scale for Assistive Technology: Results of a Pilot Study of Aging and Technology. *Phys. Ther.*, 91(12):1780–1788.

McCreadie, C. and Tinker, A. (2005). The acceptability of assistive technology to older people. *Ageing Soc.*, 25(1):91–110.

Reference to a Book:

Brownsell, B. (2003). *Assistive Technology and Telecare: Forging Solutions for Independent Living.* Policy Press, Bristol.

Fisk, M. J. (2003). *Social Alarms to Telecare: Older People's Services in Transition.* Policy Press, Bristol, 1st edition.

Reference to a Chapter in an Edited Book:

Brownsell, S. and Bradley, D. (2003). New Generations of Telecare Equipment. In *Assist. Technol. Telecare Forg. Solut. Indep. Living*, pages 39–50.

Web references The full URL should be given together with the date the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately or can be included in the reference list.

References in a Special Issue Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Journal Abbreviations Journal names should be abbreviated according to:

-Index Medicus journal abbreviations: `http://www.nlm.nih.gov/tsd/serials/lji.html`;

-List of title word abbreviations: `http://www.issn.org/2-22661-LTWA-online.php`;

-CAS (Chemical Abstracts Service): `http://www.cas.org/sent.html`.

Video data Xjenza accepts video material and animation sequences to support and enhance the presentation of the scientific research. Authors who have video or animation files that they wish to submit with their article should send them as a separate file. Reference to the video material should be clearly made in text. This will the modified into a linked to the paper's supplementary information page. All submitted files should be properly labelled so that they directly relate to the video files content. This should be within a maximum size of 50 MB.

Submission check list

The following list will be useful during the final checking of a manuscript prior to sending it to the journal for review. Please consult the Author Guidelines for further details of any item.

- One author has been designated as the corresponding author with contact details:
  - E-mail address.
  - Full postal address.
  - Telephone and fax numbers.
- All necessary files have been sent, and contain:
  - All figures are given separately in PDF, SVG, JPEG of PNG format.
  - Caption for figures is included at the end of the text.
  - All tables (including title, description, footnotes) are included in the text and large tables have been given separately as CSV.
  - The reference list has been given in XML, RIS, zotero.splite or BIB file format.
- Further considerations

- Abstract does not exceed about 250 words.
- Manuscript has been ‘spell-checked’ and ‘grammar-checked’.
- References are in the required format.
- All references mentioned in the reference list are cited in the text, and vice versa.
- Bibliographic data for all cited material has been provided.
- Permission has been obtained for use of copyrighted material from other sources (including the Web).
- A PDF document generated from the word processor used is submitted.

After Acceptance

Use of the Digital Object Identifier The Digital Object Identifier (DOI) may be used to cite and link to electronic documents. The DOI consists of a unique alpha-numeric character string which is assigned to a document by the publisher upon the initial electronic publication. The assigned DOI never changes. Therefore, it is an ideal medium for citing a document, particularly ‘Articles in press’ because they have not yet received their full bibliographic information. When you use a DOI to create links to documents on the web, the DOIs are guaranteed never to change.

Proofs, Reprints and Copyright The corresponding author will receive an electronic proof of the article and have an opportunity to review editorial changes and to double-check accuracy of content, tables, and statistics before publication. A list of any necessary corrections should be sent by email to the managing editor within a week of proof receipt to avoid unnecessary delays in the publication of the article. Alterations, other than essential corrections to the text of the article, should not be made at this stage. Manuscripts are accepted for publication on the understanding that exclusive copyright is assigned to Xjenza. However, this does not limit the freedom of the author(s) to use material in the articles in any other published works.

Sebu, C. (2021). *Xjenza Online*, 9:1.

Xjenza Online - Science Journal of the Malta Chamber of Scientists
www.xjenza.org

Editorial

Return to Normality

Cristiana Sebu[*1]
[1]*Department of Mathematics, University of Malta, Msida, Malta*

Dear readers and authors of Xjenza Online, as Editor-in-Chief, I am very pleased to announce the release of the first issue of 2021 of Xjenza Online.

This issue of Xjenza Online marks the return to our usual publishing schedule which has experienced some undesired but uncontrollable disruptions and delays since the start of the COVID-19 pandemic. Nevertheless, in spite of all difficulties faced by the society, the journal demonstrated continuity in supporting the scientific endeavour in the Maltese Islands, particularly the one drawn on the local research expertise.

The issue opens with an important and timely study by Scerri and Borg on the influence of desalination plant effluent on shore macroinvertebrate assemblages. Unfortunately, rapid global population growth, misuse of water resources and the effects of climate change contribute to global water scarcity. One of the ways to circumvent this problem is desalination of sea water which, as this research reveals, impacts on shore biotic assemblages in the vicinity of the discharge point of hypersaline effluent.

The following article by Abela and Theuma provides a detailed insight on the GRAS method which allows for balancing and updating of Input-Output (I-O) tables and Social Accounting Matrices (SAMs) with positive and negative entries. The GRAS algorithm was then applied on the 2010 Macro SAM for Malta SAM including updated Rest of World account totals.

The issue concludes with an investigation by Saliba, Cortis and Madhloom on the relevance of risk management implementation throughout sport organizations. The authors analyzed the results of an empirical study conducted across all 47 youth academies in Malta and identified the main key hazards concerns, namely injuries, liability risk and inadequate facilities. The suggested key measures to avoid and minimize most risks are coaches' continuous professional development and the need of insurance policies to offer the ability to transfer risk.

To conclude, the Editorial Board of Xjenza Online would like to express our commitment to continue to serve the local professional scientific community, to publish high-quality original findings in a peer-reviewed environment, and to help early-career researchers to advance their scientific discourse in the community.

**Correspondence to*: C. Sebu (cristiana.sebu@um.edu.mt)

© 2021 Xjenza Online

Scerri, R-M. & Borg, J. A. (2021). *Xjenza Online*, 9:2–13.

Xjenza Online - Science Journal of the Malta Chamber of Scientists
www.xjenza.org
DOI: 10.7423/XJENZA.2021.1.01

Research Article

Influence of Desalination Plant Effluent on Shore Macroinvertebrate Assemblages

R-M. Scerri*[1], J. A. Borg[1]
[1] *Department of Biology, Faculty of Science, University of Malta, Msida, Malta*

Abstract. The present study was aimed to establish whether effluent from two desalination plants at different locations in Malta has an influence on biological attributes of rocky shore assemblages, and if so to determine the spatial extent of such influence, and whether the magnitude and extent of effects differs between the two plants. Samples of biota were collected from the Lower Mediolittoral Zone (LMZ) and Upper Mediolittoral Zone (UMZ) using a 20×20 cm quadrat, and from the Supralittoral Zone (SZ) using a 30×30 cm quadrat, at distances of 0 m, 15 m, 30 m, 80 m and 150 m away from the effluent outfall on either side of it. The collected biota were then sorted and identified in the laboratory. The results indicated that the influence of the desalination effluent on shore macroinvertebrate assemblages was localized at both study localities. Within the LMZ and UMZ, the influence was most evident 15 m away from the outfall, decreased beyond 30 m and was almost negligible 150 m away. In the case of the SZ, the influence was evident in the immediate vicinity of the outfall. Differences in the magnitude of the effect of effluent between the two study localities were attributed to the exposure of the shore to different flow regimes of the effluent discharge.

Keywords: reverse osmosis, hypersaline discharge, shore assemblages, macrofauna, Mediterranean

Acknowledgements. We thank Ing David Sacco [Manager, Water Production at Malta Water Services Corporation] and the Water Services Corporation for providing information on operations at the Ċirkewwa and Pembroke desalination plants. This work was supported by a grant awarded to JAB by the University of Malta's Research Support Services Directorate.

1 Introduction

Rapid global population growth, misuse of water resources and the effects of climate change all contribute to the issue of global water scarcity (Cisneros et al., 2014). One way to circumvent this problem is desalination; the process by which input water from sources such as seawater, brackish water, river water or wastewater is separated into two components: (i) water that may be used for human consumption, industry, irrigation for crop production, amongst others; and (ii) water with a high concentration of salts (Desaldata, 2018 as cited by Jones et al., 2019). The hypersaline effluent is usually discharged back into the same body of water (used as source) through an effluent outfall (Khordagui, 2015). Seawater desalination is regarded as a promising alternative to water extraction as it does not rely on climate-based water sources, and therefore does not exploit natural sources of freshwater. Additionally, the resultant freshwater output from the process is of high quality and can be provided continuously (Elimelech et al., 2011). Water treatment by Reverse Osmosis (RO) is the most widely used desalination process worldwide. The procedure increased in popularity in the 1980s following gradual transition from use of thermal technologies, namely Multi-Stage Flash (MSF) and Multiple-Effect Distillation (MED), to membrane-based ones (Jones et al., 2019).

Although desalination plants counteract water scarcity, their operation may have negative impacts on the environment. Desalination is an energy-intensive process, which uses an average of 4.0kWh/m^3; and most plants are currently reliant on burning fossil fuels, thus augmenting greenhouse gas emissions (Cooley et al., 2013). The marine environment is susceptible to negative impacts of desalination where plants are located in coastal areas, as it serves as the receiving body for

**Correspondence to*: R-M. Scerri (rebecca-maria.scerri.16@um.edu.mt)
© 2021 Xjenza Online

the hypersaline discharge (Khordagui, 2015), which may have a salinity that is twice that of the receiving water (Tularam et al., 2007). In the absence of adequate mixing, the high density gradient between seawater and hypersaline water causes the latter to sink to the seabed, thus imposing hypersaline stress on benthic stenohaline biota (Khordagui, 2015). For example, in the Mediterranean, hypersaline effluent from RO desalination may have an adverse impact on seagrass *Posidonia oceanica* (Linnaeus) Delile habitat (Sanchez-Lizaso et al., 2008; Sandoval-Gil et al., 2012). Low tolerance to hypersaline stress has been shown in faunal groups such as polychaetes and echinoderms. For example, Del-Pilar-Ruso et al. (2008) noted that hypersaline effluent caused a decrease in polychaete species richness, abundance and diversity. Fernández-Torquemada et al. (2005) reported that hypersaline effluent caused the disappearance of echinoderm populations in the vicinity of an effluent outfall. Although studies of the influence of hypersaline effluent from desalination operations on sublittoral benthic assemblages are available (e.g. Del-Pilar-Ruso et al., 2008; Fernández-Torquemada et al., 2005; Sanchez-Lizaso et al., 2008; Sandoval-Gil et al., 2012), none appear to have been made to assess the influence of such brine discharge on rocky shore biotic assemblages.

Hypersaline discharge may contain chemical additives that are required for pre- and post-treatment in the plant equipment, and which may also have a negative impact on marine ecology (Tularam et al., 2007). The chemical additives may include anti-scalants, coagulants, biocides, cleaning chemicals and nutrients. The toxicity of some chemical additives such as anti-scalants are considered minimal. However, other additives such as heavy metals and nutrients may pose a threat to marine ecosystems if discharged at high concentrations. Heavy metals such as copper, nickel, chromium and molybdenum may accumulate in sediments and algae and persist in the marine environment in the vicinity of a desalination plant (Khordagui, 2015; Tularam et al., 2007). Algae are effective bioaccumulators of heavy metals, and high levels of these chemicals can negatively influence the abundance, feeding and survival rate of algal-associated fauna (Roberts et al., 2006). Nutrients such as nitrogen and iron, which are limited in marine systems, can affect primary production as high levels of these may result in eutrophication (RPS, 2009).

At present, desalination in Malta is carried out by three large plants, all of which use RO technology: one is located at Għar Lapsi on the southwestern coast and two are located on the northeastern coast at Ċirkewwa and Pembroke. The present study was aimed at establishing whether effluent from two desalination plants at different locations in Malta has an influence on biological attributes of shore assemblages, and if so the spatial extent of such influence, and whether the magnitude and extent of effects differs between the two plants.

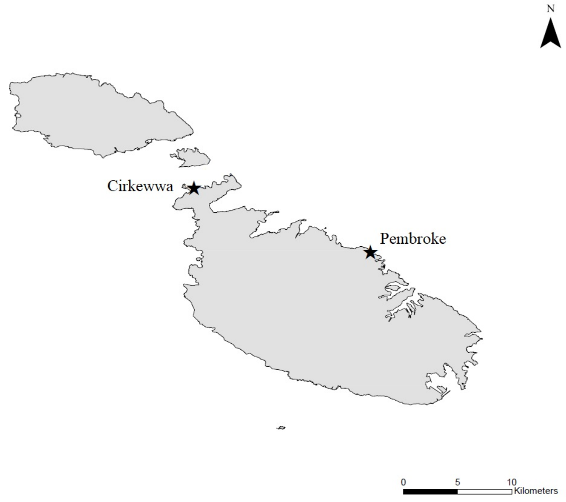

Figure 1: Map of the Maltese Islands showing the locations of the effluent outfall at Ċirkewwa and Pembroke

2 Materials and Methods

2.1 Study sites

The study localities where the two desalination plants are sited are Ċirkewwa and Pembroke (figure 1). Information provided by the Water Services Corporation (Ing D. Sacco, personal communication, 12th June 2020) indicates that the desalination plant at Ċirkewwa has a daily capacity of 8,400 m^3 between October and June, and increases to 11,600 m^3 between July and September. The corresponding daily production of hypersaline effluent is 12,600 m^3 and 17,400 m^3 respectively. The desalination plant at Pembroke has a daily capacity of 29,000 m^3 between October and June, and increases to 35,000 m^3 between July and September. The corresponding daily production of hypersaline effluent is 43,500 m^3 and 52,500 m^3 respectively. At both desalination plants, the chemical composition of the hypersaline effluent consists predominantly of chloride, sodium, magnesium, calcium, potassium, bicarbonate as well as total dissolved solids. The pH of the effluent is slightly acidic to neutral, ranging between 6.8 and 7.0. On average, the temperature of the effluent is between 19°C and 19.5°C and peaks at 21°C between August and October. The hypersaline discharge at the two desalination plants has a brine loading of around 70.2 g/L to 76 g/L. This means that over a 24 hour period between October and June, some 884,520 to 957,600 kg and 3,053,700 to 3,306,000 kg of brine are released to the marine environment at Ċirkewwa and Pembroke, respectively. Over a 24 hour period between July and September, some 1,221,480 to 1,322,400 kg and

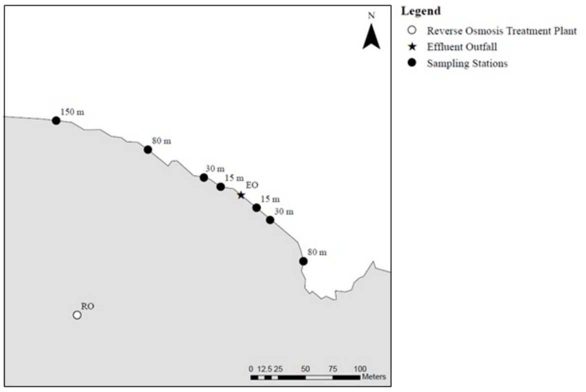

Figure 2: Map of the Ċirkewwa study area showing the locations of sampling stations and their respective distance (number in m) from the outfall. The location of the Ċirkewwa Reverse Osmosis Treatment Plant is also shown

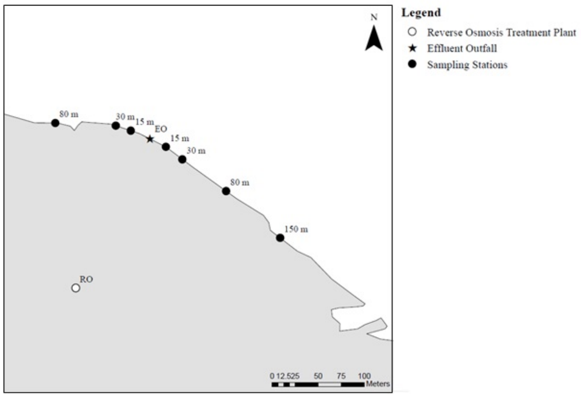

Figure 3: Map of the Pembroke study area showing the locations of sampling stations and their respective distance (number in m) from the outfall. The location of the Pembroke Reverse Osmosis Treatment Plant is also shown

3,685,500 to 3,990,000 kg of brine are released to the marine environment at Ċirkewwa and Pembroke, respectively.

At each of these two localities, the effluent originates from a desalination plant located behind the rocky shore. At both localities, the rocky shore faces north and the substratum, which comprises Coralline Limestone (Continental Shelf Department, 2016), is gently sloping with an inclination of 12° to 15° (Borg Axisa et al., 2013 as cited by Cassar et al., 2007).

2.2 Sample Collection and Processing

At each study area, sampling was carried out at stations located in the vicinity of the outfall and at several distances from it, on either side (east and west); these were: 15 m, 30 m and 80 m east and 15 m, 30 m, 80 m and 150 m west at Ċirkewwa, and 15 m, 30 m, 80 m and 150 m east and 15 m, 30 m and 80 m west at Pembroke; see figures 2 and 3. At each study area, samples of benthic macrobiota (fauna and flora) were taken from each sampling station. Two replicate samples were taken from the Lower Mediolittoral Zone (LMZ) and Upper Mediolittoral Zone (UMZ) using a 20 × 20 cm quadrat, and five replicate samples were taken from the Supralittoral Zone (SZ) using a 30 × 30 cm quadrat. The collected samples were preserved in 5% formal saline, and subsequently sorted to separate the macrofauna from algal material. The fauna were then identified to the lowest taxon possible; for the purpose of the present study all fauna were grouped at the family level, while algae were identified at least to the genus level. Following identification, the algal samples were dried at 70°C for 24 hours, following which the species biomass was recorded to the nearest 1/1000 g using an electronic balance.

2.3 Data Analysis

Mean values of total macrofaunal abundance in each of the three zones i.e. LMZ, UMZ and SZ, total number of macrofaunal families, and total algal biomass within the LMZ and UMZ, were used to show variation of these attributes amongst sampling stations and between the two study areas. Only two families were recorded from the SZ.

The Similarity Percentages analysis (SIMPER) was used to identify and select the three most important macrofaunal families in terms of the highest contribution to dissimilarity between different sampling stations at each of the two study areas. Bray–Curtis similarity was calculated on square-root-transformed data. The analysis was carried out using family abundance data for the LMZ and UMZ.

To test for significant differences in biological attributes of the shore biotic assemblages between sampling stations in the LMZ and UMZ at the two study areas, univariate one-way PERMANOVA tests were carried out on the data for number of macrofaunal families, for Pielou's evenness and Shannon-Wiener Diversity using the macrofaunal abundance, and for algal biomass. One-way PERMANOVA tests were also carried out using data for abundance of taxa which SIMPER analysis indicated as having the highest contribution to dissimilarity amongst sampling stations. Euclidean distance was used as a resemblance measure, alpha was set at 0.05, and the permutation number set to 9999. A multivariate one-way PERMANOVA was carried out using data for family abundance from the LMZ and UMZ from the two study areas. The data were square-root transformed to downweigh the abundant families, and to account for the less abundant and rare families (Clarke et al., 2001). The Bray-Curtis similarity measure was used to construct the similarity matrix, alpha was set at 0.05, and the permutation number set to 9999. Due to low values of possible permutations obtained for most of the tests, for both univariate and multivariate one-way PERMANOVA, Monte Carlo tests were carried out. In the event of a significant difference indicated by the PERMANOVA, a pair-wise PERMANOVA test was carried out to identify the source of significant difference for a given attribute between sampling stations. A principal coordinate analysis (PCO) was carried out to identify similarities or dissimilarities in the data indicated by the PERMANOVA analyses (Anderson et al., 2008).

All analyses were carried out using the PRIMER v7 software with PERMANOVA+ add-on.

3 Results

A total of 13,375 individuals belonging to 67 macrofaunal families were recorded; of these, 2,601 individuals belonging to 42 families were recorded from the Ċirkewwa study area, and 10,774 individuals belonging to 63 families were recorded from the Pembroke study area. A total of twelve species of algae, and two species of cyanobacteria were recorded, which together had a total biomass of 273.665 g.

The mean total macrofaunal abundance recorded from each sampling station from all three zones was higher at Pembroke than at Ċirkewwa for most (LMZ and UMZ) or all (SZ) stations. Macrofaunal abundance was low in one or both directions 15 m away from the effluent outfall in the LMZ and UMZ (figure 4A and B respectively) and nil at 0 m in the SZ (figure 4C) at Pembroke. Overall, an increase in mean total number of macrofaunal families recorded from the mediolittoral zone (LMZ + UMZ) was evident between the 15 m station and stations located further away from the effluent outfall, at both study areas (figure 5A and B respectively). Values of algal biomass were low, particularly at Ċirkewwa; however, a peak in biomass was evident at stations located at a distance of 30 m on either side of the effluent outfall at Pembroke (figure 6).

Univariate one-way PERMANOVA for the LMZ at Ċirkewwa indicated a significant difference [$p < 0.05$] for evenness, which the pair-wise tests indicated to result from a difference in evenness between the station located at 15 m and the station located at a distance of 80 m from the outfall. At Pembroke, a significant difference [$p < 0.05$] was indicated for number of macrofaunal families, Pielou's evenness and Shannon–Wiener diversity. For number of macrofaunal families, the pair-wise tests indicated significant differences between the stations located at a distance of 15 m and stations located at a distance of 30 m from the outfall. For diversity, the pair-wise tests indicated significant differences between the stations located at 15 m and stations located at 80 m and 150 m from the outfall. Univariate one-way PERMANOVA for the UMZ at Ċirkewwa indicated a significant difference [$p < 0.05$] for evenness

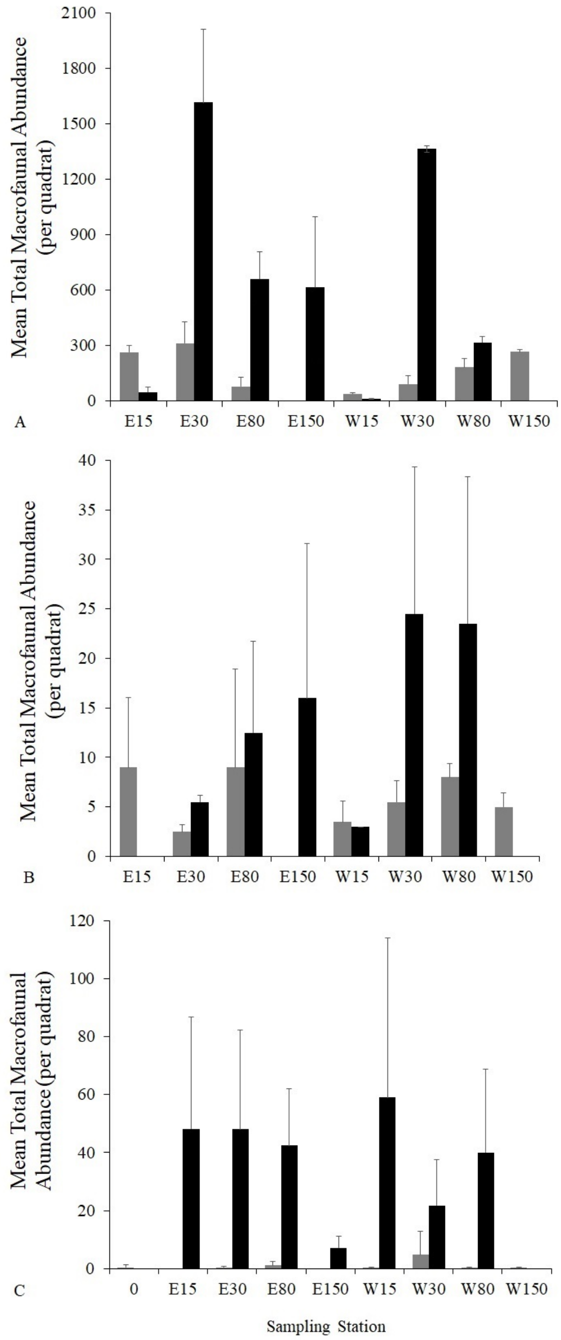

Figure 4: Mean total macrofaunal abundance per quadrat recorded from: A) Lower Mediolittoral Zone, B) Upper Mediolittoral Zone, C) Supralittoral Zone recorded from Cirkewwa (grey) and Pembroke (black). Error bars represent ±1 Standard Deviation. E = east side of the effluent outfall; W = west side of the effluent outfall; 15, 30, 80 and 150 represent the distance (m) from the effluent outfall

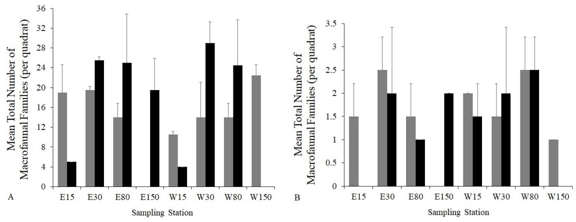

Figure 5: Mean total number of macrofaunal families per quadrat recorded from: A) Lower Mediolittoral Zone, B) Upper Mediolittoral Zone recorded from Cirkewwa (grey) and Pembroke (black). Error bars represent ±1 Standard Deviation. E = east side of the effluent outfall; W = west side of the effluent outfall; 15, 30, 80 and 150 represent the distance (m) from the effluent outfall

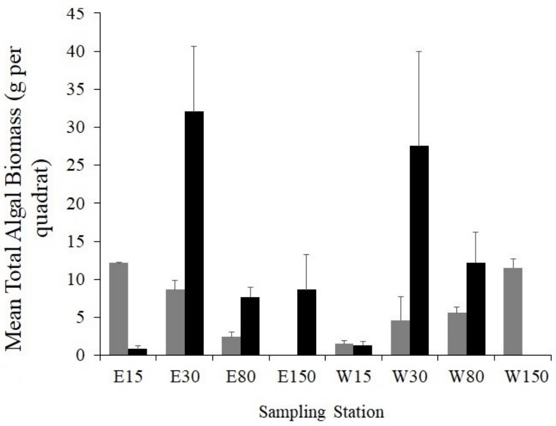

Figure 6: Mean total algal biomass in g per quadrat recorded from Ċirkewwa (grey) and Pembroke (black). Error bars represent ±1 Standard Deviation. E = east side of the effluent outfall; W = west side of the effluent outfall; 15, 30, 80 and 150 represent the distance (m) from the effluent outfall

and diversity. For both these attributes, the pair-wise tests indicated a significant difference between the station located at 15 m and the station located at 150 m from the outfall. A significant difference was also indicated by the pair-wise tests for evenness between the station located at 30 m and the station located at 80 m from the outfall; and for diversity between the station located at 30 m and the station located at 150 m from the outfall. No significant differences were detected for any of the considered attributes at Pembroke (table 1).

The macrofaunal families identified by the SIMPER analysis as contributing most to dissimilarity between stations at Ċirkewwa were Ampithoidae, Hyalidae and Sabellidae. Results from univariate one-way PERMANOVA showed a significant difference [$p < 0.05$] for abundance of Ampithoidae and Hyalidae (table 2). For both families, the pair-wise tests indicated a significant difference between the station located at 15 m and all other stations located at a greater distance from the outfall. A significant difference [$p < 0.05$] for abundance of Ampithoidae was also indicated between the eastern station located at a distance of 30 m and stations located at a distance of 80 m on the eastern side and 150 m on the western side from the outfall. The macrofaunal families identified by SIMPER analysis as contributing most to dissimilarity between stations in the LMZ at Pembroke were Ampithoidae, Sabellidae and Tanaididae. A significant difference [$p < 0.05$] was indicated by univariate one-way PERMANOVA for the abundance of Ampithoidae and Tanaididae (table 2). For both families, the pair-wise tests indicated a significant difference in abundance between the stations located at 15 m and the station located at 80 m on the western side (Ampithoidae) and that at 30 m on the eastern side (Tanaididae). A significant difference [$p < 0.05$] was also indicated by the pair-wise tests for abundance of Ampithoidae between the station located at a distance of 30 m on the eastern side and the station located on the western side at a distance of 80 m from the outfall. Significant differences were indicated by the pair-wise tests in abundance of Tanaididae between the station on the eastern side at a distance of 30 m from the outfall and stations located at a distance of: (i) 80 m from the outfall on both eastern and western sides; and (ii) 150 m on the eastern side, from the outfall.

The macrofaunal families identified by SIMPER analysis for the UMZ data from Ċirkewwa and Pembroke were Chthamalidae, Patellidae and Trochidae. At Ċirkewwa, a significant difference [$p < 0.05$] in abundance was detected by univariate one-way PERMANOVA only for Trochidae. The pair-wise tests showed that the source of the significant difference was between: (i) stations located at a distance of 15 m and stations located at a distance of 80 m from the outfall, on both western

Source of Variation	df			Number of Macrofaunal Families Pseudo-F	Number of Macrofaunal Families p-value	Pielou's Evenness Pseudo-F	Pielou's Evenness p-value	Shannon–Wiener Diversity Pseudo-F	Shannon–Wiener Diversity p-value
Study area	6	Ċirkewwa	LMZ	2.3768	0.1451	6.7074	**0.0124**	3.6903	0.057
			UMZ	1.8	0.2241	4.4464	**0.0361**	4.7687	**0.0306**
		Pembroke	LMZ	6.0842	**0.0168**	4.3478	**0.0362**	8.1175	**0.0069**
			UMZ	1.9667	0.1975	5.0512	0.0842	1.7045	0.2492
Residual	7								
Total	13								

Table 1: Results of univariate one-way PERMANOVA for number of macrofaunal families, Pielou's evenness and Shannon–Wiener diversity from analyses of Lower Mediolittoral Zone (LMZ) and Upper Mediolittoral Zone (UMZ) macrofaunal data for Ċirkewwa and Pembroke. df = degrees of freedom. Significant p-values ($p < 0.05$) are indicated in bold.

Source of Variation	df		Ampithoidae Pseudo-F	Ampithoidae p-value	Hyalidae Pseudo-F	Hyalidae p-value	Sabellidae Pseudo-F	Sabellidae p-value	Tanaididae Pseudo-F	Tanaididae p-value
Study area	6	Ċirkewwa	10.957	**0.0038**	5.3105	**0.0236**	2.4771	0.1284		
		Pembroke	4.2593	**0.038**			0.84167	0.577	32.703	**0.0002**
Residual	7									
Total	13									

Table 2: Results of univariate one-way PERMANOVA for abundance of Ampithoidae, Hyalidae, Sabellidae and Tanaididae from SIMPER analyses of Lower Mediolittoral Zone (LMZ) data for Ċirkewwa and Pembroke. df = degrees of freedom. Significant p-values ($p < 0.05$) are indicated in bold.

and eastern sides; and (ii) the station located at a distance of 30 m from the outfall on the western side and the station located at a distance of 80 m from the outfall on both western and eastern sides. At Pembroke, univariate one-way PERMANOVA indicated a significant difference [$p < 0.05$] in abundance only for Patellidae. The pair-wise tests showed that the source of this difference was between the station located at 15 m on the eastern side and (i) stations located at a distance of 30 m on both western and eastern sides and (ii) 80 m from the outfall on the western side (table 3).

Univariate one-way PERMANOVA indicated a significant difference [$p < 0.05$] for number of algal species and total algal biomass in the LMZ at both Ċirkewwa and Pembroke (table 4). For both study areas, the pair-wise tests did not indicate a significant difference between pairs of stations for number of algal species but the procedure indicated a significant difference for total algal biomass. For Ċirkewwa, the source of this difference was between: (i) the station located at a distance of 15 m on the western side and stations at 30 m on the eastern side, 80 m and 150 m from the outfall on the western side; and (ii) the station located at a distance of 15 m on the eastern side and stations at 80 m from the outfall on both western and eastern sides. The pair-wise tests also indicated a significant difference between: (i) the station at 80 m from the outfall on the eastern side and stations at 30 m and 150 m on the eastern and western sides respectively; and between: (ii) the station at 80 m on the western side and the station at 150 m from the outfall on the western side. For Pembroke, the source of this significance was between: (i) the station at a distance of 15 m from the outfall on the western side and stations at 30 m and 80 m from the outfall on the eastern side; and (ii) the station at a distance of 15 m from the outfall on the eastern side and stations at 30 m and 80 m from the outfall on the eastern side. The detected differences in biological attributes between the station located at a distance of 15 m and stations located further away from the outfall was corroborated by the results of multivariate analysis, in particular for the Pembroke study area. The results of multivariate one-way PERMANOVA (table 5) and pair-wise tests for the macrofaunal data from the LMZ at this study area indicated a significant difference [$p < 0.05$] in total abundance of macrofauna; the source of this difference was between: (i) the station located at a distance of 15 m from the outfall on the western side and stations at 30 m, 80 m and 150 m on the eastern side and 30 m on the western side; and (ii) the station located at a distance of 15 m from the outfall on the eastern side and stations at 30 m from the outfall on both western and eastern sides. At Ċirkewwa, the results of multivariate one-way PERMANOVA did not indicate a

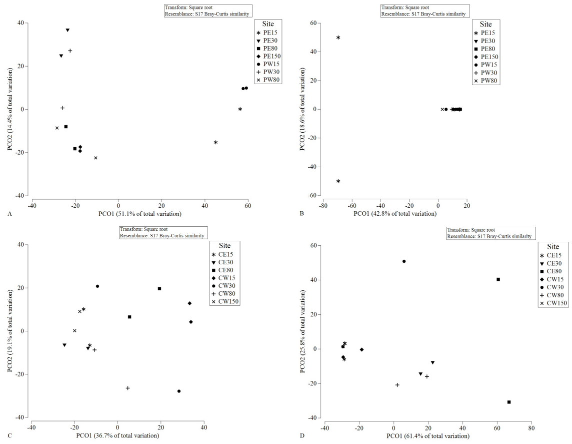

Figure 7: Plots from Principal Coordinates Analysis based on square-root transformed abundance data from: A) Lower Mediolittoral Zone at Pembroke, B) Upper Mediolittoral Zone at Pembroke, C) Lower Mediolittoral Zone at Cirkewwa and D) Upper Mediolittoral Zone at Cirkewwa. PE = Pembroke east; PW = Pembroke west; CE = Cirkewwa east; CW = Cirkewwa west. The numbers in the station codes represent the distance (in m) from the outfall

significant difference in total abundance of macrofauna between stations in the LMZ. The results of multivariate one-way PERMANOVA for macrofaunal data from the UMZ at Ċirkewwa indicated a significant difference [$p < 0.05$] between stations in total abundance of macrofauna; the pair-wise tests indicated that the source of this difference was between the station located at a distance of 30 m from the outfall on the eastern side and the station located at a distance of 150 m from the outfall on the western side. A significant difference [$p < 0.05$] between stations was also indicated for total abundance of macrofauna in the UMZ at Pembroke but the pair-wise tests did not identify the source of this difference. The plots from the PCO analyses for abundance data from the LMZ and UMZ at Pembroke (figure 7 A and B respectively) showed a separation between the station located at a distance of 15 m and stations located at a greater distance from the outfall on both western and eastern sides. These results corroborate those from the multivariate one-way PERMANOVA tests. The plot for macrofaunal data from the LMZ at Pembroke also indicates that stations located at a distance of 30 m from the outfall were grouped separately from rest of the stations. The respective plots for the LMZ and UMZ at Ċirkewwa (figure 7C and D respectively) indicated less separation of samples.

4 Discussion

Differences in macrofaunal abundance, number of macrofaunal families and algal biomass between the two study areas indicate that the influence of the hyper-

Source of Variation	df		Chthamalidae Pseudo-F	Chthamalidae p-value	Patellidae Pseudo-F	Patellidae p-value	Trochidae Pseudo-F	Trochidae p-value
Study area	6	Ċirkewwa	0.87577	0.5564	3.0406	0.084	19.093	**0.0002**
		Pembroke	0.98154	0.5072	4.8885	**0.029**	1.5	0.3084
Residual	7							
Total	13							

Table 3: Results of univariate one-way PERMANOVA for abundance of Chthamalidae, Patellidae and Trochidae from SIMPER analysis of Upper Mediolittoral Zone (UMZ) data for Ċirkewwa and Pembroke. df = degrees of freedom. Significant p-values ($p < 0.05$) are indicated in bold.

Source of Variation	df		No. of Algal Species Pseudo-F	No. of Algal Species p-value	Total Algal Biomass Pseudo-F	Total Algal Biomass p-value
Study area	6	Ċirkewwa	7.5	**0.0099**	19.163	**0.0009**
		Pembroke	1.2778	0.3726	7.9191	**0.0083**
Residual	7					
Total	13					

Table 4: Results of univariate one-way PERMANOVA for number of algal species and total algal biomass from analysis of Lower Mediolittoral Zone (LMZ) algal data for Ċirkewwa and Pembroke. df = degrees of freedom. Significant p-values ($p < 0.05$) are indicated in bold.

Source of Variation	df			Pseudo-F	p-value
Study area	6	Ċirkewwa	LMZ	1.7348	0.0569
			UMZ	3.4257	**0.0132**
		Pembroke	LMZ	4.707	**0.0001**
			UMZ	2.0748	**0.0397**
Residual	7				
Total	13				

Table 5: Results of multivariate one-way PERMANOVA from analyses of Lower Mediolittoral Zone (LMZ) and Upper Mediolittoral Zone (UMZ) macrofaunal data for Ċirkewwa and Pembroke. df = degrees of freedom.

saline effluent was greater at Ċirkewwa compared to Pembroke. This may be attributed to exposure of the shore to different flow regimes of the effluent discharge; at Ċirkewwa, the effluent flows down a single channel directly into the open sea, whereas at Pembroke the effluent flows into several diverging channels before entering the open sea. Some of the latter channels terminate into rockpools, which receive the discharged effluent, and eventually overflow. Therefore, although the shore biotic assemblages at Pembroke appear to be influenced by the hypersaline effluent, while the volume of effluent released there is greater, the magnitude of this influence may be lower at this study area due to dispersal of the effluent into smaller bodies of water before it enters the sea. Another difference in results between the two study localities is that macrofaunal abundance and number of faunal families in the LMZ at Cirkewwa decreased on moving eastwards from the effluent outfall and increased on moving westwards, while such trend was not evident at Pembroke (figures 4 and 5). This could possibly be attributed to the higher exposure of the shore at Ċirkewwa to the locally-predominant northwesterly wind (Galdies, 2012) which would generate wave action and water movement that is expected to displace the effluent eastward, thereby influencing the shore biota present east of the discharge point to a greater extent than that present west of it. On the other hand, such influence is less at Pembroke which is less exposed (figures 4 and 5) to the northwesterly wind and related wave action.

The present results indicate that the influence of hypersaline effluent on shore biotic assemblages in the vicinity of the outfall at both desalination plants is highest within the stretch of shore located within a distance of 15 m from the discharge point. In the LMZ and UMZ at both Ċirkewwa and Pembroke, the influence of the hypersaline discharge was manifested by low values of abundance and number of families of macrofauna at the station located 15 m from the outfall, while an increase in values of these attributes occurred with increasing distance from the discharge point. The results of univariate and multivariate one-way PERMANOVA tests indicated differences in biological attributes; namely number of macrofaunal families, Pielou's evenness, Shannon-Wiener diversity and algal biomass between the station located at a distance of 15 m from the outfall and stations located at a greater distance from it, and that the observed differences with increasing distance from the discharge point were more evident at Pembroke compared to Ċirkewwa. These results were corroborated by the output from the PCO analysis of biological data from Pembroke (figure 7A and B) which clearly indicated that the stations at 15 m are distinguishable from the other stations.

Results from univariate one-way PERMANOVA tests for the LMZ indicated a significant difference in abundance of Ampithoidae between sampling stations at both study areas. Most of the pairs of stations that were significantly different included the station located at a distance of 15 m and stations located at a greater distance from the outfall. De-La-Ossa-Carretero et al. (2016) showed that amphipod abundance and diversity decreased in response to elevated salinity of brine effluent, especially in the vicinity of a hypersaline outfall. Results from univariate one-way PERMANOVA tests for the UMZ indicated a significant difference for Trochidae at Ċirkewwa between stations at 15 m and 80 m and between those at 30 m and 80 m and for Patellidae at Pembroke between stations at 15 m and 30 m and between those at 15 m and 80 m. *Phorcus turbinatus* (Born, 1778), the most abundant member of Trochidae recorded from the UMZ in the present study, is sensitive to changes in salinity (Menzies et al., 1992), hence decreased abundance of this species with decreased distance from the outfall may be due to the high salinity levels to which the shore habitat is exposed. Information on tolerance of Patellidae to above-ambient salinity levels appears to be lacking, but one would expect that species from this family will be as affected adversely by high salinity levels, particularly during their juvenile stages. As a consequence of external fertilization, the larval stages of marine gastropods, such as patellids, are planktonic. Mortality rates of the planktonic larval stage would be expected to be higher when exposed to unfavourably high salinity levels that lead to desiccation (Denny et al., 2007).

The results from univariate one-way PERMANOVA tests for algal biomass indicated a significant difference between the station located at a distance of 15 m and stations located at a greater distance away from the outfall on both western and eastern sides. A concurrent increase in algal structural complexity with increasing algal biomass would be expected as one moves further away from the effluent discharge point. At the station located at a distance of 15 m from the outfall, *Ulva* sp. and Cyanobacteria were the dominant flora; these are characterised by low structural complexity, which in turn would be expected to support a lower associated macrofaunal abundance (Hacker et al., 1990) and diversity (Hicks, 1985 as cited by Hauser et al., 2006). The genus *Ulva* comprises euryhaline species (Black et al., 1972), which have a high tolerance to elevated salinity compared with other macroalgae exposed to the same environmental conditions (Einav et al., 1995). Similarly to *Ulva* sp., some cyanobacteria species have a high tolerance to salinity levels. One of the two cyanobacterial species identified in the present study is *Symploca* sp., which is capable of tolerating salinity levels ranging between 48 PSU and 62 PSU (Nagasathya et al., 2008). At stations located at a distance of 30 m and more from the outfall, the influence of the hypersaline effluent is less pronounced and environmental conditions are more similar to background ones. This would allow the presence of algae that are more characteristic of natural ambient conditions, and which would have a higher biomass, as noted from the present results, and hence higher structural complexity that would be expected to support a higher diversity of associated macrofauna. The flora which dominated the stations located at a distance of 30 m and greater away from the outfall included *Jania rubens*, *Gelidium* sp., *Titanoderma* sp. and *Padina pavonica*, all of which are more typical of the rocky shore LMZ around the Maltese Islands

The results of the present study also show that the hypersaline discharge influenced shore biotic assemblages within the mediolittoral zone at a distance of 30 m away from the outfall but such influence was less than 15 m away from the discharge. This suggests that the influence of the effluent is localized, being most evident at a distance of 15 m from the outfall, and is lower at a distance of 30 m, and becomes negligible further away.

The supralittoral macrofauna comprised members of the families Littorinidae and Chthamalidae. Chthamalidae individuals were only recorded at Pembroke in one replicate sample. The abundance of the littorinid *Melarhaphe neritoides* (Linnaeus, 1758) was higher at Pembroke than at Ċirkewwa, and contrary to the obtained results for macrofaunal abundance in the LMZ and UMZ, the abundance of this species at stations located at a distance of 15 m from the outfall was comparable to that recorded from stations located at a greater distance from the discharge point; only in the immediate vicinity of the effluent outfall, i.e. at 0 m, was this species absent and hence its abundance was '0'. Thus, the influence of the effluent on littorinids within this zone may not be so large compared to that on other macrofaunal groups present in the LMZ and UMZ; this is probably due to the presence of ecotypes, i.e. a population adapted to the specific environmental conditions provided by the effluent (Brewer, 1994), the behavioural strategies of species from this family, and the lower exposure of the zone to wave action. *M. neritoides* typically shelters itself from harsh physical conditions such as wave action by occurring in dense aggregates within crevices on the rocky shore, as well as in pits and under overhangs, where the microclimate is benign. Moreover, the supralittoral zone receives sea-spray but is not submerged and it is only during strong wave action that this zone is wetted by the sea (Grech et al., 1989). Since the hypersaline effluent directly enters the sea, the supralittoral zone which is further inland is less affected than the mediolittoral zone further down. Therefore, exposure of *M. neritoides* to the effluent is minimal, especially due to the reduced wave action during the summer months.

5 Conclusions

Overall, the present results indicate a similar pattern of influence of hypersaline effluent on shore biotic assemblages in the vicinity of the discharge point, at both desalination plants under study. However, some differences in macrofaunal abundance, number of macrofaunal families and algal biomass were noted between the two study areas. This is to be expected and would result from differences in environmental factors between the two study localities, which would influence attributes of the shore biotic assemblages, as was noted in the present study wherein a different pattern of change in abundance and number of families of macrofauna between Ċirkewwa and Pembroke, on moving away from the effluent source, was evident. The influence of the hypersaline discharge was greater at Ċirkewwa compared to Pembroke; this was attributed to exposure of the shore to different flow regimes of the effluent discharge between the two desalination plants. Results for the LMZ and UMZ infer the largest influence of the hypersaline effluent on the shore biotic assemblages occurred within the stretch of shore located within 15 m away from the effluent outfall, and this observation was common to both study areas. The influence decreased beyond a distance of 30 m and was almost negligible at a distance of 150 m. In the SZ, the influence of the effluent on the shore biota was evident in the immediate vicinity of the outfall, at 0 m, where no species were recorded, while at a distance of 15 m from the outfall, the abundance of Littorinidae was comparable with that recorded from stations located at a greater distance from the discharge point. As far as the present authors are aware, this is the first time that the influence of hypersaline effluent from desalination operations on rocky shore biotic assemblages, specifically in the Mediterranean, has been assessed. The results from the present study, which should be considered preliminary especially given the limited effort adopted during sampling of the biota, suggest that dispersal of desalination effluent at the discharge point may decrease the level of adverse influence on shore biotic assemblages, while the overall findings should help coastal managers and planners in decision-making processes that concern site selection for desalination plants and aspects of the effluent discharge to the sea. Further investigations, which could include assessment of water quality, hydrodynamic aspects and other physico-chemical environmental factors, as well as more extensive sampling of biota associated with the different littoral and sublittoral zones, would be very useful as further evaluation of the influence of desalination effluent on shore and shallow water marine ecology.

Declarations

The authors have no relevant financial or non-financial interests to disclose. Conflict of Interest: The authors declare that they have no conflict of interest.

References

Anderson, M. J., Gorley, R. N. & Clarke, K. R. (2008). *PERMANOVA+ for PRIMER: Guide to software and statistical methods*. Devon: PRIMER-E Ltd.

Black, D. R. & Weeks, D. C. (1972). Ionic relationships of *Enteromorpha Intestinalis*. *New Phytologist*, *71*, 119–127.

Borg Axisa, G., Sciberras, J., Sciberras, A., Pisani, L., Sultana, J. et al. (2013). Visitors' site guide Pembroke Heritage Project [Retrieved April 26, 2019, from European Regional Development Fund Malta 2007–2013].

Brewer, R. (1994). *The science of ecology* (second ed.). Saunders College Publishing.

Cassar, L. F., Lanfranco, S. & Schembri, P. J. (2007). An ecological appraisal of the special area of conservation – candidate site of international importance, in the Pembroke Area, Malta. *Report prepared by Ecoserv Ltd for Nature Trust (Malta)*, *38*.

Cisneros, J. B., Oki, T., Arnell, N. W., Benito, G., Cogley, J. G. et al. (2014). Freshwater resources. In C. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea et al. (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. part a: Global and sectoral aspects. contribution of working group ii to the fifth assessment report of the intergovernmental panel on climate change* (pp. 229–269). Cambridge University Press.

Clarke, K. R. & Warwick, R. M. (2001). *Change in marine communities: An approach to statistical analysis and interpretation* (second ed.). PRIMER-E Plymouth.

Continental Shelf Department. (2016). Geological map of the maltese islands [Retrieved April 26, 2019, URL: https://malta-contshelf.maps.arcgis.com/apps/MapTools/index.html?appid=79ad35031ff4449ea92df25a2e2e505e].

Cooley, H. & Heberger, M. (2013). *Key issues for seawater desalination in California: Energy and greenhouse gas emissions*. Oakland, CA: Pacific Institute.

De-La-Ossa-Carretero, J. A., Del-Pilar-Ruso, Y., Loya-Fernandez, A., Ferrero-Vicente, L. M., Marco-Mendez, C. et al. (2016). Response of amphipod assemblages to desalination brine discharge: Impact and recovery. *Estuarine, Coastal and Shelf Science*, *172*, 13–23.

Del-Pilar-Ruso, Y., De-la-Ossa-Carretero, J. A., Gimenez-Casalduero, F. & Sanchez-Lizaso, J. L. (2008). Effects of a brine discharge over soft bottom polychaeta assemblage. *Environmental Pollution*, *156*, 240–250.

Denny, M. W. & Gaines, S. D. (2007). *Encyclopedia of tidepools and rocky shores*. University of California Press.

Einav, R., Breckle, S. & Beer, S. (1995). Ecophysiological adaptation strategies of some intertidal marine macroalgae of the israeli mediterranean coast. *Marine Ecology Progress Series*, *125*, 219–228.

Elimelech, M. & Phillip, W. A. (2011). The future of seawater desalination: Energy, technology, and the environment. *Science*, *333*(6043), 712–717.

Fernández-Torquemada, Y., Sánchez-Lizaso, J. & González-Correa, J. (2005). Preliminary results of the monitoring of the brine discharge produced by the SWRO desalination plant of Alicante (SE Spain). *Desalination*, *182*(1), 395–402.

Galdies, C. (2012). The climate of the maltese islands. *Sustainable Energy 2012: The ISE Annual Conference Proceedings*, 65–69.

Grech, M. & Schembri, P. J. (1989). A laboratory study of the behavioural responses of littorina neritoides (mollusca: Gastropoda) in relation to its zonation on Maltese shores (central Mediterranean). *Marine Behaviour and Physiology*, *15*, 123–135.

Hacker, S. D. & Steneck, R. S. (1990). Habitat architecture and the abundance and body-size-dependent habitat selection of a phytal amphipod. *Ecology*, *71*(6), 2269–2285.

Hauser, A., Cotton, P. A. & Attrill, M. (2006). Effects of habitat complexity on the diversity and abundance of macrofauna colonising artificial kelp holdfasts. *Marine Ecology Progress Series*, *325*, 93–100.

Hicks, G. R. (1985). Meiofauna associated with rocky shore algae. In P. G. Moore & R. Seed (Eds.), *Ecology of rocky coasts*. Hodder & Stoughton.

Jones, E., Qadir, M., van Vliet, M. T., Smakhtin, V. & Kang, S. (2019). The state of desalination and brine production: A global outlook. *Science of the Total Environment*, *657*, 1343–1356.

Khordagui, H. (2015). Final report assessment of potential cumulative environmental impacts of desalination plants around the Mediterranean sea. *Sustainable Water Integrated Management (SWIM) - Support Mechanism, Activity 1.3.2.1*.

Menzies, R., Cohen, Y., Lavie, B. & Nevo, E. (1992). Niche adaptation in two marine gastropods, Monodonta turbiformis and M. turbinata. *Bollettino di zoologia*, *59*(3), 297–302.

Nagasathya, A. & Thajuddin, N. (2008). Cyanobacterial diversity in the hypersaline environment of the saltpans of southeastern coast of India. *Asian Journal of Plant Sciences*, *7*(5), 473–478.

Roberts, D. A., Poore, A. G. & Johnston, E. L. (2006). Ecological consequences of copper contamination in macroalgae: Effects on epifauna and associated herbivores. *Environmental Toxicology and Chemistry*, *25*(9), 2470–2479.

RPS. (2009). Effects of a desalination plant discharge on the marine environment of Barrow island.

Sanchez-Lizaso, J., Romero, J., Ruiz, J., Gacia, E. & Buceta, J. (2008). Salinity tolerance of the mediterranean seagrass *Posidonia oceanica*: Recommendations to minimize the impact of brine discharges from desalination plants. *Desalination*, *221*, 602–607.

Sandoval-Gil, J., Marín-Guirao, L. & Ruiz, J. (2012). Tolerance of Mediterranean seagrasses (*Posidonia oceanica* and *Cymodocea nodosa*) to hypersaline stress: Water relations and osmolyte concentrations. *Marine Biology*, *159*(5), 1129–1141.

Tularam, G. A. & Ilahee, M. (2007). Environmental concerns of desalinating seawater using reverse osmosis. *Journal of Environmental Monitoring*, *9*, 805–813.

Abela, K. & Theuma, A. (2021). *Xjenza Online*, 3:14–23.

Xjenza Online - Science Journal of the Malta Chamber of Scientists
www.xjenza.org
DOI: 10.7423/XJENZA.2021.1.02

Research Article

Exposition of the GRAS Method

Kevin Abela*[1], Adrian Theuma[1]
[1]*National Statistics Office, Valletta, Malta.*

Abstract. The goal of this study is to provide a detailed insight on the GRAS method put forward by Junius et al. (2003) and its subsequent changes proposed by Lenzen et al. (2007) and Temurshoev et al. (2013). The GRAS method allows for balancing and updating of Input-Output (I-O) tables and Social Accounting Matrices (SAMs) with positive and negative entries. The GRAS algorithm provided by Temurshoev et al. (2013) is applied on the 2010 Macro SAM for Malta. The totals of the Rest of World account are revised subject to official publicly available data (Eurostat, 2020). The newly generated Macro SAM includes updated Rest of World account totals such that it represents more accurately the current account of the Maltese economy. Although the Rest of World account totals of the newly balanced Macro SAM conform to the latest Balance of Payments statistical developments during the time of study, the generated SAM elements may not adhere to publicly available data because of additional mathematical assumptions invoked by the GRAS method. However, the newly generated Macro SAM for Malta can be utilised by researchers, students and statisticians who are interested in the 2010 Macro SAM with an updated Rest of World account and are not influenced by the imposition of additional mathematical assumptions.

Keywords: GRAS, Macro SAM, Matrix Balancing, Minimum-Information Principle.

1 Introduction

The objective of this study is to introduce an updated version of GRAS method proposed by Temurshoev et al. (2013). This includes an application of the GRAS method to update the 2010 Macro SAM for Malta by revising the Rest of World (RoW) account. The newly updated 2010 Macro SAM should represent more accurately any current account developments within the Maltese economy during the time of study.

In his Cambridge Growth Project (Bates et al., 1963), Stone and his team developed the first bi-proportional technique to balance a matrix known as the RAS (Bates et al., 1963). The term RAS refers to the pre and post multiplication to the technical coefficients matrix **A** by two matrices termed **R** and **S** to update matrix **A**.[1] Bacharach (1970) and Omar (1967) demonstrate that the RAS procedure can also take the form of a loss minimisation problem (Günlük-Şenesen et al., 1988). The RAS balancing technique was later expanded by Günlük-Şenesen et al. (1988) to allow for updating or balancing a matrix with negative values (Günlük-Şenesen et al., 1988). A decade and a half later, Junius et al. (2003) re-discovered and formulated a theoretical alternative generalisation which they coined GRAS. The GRAS algorithm allows I-O tables with positive and negative entries to be balanced and updated (Junius et al., 2003). Lenzen et al. (2007) adjust the minimum information function of the GRAS procedure adopted by Junius et al. (2003) to obtain a more accurate result (Lenzen et al., 2007). Temurshoev et al. (2013) take into consideration the updated minimum-information principle suggested by Lenzen et al. (2007) and expand further the GRAS introduced by Junius et al. (2003) to allow for matrix balancing and updating with zeros and negative figures across entire rows and columns (Temurshoev et al., 2013).

The RAS balancing technique proposed by Stone and his team (Bates et al., 1963) adjusts an unbalanced matrix $\mathbb{X}_0$ to satisfy updated row and column totals (Bates et al., 1963).[2] The RAS method minimises information loss as long as the unbalanced matrix contains non-negative figures (Bacharach, 1970). Junius et al. (2003) note that before their GRAS formulation, there were two

[1]Matrix **A** can take the form of a non-square matrix. However, **R** and **S** are square matrices.
[2]In this article, matrix **A** and $\mathbb{X}_0$ are identical.

**Correspondence to*: K. Abela (kevin_abela@hotmail.com)

© 2021 Xjenza Online

ad-hoc approaches on how to apply the RAS method on the matrix $\mathbb{X}_0$ with negative values. The first ad-hoc approach was to apply the RAS on $\mathbb{X}_0$ with negative entries. However, this could potentially change the structure of the new balanced matrix $\mathbb{X}^*$ such that its elements would greatly deviate from that of the unbalanced matrix $\mathbb{X}_0$. This is because the negative integers would have a negative contribution during every iteration when performing the RAS procedure. The higher the magnitude of the negative value, the greater the deviation from the unbalanced matrix. Junius et al. (2003) further pinpoint that the second ad-hoc approach was to treat the negative elements outside the RAS method. This is done by first decomposing the matrix $\mathbb{X}_0$ in two matrices: (i) $\mathbb{P}$ with the non-negative entries of $\mathbb{X}_0$, and (ii) $\mathbb{N}$ with the absolute values of the negative entries of $\mathbb{X}_0$. Let $\mathbf{e}^\intercal$ represents a transposed summation vector, $\mathbf{u}$ represents the row summation vector and $\mathbf{v}$ represents the column summation vector of the unbalanced matrix $\mathbb{X}_0$. The column ($\tilde{\mathbf{v}}$) and row ($\tilde{\mathbf{u}}$) summation vectors of matrix $\mathbb{P}$ can be obtained via $\tilde{\mathbf{u}} = \mathbf{u} + \mathbb{N}\mathbf{e}$ and $\tilde{\mathbf{v}} = \mathbf{v} + \mathbf{e}^\intercal\mathbb{N}$.[3] The RAS algorithm is applied to the matrix $\mathbb{P}$, $\tilde{\mathbf{u}}$ and $\tilde{\mathbf{v}}$, which gives a target matrix $\widetilde{\mathbb{X}}$. The final target matrix is obtained by $\mathbb{X}^* = \widetilde{\mathbb{X}} - \mathbb{N}$.

The problem with the second ad-hoc approach was that negative entries are completely ignored. The negative values would no longer have a negative or a positive contribution during each iteration process of the RAS, which would lead to a sub-optimal result. The GRAS formulated by Junius et al. (2003) not only accounts for negative values in the unbalanced matrix $\mathbb{X}_0$, but also accepts negative values as row and column totals (Junius et al., 2003). The GRAS that shall be utilised in this paper was proposed by Temurshoev et al. (2013) who expand on the GRAS adopted by Junius et al. (2003) to allow entire column and row elements to have zeros and negative values (Junius et al., 2003). Furthermore, they utilise an updated minimum-information principle that was proposed by Lenzen et al. (2007).

The application of the GRAS was originally in the context of balancing and updating I-O tables. For instance, Günlük-Şenesen et al. (1988) compare different mechanical balancing techniques to analyse their efficacy on an I-O table for Turkey (Günlük-Şenesen et al., 1988). Furthermore, Junius et al. (2003) applied the GRAS on a hypothetical I-O table to formulate a generalised matrix balancing technique (Junius et al., 2003). The GRAS was also adopted to balance and update SAMs, such as in Thissen et al. (1998). Recent studies focus on comparative analysis between the RAS, Cross Entropy (CE), Least Squares (LS) and Linear Programming Optimisation methods to highlight their strengths, limitations, and efficacy. Robinson et al. (2001) and Lemelin et al. (2013) compare the RAS and CE methods, while Lee et al. (2014) extend the comparisons to Least Squares (LS) and Linear Programming Optimisation methods. Within the local context, studies utilising the RAS are limited to Blake et al. (2003) who balance a Maltese I-O table for 2001. To the authors' knowledge this study is the first exposition and application of the GRAS within the local context. The application of the GRAS as put forward by Temurshoev et al. (2013) is not as widely utilised as its predecessor, the RAS. As a result, this study sheds light on the GRAS and its application.

A SAM in the form of a matrix[4] represents an entire economy's circular flow of income and expenditure (Pyatt et al., 1985), which is also articulated as flexible (Round, 2003) and comprehensive (Robinson et al., 2001). The flexibility of the SAM allows for further disaggregation of activities, factors, or institutions to accommodate the scope of study. The SAM is also considered as comprehensive framework such that it captures every main economic activity, providing a static visualisation of the entire economy under study. Pyatt et al. (1985) describe the two main objectives of a SAM. The first SAM objective is that of a statistical database to obtain an organised structure of an economy. The second objective of a SAM is to allow, amongst others, the formulation of Computable General Equilibrium (CGE) models (Pyatt et al., 1985). Amongst others, CGE models can be formulated to undertake socio-economic policy analysis on matters such as poverty allectiation, monetary policy, income inequality and tourism.[5] Taffesse et al. (2004) note that a unique feature of a SAM is the high degree of consistency within the framework, such that total income and total expenditure equate (Taffesse et al., 2004).

Different SAM-types exist,[6] which application and construction depends on the scope of study. Two of the most utilised and constructed SAM-types are the Macro and Micro SAMs. The Macro SAM consists mainly of aggregate national accounts figures, with an aggregated production account. The Micro SAM further adds sectoral disaggregation to the production account, disaggregating production, factors and final demand of every institution for each sector. Therefore, the main difference between the two SAM-types is the level of sectoral disaggregation. For the context of this study, a Macro SAM shall be utilised that comprises of an aggregated production account. Numerous SAMs have been con-

[3] $\mathbf{e}$ represents a column summation vector of dimensions $n \times 1$.

[4] There are instances where the dimensions of a SAM take the form of a non-square matrix. This generally depends on the SAM disaggregation level and scope of study.

[5] Refer to Dixon et al. (2012) for a detailed discussion on CGE models.

[6] For a further discussion on the different types of SAMs, refer to Miller et al. (2009) and Cassar et al. (2013).

structed across the world.[7] Within the local context, the first reliable and coherent SAM was constructed in the doctoral dissertation by Cassar et al. (2013) that conforms to the ESA 1995. A previous attempt at constructing a SAM was done by Blake et al. (2003) but did not conform to the basic SAM structure proposed by Pyatt et al. (1976). The SAM constructed by Blake et al. (2003) was also based on an I-O table that was in turn based on two previously mechanically balanced I-O tables. During the time of this study, the latest SAM constructed for Malta was by Theuma (2020). Within the local context, the author constructed the first household extended SAM for the year 2010 (Theuma, 2020). To provide a deeper insight on the GRAS and its application, the 2010 SAM for Malta constructed in Theuma (2020) shall be updated. Therefore, this implies that the circular flow of income and expenditure of the Maltese economy shall also be updated.

2 Data and Methodology

In order to update the SAM via the GRAS, the Maltese 2010 Macro SAM was obtained from the post-graduate dissertation published by Theuma (2020). The 2010 Macro SAM for Malta was readily available and adheres by the latest European System of National and Regional Accounting (ESA 2010) framework and the second revision of the Statistical Classification of Economic Activities in the European Community (NACE). The Macro SAM is encompassed of five institutional accounts of which three are domestic, two factor accounts, and an aggregated production account. The three domestic institutional accounts are namely the household, government and enterprises institutions. The factor account is split between labour and other value added. The production account of the SAM is aggregated to a single cell and hence explains its name Macro SAM. The updated BoP data that shall be utilised to update the Macro SAM was obtained directly from Eurostat (Eurostat, 2020). More specifically, the current account total of the Macro SAM was revised to match the latest BoP statistical developments. To update and balance the Macro SAM, MATLAB shall be utilised which is a proprietary multi-paradigm programming language and numerical computing environment developed by MathWorks. The applied MATLAB code for GRAS is publicly available by Temurshoev (2020).

The RAS algorithm is known as a biproportional technique (Lahr et al., 2004). The main idea behind biproportional technique algorithms is to transform an initial matrix $\mathbb{X}_0$ to a target matrix $\mathbb{X}^*$ of the same dimensions. The RAS procedure is an iterative algorithm where the rows and columns of matrix $\mathbb{X}_0$ are updated using proportions that are based on known row and columns sums of $\mathbb{X}^*$. Let $\langle\zeta\rangle$ be a square matrix with the vector ζ on its diagonal and zeros elsewhere, and let $\mathbf{e}$ be a summation vector consisting of ones with appropriate dimensions. The RAS iteratively adjusts the column ($\mathbf{v}$) and row ($\mathbf{u}$) sums of an initial matrix $\mathbb{X}_0$ to approximate a new matrix $\mathbb{X}^*$ with given target row and column sums. The scaling for the row and column sums is given in steps 2 and 3. An example of the RAS procedure is presented in the Appendix section of this study. The RAS iterative steps are described in Lahr et al. (2004) as follows.

Step 1 (Initialization). Set $p = 0$, where p refers to the number of iterations. Let $\mathbb{X}_0^0 = \mathbb{X}_0$.

Step 2 (Row Scaling). Let $p = p + 1$, and $\mathbb{R}^p = \langle\mathbb{X}^*\mathbf{e}\rangle\langle\mathbb{X}_0^{p-1}\mathbf{e}\rangle^{-1}$ and $\mathbb{X}_0^{p-\frac{1}{2}} = \mathbb{R}^{(p)}\mathbb{X}_0^{p-1}$. Where $\mathbb{X}_0^{p-1}$ is the updated matrix $\mathbb{X}_0$ after $p-1$ iterations and $\mathbb{X}_0^{p-\frac{1}{2}}$ represents the matrix $\mathbb{X}_0^{p-1}$ after computing row scaling.

Step 3 (Column Scaling). Next let $\mathbb{S}^p = \langle\mathbf{e}^\intercal\mathbb{X}^*\rangle\langle\mathbf{e}^\intercal\mathbb{X}_0^{p-\frac{1}{2}}\rangle^{-1}$ and $\mathbb{X}_0^p = \mathbb{X}_0^{p-\frac{1}{2}}\mathbb{S}^p$.

The above presented steps describe a single full iteration of the RAS bi-proportional algorithm, which are repeated until a desirable matrix is achieved. Bacharach (1970) put forward the notion that a solution for this algorithm always exists. In fact, the author demonstrated that this simple bi-proportional algorithm can be derived from minimizing a minimum information function

$$f(\mathbb{X}^*, \mathbb{X}_0) = \sum_{i,j} x_{ij}^* \ln\left(\frac{x_{ij}^*}{e x_{0ij}}\right),^{8} \quad (1)$$

where e denotes the irrational exponential constant. Equation 1 is subject to the constraints $\mathbf{u}$ and $\mathbf{v}$ of known row and column totals

$$\sum_j x_{ij}^* = u_i \quad \text{and} \quad \sum_i x_{ij}^* = v_j.$$

Unfortunately, the RAS is erratic when negative values are present in the initial matrix $\mathbb{X}_0$. Applying the RAS method on $\mathbb{X}_0$ with negative values could lead to $\mathbb{X}^*$ that is not comparable to the initial matrix $\mathbb{X}_0$. Building on previous work, Junius et al. (2003) provided a minimization information loss problem, similar to the one solved by Bacharach (1970), but they account for the negative values in matrix $\mathbb{X}_0$. This method is referred to as the GRAS. The argument lies in minimizing

$$f(\mathbb{X}^*, \mathbb{X}_0) = \sum_{i,j} |x_{ij}^*| \ln\left(\frac{x_{ij}^*}{x_{0ij}}\right) \quad (2)$$

[7] Refer to Theuma (2020) for an overview of SAMs constructed internationally.

[8] The value x_{0ij} can be negative. However, x_{0ij}^* will also be negative, implying that $\ln\left(\frac{x_{0ij}}{x_{0ij}^*}\right)$ can be calculated.

subject to the constraints $\mathbf{u}$ and $\mathbf{v}$ of known row and column totals

$$\sum_j x^*_{ij} = u_i \quad \text{and} \quad \sum_i x^*_{ij} = v_j$$

Define $z_{ij} = \frac{x^*_{ij}}{x_{0ij}} > 0$ if $x_{0ij} > 0$ and $z_{ij} = 0$ if $x_{0ij} = 0$. Then the problem in equation 2 can be re-written as

$$f(\mathbb{Z}, \mathbb{X}_0) = \sum_{i,j} |x_{0ij}| z_{ij} \ln(z_{ij}) \tag{3}$$

with the Lagrange function

$$L(Z, \lambda, \tau) = \sum_{(i,j)\in P} x_{0ij} z_{ij} \ln(z_{ij}) - \sum_{(i,j)\in N} x_{0ij} z_{ij} \ln(z_{ij}) + \sum_i \lambda_i \left(u_i - \sum_j x_{0ij} z_{ij}\right) + \sum_j \tau_j \left(v_j - \sum_i x_{0ij} z_{ij}\right)$$

where P are the pair of indices (i, j) for which $x_{0ij} \geq 0$ and N the set of pairs of indices (i, j) for which $x_{0ij} < 0$. From the Lagrange equation the following theorem follows.

Theorem 1. *Let* $Z = \{z_{ij}\}$, $\lambda = \{\lambda_1, \ldots, \lambda_m\}$ *and* $\tau = \{\tau_1, \ldots, \tau_n\}$. *Then*

$$z_{ij} = \frac{r_i s_j}{e} \quad \text{if } x_{0ij} \geq 0 \tag{4}$$

$$z_{ij} = \frac{1}{r_i s_j e} \quad \text{if } x_{0ij} < 0 \tag{5}$$

where $r_i = e^{\lambda_i}$ *and* $s_j = e^{\tau_j}$.

Proof. Consider the optimality condition

$$\frac{\partial L(Z, \lambda, \tau)}{\partial z_{ij}} = 0.$$

For $x_{0ij} \geq 0$ we have

$$x_{0ij} \ln z_{ij} + x_{0ij} - \lambda_i x_{0ij} - \tau_j x_{0ij} = 0,$$

this is equivalent to

$$\ln(z_{ij}) = \lambda_i + \tau_j - 1 \implies z_{ij} = e^{\lambda_i} e^{\tau_j} e^{-1}.$$

For $x_{0ij} < 0$ we have

$$-x_{0ij} \ln z_{ij} - x_{0ij} - \lambda_i x_{0ij} - \tau_j x_{0ij} = 0,$$

this is equivalent to

$$\ln(z_{ij}) = -\lambda_i - \tau_j - 1 \implies z_{ij} = e^{-\lambda_i} e^{-\tau_j} e^{-1}. \quad \square$$

Corollary 2. *For the target matrix* $\mathbb{X}^*$ *it follows that*

$$x^*_{ij} = \frac{r_i x_{0ij} s_j}{e} \geq 0 \quad \text{if } x_{0ij} \geq 0 \tag{6}$$

and

$$x^*_{ij} = \frac{x_{0ij}}{r_i s_j e} < 0 \quad \text{if } x_{0ij} < 0 \tag{7}$$

Theorem 3. *The diagonal matrices* $\mathbb{S}$ *and* $\mathbb{R}$ *are the solution of the system of non-linear equations :*

$$(\mathbb{RPS} - \mathbb{R}^{-1}\mathbb{NS}^{-1})\boldsymbol{e} = \boldsymbol{u}^\star \tag{8}$$

$$\boldsymbol{e}^\intercal(\mathbb{RPS} - \mathbb{R}^{-1}\mathbb{NS}^{-1}) = \boldsymbol{v}^\star \tag{9}$$

where

$$p_{ij} = \begin{cases} x_{0ij} & x_{0ij} \geq 0 \\ 0 & x_{0ij} = 0 \end{cases}$$

$$n_{ij} = \begin{cases} -x_{0ij} & x_{0ij} < 0 \\ 0 & x_{0ij} \geq 0 \end{cases}$$

$\boldsymbol{u}^\star = e\boldsymbol{u}$ *and* $\boldsymbol{v}^\star = e\boldsymbol{v}$.

An algorithm similar to the RAS can be formulated for the GRAS. It is described as follows:

Step 1 (Initialization). Start from a given initial matrix $\mathbb{R}(0)$.

Step 2 Use equation 8 to calculate the matrix $\mathbb{S}(1)$.

Step 3 Use equation 9 to calculate the matrix $\mathbb{R}(1)$ using the matrix $\mathbb{S}(1)$ obtained in the previous step.

Step 4 The algorithm continues this way by finding $\mathbb{R}(0) \to \mathbb{S}(1) \to \mathbb{R}(1) \to \mathbb{S}(2) \to \mathbb{R}(2) \to$ *etc.*

Step 5 It reaches its solution of diagonal matrices $\mathbb{R}$ and $\mathbb{S}$ if for an arbitrary $\epsilon > 0$,

$$\left\|(\mathbb{RPS})\mathbf{e} - (\mathbb{R}^{-1}\mathbb{NS}^{-1})\mathbf{e} - \mathbf{u}^\star\right\| < \epsilon \left\|\mathbf{u}^\star\right\|$$

$$\left\|\mathbf{e}^\intercal(\mathbb{RPS}) - \mathbf{e}^\intercal(\mathbb{R}^{-1}\mathbb{NS}^{-1}) - \mathbf{v}^\star\right\| < \epsilon \left\|\mathbf{v}^\star\right\|$$

For the initial matrix $\mathbb{R}(0)$, Junius et al. (2003) suggest $\langle \mathbf{e} \rangle$. For motivation behind this suggestion one can check Stone (1961), Toh (1998) and van der Linden et al. (2000).

In their work, Lenzen et al. (2007) outlined a problem with the construction of Junius et al. (2003). The authors outline an issue that occurs when starting with an initial matrix $\mathbb{X}_0$ already satisfying row and columns sums. In such a case, the initial estimate should be optimal solution but by construction, the algorithm of Junius et al. (2003) generates a suboptimal solution. To solve this issue, Lenzen et al. (2007) provided a new target function by including an irrational exponent e:

$$f(\mathbb{Z}, \mathbb{X}_0) = \sum_{i,j} |x_{0ij}| z_{ij} \ln\left(\frac{z_{ij}}{e}\right), \tag{10}$$

where $z_{ij} = \frac{x^*_{ij}}{x_{0ij}}$. The Lagrangean function is formulated by

$$L(Z,\lambda,\tau) = \sum_{(i,j)\in P} x_{0ij} z_{ij} \ln\left(\frac{z_{ij}}{e}\right) - \sum_{(i,j)\in N} x_{0ij} z_{ij} \ln\left(\frac{z_{ij}}{e}\right) + \sum_i \lambda_i \Big(u_i - \sum_j x_{0ij} z_{ij}\Big) + \sum_j \tau_j \Big(v_j - \sum_i x_{0ij} z_{ij}\Big).$$

Theorem 4. *Let $Z = \{z_{ij}\}$, $\lambda = \{\lambda_1, \dots, \lambda_m\}$ and $\tau = \{\tau_1, \dots, \tau_n\}$. Then*

$$z_{ij} = r_i s_j \quad \text{if } x_{0ij} \geq 0 \tag{11}$$

$$z_{ij} = \frac{1}{r_i s_j} \quad \text{if } x_{0ij} < 0 \tag{12}$$

where $r_i = e^{\lambda_i}$ and $s_j = e^{\tau_j}$.

Proof. Consider the optimality condition

$$\frac{\partial L(Z,\lambda,\tau)}{\partial z_{ij}} = 0.$$

For $x_{0ij} \geq 0$ we have

$$x_{0ij} \ln\left(\frac{z_{ij}}{e}\right) + x_{0ij} - \lambda_i x_{0ij} - \tau_j x_{0ij} = 0,$$

this is equivalent to

$$\ln(z_{ij}) = \lambda_i + \tau_j \implies z_{ij} = e^{\lambda_i} e^{\tau_j}.$$

For $x_{0ij} < 0$ we have

$$-x_{0ij} \ln\left(\frac{z_{ij}}{e}\right) - x_{0ij} - \lambda_i x_{0ij} - \tau_j x_{0ij} = 0,$$

this is equivalent to

$$\ln(z_{ij}) = -\lambda_i - \tau_j \implies z_{ij} = e^{-\lambda_i} e^{-\tau_j}.$$

□

Corollary 5. *For the target matrix $\mathbb{X}^*$ it follows that*

$$x^*_{ij} = r_i x_{0ij} s_j \geq 0 \quad \text{if } x_{0ij} \geq 0 \tag{13}$$

and

$$x^*_{ij} = \frac{x_{0ij}}{r_i s_j} < 0 \quad \text{if } x_{0ij} < 0 \tag{14}$$

Theorem 6. *The diagonal matrices $\mathbb{S}$ and $\mathbb{R}$ are the solution of the system of non-linear equations:*

$$(\mathbb{RPS} - \mathbb{R}^{-1}\mathbb{NS}^{-1})\boldsymbol{e} = \boldsymbol{u} \tag{15}$$

and

$$\boldsymbol{e}^\intercal(\mathbb{RPS} - \mathbb{R}^{-1}\mathbb{NS}^{-1}) = \boldsymbol{v} \tag{16}$$

where

$$p_{ij} = \begin{cases} x_{0ij} & x_{0ij} \geq 0 \\ 0 & x_{0ij} = 0 \end{cases}$$

$$n_{ij} = \begin{cases} -x_{0ij} & x_{0ij} < 0 \\ 0 & x_{0ij} \geq 0 \end{cases}$$

The multipliers r_i and s_j are derived from the solution of the quadratic equations

$$p_i(s) r_i^2 - u_i r_i - n_i(s) = 0 \tag{17}$$

$$p_j(r) s_j^2 - v_j s_j - n_j(r) = 0 \tag{18}$$

where

$$p_i(s) = \sum_j p_{ij} s_j, \quad p_j(r) = \sum_j p_{ij} r_i \tag{19}$$

$$n_i(s) = \sum_j \frac{n_{ij}}{s_j}, \quad n_j(s) = \sum_i \frac{n_{ij}}{s_i}$$

The solutions are given by

$$r_i = \frac{u_i + \sqrt{u_i^2 + 4p_i(s) n_i(s)}}{2p_i(s)} \tag{20}$$

and

$$s_j = \frac{v_j + \sqrt{v_j^2 + 4p_j(r) n_j(r)}}{2p_j(r)} \tag{21}$$

The algorithm for this updated GRAS is given by

Step 1 (Initialization). Start from a given initial matrix $\mathbb{R}(0) = \langle \mathbf{e} \rangle$.

Step t For $t \in \{1, 2, ..., N\}$. Find $s_j(t)$ and $r_i(t)$ using equations 20 and 21.

Step N Stop when $s_j(N) - s_j(N-1) < \epsilon$ for every j and a sufficiently small ϵ. Calculate the value of x^*_{ij} using equations 13 and 14, $r_i(N)$ and $s_j(N)$.

The two methods described above suffice provided that matrix $\mathbb{P}$ satisfying $\mathbb{X}_0 = \mathbb{P} - \mathbb{N}$ does not have an entire rows of 0. In practice this might not always be the case. To solve this, an improvement was made by Temurshoev et al. (2013). Define

$$r_i = \begin{cases} \frac{u_i + \sqrt{u_i^2 + 4p_i(s) n_i(s)}}{2p_i(s)} & p_i(s) > 0 \\ -\frac{n_i(s)}{u_i} & p_i(s) = 0 \end{cases} \tag{22}$$

$$s_j = \begin{cases} \frac{v_j + \sqrt{v_j^2 + 4p_j(r) n_j(r)}}{2p_j(r)} & p_i(s) > 0 \\ -\frac{n_j(r)}{v_j} & p_j(r) = 0 \end{cases} \tag{23}$$

This modification suffices to solve the issue of the matrix $\mathbb{P}$ having entire rows and columns of zeros. Furthermore, it is evident that the values of r_i and s_j are positive. The iterative process is identical to the algorithm used in the work of Lenzen et al. (2007).

3 Results and Discussion

Table 1 presents the original Macro SAM constructed by Theuma (2020). This is utilised to generate the matrix $\mathbb{X}_0$ with updated RoW totals. The Macro SAM depicted in Table 1 takes the form of a 9×9 dimensional matrix, which provides a static picture of the entire circular flow of income and expenditure of the Maltese economy for the reference year of 2010. Table 1 contains a negative entry of -136.78 million euro, which reflects a situation of dissavings coming from the Enterprises Institution.[9] From Table 1 it can be observed that there are no rows and columns comprised of only zeros or negative values. From the same table, the rows and columns which contain a negative value also have at least one positive entry. This implies that the GRAS algorithm proposed by Junius et al. (2003) can also be applied to update the Maltese Macro SAM for the reference year of 2010. We utilise the GRAS algorithm proposed by Temurshoev et al. (2013) to make use of the latest GRAS modification, which includes the revised minimum information criteria by Lenzen et al. (2007). The RoW totals of the original Macro SAM in Table 1 are updated to match those in Table 2. Therefore, as depicted in Table 4, the RoW totals were revised upwards to 24,888.04 million euro (Eurostat, 2020) to better represent the current account and simultaneously conform to the latest BoP statistical developments. With the exception of the RoW Account, the other Macro SAM totals found within Table 2 remain unchanged.

The publicly available MATLAB code (Temurshoev, 2020) proposed by Temurshoev et al. (2013) with a threshold level of $\varepsilon = 10^{-6}$ generates an updated 2010 Macro SAM for Malta in Table 3 within 34 iterations. The row and column totals of every SAM account in Table 3 conform exactly to those set in Table 2. The GRAS algorithm generated the upper left block matrix in Table 3 with dimensions 9×9, subject to the revised RoW totals. The changes between Tables 1 and 3 are clearly listed in Table 4. There are several important findings that deserve attention from the newly generated Macro SAM in Table 3. The first point to notice from Table 3 is that the elements of the Labour (L) and the Other Value Added (K) accounts remain the same when compared to Table 1. This happened for two reasons. The first reason is because the totals of the Labour (L) and Other Value Added (K) accounts remain unchanged.[10] Secondly, the Labour (L) and Other Value Added (K) accounts constitute only of one element. The entries of the Labour (L) and Other Value Added (L) accounts of 2,846.27 and 2,960.51 million euro, respectively, represent the reward-payments for the utilisation of factors of production by productive activities, which are generally encompassed of land, labour and capital. Since there are no differences between the Factor Account generated by the GRAS procedure and the one constructed in Theuma (2020), a high degree of consistency is retained with respect to the Labour (K) and the Other Value Added (K) Accounts.

The second important finding is the significant change in the aggregate Intermediate Consumption element found within the production account as depicted in Table 4. At sectoral level, the aggregate output for every sector would still remain the same because total output for every sector would be treated as control totals. However, the interindustry transactions would be subject to change following the GRAS procedure. This in turn directly influences researchers, statisticians or students who intend to analyse the production structure of Malta at a sectoral level. More specifically, the amount of input purchases required for the production processes to produce goods and services would change. One reason why the Aggregate Intermediate Consumption element changed drastically is due to the fact that it has a large magnitude which absorbs the RoW revisions since the Labour (L) and Other Value Added (K) account elements remained unchanged. This suggests that the GRAS-generated Macro SAM in this study should be utilised with caution, depending on the scope of study. For instance, studies that utilise the GRAS-generated SAM to estimate Demand-Driven Leontief multipliers could end up with different estimates when compared to a non-mathematically balanced SAM. This is because the interindustry transactions in the latter SAM would be assumed to make more economic sense without imposing further mathematical assumptions.

From Table 3, it can be observed that after updating the totals of the RoW Account in Table 2 and performing the GRAS-algorithm, imports and exports of goods and services amount to 9,403 and 10,673 million euro respectively. However, from official publicly available data (Eurostat, 2020), one can observe that imports and exports of goods and services should amount to around 10,115 and 10,154 million euro respectively. Therefore, a limitation of the GRAS is that although the row and column totals of the RoW Account were updated, the elements within the Macro SAM are mathematically generated according to the GRAS algorithm suggested

[9] Theuma (2020) pinpoints that this figure was obtained as a balancing entry of the Capital Account. However, this figure had been estimated after already having obtained reliable estimates for the other SAM Accounts

[10] Recall that the totals of the RoW Account were the ones subject to change in this study.

by Temurshoev et al. (2013). Since these elements are generated by the GRAS-algorithm, they cannot be equal to official published statistical figures as they may lose economic sense. One way to solve this issue is to keep some entries fixed before running the GRAS. However, this would produce a suboptimal solution when compared to the scenario of keeping no elements fixed. The GRAS would have less entries on which to balance the Macro SAM and as a result would increase the magnitude to which the remaining elements would change, producing results that could make no economic sense.

Another important finding worth discussing is that the highest discrepancies come from the RoW Account, as visualised in Table 4. A reason behind this is that the RoW account already had elements with substantial magnitudes. In fact, when comparing Tables 1 and 3, it can be seen that throughout the Macro SAMs, the elements with significant flow entries experience a larger difference as seen from Table 4. Similarly, the elements with lower magnitudes experience lower changes as observed from Table 4. However, the magnitude of changes by the GRAS balancing process depends on how much the SAM totals change and whether several entries will remain fixed. In other words, the magnitude of the elements in the Macro SAM when performing the GRAS algorithm will change based on the magnitude of the revised totals.

4 Conclusion

The main aim of this study is to provide a detailed exposition of the GRAS algorithm. An advantage of the GRAS is its versatility to be applied when negative entries are present in the initial matrix. This naturally puts the GRAS method as a possible tool to use when balancing a matrix with negative values.

In this study, the GRAS was applied to update the 2010 Macro SAM for Malta. This was done by updating the totals of the RoW account and balance it accordingly. The GRAS was important because of the negative value that is present in the initial Macro SAM provided for the reference year of 2020 (Theuma, 2020). The final result obtained represents more accurately the current account of the Maltese economy while simultaneously reflecting the latest BoP statistical developments.

In general, there are various ways of constructing a SAM. The Results section presents that our SAM exhibits notable changes after performing the GRAS when compared to the SAM constructed by Theuma (2020). The Factor account did not result any changes after performing the GRAS, which ensures a high degree of consistency with the initial Macro SAM. However, every element of the RoW account exhibited notable changes after performing the GRAS. Also, the Intermediate Consumption aggregate changed after performing the GRAS, which suggests that the purchases required for every sector to produce goods and services changed. The SAM generated in the study can be utilised by researchers, statisticians and students depending on the scope of their research. This is because the elements of the generated SAM elements do not compare to publicly available data. This is important because the GRAS applied in this study was carried out without keeping any elements fixed in the initial Macro SAM. It is possible to keep some values fixed in the initial Macro SAM by using a similar procedure as described by Junius et al. (2003). However, one should keep in mind that the consequence of keeping fixed entries would result in a suboptimal solution. For future studies, one can opt to use several methods similar to the GRAS, including the KRAS, Linear Programming Optimisation, CE and LS to analyse and compare different generated SAMs. The main aim of the study was to explore the GRAS method. To this end, no entries were kept fixed in order to obtain an optimal GRAS solution.

References

Bacharach, M. (1970). *Biproportional matrices and input-output change* (Vol. 16). CUP Archive.

Bates, J. & Bacharach, M. (1963). *Input-output relationships, 1954-1966*. Chapman & Hall.

Blake, A., Sinclair, M. T., Sugiyarto, G. & DeHaan, C. (2003). The development of the 2001 input-output table and social accounting matrix for malta.

Cassar, I. P. et al. (2013). *A study of the production structure of the maltese economy: An input-output approach* (Doctoral dissertation). Heriot-Watt University.

Dixon, P. B. & Jorgenson, D. (2012). *Handbook of computable general equilibrium modeling* (Vol. 1). Newnes.

Eurostat. (2020). https://ec.europa.eu/eurostat/data/database

Günlük-Şenesen, G. & Bates, J. M. (1988). Some experiments with methods of adjusting unbalanced data matrices. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *151*(3), 473–490.

Junius, T. & Oosterhaven, J. (2003). The solution of updating or regionalizing a matrix with both positive and negative entries. *Economic Systems Research*, *15*(1), 87–96.

Lahr, M. & De Mesnard, L. (2004). Biproportional techniques in input-output analysis: Table updating and structural analysis. *Economic Systems Research*, *16*(2), 115–134.

Lee, M.-C. & Su, L.-E. (2014). Social accounting matrix balanced based on mathematical optimization method and general algebraic modeling system.

Journal of Economics, Management and Trade, 1174–1190.
Lemelin, A., Fofana, I. & Cockburn, J. (2013). Balancing a social accounting matrix: Theory and application (revised edition). *Available at SSRN 2439868.*
Lenzen, M., Wood, R. & Gallego, B. (2007). Some comments on the gras method. *Economic Systems Research*, *19*(4), 461–465.
Miller, R. E. & Blair, P. D. (2009). *Input-output analysis: Foundations and extensions.* Cambridge university press.
Omar, F. H. (1967). *The projection of input-output coefficients with application to united kingdom* (Doctoral dissertation). University of Nottingham.
Pyatt, G. & Round, J. I. (1985). *Social accounting matrices: A basis for planning.* The World Bank.
Pyatt, G., Thorbecke, E. et al. (1976). Planning techniques for a better future; a summary of a research project on planning for growth, redistribution and employment.
Robinson, S., Cattaneo, A. & El-Said, M. (2001). Updating and estimating a social accounting matrix using cross entropy methods. *Economic Systems Research*, *13*(1), 47–64.
Round, J. (2003). Constructing sams for development policy analysis: Lessons learned and challenges ahead. *Economic Systems Research*, *15*(2), 161–183.
Stone, R. (1961). Input-output and national accounts (paris, organisation for economic co-operation and development).
Taffesse, A. S. & Ferede, T. (2004). The structure of the ethiopian economy-a sam-based characterisation. *A Country Economic Memorandum, Report*, (29383-ET).
Temurshoev, U. (2020). *Generalized ras, matrix balancing/updating, biproportional method.* https://www.mathworks.com/matlabcentral/fileexchange/43231-generalized-ras-matrix-balancing-updating-biproportional-method
Temurshoev, U., Miller, R. E. & Bouwmeester, M. C. (2013). A note on the gras method. *Economic Systems Research*, *25*(3), 361–367.
Theuma, A. (2020). Contribution of the financial services and gaming sectors to the wages of maltese households: A sam-based hea.
Thissen, M. & Löfgren, H. (1998). A new approach to sam updating with an application to egypt. *Environment and Planning a*, *30*(11), 1991–2003.
Toh, M.-H. (1998). The ras approach in updating input–output matrices: An instrumental variable interpretation and analysis of structural change. *Economic Systems Research*, *10*(1), 63–78.
van der Linden, J. A. & Dietzenbacher, E. (2000). The determinants of structural change in the european union: A new application of ras. *Environment and Planning A*, *32*(12), 2205–2229.

Appendix

Example 7. *Set $p = 0$ and*

$$\mathbb{X}_0^0 = \begin{bmatrix} 2 & 4 \\ 2 & 4 \end{bmatrix}$$

We need to find a matrix $\mathbb{X}^*$ with target row sums

$$\begin{bmatrix} 12 \\ 6 \end{bmatrix}$$

and target column sums

$$\begin{bmatrix} 9 & 9 \end{bmatrix}$$

Set $p = 1$ and start the row scaling

$$\mathbb{R}^1 = \begin{bmatrix} 12 & 0 \\ 0 & 6 \end{bmatrix} \begin{bmatrix} \frac{1}{6} & 0 \\ 0 & \frac{1}{6} \end{bmatrix} = \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix}$$

Let

$$\mathbb{X}_0^{p-\frac{1}{2}} = \mathbb{X}_0^{\frac{1}{2}} = \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 4 \\ 2 & 4 \end{bmatrix} = \begin{bmatrix} 4 & 8 \\ 2 & 4 \end{bmatrix}$$

From the above, the rows sums of matrix $\mathbb{X}_0^{\frac{1}{2}}$ satisfy the required target row sums. However, the column sums of matrix $\mathbb{X}_0^{\frac{1}{2}}$ do not satisfy the required column sums. Next we adjust the columns sums with respect to the target columns sums.

$$\mathbb{S}^1 = \begin{bmatrix} 9 & 0 \\ 0 & 9 \end{bmatrix} \begin{bmatrix} \frac{1}{6} & 0 \\ 0 & \frac{1}{12} \end{bmatrix} = \begin{bmatrix} \frac{3}{2} & 0 \\ 0 & \frac{3}{4} \end{bmatrix}$$

Let

$$\mathbb{X}_0^1 = \begin{bmatrix} 4 & 8 \\ 2 & 4 \end{bmatrix} \begin{bmatrix} \frac{3}{2} & 0 \\ 0 & \frac{3}{4} \end{bmatrix} = \begin{bmatrix} 6 & 6 \\ 3 & 3 \end{bmatrix}$$

The matrix $\mathbb{X}_0^1 = \mathbb{X}^*$ satisfies the target row and column sums. In this case, the process stops here. However, if the matrix $\mathbb{X}_0^1$ does not satisfy the target row and column sums, set $p = 2$ and repeat the process above.

Table 1: Original 2010 Macro SAM for Malta

MacroSAM in Euro Millions (000's)	P	H	F	G	C	E	L	K	T	Tot
Production Activities (P)	3,880.95	3,020.91	0	1,247.73	872.117	8,577.18	0	0	0	17,598.89
Households (H)	0	0	189.79	863.99	0	1,738.25	2,846.27	677.9	0	6,316.21
Enterprises (F)	0	991.14	0	220.08	0	3,982.49	0	2,030.78	0	7,224.54
Government (G)	0	577.48	59.05	0	0	1,123.48	0	251.83	792.74	2,804.55
Capital (C)	0	193.88	-136.78	427.19	0	1,073.94	0	0	0	1,558.18
RoW Imports (E)	7,748.25	1,054.81	7,112.47	32.80	577.46	692.68	0	0	0	17,218.46
Compensation of Employees (L)	2,846.27	0	0	0	0	0	0	0	0	2,846.27
Other Value Added (K)	2,960.51	0	0	0	0	0	0	0	0	2,960.51
Net Taxes on Products and Production (T)	162.908	478	0	12.79	108.64	30.4	0	0	0	792.70
Total (Tot)	17,598.91	6,316.21	7,224.54	2,804.55	1,558.18	17,218.46	2,846.27	2,960.51	792.70	59,320.36

Source: (Theuma, 2020).

Table 2: Updated Macro SAM Row and Column Totals

MacroSAM in Euro Millions (000's)	P	H	F	G	C	E	L	K	T	Tot
Production Activities (P)										17,598.89
Households (H)										6,316.21
Enterprises (F)										7,224.54
Government (G)										2,804.55
Capital (C)										1,558.18
RoW Imports (E)										24,888.04
Compensation of Employees (L)										2,846.27
Other Value Added (K)										2,960.51
Net Taxes on Products and Production (T)										792.70
Total (Tot)	17,598.91	6,316.21	7,224.54	2,804.55	1,558.18	24,888.04	2,846.27	2,960.51	792.70	66,989.91

Source: Authors' own calculations.

Table 3: Updated GRAS 2010 Macro SAM for Malta

MacroSAM in Euro Millions (000's)	P	H	F	G	C	E	L	K	T	Tot
Production Activities (P)	2,288.57	2,638.78	0	1,431.04	566.64	10,673.9	0	0	0	17,598.89
Households (H)	0	0	39.34	656.78	0	2,087.12	2,846.27	686.68	0	6,316.21
Enterprises (F)	0	416.78	0	162.56	0	4,646.33	0	1,998.82	0	7,224.54
Government (G)	0	269.43	13.19	0	0	1,454.27	0	275.01	792.70	2,804.55
Capital (C)	0	103.44	-535.28	400.35	0	1,590	0	0	0	1,558.18
RoW Imports (E)	9,403.64	2,386.51	7707.28	130.26	912.04	4,348.29	0	0	0	24,888.04
Compensation of Employees (L)	2,846.27	0	0	0	0	0	0	0	0	2,846.27
Other Value Added (K)	2,960.51	0	0	0	0	0	0	0	0	2,960.51
Net Taxes on Products and Production (T)	99.91	501.27	0	23.56	79.5	88.45	0	0	0	792.70
Total (Tot)	17,598.91	6,316.21	7,224.54	2,804.55	1,558.18	24,888.04	2,846.27	2,960.51	792.70	66,989.91

Source: Authors' own calculations.

Table 4: Differences Between the Initial and the New GRAS 2010 Macro SAM for Malta

MacroSAM in Euro Millions (000's)	P	H	F	G	C	E	L	K	T	Tot
Production Activities (P)	-1,592	-382	0	183	-305	2,097	0	0	0	0
Households (H)	0	0	-150	-207	0	349	0	9	0	0
Enterprises (F)	0	-574	0	-58	0	664	0	-32	0	0
Government (G)	0	-308	-46	0	0	331	0	23	0	0
Capital (C)	0	-90	-398	-27	0	516	0	0	0	0
RoW Imports (E)	1,655	1,332	595	97	335	3,656	0	0	0	7,670
Compensation of Employees (L)	0	0	0	0	0	0	0	0	0	0
Other Value Added (K)	0	0	0	0	0	0	0	0	0	0
Net Taxes on Products and Production (T)	-63	23	0	11	-29	58	0	0	0	0
Total (Tot)	0	0	0	0	0	7,670	0	0	0	7,670

Source: Authors' own calculations.

Saliba, B. et al. (2021). *Xjenza Online*, 9:24–36.

Xjenza Online - Science Journal of the Malta Chamber of Scientists
www.xjenza.org
DOI: 10.7423/XJENZA.2021.1.03

Research Article

Insurance, Risk Management and Youth Soccer Academies: A Maltese Case-Study

B. Saliba*[1], D. Cortis[1], O. Madhloom[2]
[1] *University of Malta, Msida, Malta*
[2] *University of Bristol, Bristol, UK*

Abstract. Our central thesis is whether Risk Management can be applied as part of a best practice management system throughout sport organizations. Our literature review reveals that the key risks faced by youth soccer and sports training in general, and the causes of legal liability. We analyse the results of an empirical study conducted across all 47 youth academies in Malta for the purpose of identifying the main risks faced. Interviews were also conducted with the official national sports organisation and an insurance broker who introduced the first (and only) such insurance policy targeted for youth soccer academies in Malta. Our findings indicate that injuries, liability risk and inadequate facilities are the key hazards of concern for youth academies. A framework is suggested to avoid and minimise the risks identified in our study. A key measure that minimizes most risks is coaches' continuous professional development. In addition, insurance policies ought to offer the ability to transfer risk.

Keywords: soccer, insurance, risk transfer, youth soccer

Acknowledgements. We would like to express our gratitude towards Miss Suzanna Pace and Mr Nicky Warrington of Melita Unipol Insurance Brokers and Mr Joe Micallef of the Maltese Youth F.A, who were of great help by providing us with significant information and opinions and assisting us with all our queries. Furthermore, we would like to also thank all the academies and head coaches who answered to our questions.

1 Introduction

Risk management has become a core focus and a buzz word especially after the financial crisis of 2007 (Barbara et al., 2017). Various risk management processes have been implemented but one can subdivide each process through a tripartite procedure: risk recognition; risk measurement; and risk minimising. We conduct a qualitative analysis of the risks encountered by the youth soccer clubs in Malta, to make recommendations in relation to the mitigation of the various risks that arise in youth soccer academies. This article also analyses the effectiveness of a new insurance policy. The aim of this article is to identify risk mitigation factors in relation to injuries, negligence, lack of fair play, and bullying in soccer academies.

The Maltese Youth Football Association (MYFA)[1] was established in 1982 with the responsibility of organizing and managing tournaments and competitions at youth level. Although starting with only eight academies, the structure now boasts the membership of 47 academies. Youth soccer academies in Malta tend to employ coaches on a part-time basis and administrators on a voluntary basis. The general trend has been of an increase in professionalism within soccer youth clubs due to a higher participation rate of students (and hence higher revenues), European grants to improve training facilities and significant MYFA involvement. Increased professionalism leads to more defined roles that require professionally certified members of staff and a stronger awareness of risks involved in the daily running of a soccer youth academy.

Risk Management can be applied as part of best practice management system throughout sport organizations. This process supports academies in identifying risk factors which can potentially lead to injuries and other hazards. These risks can be estimated and evaluated according to their severity. Information obtained

[1] We use the term soccer to refer to the sport. However many associations outside the USA tend to have the word 'football'. Another term that is at times used is 'associate football'.

*Correspondence to: B. Saliba (brandon.saliba.14@um.edu.mt)

© 2021 Xjenza Online

from risk management processes can be used proactively to reduce or mitigate such risks. The acceptability of risk within particular sports is, however, reliant on the subjective perceptions of the participants involved (C. Fuller et al., 2004).

There are four main methods of how risk can be managed: risk avoidance, risk reduction, risk transfer and risk retention. Risk avoidance and risk retention are on the opposite ends, the choice depends on whether the perceived dangers of the risk offset the potential benefits. C. W. Fuller (2007) explains that the risks of some sports injuries are acceptable. 'Acceptability', for the purposes of this article, depends on the presence of consent between the parties and the injury being sustained within the rules/regulations of the specific sport. Other than evading the risk altogether by not participating, the risks can be reduced, by for example applying control processes, or transferring the risk to a third party, usually through an insurance (C. Fuller et al., 2004).

1.1 Current Insurance Cover in Malta

Currently, the only insurance policy available at youth level is offered through the MYFA. The association had interest in providing this risk transfer for quite some time, however premiums quoted resulted to be too expensive. Moreover, academies were not prepared for such change, as insurance was not considered as the main priority due to high costs involved. This resulted into the MYFA postponing the implementation of risk transfer throughout Maltese youth football. The drive for introducing this policy followed attendance of a course with the Scottish Youth Football Association, whereby the latter explained that a youth team cannot compete in Scotland unless insured. Following this the MYFA helped source an insurance policy with a local broker. Adopting a similar approach to the Scottish decision, the MYFA decided that the policy should be mandatory for all academies competing in the Youth FA events and leagues.[2] The policy was launched in July 2017 and is currently in its third season of existence.[3]

The current insurance policy covers three main areas: personal accident, public liability and professional indemnity. Personal accident outcomes relate to accidental death, permanent total disablement, loss of one or more limbs, loss of sight in one or both eyes, emergency expenses and physiotherapy benefit. Public liability covers up to two milion euro for an incidence for 'player to player' injuries but excludes premises liability. Hence if an individual is injured on the youth soccer academy's premises due to building damage, that should be covered by the building's insurance policy. The policy covers the professional indemnity of coaches for the same limit in aggregate.[4]

2 A review of the literature concerning injuries and liabilities

Youth academies are subject to several perils and risks. The most frequent risk faced by youth academies are injuries. Youth clubs also encounter less frequent yet more severe risks such as fatalities and liability claims.

2.1 Injuries

The prevalence of injuries in soccer is relatively higher as it is a contact sports. A study conducted in France over a ten-season period investigated several types of injuries sustained by soccer players in Under 14, Under 15 and Under 16 years old groups. Injuries were identified and documented by sports physicians according to type, location, severity, the date the injury occurred, and playing position. It was concluded that players younger than the Under 14 age group suffered most injuries during training rather than matches. Most of these injuries were due to growth related overuse disorders. The majority of injuries for all age groups were contusion, sprain and muscle strain (Le Gall et al., 2007). Moreover, concussion is a common risk found in soccer since a unique feature of soccer is the practice of the heading the football (Boden et al., 1998). Specifically, neurophysiologic and neuro psychologic changes have been observed in soccer players, with heading being the main cause identified, which could have an impact of the brain's function (Barnes et al., 1998). The risk of concussion is not only due to heading since falling is another major hazard in soccer.

Recent research shows that four out of ten emergency room visits for children between 5 and 14 years of age are related to sports injuries (Serena, 2017). Repetitive-strain injuries are increasing in number because the competition in youth sports has increased drastically. Children train on a continuous basis and may not be including sufficient rest time in their regimen to allow their body to recover. The reasons for this lack of recovery could be due to the fact that some children might be participating in more than one sport and follow a schedule with a training structure that pushes them to not take rest periods. This contrasts with children moderating their activities when playing on their own as they tend to take breaks (Serena, 2017).

Motivation and concentration in a particular sport can create an aspiration to only engage in that sport as the athlete's ability level and success increase. This might lead to burnout, which is defined as physical and

[2] Coverage for under 13, under 15 and under 17 is mandatory while coverage in relation to younger age groups is voluntary.

[3] A soccer season in Europe represents the year during which tournaments are held. This runs from August to May/June of each year.

[4] For example, injuries sustained due to a training regime change.

emotional fatigue from the strains of an athlete's sport. This factor increases the risk of injury and can simply occur when someone is constantly competing without adequate rest. Unlike professional athletes' physiques that are in a more mature state and can handle the stress that is placed on muscles and joints, young athletes are still in the process of growth (Dugas, 2017).

There is the tendency that children always push themselves to their limits due to their desire to want to play and have fun. In some instances, an injured child might continue to play without advising anyone that they are experiencing discomfort. This would make the situation worse and might aggravate the injury. Moreover, a sign of discomfort or pain is an indication of an injury and that children should never play or train with pain (Serena, 2017).

Sport diversification and non-specialization is fundamental in allowing proper development in young athletes. Participating in several sports, with adequate rest, permits an athlete to improve diverse skills that can aid in success in other areas. This also can lead to less burnout and allow youth sports to be healthier and remain competitive (Dugas, 2017).

2.2 Fatalities

The risk of fatalities is another type of risk faced by organizations. There were 120 sports-related deaths of young athletes in 2008-2009; 49 in 2010; and 39 in 2011 throughout the United States (Youth Sports Safety Alliance, 2013). 31 high school football players died of heat stroke complications between 1995 and 2009 (Youth Sports Safety Alliance, 2013). Some potential main risks that can lead to fatalities are sudden cardiac arrest, heart illness and sickle cell trait which includes heat, dehydration, altitude, asthma, high intensity exercise with few rest intervals.

In Malta, there are less cases related to fatalities in youth sport activities than the US due to the population size. However, fatalities do occur. In 2003 a fourteen-year-old boy, died when one of the goalposts toppled on him during a physical education lesson. The goal posts were made of thick metal pipes and although they were not shifted around, they were not fixed to the ground (Fenech, 2013).

2.3 Civil Liability

Coaches play an important role in youth sports. In the field of sports, one can observe several personal relationships including athlete-athlete, athlete-team manager, athlete-team physician. These relationships might have an influence on the performance of players. The relationship between a coach and the player is critical since it is unique and central for team sports (Jowett et al., 2002; Lyle, 1999, 2002). This type of relationship is one in which the coach governs critical factors such as skill, training and energy (Emerick, 1997). This relationship affects the performance and the motivation of the young athletes. This connection does not end here as Engelhorn (2005) argues that coaches also have a legal relationship with the athletes. The obligations of these type of relationships are not defined by the parties involved, because they are defined by case law and statutes (Carpenter, 2008). However, there is an additional duty, one which is based in tort of negligence. This legal relationship obliges coaches to always prevent harm and protect his athletes. The wage level of the coaches is irrelevant as the duties are the same for every coach. Therefore, a paid coach and a volunteer have the same duties towards their athletes. Individuals and organisations who manage and organise sport programs and events have a duty to make such activities as safe as possible for anyone who participates. This is not based on a contractual relationship between the parties, it is based on a 'duty of care'.

The Duty of Care principle was formed due to the case of Donoghue v Stevenson [1932] UKHL 100. According to this principle, any individual or business that manufactures a product or offers a service must contemplate the safety of the users of that product or service. If there is a risk that the user of the product or service will sustain injury, illness or other harm, then the product or service should be withdrawn until the product or service is remedied. Therefore, coaches may be liable for any injuries sustained if it is established that they owed a duty of care to the children; they breached that duty; the breach of duty caused the injury; and the injury sustained was not too remote. Thus, a coach or an academy runs the risk of a court action for negligence, which occurs when there is a breach of the duty of care and an injury is caused as a result of that breach. The implications of this duty is that an individual coach might find themselves personally liable for the injury caused. This occurs where the academy is not liable because the coach was acting on a 'frolic on his own' (Joel v Morison [1834] EWHC KB J39) by departing from the normal course of employment and, accordingly, will fall outside the scope of vicarious liability of the employer.

In addition to the legal duties under statute and common law, a coach's duties are also defined by sports associations of a national standard (Engelhorn, 2005). The legal duties of coaches have been investigated by many (Borkowski, 2004; Carpenter, 2008; Doleschal, 2006; Fast, 2004; Figone, 1989; Hensch, 2006; Labuschagne et al., 1999; McCaskey et al., 1996; McGirt, 1999; Porter et al., 1980; Schwarz, 1996). The most significant of them, which enclosed most areas of coaches' legal duties, were originally categorized by Figone (1989) and then improved on by Engelhorn (2005). Mohamadinejad et al. (2014) also subdivided coaches' legal duties into seven sections. We merge these to Engelhorn's (2005) to produce a list of duties as the provision of a safe sport environment through the conduction of appropriate training methods together with supervision, the use of best practices in delivering training, making use of appropriate and well- functioning equipment, adequate planning of both short and long-term training programs. Furthermore, coaches must properly match athletes, in both training and competition, based on their skill, size and power. The coach has the duty to warn athletes and their parents about the inherent risks involved in their specific sport. In addition to that, proper medical care must be always provided in order to tackle any injuries immediately. Finally, coaches must always prevent sexual harassment or harassment by other athletes and coaching staff.

When coaches fail to have sufficient knowledge about their main responsibilities and necessary precautions, athletes are being placed in unsafe situations. The violation of such duty might possibly result in criminal prosecution (Wenham, 1994). Conversely, the accident causing injury to the player may result into a civil prosecution against the coach (Wenham, 1999).

Coaches normally have the closest relationship with athletes and have the most direct control over them in any sport (Labuschagne et al., 1999). The coach-athlete relationship is special; therefore, coaches are responsible of doing everything in their power to mitigate foreseeable risks of harm to participants (Guskiewicz et al., 2010; Wehman, 2006; Whang, 1995). Coaches have the duty to continuously monitor and supervise their athletes to protect them from injuring or harming themselves. Labuschagne et al. (1999) explain that given the nature of the relationship between the coach and his athletes, coaches often find themselves facing civil liability. Nevertheless, it is crucial to mention that there is no automatic liability for coaches because the injury happened under their supervision. The source of civil liability is normally based on the tort of negligence (Labuschagne et al., 1999). Civil liability rises when a harmful action has occurred, creating damage or loss for the injured athlete and the loss is not too remote. Cases vary and diverse elements of evidence is used to provide any proof of evidence. The most crucial aspect in determining whether a coach is liable for injuries of his players is to conclude if the coach has satisfied their duty towards their players.

2.4 Criminal Liability

With regards to, criminal liability, the relevant provisions are contained in Chapter 9 of the Criminal Code of the Republic of Malta (1854, amended 2018) (The Code, n.d.). Coaching comprises a complex set of responsibilities ranging from emotional to physical that gives the coach a chance to reformulate coaching styles and interpersonal relationships (Dowey, 2008). The relationship between coaches and players is not based on an equivalent collaboration, which results in the coaches having more power than players (Dodge et al., 2004). Moreover, in most cases young athletes often obey and uncritically agree to the coach's decisions. This shows that the relationship between the coach and their athletes is based on an imbalance of power (Fasting et al., 2009). An important value that is crucial in this type of relationship is trust (Williams, 2003). Coaches are supposed to be trustworthy, since they have a great responsibility of taking care of their players (Dowey, 2008). When dealing with youth players and minors, the responsibility is greater as their parents are trusting in the coach's behaviour and actions. The notion of trust is linked to the concept of autonomy. Philosophers (Kupfer, 1987; May, 1994; Meyer, 1987) make a distinction between two distinct notions of autonomy. According to Meyer's (1987, p. 267):

> "[t]he first view might be called negative autonomy: an autonomous person is not directed by another. The second view could be called positive autonomy: an autonomous person is actively self-directed. One might better distinguish these two positions by noting that negative autonomy is a social conception, a conception of liberty. On the other hand, positive autonomy involves having a certain relationship with the 'natural' world of one's own emotions and desires."

Kupfer argues that '[i]t is not enough simply to be free from others' interference; autonomy requires awareness of control over one's relation to others, including their access to us' (Kupfer, 1987, p. 132). O'Neill (2002) stresses the importance of combining the accepted notion of autonomy with the equally important concept of trust. Trust and power can provide opportunities for coaches to misuse them (Fried, 1996; Williams, 2003). The complexity of legal suits is a powerful indication of the potential misuse of authority and power that coaches can deliberately or accidentally inflict in their relationship with athletes (Dowey, 2008). For instance, the usual physical contact between coach and athlete in order to teach several skills associated with movement, can be abused by some coaches who may not respect appropriate boundaries between the athletes and themselves (Bringer et al., 2002). However, sometimes the coach's action may be in good faith but might be misinterpreted and consequently trigger an impression of physical, sexual, or emotional abuse, or the subject of false allegations (Dowey, 2008). Consequently, the coach-athlete relationship is an unequal power relation based on power and trust that, if not carefully managed, may easily lead to emotional or physical exploitation (Toftegaard, 2005). At youth level, coaches need to be more cautious and manage their relationship in a careful manner. Drewe (2000) reported that a few of the coaches saw potential dilemmas involving the possibility of an intimate relationship developing between coach and the athlete and how such a relationship might be 'perceived from the outside as sexual harassment'.

Corbett (1993) explains that according to criminal law, someone in a position of authority or trust towards a minor must never engage in a sexual activity with the minor even if the activity is consensual. Article 201 of the Code states:

> "Unlawful carnal knowledge and any other indecent assault, shall be presumed to be non-consensual: (a) when it is committed on any person under twelve years of age; (b) when the person abused was unable to offer resistance owing to physical or mental infirmity, or for any other cause independent of the act of the offender, or in consequence of any fraudulent device used by the offender."

With regards to, defilement of minors, Article 203(1) provides, 'Whosoever, by lewd acts, defiles a person who has not completed the age of sixteen years, shall, on conviction, be liable to imprisonment'. Unfortunately, sexual abuse victims, take an undesirable road, in keeping everything to themselves, rather than reporting the case. This is usually done out of shame and/or embarrassment. Fearing the worse, such as pay-backs, deselection, and not being taken seriously, is another major contributor to coaches and those in authority not facing the criminal justice system (Brackenridge et al., 1997). Nevertheless, examples of youth sport coaches preying on youth are vast (Wenham, 1994).

This could be illustrated through several real-life cases. For example, a former Malta Football Association coach was implicated in a sexual abuse scandal within English soccer. The BBC has conveyed that in 1997 more letters were sent to soccer clubs warning them about Bob Higgins. Higgins was working with the MFA throughout 1992 and 1994. His five year-contract was withdrawn by then MFA president George Abela over investigations of sexual abuse against him in England (Vella, 2016).

Criminal law issues also arise in the context of bodily harm, which may be 'grievous or slight' (Article 215). By virtue of Article 214 of the Code:

> "Whosoever, without intent to kill or to put the life of any person in manifest jeopardy, shall cause harm to the body or health of another person, or shall cause to such other person a mental derangement, shall be guilty of bodily harm. "

However, it is generally accepted that during sporting activity, such as soccer, the use of force is permitted which in other circumstances would be unlawful (McCutcheon, 1994). McCutcheon (1994) argues:

> "Applications of force which would normally be criminal assaults are lawful when inflicted in the course of a game. The traditional explanation has been that the law recognises the consent of the participants as providing a defence. By the same token, it is accepted (with increasing regularity) that there are limits to the amount of force which might lawfully be inflicted in the course of a game and it is said that participation in sport does not confer a licence to abandon the restraints of civilisation. Thus, there is a point beyond which the consent of the participant is considered immaterial and the conduct is treated as unlawful."

For the injury suffered to be outside the remit of the Code, three factors ought to be satisfied (Child et al., 2017). Firstly, it must be established that the 'sport' is played legally. in other words, it must be a sport recognised by law. Secondly, the rules of the sport will need to be examined. As a general rule, the law will accept that no offence is committed if it is conducted within the rules of the sport. The rationale for this is that the risks are implicitly consented to by the participants. Thirdly, the injuries that occur outside the rules of a recognised game, such as soccer, will need to be considered. This requires distinguishing between a legitimate foul play from illegitimate foul play. This distinction was highlighted in the English case of R v Barnes [2005] 1 WLR 910, where the defendant, playing in an amateur soccer match, mistimed a sliding tackle against the victim, causing serious injury. The defendant was found guilty of section 20, Offences Against the Person Act 1861. His appeal was allowed by the Court Appeal on the grounds that conduct can be outside the rules of the game and still be validly consented to. The Court of Appeal established a number of factors that should be considered when considering whether a risk is impliedly consented to by those involved, even though it is outside the rules of the game. The factors are: the type of sport, the level at which it is being played, the nature of the act, the degree of force, the extent of the risk of injury and the defendant's state of mind. Child et al. (2017) argue that, in relation to the last factor, the defendant's state of find requires special attention. Outside contact sports, such as boxing and rugby plying sport should not involve a defendant intentionally causing a victim harm. Thus, in sports such as cricket and soccer, a victim does not consent to a defendant intentionally causing them an injury. Where such an injury results, it can be argued that the victim did not consent.

3 Methodology

Primary data was collected through questionnaires sent to all 47 youth soccer academies registered with the Youth Football Association. A total of 43 responses were received (91.5%). The aim of this questionnaire was to understand and gather thoughts of youth soccer academies about several risks that are encountered and their opinion about the newly implemented insurance coverage. The questionnaire consisted of three different kinds of questions including simple 'yes' or 'no' questions, multiple choice questions and open-ended questions. The use of multiple-choice questions facilitates and simplifies as much as possible the questionnaire. The aim of this study is to gain an insight into the opinions of the various clubs representatives. The purpose of the first questions was to introduce and reveal particular significant aspects rather than produce a quantitative summarization or hypothesis testing.

The first question required the participants to disclose their role within the academy. Questions two and three consisted of gathering more information about the number of teams and children that are registered within the academies. The scope of such questions was to enable us to gain an in depth understanding of the level of risk present in the club of each respondent. The subsequent set of questions were related to the number of coaches involved within the academy, the number of full-time coaches working with the academy, qualifications and if coaches are required to have a first aid qualification to work within the academy. Since coaches are critical in the management of an academy, these questions were very important in order to provide a better insight of the management of the respondent's academy.

Questions 1–7, inclusive, gathered demographic data and were disregarded for the purposes of this article. Questions 8 and 9 were designed to analyse the risks faced by each responded. Question 8 required respondents to disclose the number of matches or tournaments their academy participates in on a weekly basis, whereas question 9 questioned the method of transportation used to arrive at the location where matches are held.

Questions 11 and 12 were open-ended, with the scope of giving freedom and to provide an opportunity for the respondents to list the main risks and hazards which they feel that their organization is exposed to. As explained by several authors (Dugas, 2017; Le Gall et al., 2007; Serena, 2017); the risk of injuries in youth soccer is a serious risk for both the academies and the youth players. Youths tend to push to their maximum limits when practicing sports and their body is still in a growth phase which makes them more susceptible to getting injured.

Furthermore, respondents were encouraged to state ideas and solutions how such hazards can be managed or mitigated. Questions 13 and 14 focused about written risk assessment plans. Academies were asked if they have a written risk assessment plan or not and whether they think that it is necessary or not to have such plan in order to manage or reduce risks. The process of risk management can be implemented in order to minimize injuries. C. Fuller et al. (2004) discuss the importance of risk mitigation tools within sports. Having a detailed risk assessment plan, which explains clearly what to do when an incident arises will helps the academy to be better prepared in tackling such instances in an organized manner.

Questions 15 and 16 focused on the actual insurance policy offered by the MYFA. Through these two questions, the respondents were given the opportunity to state their opinion about the current insurance policy provided by the MYFA. One of the main risk actions is when part of the risk is transferred (C. W. Fuller, 2007). The use of insurance policies is the main form of risk transfer whereby academies can protect their players and themselves from potential injuries of liability occurrences. The purpose was to identify the perception of academies regarding the actual insurance policy currently provided within local soccer.

Question 17 required academies to state their opinions and compare the current situation of Malta with foreign countries and to specify whether enough focus and attention, is being provided in Malta when compared to foreign countries. The subsequent question, involved in asking respondents if insurance is considered as an effective method of risk transfer. The purpose of this question was to test if academies consider insurance as an important method of increasing protection.

The final question identified alternative measures to increase safety and protection other than the use of insurance. The use of alternative measures can assist soccer academies in adopting better risk management strategies leading to added safety.

Primary data was also acquired through semi-structured interviews conducted with the MYFA, and Melita Unipol, the broker offering the insurance policy which covers Youth Football organizations.

4 Results

Responses obtained from the both the questionnaires and the interviews were used to evaluate and gather a better understanding of the current insurance policy focusing mainly on the benefits and its weaknesses.

4.1 Academies' Questionnaires

As explained in the methodology, a questionnaire was distributed to all academies registered with the MYFA.

The purpose of the questionnaire was to gather a better understanding about their perception related to insurance in general, the policy offered by the MYFA and also the factors related to risk management. The highest number of respondents were youth academy secretaries, followed by administrators, coaches, chairman and director of youth coaching (figure 1).

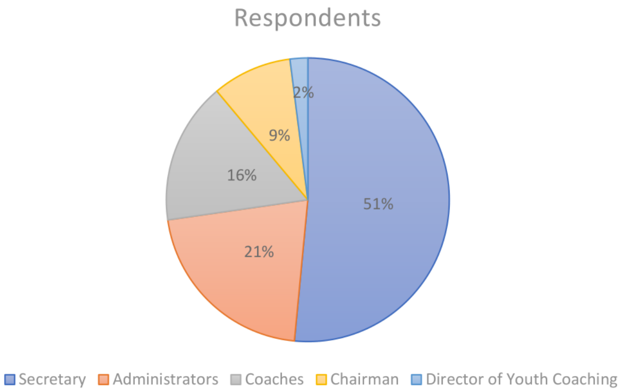

Figure 1: Respondents Role

Exposure to risk can be measured via the size of the soccer academy, coaches' qualifications and matches played. The number of coaches working within each academy varied between 3 and 25 with the average being 10 coaches and a standard deviation of 5.28. As expected, there is strong evidence that academies required more coaches for a higher number of registered youths ($r = 0.5504$, $p < 0.01$). 31 of the respondents have no full-time coaches, 2 of the respondents have one full time coach, and 1 of the respondents have two or more full time coaches. The remaining 8 respondents preferred not to answer the question. 52.17% of the respondents have more than 5 coaches who hold at least UEFA C qualification, an assessed qualification accredited by the European Football Association (UEFA), which focuses on youth development. Coaches with higher qualifications are expected to provide training sessions and guidance at a higher professional level and thus minimizing the frequency or severity of injuries or other claims. We also measured exposure to injuries via matches played (figure 2). Eight respondents participate in two and four matches respectively, whereas seven academies participate in three matches. Six respondents participate in more than four matches per week. The number of matches played per week was positively correlated with the number of teams involved with the club ($r = 0.5905$, $p < 0.01$).

Injuries ranked high as a significant source affecting the dropout rate although the major reason cited was the focus on studies (figure 3). This is matched by the academy's responses on the main hazards being faced (table 1) as injuries (90%), liability risk (60%) and unsafe facilities (52.5%) are the most common responses. The largest 2 and smallest 9 academies (by number of youths registered) all listed injuries as a hazard. On the other hand, 7 and 18 academies from 9 and 20 academies with 61 to 80 and 81 to 100 youths registered respectively listed injuries as a potential hazard. This was not considered to be significantly different than 90% ($p > 0.2$).

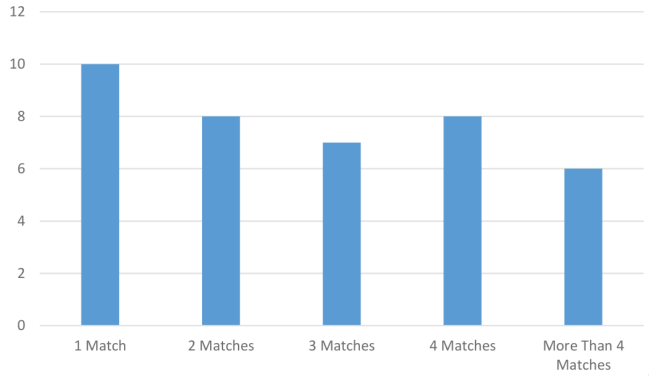

Figure 2: Number of matches played

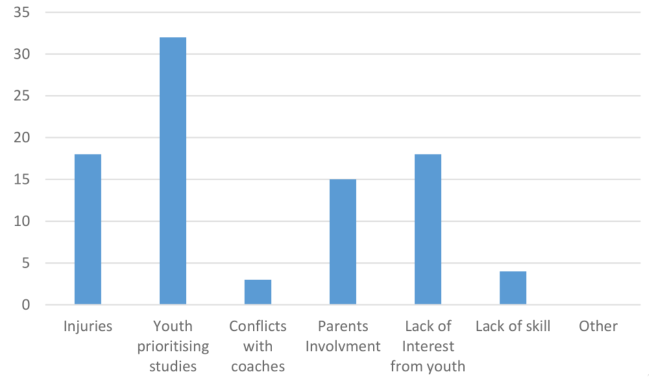

Figure 3: Factors affecting dropout rate

We would have presumed that the larger academies, that is those with more youths, would be able to list more hazards (figure 4). However, we did not find evidence of a difference either when using correlation analysis ($r = 0.35418$, $p > 0.1$). When splitting the academy sizes in ranges of 20 youths (i.e. 40–60 youths, 61–80 youths, 81–100 youths and 101+ youths), we found that the latter group showed evidence of being having a higher mean when compared to any other group ($p < 0.05$) using a t-test for independent samples. We have also conducted the same analysis but subdividing by the number of games played, finding no evidence of a relationship between number of games played and number of hazards identified ($r = -0.27$, $p > 0.1$). Table 2 identifies the potential solutions that can be adopted to manage or mitigate the mentioned hazards, according

Hazards Identified	
Hazard Mentioned	# of times Mentioned
Risk that Child gets injured	36
Liability Risk	24
Unsafe Facilities	21
Equipment not up to standard	17
Posts Falling	8
Lack of fair play	6
Injuries to coaches and officials	3
Financial Problems	3
Fines	4
Bullying	1

Table 1: Main Hazards mentioned by respondents

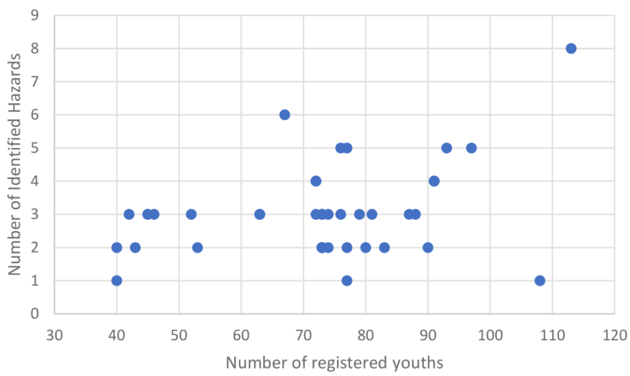

Figure 4: Number of Hazards identified by Academy Size

Solutions Identified	
Hazard Mentioned	# of Times Mentioned
Safer Locations and Training Grounds	33
Investing in Better Equipment	31
First Aid Courses	28
Insurance	19
Educating Parents and Children	12
Secure Goal Posts	6
Periodical Meetings	6
Financial Investment in youth academies	5
More Equal Opportunities	1
Nothing can be done due to lack of investment	1

Table 2: Solutions identified by respondents

to academies. Investing in training grounds and better equipment were the most popular. The use of first aid courses and the insurance policies were also popular choices amongst respondents. These solutions can be easily related to the liability risks and injuries mentioned throughout the previous question. Other significant responses included education, periodical meetings and financial investment throughout youth academies.

Through questions 13 and 14 it was identified that 83% of the respondents stated that academies do not have a written risk assessment plan, whereas the remaining 16.5% stated that they have such a plan. Despite this, 87.5% of the academies believe that a written risk assessment plan helps in managing risks, while 10% stated that it is not necessary. The remaining 3% of the respondents were unsure. The role of respondent has been linked to whether the respondent considers the use of a risk assessment plan as useful within the structure of the club (table 3). Most of respondents are in agreement that the use of a risk assessment plan is important to manage and mitigate risks. However, one outcome of this analysis was that two out of three chairpersons do not consider the use of a risk assessment plan as useful. Using a z-score for proportion test, we find that this proportion of only one third in agreement is significantly different than the 87.5% of the total sampled population ($p < 0.01$). We have also examined the 4 respondents who did not consider the risk assessment important and the one that one was unsure for other variables but could not find any statistical significance. Furthermore, 65% of the respondents specified that the insurance policy is actually good and necessary, 28% stated that they do not find the policy beneficial. 7% of the respondents explained that it is a good policy, however it could be more

Risk Assessment Importance	Total	Yes	No / Unsure
Administrator	8	7	1
Chairperson	3	1	2
Coach	6	5	1
Director of Youth Coaching	1	1	0
Secretary	22	21	1

Table 3: Risk Assessment Plan Importance by role of respondent

Figure 5: Respondent Opinion on the Insurance Policy

detailed and certain changes are required. Figure 5 lists the most popular comments mentioned by academies.

4.2 Respondent Opinion on the Insurance Policy

As explained the methodology section, interviews with Melita Unipol Brokers and the Maltese YFA were conducted. The main themes and topics that emerged during the interviews are related to the main benefits of the insurance policy, the risks faced by youth academies, safety and injuries, the underwriting factors applied, the claims process and the possibility of applying a similar insurance policy within other sports.

The interviews conducted with YFA were more in depth as risks other than those mitigated by the insurance policy were discussed. The topics discussed included the youth academy's structure; managing parents' expectations; referees; the challenges of meeting the needs of a senior team while simultaneously catering for the needs of the soccer academy team; and the benefits of soccer participation among youths.

Albeit, insurance being a useful form of risk transfer mechanism, it is a partial form of risk transfer—academies should always be responsible and take appropriate measures to increase safety. Furthermore, there will always be a gap in insurance due to the exclusions inherent in every policy. Academies will always retain some form of risk. Additionally, it was pointed out that insurance comes at a cost and ultimately the use of insurance depends mainly on the financial resources of the academy and its risk appetite.

5 Results and Analysis

The policy offered for youth soccer academies is the only policy offered throughout youth sports within Malta. The policy provides benefits not only to youths but also to coaches and academy officials. Furthermore, this policy offers additional safety and protection to youths. Several Maltese academies stated that the insurance policy is necessary and was needed in Malta. Most of the respondents consider insurance as an effective risk transfer mechanism and consider such policy as valuable. Table 4 shows the key perils identified in our literature review.

Key Perils Identified
Injuries
Unsafe Facilities and Equipment
Lack of Fair Play
Coaches' civic liability
Coaches' criminal liability

Table 4: Key Perils Identified

5.1 Reducing Injuries

The majority of the academies listed injuries as one of their major concerns as it is one of the most popular factors that lead youths to dropout from soccer at a certain point is due to injuries; especially contusion, muscle sprain, growth related overuse disorders (Le Gall et al., 2007) and at times concussion (Boden et al., 1998),

The most appropriate risk mitigation method is the insurance policy provided by the MYFA. The insurance policy provides benefits such as physiotherapy facilities that help in mitigating the risk of injuries. Through insurance, youths are being protected and covered in the event of injuries, which can even threaten their carrier if not dealt with immediately.

However, insurance is not the only risk mitigation method to be used when assessing injury risks. Another critical solution explained by the respondents is a proper financial investment in youth academies, focusing mainly on better equipment, training ground and sports facilities. Through adequate facilities, academies benefit from increased safety which leads to a lower frequency of injured players.

Respondents also highlighted the importance of first aid courses as it can be another significant method in managing risks. Having a first aid course minimizes the impact of the injury as certain preventive measures are taken immediately which reduces the severity of the risk. Finally, having educated coaches helps in providing the most suitable training plans which maximizes performance, player development and minimizes the risk of injuries. This reduces both the severity and the frequency of injuries since players benefit from the efficient training provided by the coach.

5.2 Protection of Coaches – Injuries to Coaches, Coaches' Civic and Criminal Liability

Coaches have a major role in youth sports. We established in our literature review that coaches have numerous responsibilities and duties towards youths that may lead to civil and criminal lawsuits (Engelhorn, 2005). Civil liability is based on the tort of negligence and rises when a harmful action has occurred, creating damage or loss for the injured athlete and the loss is not too remote (Labuschagne et al., 1999). On the other hand, criminal liability is related to the abuse of power that the coach has over his young athletes focusing mainly on non-fatal offences against the person, namely sexual offences and wilful offences against the person.

The insurance policy provides coverage for non-criminal negligent acts and omissions covering mainly the civil liability part. The aim of the cover is to provide protection to coaches for any potential mistakes such as providing wrong training, which increases the injury rate, and this offers more security to coaches.

Since incidents involving civil and criminal liability are typically long tail claims, which take a long period to be settled, internal solutions mitigating this risk are necessary. With regards to civil liability, education has an important role in reducing the frequency of negligent acts and increase protection for coaches. Educated officials and coaches lead to better training regimes, less injuries and hence less likelihood of civil lawsuits.

The likelihood of a criminal act can be tackled through other solutions such as having regulations ensuring that the coach has a clean criminal record and is fit and proper to respect their role in the most suitable manner. Furthermore, an open environment must be created making sure that players know that they will be supported in case they need any help with anything making them uncomfortable. This can be done through periodical meetings evaluating any incidents and potential mishaps that might have occurred.

5.3 Unsafe Facilities and Equipment

The lack of safe facilities results in significant hazards identified in both the literature review and the in the results. In 2003 there was a fatality in Malta caused from a falling goal-post (Fenech, 2013). Although, fortunately fatality cases are few in Malta, a significant number of respondents mentioned this as peril. A key example mentioned, possibly also influenced by the fatality experience, is that goal posts are not securely fixed to the ground and it represent a great risk, especially in adverse weather conditions.

The insurance policy covers personal accident including accidental death and permanent disability. While this minimizes the effect of a claim, the main priority for academies is to reduce the likelihood of such cases occurring. The best solution is adequate financial investments in order to have safer facilities and equipment up to standard, together with regular maintenance. Furthermore, secure fixed goalposts is the ideal solution related to falling posts, as it would practically mitigate the frequency of this risk completely.

5.4 Lack of Fair Play

Lack of fair play[5] was another significant issue mentioned by respondents. Unfortunately, some coaches focus only on winning without prioritising the development or the attitude of the child. At young ages, the most critical aspect is to develop the skills of the child and making them a better person. Insurance cannot be a mitigating factor in this respect. Indeed, the ideal risk mitigation solution is once again education. Education must be provided to the children, coaches and even parents promoting and highlighting the importance of clean fair play. Furthermore, academies should create a respectful culture enhancing and stressing the importance of fair play and zero tolerance measures against lack of fair should be adopted.

5.5 Other Perils identified from interviews and questionnaires

Other issues mentioned by the respondents were financial problems, fines and bullying. For such circumstances, internal mitigation strategies must be implemented in order to reduce the frequency and severity of such risks. With regards to, financial problems, it is very important that a budget is set up with some form of limits as a guidance. In the case of fines, it is very important to have academy officials monitoring the MYFA's regulations in order to adhere to them and lessen the likelihood of such risk. When dealing with bullying issues, education is the ideal solution in order to implement a culture where bullying is not tolerated. The academies that usually use part-time coaches may find benefit in having staff that are educators in their main full time role.

[5] Fair play is a concept that comprises and embodies a number of fundamental values such as fair competition, respect, friendship and team spirit that are integral to sports (International Fair Play committee, 2019).

5.6 Same coverage for all teams

Being a new and innovative insurance policy, it can be improved and additional features could be used in order to update and upgrade the current policy. One of the main disadvantages is that same coverage and exact premium is charged for each team. However, not every team represents the same risk. For example, an academy with a large number of children is subject to greater risk than a team with less children. Furthermore, some teams benefit from better and safer equipment than other teams. Nevertheless, through the interviews conducted it was identified that until now it is not feasible for the insurance providers to underwrite and evaluate academies individually.

Some academies do not consider insurance as an efficient risk transfer tool. Thus, demand for flexible insurance covers could be low. Additionally, some academies might have financial problems and may consider such policy as a financial burden rather than an advantage for their academy.

5.7 Future Opportunities

One of the main questions asked during the interviews concerned the possibility of insuring sports other than soccer. The responses obtained indicated a positive feedback as it was stated that it is a future possibility to have similar insurance policies covering various sports. Nonetheless, each sport needs to be evaluated according to its nature and specific risks, since not every sport gives rise to the same risks. Given the small size of youth training set-ups for sports other than soccer in Malta, the feasibility of insurance cover is deemed to be low.

6 Conclusion

Insurance is one of the main forms of adding and enhancing the level of protection and risk transfer within youth sports. However, other methods together with insurance could be applied to create a safer environment for youths. This article, through an empirical study, has identified that continuous professional development (CPD) combined with the use of the insurance policy as the most significant risk mitigation factors with respect to injuries, negligence, lack of fair play, and bullying. One must note that coaches with a UEFA C licence need to follow a certain number of CPD hours per year to maintain their licence. Future CPD session should include training in risk management within sports setting. Other specific methods identified include: written risk assessments; education; first aid training; health and safety seminars; regular medical checks; and government grants. The application of these risk mitigation methods has the potential to improve youth sports, broadly speaking. By adopting such measures, an effective framework of protection and safety will be created leading to numerous benefits such as the reduction of injuries and increase in number of youth athletes. Throughout this research, Malta was used as a case study representing a small state which is still at a developing phase related to soccer and sports. The introduction of the insurance policy is still a recent upgrade within Maltese youth soccer. The discussion and results obtained throughout the study could be attributed to small states and developing countries which still do not have the resources and facilities such as Germany, Italy and the UK, where these countries have more facilities and are well developed. Youths represent the future in each type of sport, therefore they need to be given further attention to establish an enhanced sports environment. To develop such an environment, it is imperative that dialogue takes place between coaches, youth soccer academy managers, and insurance companies.

References

Barbara, C., Cortis, D., Perotti, R., Sammut, C. & Vella, A. (2017). The european insurance industry: A PEST analysis. *Joural of Financial Studies*, *5*(2), 14.

Barnes, B., Kirkendall, D. & Garrett, W. (1998). Concussion history in elite male and female soccer players. *The American Journal of Sports Medicine*, *26*(3), 433–438.

Boden, B., Kirkendall, D. & Garrett, W. (1998). Concussion incidence in elite college soccer players. *The American Journal of Sports Medicine*, *26*(2), 238–241.

Borkowski, R. P. (2004). Coaching management [Retrieved from: http://www.momentummedia.com/articles/cm/cm1203/safelandings.htm, Last accessed 21 Oct 2017].

Brackenridge, C. & Kirby, S. (1997). Playing safe: Assessing the risk of sexual abuse to elite child athletes. *International Review for the Sociology of Sport*, 407–418.

Bringer, J. D., Brackenridge, C. H. & Johnston, L. H. (2002). Defining appropriateness in coach-athlete sexual relationships: The voice of coaches. *Journal of Sexual Aggression*, 83–98.

Carpenter, L. J. (2008). *Legal concepts in sport: a primer* (third ed.).

Child, D. & Ormerod, D. (2017). *Smith, Hogan and Ormerod's essentials of criminal law*. Oxford University Press.

Corbett, R. (1993). Parents can help to cut risk of sexual abuse by coaches [Retrieved from: http://www.sportlaw.ca/1993/12/parents-can-help-to-cut-risk-of-sexual-abuse-by-coaches/, Last accessed 21 Oct 2017].

Dodge, A. & Robertson, B. (2004). Justifications for unethical behavior in sport: The role of the coach. *Coaching Association of Canada*, 23–29.

Doleschal, J. K. (2006). Managing risk in interscholastic athletic programs: 14 legal duties of care. *Marquette Sports Law Review*, 293–342.

Dowey, P. (2008). Power in the coach-athlete relationship [Retrieved from: http://www.procoachuk.com/resources/Power+in+the+Coach-Athlete+Relationship.pdf, Last accessed 21 Oct 2017].

Drewe, S. (2000). An examination of the relationship between coaching and teaching. *Quest*, *52*(1), 79–88.

Dugas, P. (2017). Early specialization versus sport diversification in youth athlete-article review. *Research and Investigations in Sports Medicine, Crimson Publishers*.

Emerick, M. L. (1997). The university/ student-athlete relationship: Duties giving rise to a potential educational hindrance claim. *UCLA Law Review*, *44*, 865.

Engelhorn, R. (2005). Legal and ethical responsibilities of a coach [Retrieved from: https://ihsaa-static.s3.amazonaws.com/RichEngelhorn.html, Last accessed 21 Oct 2017].

Fast, K. S. (2004). Sport liability law: A guide for amateur sports organizations and their insurers.

Fasting, K. & Brackenridge, C. (2009). Coaches, sexual harassment and education. *Sport, Education and Society*, 21–35.

Fenech, N. (2013). Boy dies in school ground accident [Retrieved from: https://www.timesofmalta.com/articles/view/20031028/local/boy-dies-in-school-ground-accident.137932, Last accessed 19 Feb 2017]. *Times of Malta Newspaper*.

Figone, A. J. (1989). Seven major legal duties of a coach. *Journal of Physical Education, Recreation and Dance*, 71–75.

Fried, G. (1996). Unsportsmanlike contact: Strategies for reducing sexual assaults in youth sports. *Journal of Legal Aspects of Sport*, 155–168.

Fuller, C. & Drawer, S. (2004). The application of risk management in sport. *Sports Medicine*, *24*(6), 350–356.

Fuller, C. W. (1995). Implications of health and safety legislation for the professional sportsperson. *British Journal of Sports Medicine*, *29*(1), 5–8.

Fuller, C. W. (2007). Managing the risk of injury in sport. *Clinical Journal of Sport Medicine*, *17*(3), 182–186.

Guskiewicz, K. M. & Pachman, S. E. (2010). Management of sport-related brain injuries: Preventing poor outcomes and minimizing the risk for legal liabilities. *Athletic Training and Sports Health Care*, 248–252.

Hanson, B. (2015). Importance of youth sports statistics [Retrieved from: http://athleteassessments.com/importance-of-youth-sports-statistics/, Last accessed 15 Oct 2017].

Hensch, L. P. (2006). Legal issues for coaches. *Soccer Journal*, 14–15.

International Fair Play committee. (2019). What is fair play? [Retrieved from: http://www.fairplayinternational.org/what-is-fair-play-, Last accessed 26 Feb 2020].

Jowett, S. & Cockerill, I. M. (2002). Incompatibility in the coach-athlete relationship. In I. Cockerill (Ed.), *Solutions in sport psychology* (pp. 11–36). London: Thomson Learning.

Kupfer, J. (1987). Privacy, autonomy, and self-concept. *American Philosophical Quarterly*, *24*(1), 81–89.

Labuschagne, J. & Skea, J. M. (1999). The liability of a coach for a sport participant's injury. *Stellenbosch Law Review*, *10*, 158–183.

Le Gall, F., Carling, C. & Rile, T. (2007). Biological maturity in elite youth football [Retrieved from: http://onlinelibrary.wiley.com/doi/10.1111/j.1600, Last accessed 21 Oct 2017]. *Medicine and Science in Sports*.

Leġiżlazzjoni Malta. Ministry for Justice, Culture and Local Government [Retrieved from: http://www.justiceservices.gov.mt/DownloadDocument.aspx?app=lom&itemid=8574, Last accessed 15 Sep 2018].

Lyle, J. (1999). Coaching philosophy and coaching behaviour. In N. Cross & J. Lyle (Eds.), *The coaching process: Principles and practice for sport* (pp. 21–49). Oxford: Butterworth–Heineman.

Lyle, J. (2002). *Sports coaching concepts: A framework for coaches' behaviour*. London: Routledge.

Macken, J. (1990). *The autonomy theme in the church dogmatics: Karl Barth and his critics*. Cambridge University Press.

May, T. (1994). The concept of autonomy. *American Philosophical Quarterly*, *31*, 133–144.

McCaskey, A. S. & Biedzynski, K. W. (1996). A guide to the legal liability of coaches for a sports participant's injuries. *Seton Hall Journal of Sport Law*, 7–125.

McCutcheon, P. (1994). Sports, violence and the criminal law. *Northern Ireland Legal Quarterly*, *45*, 267.

McGirt, M. D. (1999). Do universities have a special duty of care to protect student-athletes from injury. *Villanova Sports and Entertainment Law Journal*, 219–241.

Meyer, M. (1987). Stoics, rights, and autonomy. *American Philosophical Quarterly*, *2*, 267–271.

Mohamadinejad, A. & Mirsafian, H. (2014). Connection between the legal knowledge and social background of sports coaches at Iranian universities. *Iranian Studies*.

MYFA. (2015). The youth football association [Retrieved from: https://theyouthfa.org.mt/association/, Last accessed 26 Oct 2017].

O'Neill, O. (2002). *Autonomy and trust in bioetics*. Cambridge University Press.

Porter, M., Noble, H. B., Bachman, D. & Hoover, R. L. (1980). Sports medicine care in Chicago area high schools. *Physician and Sport Medicine*, *8*(2), 93–98.

Schwarz, T. C. (1996). *Coaches and liability: Preventing litigation through the legal duties of coaches* (Doctoral dissertation). Washington State University, USA.

Serena, G. (2017). More kids are suffering sports injuries [Retrieved from: http://abcnews.go.com/Health/Healthday/story?id=4508484&page=1, Last accessed 18 Oct 2017].

Toftegaard, J. (2005). Sexual harassment. In D. Levinson & K. Christensen (Eds.), *Berkshire encyclopedia of world sport, 3rd edition* (pp. 1350–1357). Berkshire: Berkshire Pub Group.

Vella, M. (2016). Former MFA development coach bob higgins implicated in UK football sex abuse scandal [Retrieved from: http://www.maltatoday.com.mt/sports/football/72337/former_mfa_development_coach_bob_higgins_implicated_in_uk_football_sex_abuse_scandal, Last accessed 18 Feb 2018]. *Malta Today Newspaper*.

Wehman, T. (2006). Not part of the game plan: School district liability for the creation of a hostile athletic environment. *University of Colorado Law review*, *77*, 765–771.

Wenham, D. (1994). Health and safety in further education: Why should it be managed. *Journal of Further and Higher Education*, 90–106.

Wenham, D. (1999). Civil liability of schools, teachers and pupils for careless behaviour. *Educational Management Administration and Leadership*, *27*(4), 365–374.

Whang, E. H. (1995). Necessary roughness: Imposing a heightened duty of care on colleges for injuries of student-athletes. *Sports Lawyers Journal*, 25–51.

Williams, Y. (2003). Government sponsored professional sports coaches and the need for better child protection. *Entertainment Law*, 55–77.

Young, J. (2000). Injuries in youth soccer: A subject review [Retrieved from: http://pediatrics.aappublications.org/content/pediatrics/105/3/659.full.pdf, Last accessed 15 Nov 2017].

Youth Sports Safety Alliance. (2013). Statistics of 2013: A subject review [Retrieved from: http://www.youthsportssafetyalliance.org/sites/default/files/docs/Statistics-2013.pdf, Last accessed 17 Feb 2018].

XJENZA ONLINE
VOLUME 9 ISSUE 1, 2021

Table of Contents

Articles